Bibblewindi Gas Exploration Pilot Expansion

Response to Submissions

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1.0 Introduction

1.1 Background

Santos NSW (Eastern) Pty Ltd (Santos), as the coal seam gas (CSG) operator of Petroleum Assessment Lease (PAL) 2, is seeking consent to drill two additional pilot wells and operate the expanded Bibblewindi Multi-Lateral Pilot for up to three years (the proposed activity). The Bibblewindi Multi-Lateral Pilot is located within the Bibblewindi State Forest, approximately 40 kilometres south of Narrabri, north western NSW.

The proposed activity includes the construction and drilling of Bibblewindi 31 and 32 pilot wells on the existing Bibblewindi 14 and Bibblewindi 19H well leases respectively, installation of surface infrastructure to connect the two wells to the existing Bibblewindi Multi-Lateral Pilot and operation of the Bibblewindi Multi-Lateral Pilot.

The proposed activity includes:

- construction: site preparation activities at existing well leases, establishment of necessary equipment, temporary structures and facilities on the lease areas to enable drilling; drilling one vertical pilot well (Bibblewindi 31) and one lateral pilot well (Bibblewindi 32) and connection to the Bibblewindi Multi-Lateral Pilot.
- operation: operating the existing Bibblewindi Multi-Lateral Pilot with the new Bibblewindi 31 and 32 wells, management of the water and gas produced during operation for up to three years and general maintenance activities.
- post operation and rehabilitation: decommissioning and rehabilitation of pilot wells and ancillary infrastructure or suspension of wells for potential future use.

The proposed activity forms part of the Energy NSW CSG Exploration and Appraisal Program (E&A Program). The E&A Program consists of a series of CSG exploration and appraisal activities including recommencing operation of a number of existing pilot wells, drilling and operating new pilot wells and constructing and operating water and gas management facilities to support the program.

A more detailed description of the proposed activity is found in Chapter 4 of the *Bibblewindi Gas Exploration Pilot Expansion Environmental Impact Statement* (RPS, 2013a).

The proposed activity is a 'State Significant Development' (SSD) to which Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) applies in accordance with the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP).

In accordance with the requirements of the EP&A Act, an Environmental Impact Statement (EIS) was prepared for the project (RPS, 2013a) and placed on public exhibition from 24 September to 7 November 2013. Public submissions were invited during this period.

1.2 Purpose of this report

There were 185 submissions received during the exhibition of the EIS. The Director-General of the Department of Planning and Infrastructure (DP&I) provided copies of the submissions to Santos. In accordance with section 85A of the *Environmental Planning and Assessment Regulation 2000*, the Director-General required Santos to address the issues raised in the submissions as considered necessary.

This Submissions Report documents and considers the submissions received on the EIS, and details Santos' responses to these submissions. The report also includes an update on consultations undertaken since preparation of the EIS, some clarifications on the proposed activity and the EIS, and a revised Statement of Commitments (SoC) in response to the issues raised in submissions.

Following consideration of the submissions, no significant changes to the design described in the EIS are proposed.

1.3 Structure of this report

This Submissions Report comprises the following chapters:

- Chapter 1: Introduction — outlines the background to the proposed activity and the purpose and structure of this report.
- Chapter 2: Consultation — provides an overview of the consultation and public display activities undertaken during and following the EIS exhibition period.
- Chapter 3: Overview of submissions—provides details of submissions received, the approach taken to consideration of submissions and the main issues raised.
- Chapter 4: Responses to issues raised in submissions — details the issues that were raised in the submissions and provides responses to the issues raised.
- Chapter 5: Revised Statement of Commitments —outlines changes to and additions to the draft SoC from the EIS.
- Chapter 6: References.

2.0 Consultation

2.1 Consultation during public exhibition period

The EIS was exhibited for 45 days, from 24 September 2013 to 7 November 2013. A range of exhibition and consultation activities were carried out during this period.

2.1.1 Public exhibition venues

The EIS was publicly exhibited at the following display locations:

- Department of Planning and Infrastructure, Information Centre, 23-33 Bridge Street, Sydney.
- Narrabri Shire Council, 46-48 Maitland St, Narrabri.
- Nature Conservation Council, Level 2, 5 Wilson Street, Newtown.

Hardcopies were also on public display for viewing at Santos' Narrabri shop front and the Narrabri Operations Centre during business hours. During the exhibition period, the public was able to review the EIS, obtain information from display materials and seek further information from staff at these offices.

2.1.2 Project enquiries telephone line, email and websites

The project enquiries and information line (1800 071 278) and project email address (energy.nsw@santos.com) were monitored throughout the exhibition period. No specific phone calls or emails were received in relation to the EIS during this period.

The EIS was, and still is, available for electronic download on the Santos website: http://www.santos.com/exploration-acreage/new-south-wales/environment/environmental-approvals.aspx and the DP&I website: http://majorprojects.planning.nsw.gov.au/page/.

2.1.3 Distribution of EIS

Upon instruction from the DP&I, Santos provided copies of the EIS to the following Government agencies and special interest groups:

- Department of Planning and Infrastructure.
- Narrabri Shire Council.
- Division of Resources and Energy.
- NSW Office of Coal Seam Gas (NSW OCSG).
- NSW Environment Protection Authority (NSW EPA).
- NSW Office of Environment and Heritage (NSW OEH).
- Namoi Catchment Management Authority (Namoi CMA).
- NSW Roads and Maritime Services.
- Heritage Branch of NSW.
- Department of Primary Industries (Fisheries, NSW Office of Water and the Office of Agricultural Sustainability and Food Security).
- NSW Health – Hunter New England Health District (NSW Health).
- Nature Conservation Council.

- Rural Fire Service (RFS).
- Forestry Corporation of NSW (Forestry NSW).

A copy of the EIS was subsequently sent to the Narrabri Local Aboriginal Land Council (Narrabri LALC), upon request by the Namoi CMA.

2.1.4 Notification to key stakeholders

Information on the EIS and links to copies of the document and the process for making a submission were provided by email to key stakeholders in Santos' September and October 2013 Monthly Activity Updates. These updates are provided to:

- Forestry NSW.
- Division of Crown Lands.
- Roads and Maritime Services.
- Narrabri Shire Council.
- Narrabri LALC.
- Narrabri Community Consultative Committee (Narrabri CCC).
- neighbouring landholders to Leewood.

2.1.5 Advertisements

The exhibition was advertised by DP&I in a media release, as well as in the local Narrabri Courier newspaper.

2.2 Consultation following public exhibition

2.2.1 Project enquiries telephone line and email

The project enquiries and information phone line and email address have been maintained during preparation of this Submissions Report, and will be maintained and regularly checked during the assessment of the EIS by the DP&I and during construction and operation of the proposed activity, should development consent be granted. No specific phone calls or emails were received in relation to the EIS during the preparation of the Submissions Report.

2.2.2 Meetings and other consultation

A number of meetings have been held between Santos and government agencies and key stakeholders since the public exhibition period, including specific presentations to provide information on the EIS with:

- Narrabri Shire Council.
- Namoi CMA Board Meeting, Gunnedah.

Meetings were also held with local officers from the following stakeholder groups during this period to provide information on the broader Narrabri Gas Project:

- Roads and Maritime Services.
- NSW Office of Water.
- Forestry NSW.
- National Parks and Wildlife Service (NPWS) and Natural Resources Commissioner.
- Presentation to the Narrabri CCC.

During those meetings, officers had an opportunity to ask questions relating to the EIS as meeting attendees were aware that it was on public exhibition.

3.0 Overview of submissions

3.1 Respondents

3.1.1 Submissions

The DP&I received 185 submissions on the EIS. The full submissions can be viewed on DP&I's website at http://majorprojects.planning.nsw.gov.au/index.pl?action=view_job&job_id=5934. Of these submissions:

- 183 were received during the submissions period (24 September to 7 November 2013).
- Two were received after the submissions period had closed, but were considered and responded to in this report.
- Two individuals made two submissions each.

A summary of all submissions received, including a reference to key areas of concern, is provided in Appendix 1. In order to protect privacy, individual names of submitters have not been included.

3.1.2 Types of respondents

Submissions were received from a number of different respondents. Of these:

- Ten submissions were from government agencies – NSW OCSG, NSW EPA, NSW OEH, Namoi CMA, NSW Roads and Maritime Services, Heritage Branch of NSW, NSW Fisheries, NSW Office of Agricultural Sustainability and Food Security, NSW Office of Water and NSW Health.
- Two submissions were from councils – Narrabri Shire Council and Coonamble Shire Council.
- Eight submissions were from special interest groups – NSW Artesian BoreWater Users Association, National Parks Association of NSW, Friends of the Pilliga, Namoi Water, The Wilderness Society, Upper Mooki Landcare Group, Northern Inland Council for the Environment and the North Coast Environment Council.
- 165 submissions were from individuals.
- There were 89 submissions that contained versions of a form letter.

3.2 Approach to consideration of submissions

Each submission received was assigned a submission number by DP&I. The submissions were reviewed and individual issues raised within each response categorised. A response has been provided to each issue within this Submissions Report. Where similar issues have been raised in different submissions, a single response has been provided.

3.3 Overview of issues raised in submissions

This section summarises the issues raised by the government agencies, councils and the community. Responses to these issues are contained in Chapter 4.

3.3.1 Main issues raised by government agencies and councils

The key issues and comments raised by government agencies and councils are presented below.

3.3.1.1 Fisheries NSW

- Fisheries NSW advised that the EIS is satisfactory, and raised no issues.

Noted - no further response required.

3.3.1.2 Heritage Council of NSW

- The mitigation measure for non-Aboriginal cultural heritage provided in the EIS is considered appropriate and recommended to form part of the approval conditions.

Noted - no further response required.

3.3.1.3 NSW Environment Protection Authority

- Santos needs to submit a variation application to the NSW EPA to add the proposed activity to the Environment Protection Licence (EPL) application.
- Erosion and sediment controls should be implemented consistent with the guidelines, principles and recommended minimum design standards contained in *Managing Urban Stormwater: Soils and Construction – Volume 1* (the Blue Book).
- The unsealed road network associated with the proposed activity should be managed and maintained consistent with the guidelines, principles and recommended minimum design standards contained in:
  - *Managing Urban Stormwater: Soils and Construction – Volume 2C Unsealed Roads*
  - *Erosion and sediment control on unsealed roads – A field guide for erosion and sediment control maintenance practices.*
- A Leak Detection and Repair program should be incorporated into the fugitive emissions monitoring program, conducted in accordance with *US EPA Method 21 - Determination of Volatile Organic Compound Leaks (40 CFR Part 60, Appendix A, Method 21)*.

Responses to these comments are provided in Chapter 4 below.

3.3.1.4 NSW Health

- Implementation of the proposed groundwater and surface water monitoring regime is strongly supported.
- The proposed water management strategy should be adequate to mitigate any potential spillages or leakages if fully implemented.
- Chemicals used in the CSG industry are of great public health concern; therefore proposed control measures must be fully implemented to mitigate against environmental pollution and health impacts.
- The EIS does not include an assessment of potential fugitive emissions from the project, which could include volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs). Santos needs to consider the potential for fugitive emissions and the impact of these emissions at the nearest receptors.
- The EIS's conclusion that the proposed activity is too relatively minor in scale to negatively impact on the psychological wellbeing of individuals may be too generalised and an independent assessment should be considered.
- An independent assessment of community satisfaction with the stakeholder consultation should be undertaken.

Acknowledgments of supported measures are noted - no further response required.

Responses to other comments and issues are provided in Chapter 4 below.

3.3.1.5 NSW Office of Agricultural Sustainability and Food Security

- From a soils perspective, the EIS and Agricultural Impact Statement (AIS) provides insufficient discussion as requested by the Director General's Requirements (DGRs).
- There are no critical agricultural issues for the proposed activity, including economic impacts.

A response to the comment on soils is provided in Chapter 4 below, while no further response is required for the latter comment.

3.3.1.6 NSW Office of Coal Seam Gas

- Generally supports the proposed activity.
- The rehabilitation proposal generally satisfies the DGRs.
- Notes that the development of the revised Produced Water Management Plan (PWMP) is currently being undertaken in consultation with NSW Office of Water for approval by NSW OCSG.
- The NSW OCSG is reviewing the existing Groundwater Monitoring and Modelling Plan's (GMMP) adequacy to address the future groundwater monitoring and modelling requirements of the E&A Program. Where a revised GMMP is required, development of the GMMP will be undertaken in consultation with NSW Office of Water for subsequent approval by NSW OCSG.

Noted - no further response required.

3.3.1.7 NSW Office of Water

- Insufficient information has been provided for the NSW Office of Water to assess the validity of the model and its suitability in making the required predictions. An additional detailed modelling report should be submitted to NSW Office of Water for review, including any peer review.
- Sufficient water quality information should be provided to allow an assessment against the minimal impact consideration for water quality in the Aquifer Interference Policy (AIP) for affected water sources.
- The following should be included as conditions of approval relating to drilling and well construction:
  - Santos must ensure the protection of the shallow formations i.e. the alluvium and the Great Artesian Basin (GAB) Southern Recharge during drilling by ensuring hydraulic isolation between sequences.
  - The drilling of the proposed exploration well is undertaken in accordance with the EIS.
  - The wells be designed and constructed in accordance with the *NSW Coal Seam Gas Code of Practice Well Integrity* (DTIRIS, 2012).
- A remedial action plan in the event of adverse impacts to the groundwater such as leakage and cross contamination between aquifers as a result of the drilling and well construction process as well as possible well failure into the future should be provided.
- A remedial action plan in the event of accidental contamination from the Bibblewindi water transfer and Leewood produced water facilities should be provided. The conditions of approval should include:
  - The Bibblewindi water transfer and Leewood produced water facilities are constructed in accordance with the EIS.
  - Monitoring data from the facilities should be made available to the NSW Office of Water on request.
- Details of construction standards for the proposed fluid treatment facility (FTF) including mitigation and monitoring and a remedial action plan in the event of accidental contamination should be provided.
- Inconsistent reporting of locations for the proposed groundwater monitoring bores should be clarified, and further details on the monitoring program should be provided.
- Appropriate water access licences (WALs) should be in place to account for any take of groundwater.

The recommended conditions of approval are supported - no further response required.

Responses to the other comments and issues are provided in Chapter 4 below.

3.3.1.8 NSW Office of Environment and Heritage

- No specific comment to make on the proposed activity at this stage.

Noted - no further response required.

3.3.1.9 NSW Roads and Maritime Services

- The following conditions of approval are recommended:
  - The intersection of X-Line Road and the Newell Highway should be upgraded to include an Auxiliary Left Turn Treatment Short and Channelised Right Turn Treatment Short on a major road in accordance with Figures 8.3 and 7.6 Part 4A Austroads 2010 respectively and RMS supplements. The intersection works should be designed and constructed to accommodate the largest vehicle accessing the intersections. Such designs shall be appropriate for the current speed zone of 110km/h.
  - X-Line Road and Westport Road should be sealed a minimum of 30 metres from the edge of the southbound travel lane on the Newell Highway.
  - As road works are required on a State road, the developer will be required to enter into a Works Authorisation Deed (WAD) with Roads and Maritime Services prior to the commencement of roads. Roads and Maritime Services will exercise its power under Section 87 of the *Roads Act 1993* (the Act) and/or the functions of the roads authority, to undertake road works in accordance with Sections 64 and 71 and/or Sections 72 and/or 73 of the Act, as applicable, for all works under the WAD.
  - Upgrades of the intersection of X-Line Road and the Newell Highway and the intersection of Westport Road and the Newell Highway should be completed prior to the commencement of construction works associated with the proposed activity.
  - A Road Occupancy Licence is required prior to any works commencing within three metres of the travel lanes in the Newell Highway.
  - All access to the pilot should be via the intersection of X-Line Road and the Newell Highway. All access to Westport Drillers Camp should be via the intersection of Westport Road and the Newell Highway. No other access from/to the state road network (Newell and Kamilaroi Highways) from/to the project area is permitted.

A response to these recommended conditions is provided in Chapter 4 below.

3.3.1.10 Narrabri Shire Council

- There will be few socio-economic benefits realised within the Narrabri Local Government Area (LGA). However, the socio-economic impacts of the proposed activity are small.
- The SoC should explicitly include the measures described in Chapter 18 of the EIS.
- An assessment of the impacts of drilling on groundwater quality needs to be undertaken to determine whether drilling fluids will be released to the environment at toxic concentrations.
- Further information on the conceptual groundwater model and the assumptions made in the groundwater modelling should be provided.
- A recent bore census covering all of the E&A Program needs to be provided and all bores within the potential drawdown area should be identified and potential impacts quantified.
- Further deep monitoring bores should be installed, or if they already exist, they need to be incorporated

into the monitoring program and this needs to be described. The bores should be installed with sufficient time to collect baseline data prior to the start of operations. The monitoring should continue over the life of the proposed activity and until the pre-existing groundwater pressures and flows return.

- Further information is required to determine the adequacy of the monitoring program. The water quality monitoring program should include parameters indicative of contamination of groundwater by drilling fluids and vertical flow of groundwater.
- Further information on the baseline monitoring results and the proposed trigger values when contingency measures will be implemented should be provided, as well as the proposed feasible contingencies.
- Council must be provided with an opportunity to review and comment on the proposed groundwater monitoring program and any proposal for fracking.
- The start of the proposed activity should be conditional on the completion of the Bibblewindi Water Transfer Facility.

Responses to these comments and issues are provided in Chapter 4 below.

3.3.1.11 Coonamble Shire Council

- One deep groundwater monitoring bore is inadequate to monitor the changes in the deep aquifer layers.
- The monitoring bores should be installed and baseline monitoring commenced prior to further drilling.
- The EIS has not provided an assessment of the impacts of the proposed activity (including drilling) on water quality.
- Greatly concerned with the potential impacts of CSG exploration on the groundwater quality and quantity within the GAB, as the town and community could not exist without it.
- Questions what further data is required to calibrate the groundwater model, given that there is a lack of ground-truthing of the model, which casts the modelling results into doubt. In addition, the lack of information on the assumptions as to how aquifers interact is cause for concern, as these assumptions are required for the model set up.
- The EIS does not identify future developments but Santos has confirmed plans for four major gas fields in this region, which would impact enormously on our town, communities, agricultural industries and region.
- The EIS does not propose any suitable means for long term management of produced water from CSG.
- While the Heritage component was removed from the DGRs, a full Aboriginal cultural heritage impact assessment should be conducted, in consultation with Coonamble Shire Council and the local Aboriginal community.
- Concerned about the health impact to the community, as well as the potential fire risk that CSG activity may cause.

Responses to these comments and issues are provided in Chapter 4 below.

3.3.1.12 Namoi Catchment Management Authority

- Santos should undertake a detailed impact analysis against the *Namoi Catchment Action Plan 2010-2020* thresholds and targets, and requirements of the *Extractive Industries Policy 2009* for the Namoi Catchment and the *Namoi CMA Biodiversity Offsets Policy 2011*. Ideally this would be requested as part of the DGRs.
- Acknowledges that the proposed activity should not impact on previously identified Aboriginal cultural heritage sites or objects, and should have negligible impact on biodiversity and surface water flow.
- The proposed mitigation and management measures for Aboriginal cultural heritage, surface water flow, groundwater quality, surface water quality and site rehabilitation are considered adequate.

- Acknowledges that appropriate measures have been undertaken to involve and consult with the Aboriginal community within the Narrabri LALC area and all other relevant stakeholders.
- Santos should ensure all relevant documents to the E&A Program are forwarded to all previously engaged Aboriginal stakeholders in a timely manner to enable their feedback.

Acknowledgments of supported measures are noted - no further response required.

Responses to the other comments and issues are provided in Chapter 4 below.

3.3.2 Main issues raised by the community

Most of the issues raised by the community were addressed in the EIS (as such, responses in Chapter 4 of this report generally mirror the EIS structure). The most common issues related to potential groundwater and biodiversity impacts, as well as bushfire risk. Other issues related to general objections to CSG both locally and as an industry, air quality, potential social impacts on health and community, and issues regarding Aboriginal cultural heritage, as listed below.

- Groundwater – This was the most common concern raised. Respondents were concerned with the perceived lack of baseline data underlying the numerical groundwater model, and hence its robustness as an impact assessment tool. Other issues included general concerns about potential impacts on groundwater resources in the area, including the GAB, resulting from drilling, well integrity and ongoing operation of the wells; as well as the possible cumulative impact of any future CSG activities in the region.
- Biodiversity – A number of respondents oppose development in the Pilliga forest generally, with concerns for the effect on biodiversity. In addition, respondents were concerned with the perceived lack of baseline data and potential direct and indirect impacts to threatened species including the Pilliga Mouse, Eastern Pygmy Possum and Barking Owl.
- Bushfire risk – Respondents noted that there is already a high bushfire risk in the Pilliga forest. Concerns were raised that CSG activities within Pilliga forest may create additional bushfire risks and that Santos appears not to have a clear bushfire strategy.
- General objections to CSG – Respondents raised concerns about the industry relating to intergenerational equity and the precautionary principle. Concerns raised included substantial crossover with other issues listed here, including groundwater and air quality. Submitters claim the potential for ongoing piecemeal CSG development within the Pilliga forest to degrade the intrinsic value of the area was also raised.
- Cultural heritage – Respondents raised concerns over the perceived inadequacy of consultation with the Aboriginal community and general disregard for the Aboriginal cultural significance of the area.
- Social impacts – Respondents raised concerns about the potential impacts on other land uses, such as agriculture, as well as the impact on general community cohesion. Some submissions also identified concerns about potential health impacts. Respondents also suggested that Santos does not have a social license to operate in the community.
- Air quality – Respondents raised concerns over the adequacy of fugitive emissions baseline data and monitoring.

4.0 Response to issues raised in submissions

This chapter contains responses to the issues raised in submissions to the EIS. Where appropriate, references to relevant sections of the EIS are contained in the responses.

As noted in Chapter 3, the submissions were reviewed individually and the issues categorised to assist with compilation of responses. Where relevant, issues were categorised according to the relevant chapter or section of the EIS. Where submissions raised the same or similar issues, a consolidated response was prepared. The issues raised are numbered under the relevant general heading and then a response to each issue is provided below next to its corresponding issue number.

4.1 General objections

4.1.1 Issue description

In summary, respondents raised the following general objections to the proposed activity:

1) The proposed activity is a direct long term threat to the health and wellbeing of land, water and air in this region and beyond. Respondents object to disruption of this fragile area by this activity, and they believe little consideration is given to the negative aspects of the proposed activity.

2) General concerns about the impacts on intergenerational equality and the future condition of the region.

3) Objections were raised to CSG exploration within the Pilliga forest or on public land.

4) It is recommended that DP&I undertake an Environmental Impact Study.

4.1.2 Response

1) Santos is seeking consent to undertake an expansion of the Bibblewindi Gas Exploration Pilot for the purposes of CSG exploration and appraisal. This proposed activity involves the drilling of two additional wells on existing well pads, and operation of the expanded Bibblewindi Multi-Lateral Pilot (14 wells) for up to three years only. On completion of operations, wells and ancillary infrastructure will either be decommissioned with lease areas rehabilitated or wells will be suspended. If exploration and appraisal activities confirm the CSG resource as commercially viable, any proposed production activities at this pilot site would be subject to further environmental assessment and government approvals.

   The area within which the proposed activity is located is entirely within 'Zone 4' (Forestry, recreation and mineral extraction (State Forests)) Community Conservation Area (CCA) under the *NSW Brigalow and Nandewar Community Conservation Area Act 2005* (BNCCA Act). As mineral extraction is a permitted use in Zone 4, the proposed activity is considered consistent with the BNCCA Act.

   Potential impacts of the proposed activity, as well as the potential cumulative impacts of the E&A Program are assessed in the EIS. Mitigation measures have been developed to ensure any potential impacts are minimised.

2) The proposed activity will not consume significant quantities of non-renewable resources or produce significant quantities of waste that will lead to long term environmental implications (refer to Table 2-1 of the EIS). Groundwater will be extracted but modelling indicates that this will have negligible

impact on the upper aquifers including the Pilliga sandstone, registered bore users or groundwater dependent ecosystems (GDEs). Drilling fluids, where possible, will be recycled for use at other drilling sites. In addition, the proposed activity is not located within Biophysical Strategic Agricultural Land (BSAL), and therefore will have negligible impact on agricultural land resources.

As discussed above, the expanded Bibblewindi Multi-Lateral Pilot is proposed to operate for up to three years only. If exploration and appraisal activities confirm the CSG resource as commercially viable, any production activities at this pilot site would be subject to further environmental assessment and government approvals.

3) The proposed activity is located within the dedicated State Forest area set aside by Government for the purposes of forestry, recreation and mineral extraction. It is located entirely within 'Zone 4' (Forestry, recreation and mineral extraction (State Forests)) CCA under the BNCCA Act. Section 8.5 of the Brigalow and Nandewar CCA Agreement provides strategic aims for activities within Zone 4 which include *'Provide for exploration, mining, petroleum production and extractive industry in accordance with the Mining Act 1992 and the Petroleum (Onshore) Act 1991'.* The proposed activity is consistent with the *Petroleum (Onshore) Act 1991.*

   The *New England North West Strategic Regional Land Use Plan* (DP&I, 2012) identifies the site and surrounding land as having high CSG resources and underground coal exploration potential.

4) It is standard practice that a project proponent undertakes impact assessment activities and prepares a report on the findings for Government assessment. An Environmental Impact Study, in the form of an Environmental Impact Statement (EIS) has been undertaken by Santos to assess the potential impacts of the proposed activity in accordance with the EP&A Act. Santos has prepared the EIS in response to the DGRs. DP&I will assess the proposed activity and prepare an assessment report and the Planning Assessment Committee (PAC) will determine the application, as outlined in Figure 6-1 of the EIS.

4.2 Objections to the CSG industry

4.2.1 Issue description

Respondents raised general objections to the CSG industry, including the following:

1) Opposition to the expansion of the Queensland liquefied natural gas (LNG) industry into NSW. Concerns that CSG development will be proposed for the Liverpool Plains, threatening existing industries such as agriculture.

2) Scientific evidence suggests significant global and national impacts from the CSG industry. References were made to projects elsewhere (e.g. Tara, Qld and USA gas fields). Concerns about impacts to water quality, land, community and ecological balance of the area. CSG is considered to be an unsafe energy source and does not provide the claimed economic benefits.

3) Suggests that there have been leakages from existing infrastructure in Australia which are not reported upon by the companies involved.

4) CSG differs from other resource extraction, as exploration wells have the same environmental impacts as operational wells.

4.2.2 Response

1) The proposed activity is a separate project to the Santos GLNG and other LNG projects in Queensland. Development of reserves in NSW has the potential to play a role in the delivery of a secure supply of domestic gas for NSW, as well as alleviate potential gas supply shortages which may expose NSW to significant energy price increases.

   The proposed activity, or the E&A Program that it is part of, is not located on any land classified as BSAL or Critical Industry Cluster (CIC). The AIS that was undertaken for the EIS (Appendix 2 of the EIS) states that the E&A Program is not located on any agricultural land (major agricultural industries e.g. cropping, grazing, horticulture and plantations). The current extent of agricultural land use within PEL 238 and PAL 2 is approximately 791,478 hectares.

   The proposed activity and the wider E&A Program is not located on the Liverpool Plains.

2) The natural gas industry is one of the most highly regulated industries in Australia. Over the last two years both the State and Federal governments have put in place a range of new measures designed to enhance the already extensive regulation. Before any work can take place, CSG activities in NSW, including those associated with exploration and appraisal, are subject to rigorous State and Federal government assessment and approvals processes to ensure impacts have been assessed and mitigated. An EIS or Review of Environmental Factors (REF) is prepared, which contains environmental, economic and social impact assessments of the proposed CSG activities.

3) Santos cannot comment on other operators. Section 4.10.1.2 of this Submissions Report outlines the matter of the pollution incidents which occurred at the Bibblewindi Water Treatment Facility prior to November 2011.

4) Santos is seeking consent to undertake an expansion of the Bibblewindi Gas Exploration Pilot for the purposes of CSG exploration and appraisal. This proposed activity involves operation of the expanded Multi-Lateral Pilot (14 wells) for up to three years only, the potential impacts of which have been assessed in the EIS. On completion of operations, wells and ancillary infrastructure will either be decommissioned with lease areas rehabilitated or wells will be suspended. If exploration and appraisal activities confirm the CSG resource as commercially viable, any proposed production activities at this pilot site would be subject to further environmental assessment and government approvals.

4.3 Objections to fossil fuel development

4.3.1 Issue description

1) General objections were raised concerning the continued mining, export and combustion of fossil fuels. For example:
   - Continued development of fossil fuels does not support the government's responsibility in respect to intergenerational equity.
   - Approving this proposed activity will prevent resources (people and capital) focusing on other activities.
   - Fossil fuels should not be supported because resource depletion and population growth are considered to unsustainably contribute to carbon emissions.
   - Australia should aim to become a leader in developing and implementing clean renewable energy systems both within Australia and as part of our exports.

4.3.2 Response

1) As an Australian-owned oil and gas company, Santos believes that natural gas is a critical part of NSW's energy mix. Over one million NSW homes and businesses use natural gas for heating, cooking and commercial uses. In addition there are about 450 large industrial users of gas in NSW. Natural gas is critical for these small businesses and major industries, and cannot be easily or cost-efficiently substituted for an alternate energy source. Natural gas complements renewable energy sources, providing base load energy when conditions for renewable energy sources are sub-optimal (e.g. in the absence of adequate solar radiation).

   NSW currently sources 95 per cent of its gas from interstate (Section 2.1 of the EIS). Contracted supplies are predicted to fall from 2014 and reach significantly low levels in 2017 due to a combination of factors including a strong demand for gas in other states, decreasing reserves and constraints on infrastructure. Santos supports the immediate development of an indigenous natural gas supply within NSW to:

   - Ensure adequate wholesale gas supply is available to NSW, resulting in reduced dependency on interstate supply and delivering security of supply for downstream NSW customers.
   - Ensure future wholesale gas supply choices beyond Victorian supply, thus reinstating competition for energy retailers and encouraging increased competition for NSW gas customers.
   - Facilitate the development of distribution networks in regional centres.

4.4 Scientific uncertainty

4.4.1 Issue description

1) The precautionary principal should be invoked and Santos' activities in the Pilliga forest halted until the scientific studies are completed, and the essential data and information made available to enable risks to be adequately addressed.

2) CSG activities should not be allowed to proceed within the region until the findings and recommendations of the Chief Scientist of NSW investigation into the NSW CSG industry have been published and discussed with the community.

4.4.2 Response

1) The natural gas industry is one of the most highly regulated industries in Australia and the proposed activity requires separate approvals from both the NSW and Federal governments.

   The use of CSG for NSW energy needs is not new. CSG was extracted at the Sydney Harbour Colliery in Balmain in the early 1900s with production continuing into the 1940s. CSG production has occurred at Camden in NSW for over 12 years.

   A precautionary approach was taken during the site selection process for the proposed activity (Table 2-1 of the EIS). Based on an environmental risk assessment and in combination with the DGRs, the EIS includes investigation into a range of issues to determine the potential impacts of the proposed activity. This included commissioning groundwater, ecological, air quality, noise, traffic and economic and social technical studies, and drawing on information from technical specialists including geologists, drilling engineers and process engineers. Where appropriate conservative scenarios were considered as part of the EIS, while a range of mitigation measures will be put in place to minimise or prevent any environmental degradation.

2) Santos supports a robust regulatory framework that enables the sustainable and safe exploration and development of Australia's valuable and abundant reserves of gas for the benefit of all Australians. The natural gas industry is one of the most highly regulated industries in Australia and the proposed activity requires separate approvals from both the NSW and Federal governments.

   The *Initial report on the Independent Review of Coal Seam Gas Activities in NSW* by the NSW Chief Scientist and Engineer was released in July 2013 and is available online at http://www.chiefscientist.nsw.gov.au/coal-seam-gas-review/initial-report-july-2013.

   A number of technical studies have been included in the EIS, which have been undertaken to assess and address the potential environmental and social issues associated with both the proposed activity and the larger E&A Program.

4.5 Future development

4.5.1 Santos' future plans in the region

4.5.1.1 Issue description

1) Santos has not revealed their future developments in the area, including confirmed plans for four major gas fields in the region, despite the DGRs to state 'the likely interactions between the development and existing, approved and proposed gas exploration and production'.

2) Santos has purchased property at Warrah Creek. Therefore, despite Santos' recent public statements that they plan only to explore and extract in the Pilliga forest, their long term plan must include expansion across the Liverpool Plains.

3) General concerns about potential expansion due to the longevity of well outputs. If the volume of extraction is not maintained, the number of wells will need to increase to maintain output.

4.5.1.2 Response

1) The proposed activity, as part of the E&A Program, is necessary for the ongoing exploration, appraisal and evaluation of the CSG hydrocarbon potential in PEL 238 and PAL 2. The E&A Program will occur over three years between 2014 and 2017. It will assist in gaining further knowledge of coal fines, gas composition and flow rates, the deliverability of the reservoir, and investigating well design, drilling and completion technologies. This information is essential to determine the location, extent, details and planning of a commercial gas production project within the areas of PEL 238 and PAL 2. The application for the proposed activity is seeking approval for that exploration and appraisal activity.

   Since the EIS for the proposed activity was finalised, Santos has released information on a future commercial gas production project, known as the Narrabri Gas Project.

   The Narrabri Gas Project includes a gas field and a pipeline to transport the natural gas to the NSW market. The project could supply up to 50 per cent of NSW's natural gas needs, create 1,200 jobs during construction and up to 200 jobs during operation, contribute $1.6 billion in royalty payments to NSW over the life of the project and $160 million as part of the Regional Community Benefit Fund for regional programs and infrastructure.

The gas field will include:

- Up to 850 production wells.
- Monitoring of wells to provide continual information about water and gas volumes and well site security.
- A central water management and treatment facility to store and treat produced water for reuse.
- A central gas processing facility to treat and compress the natural gas.

The Narrabri Gas Project will require preparation of a detailed EIS for petroleum production activities, development consent and the granting of a Petroleum Production Licence (PPL).

Further details of the Narrabri Gas Project can be found at http://www.santos.com/exploration-acreage/new-south-wales/narrabri-gas-project.aspx.

2) In March 2010 Santos purchased a property approximately seven kilometres west of Willow Tree in the Warrah Creek area. The purchase was made at a time when an exploration program was being considered in this area. This area is not part of Santos' current plans for exploration, appraisal or gas field production activities.

   The Narrabri Gas Project area that Santos proposes to develop is located south of Narrabri, well over 100 kilometres from the site at Warrah Creek. The project area is shown in the project factsheet, available on Santos' website: http://www.santos.com/library/FACT%20SHEET%20Narrabri%20Gas.pdf. More than half of the Narrabri Gas Project area is located within the Pilliga forest and the proposed gas field operations will take up less than one per cent of the overall project area. The pipeline to connect the gas into the NSW domestic market will run south from the Narrabri area and link up with existing pipeline infrastructure.

3) The proposed activity involves the operation of the expanded Bibblewindi Multi-Lateral Pilot (14 wells) for up to three years as part of the E&A Program. If exploration and appraisal activities confirm the CSG resource as commercially viable, any proposed production activities at this pilot site would be subject to further environmental assessment and government approvals. Exploration activities seek to measure the gas potential of the area. Different to production, there is no commitment to provide a consistent gas supply.

4.5.2 Cumulative impacts

4.5.2.1 Issue description

1) Cumulative impacts should be assessed more broadly, at a national and global scale.

2) Project staging and REFs for individual pilots has not enabled a proper cumulative impact assessment to be undertaken. The cumulative impacts of all of the Pilliga gas exploration in the past, present and future should be considered in the EIS. Broader impacts of numerous gas fields should be assessed as the EIS does not sufficiently address cumulative impacts of the whole project with 1100 wells.

3) Cumulative impacts of the proposed activity with the Glasserton Project need to be addressed.

4) DP&I needs to consider all mining activities taking place in the Pilliga forest and in context of the whole North West region.

4.5.2.2 Response

1) The cumulative impacts of the E&A Program have been assessed as part of the EIS. The scope of the cumulative impact assessment is considered adequate given the scale of the proposed activity and E&A Program and its likely negligible to minimal potential impacts.

2) The cumulative impact assessments presented in the EIS have taken into consideration existing, approved and currently proposed Santos' CSG activities for the E&A Program within the Pilliga forest, including existing infrastructure and recently approved activities. In particular, the ecological assessment has considered the clearing of vegetation that has occurred over the past 10 years by Eastern Star Gas (ESG). Any future exploration, appraisal or production activities beyond the E&A Program, including any application for the Narrabri Gas Project, will be assessed when the relevant applications are lodged. These assessments will continue to incorporate cumulative impact assessments.

   A number of respondents referred to a proposed production program of 1100 wells in the region. This number originally comes from a previous ESG proposal, which was subsequently withdrawn.

   In December 2013, Santos identified the proposed project area currently being considered for the Narrabri Gas Project. The project area is shown in the project factsheet, available on Santos' website: http://www.santos.com/library/FACT%20SHEET%20Narrabri%20Gas.pdf.

   The information collected as part of the E&A Program will inform the nature and configuration of the future Narrabri Gas Project and needs to commence prior to construction of the project. The E&A Program which the proposed activity is part of will occur over three years between 2014 and 2017 whilst the Narrabri Gas Project will require preparation of a detailed EIS for petroleum production activities, development consent, the granting of a PPL and project financing.

3) The cumulative impacts of the E&A Program have been assessed as part of the EIS. The Glasserton pilot wells are located at Spring Ridge approximately 45 kilometres south of Gunnedah, and approximately 100 kilometres south-east of the E&A Program area. The pilot wells are currently not operating. However, even if these wells were operational, it is unlikely there would be any cumulative impacts of these wells with the E&A Program given the significant distances between the two locations.

4) The proposed activity will be assessed by DP&I and determined by the Planning Assessment Commission in accordance with Section 79C of the EP&A Act.

4.6 Adequacy of the EIS

4.6.1 Issue description

1) The EIS fails to address issues raised by government agencies. For example, Fisheries NSW required Santos to comply with relevant legislation, policies and guidelines, while NSW EPA raised water minimisation and opportunities to reuse and recycle.

2) The EIS appears to rely on the multiple REF documents lodged some time ago to the government, which were not made publicly available online as they should have been.

3) Appendix 1 of the EIS has not included 'likely interactions between the development and existing, approved and proposed gas exploration and production activities in the vicinity of the site' or 'plans of any proposed building works'.

4.6.2 Response

1) The EIS addresses the issues raised by government agencies, as shown in Table 5-2 of the EIS. Chapter 6 of the EIS indicates that Santos has considered, and is in the process of ensuring they comply with all necessary regulations, including obtaining required EPLs and WALs. Santos is committed to the responsible management of water resources and aims to reduce water consumption and improve the reuse and recycling of water across its sites. Santos is currently investigating water treatment technologies for the Leewood Produced Water Facility and options to beneficially reuse treated water.

2) The REF prepared for the existing Bibblewindi Multi-Lateral Pilot (ESG, 2008) is referred to in the EIS, in the context of the Aboriginal cultural heritage assessment undertaken for the site. This is considered appropriate given that the proposed activity occurs within the existing Bibblewindi Multi-Lateral Pilot site. A copy of the REF can be found on Santos' website: http://www.santos.com/library/PAL%202%20Lateral%20Production%20Pilot%20A.pdf

   or the NSW Division of Resources and Energy website: http://www.resources.nsw.gov.au/__data/assets/pdf_file/0005/256514/20081029-PAL2-REF-Eastern-Star-Gas-Coal-Seam-Gas-Pilot-Narrabri-Shire.pdf

3) The likely interactions between the proposed activity and existing, approved and proposed gas exploration activities (the E&A Program) are discussed in Chapters 8 to 19 of the EIS as part of the cumulative assessment for each identified potential issue.

   The information collected as part of the E&A Program will inform the nature and configuration of the future Narrabri Gas Project and needs to commence prior to construction of the project. The E&A Program, which the proposed activity is part of, will occur over three years between 2014 and 2017. The Narrabri Gas Project will require preparation of a detailed EIS for petroleum production activities, development consent and the granting of a Petroleum Production Licence.

   There are no proposed permanent building works incorporated into the proposed activity. Temporary infrastructure will be present during drilling activities which is estimated to take 35 days (Section 4.3.1 and Figure 4.2 of the EIS).

4.7 Need and justification

4.7.1 Gas shortage

4.7.1.1 Issue description

1) There is no shortage of gas. Demand for gas is dropping and there is enough natural gas in production already. Gas is available under large areas of Australia, including Western Australia and Bass Strait.

   Household energy prices will not be alleviated within NSW by development of the CSG industry. Gas prices are rising due to construction of processing plants and export terminals in Queensland, and a desire to export CSG, not because of any impending shortage of supply.

   Concerns were also raised that gas will be used for export due to high demand and high prices, and not to supply NSW.

4.7.1.2 Response

1) As an Australian-owned oil and gas company, Santos believes that natural gas is a critical part of NSW's energy mix. Over one million NSW homes and businesses use natural gas for heating, cooking and commercial uses. In addition there are about 450 large industrial users of gas in NSW. Natural gas is critical for these small businesses and major industries, and cannot be easily or cost-efficiently substituted for an alternate energy source. Gas-fired power stations typically produce fewer emissions than coal-fired facilities per unit of electricity generated.

   NSW currently sources 95 per cent of its gas from interstate (Section 2.1 of the EIS). Contracted supplies are predicted to fall from 2014 and reach significantly low levels in 2017 due to a combination of factors including an increase in demand for gas in other states (for domestic use and export), decreasing reserves that existing NSW contracts draw from, and constraints on infrastructure.

   With contracts expiring, NSW needs to either re-negotiate new contracts (where uncontracted supply is available) or develop its own reserves.

   Santos supports the immediate development of an indigenous natural gas supply within NSW to:

   - Ensure adequate wholesale gas supply is available to NSW, resulting in reduced dependency on interstate supply and delivering security of supply for downstream NSW customers.
   - Ensure future wholesale gas supply choices beyond Victorian and South Australian supply, thus reinstating competition for energy retailers and encouraging increased competition for NSW gas customers.
   - Facilitate the development of distribution networks in regional centres.

4.7.2 Renewable energy sources

4.7.2.1 Issue description

1) Available renewable energy options should be explored over gas exploration and mining. Products from mining are temporary and finite and should be replaced with sustainable commodities. Climate change is considered a real threat.

   A respondent suggested that a solar thermal plant in the Pilliga region could provide baseload power and storage, which are the two arguments most commonly cited for the need for gas.

4.7.2.2 Response

1) Natural gas is a critical part of NSW's energy mix. Over one million NSW homes and businesses use natural gas for heating, cooking and commercial uses. In addition there are about 450 large industrial users of gas in NSW. Natural gas is critical for these small businesses and major industries, and cannot be easily or cost-efficiently substituted for an alternate energy source. Natural gas complements renewable energy sources, providing base load energy when conditions for renewable energy sources are sub-optimal (e.g. in the absence of adequate solar radiation).

4.8 Description of the Proposed Activity

4.8.1 Hydraulic fracturing (fracking)

4.8.1.1 Issue description

1) Concerns were raised over the potential use of hydraulic fracturing (fracking), including:
   - The precautionary principle should be invoked as fracking is not good for the environment. It should be banned, as it is in other countries.
   - Concern that 'fracking' fluids contain benzene, toluene, ethylbenzene, xylene, uranium, bromide, lead, cyanide, nitrate and monochloramine. These will pollute the local environment with toxic chemicals and known carcinogens. Once groundwater has been contaminated by multiple chemicals, as found in hydraulic fracturing fluids, it is not possible to remove them.
   - Fracking directly impacts tectonic plates and causes seismic disturbances. In the UK in 2011, the British Geological Society confirmed seismic events were a direct result of drilling and fracking activities by Cuadrilla Resources.
   - Narrabri Shire Council must be provided with an opportunity to review and comment on any proposal for fracking.

4.8.1.2 Response

1) Fracking will not be undertaken as part of the proposed activity or the E&A Program (Section 9.2 of the EIS). The geology of the area indicates hydraulic fracturing will not increase gas flow rates. If additional geological data supported the use of hydraulic fracture stimulation to improve the gas flows in the future, a range of additional government approvals would be required and consultation would be undertaken.

4.8.2 Produced water management

4.8.2.1 Issue description

1) Concerns were raised that the EIS does not adequately explain the strategy for produced water management, including its treatment and use or disposal. The trucking of water from the existing ponds is not a long term viable option. Facilities for water treatment must be finalised before drilling commences.

   No approval of the initial stages should be given until Santos has provided a detailed risk and water management plan that will be enforced by the NSW Government, addressing how Santos will deal with the produced water and salt from all their activities in the Pilliga forest. This plan must be available for public, government and independent scientific scrutiny.

4.8.2.2 Response

1) Santos is continually striving for best practice in produced water management and will continue to work closely with communities, regulators and other key stakeholders to ensure the most appropriate options are pursued. The water transfer and treatment process for the proposed activity will be as follows (Section 4.4.2 of the EIS):
   - At each well, the lifted water produced will be pumped through the water gathering system to Bibblewindi Water Transfer Facility, via the existing flow line.

- the Bibblewindi Water Transfer Tank located at the Bibblewindi Water Transfer Facility will be used to provide a short buffer (up to 24 hours) prior to the produced water being pumped to the Leewood Produced Water Facility via the Leewood Water Pipeline.
- once at the Leewood Produced Water Facility, produced water will be stored in one of the 300 megalitre ponds.

Produced water from the Leewood Produced Water Facility will be transported by road tankers to an appropriately licensed facility in the Sydney metropolitan area for treatment, reuse and/or disposal.

Santos is currently developing plans to treat produced water at the Leewood Produced Water Facility by reverse osmosis or other methods instead of transporting produced water from Leewood to a licensed facility.

Based on the extensive experience from Santos' CSG operations in Queensland, it is estimated around 80 per cent of the produced water could be made available for beneficial use e.g. agricultural activities and ecosystem replenishment. For CSG activities in the Pilliga, appropriate treatment levels and identification of options for using the beneficial water are being explored, with ongoing engagement with government agencies and the community.

Following adequate project definition and concept design, Santos will apply for the appropriate environmental approvals for any water treatment facility or beneficial reuse option.

Activities within the PAL must be carried out in accordance with the Petroleum Operations Plan (POP) which has been approved by the Director-General of NSW Trade and Investment. Under the POP, a Produced Water Management Plan (PWMP) identifying storage of produced water at Leewood Produced Water Facility has been developed by Santos, and approved by the NSW Government. If treatment of the produced water at the Leewood Produced Water Facility is considered feasible, the PWMP will be revised in consultation with NSW Office of Water, for approval by NSW OCSG.

4.8.3 Rehabilitation

4.8.3.1 Issue description

1) The EIS does not sufficiently address remediation.

2) Before further damage to the environment occurs the process for rehabilitation at the Bibblewindi spill should be verified to confirm that the landscape can be returned to pre-drilling condition.

   Testing of pH levels, benzene and other additives in the surrounding soil should be undertaken to ascertain and link unknown eucalyptus and native *allocasaurina* dieback to acidification of the soils.

   Practices to date in the Pilliga forest have been largely unsuccessful - no regrowth after a year, dieback areas increasing, soil contamination taking 12 years to recover. Santos staff on a public bus tour on 25 October 2013 told members of the public that the kill areas would take around 50 years to regenerate.

3) The following recommendations were made:
   - adherence to proper restoration techniques after decommissioning of CSG infrastructure.
   - allocating lots to tree planting and letting natural regeneration of seed stock occur both aerially and through natural progression of existing plant communities repopulating old well sites; there could be potential for future conservation projects.

4.8.3.2 Response

1) An overview of the rehabilitation strategy for the proposed activity is provided in Section 4.5 of the EIS. The final land use would be consistent with the surrounding area as State forest.

2) Santos has spent much of 2012 and the first quarter of 2013 rehabilitating and upgrading a number of CSG exploration sites in the Pilliga forest. The sites were acquired in November 2011, when Santos took over from ESG.

   The operations in the Pilliga forest were shut down in December 2011 and Santos began a thorough review of all existing sites.

   Following this review, a detailed work program for the rehabilitation of sites in the Pilliga forest was formulated. Extensive testing was carried out and site specific rehabilitation plans were prepared to ensure each site is successfully remediated. To-date, Santos has committed more than $17 million to remediation works and substantial progress has been made with rehabilitation of approximately 28 hectares of land throughout PEL 238 and PAL 2. Rehabilitation activities have included:

   - reducing the size of existing well leases back to the minimum area required for operations.
   - plugging and abandoning, according to legislative requirements, wells that are no longer required for exploration and appraisal, and rehabilitating associated well leases.
   - rehabilitating a number of water storage ponds that are no longer required for exploration and appraisal activities.
   - rehabilitating vegetation dieback areas resulting from ESG's previous operations.

   Rehabilitation has included soil remediation (where necessary in vegetation dieback areas), replacing topsoil, creating micro-relief, re-installing habitat features such as fallen timber and bush rock, natural re-establishment of slashed and cleared native vegetation, and direct seeding where required. Rehabilitation activities have been undertaken in consultation with the NSW OCSG, Forestry NSW and NSW EPA.

   Monitoring of existing rehabilitation activities has shown an overall average site value close to 45 per cent of nearby reference (control) sites after two years. The replacement of topsoil is producing encouraging results, with sites showing a high number of native species when compared to reference sites. Rehabilitation measures undertaken have been considered using adaptive management principles with monitoring informing future modifications to works and methodologies.

   Rehabilitation works associated with the proposed activity will follow the methods developed for the existing rehabilitation activities.

3) These recommendations are in line with the rehabilitation strategy for the proposed activity provided in Section 4.5 of the EIS, particularly in regards to the rehabilitation performance criteria provided in Table 4-8 of the EIS.

4.8.4 CSG Infrastructure

4.8.4.1 Issue description

1) Construction standards for the proposed FTF, including mitigation and monitoring and a remedial action plan in the event of accidental contamination, should be provided.

2) The start of the proposed activity should be conditional on the completion of the Bibblewindi Water Transfer Facility.

4.8.4.2 Response

1) Development consent for the FTF was issued by Narrabri Shire Council on 1 October 2013 (DA769/2013). The FTF does not form part of the proposed activity and therefore the information requested by the NSW Office of Water has not been included. However, extensive information regarding the construction standards for the FTF was included in the development application (DA) made by Santos. During its assessment of DA769/2013, Narrabri Shire Council made an assessment of the environmental impacts of the FTF, in accordance with section 79C of the EP&A Act. In addition, as the application was integrated development it was referred to the NSW EPA for their approval. The NSW EPA assessed the application and provided their general terms of approval, which form part of the development consent.

   The operation of the FTF will be subject to an EPL under the *Protection of the Environment Operations Act 1997* (POEO Act), which will ensure that the operations are appropriately managed and monitored.

2) The Bibblewindi Water Transfer Facility is currently under construction and will be completed prior to the operation of the proposed expanded Bibblewindi Multi-Lateral Pilot.

4.9 Community and stakeholder consultation

4.9.1 Consultation with the Aboriginal communities

4.9.1.1 Issue description

1) There is a Native Title claim over the project area and Santos must include the Gomeroi Native Title Claimants, Gomeroi Traditional Owners of the Pilliga and the Narrabri LALC in their consultation.

2) The Gomeroi Traditional Owners were not consulted as part of this proposed activity.

3) The Narrabri LALC did not receive a copy of the EIS.

4.9.1.2 Response

1) Santos is actively engaging with the relevant Aboriginal groups regarding Native Title in parallel to the NSW environmental approval process. Santos will work towards an agreement with the native title parties in relation to the land in which it plans to operate and ensure that Aboriginal stakeholders share in the social and economic benefits of a CSG industry. Consultation with the Gomeroi Native Title Claimants, Gomeroi Traditional Owners of the Pilliga and the Narrabri LALC is described in Section 5.3.4.2 of the EIS.

2) There is ongoing consultation with the Gomeroi Traditional Owners to keep them informed of the proposed activity and the broader E&A Program. This is described in Section 5.3.4.2 of the EIS.

3) Upon request from the Namoi CMA, a copy of the Bibblewindi EIS was sent to the Narrabri LALC. Santos will endeavour to forward documents on public exhibition to all previously engaged Aboriginal stakeholders in a timely manner to enable their feedback.

4.9.2 Consultation with the local community

4.9.2.1 Issue description

1) Consultation with the residents of the Narrabri area has been inadequate.

2) The Coonabarabran and Baradine communities are ignored and advertisements for consultation appear only in the Narrabri and Gunnedah media.

3) Continued consultation with Narrabri Shire Council, particularly on project and schedule updates is requested.

4) An independent assessment of community satisfaction with the stakeholder consultation should be undertaken, to provide reassurance of the applicant's performance in this important area and guidance for future improvement if required.

4.9.2.2 Response

1) Santos has developed a community engagement and consultation framework to specifically target the different needs and requirements of stakeholders and the community to inform and consult on the E&A Program and the CSG industry more broadly (Chapter 5 of the EIS). Santos is committed to undertaking ongoing community engagement and consultation. Specific consultation undertaken for the proposed activity includes:
   - A presentation at Narrabri Shire Council.
   - Narrabri CCC updates including how to lodge a submission.
   - Monthly updates published in the Narrabri Courier.
   - Hard copies of the EIS on display at Narrabri Shire Council, Santos Narrabri Operations Centre and Santos Maitland Street shopfront.

2) The advertisement was undertaken in accordance with Section 89F of the EP&A Act, with the process hosted on the DP&I website. The E&A Program is located within the Narrabri LGA, therefore the focus of Santos' community engagement has been within this region. If, in the future, Santos was to expand their activities outside of this region, engagement with affected communities would be established. Communities outside the Narrabri LGA are able to access information, including environmental assessments of proposed works, through the Santos website and media announcements. The Project information line and the Narrabri shopfront are also available for anyone who is seeking further information on the proposed activity.

3) Santos has a program of consultation with stakeholders with a specific interest in local activities including local government representatives. Consultation through regular meetings with local government staff and elected representatives has occurred. Santos will ensure that these monthly discussions will continue to be offered, in line with its commitment to the Council. In addition, quarterly Government Information Forums are held with invitations extended to local officers of state government departments to provide information on projects and work schedules.

4) It is unclear what benefit there would be in undertaking a post-consultation assessment for the Bibblewindi EIS. The community engagement and consultation framework that Santos has in place has been specifically written to meet the requirements set in place by the NSW Government. If the current NSW Government guidelines are perceived as inadequate and are subsequently modified, Santos will ensure that its engagement and consultation framework is updated to reflect any changes that are made to that guideline.

4.10 Planning and statutory framework

4.10.1 Regulatory compliance

4.10.1.1 Issue description

1) Concern over past incidents by ESG including spills to Bohena Creek, and that existing infrastructure is not adequate to prevent further incidents occurring.

   Santos is requesting approval for expansion of their activities before their prosecutions have been closed out.

2) What type of bond is being required to make good when an accident occurs? If Santos breach again will their approvals be revoked?

3) One respondent raised concern over environmental compliance of the mining and industrial sectors in general.

4.10.1.2 Response

1) Santos Limited acquired ESG on 17 November 2011. In July 2012 ESG was issued two penalty infringement notices (PINs) for pollution incidents which occurred at the Bibblewindi Water Treatment Facility prior to November 2011. The details of these PINs are as follows:

   - Pollution of Bohena Creek on 11 March 2010 due to discharge of permeate, from the reverse osmosis (RO) plant at Bibblewindi, with electrical conductivity (EC) levels above background.
   - Pollution of Bohena Creek on 25 November 2010 due to discharge of permeate, from the RO plant at Bibblewindi, with EC levels above background.

   Santos Limited publicly released a report in February 2012 relating to incidents at the Bibblewindi Water Treatment Facility arising from ESG's operations prior to 17 November 2011. In June 2013, proceedings were commenced in the Land and Environment Court against Santos for breaches of the *Petroleum (Onshore) Act 1991* for notification and reporting failures relating to incidents which occurred prior to 17 November 2011 in relation to ESG's CSG operations within PAL 2. Santos NSW Pty Ltd pleaded guilty to these proceedings on 20 September 2013 and the penalty hearing in the Land and Environment Court was held on 18 December 2013.

   On 10 January 2014, the NSW Land and Environment Court handed down its decision regarding reporting failures in relation to coal seam gas operations in the Pilliga Forest, NSW, previously owned and operated by ESG. Santos accepted the imposed fine of $52,500. The incidents occurred when the operations were conducted by different management and Santos recognises the importance of ensuring that industry complies with the high environmental standards expected by the community. Santos acted transparently throughout the process, releasing a report on the operational issues uncovered in the Pilliga and bringing them to the attention of the regulator.

   Since ESG was acquired by Santos Limited on 17 November 2011, new management has been appointed to ESG and ESG has been renamed Santos NSW Pty Limited. The RO plant at Bibblewindi Water Treatment Facility (the subject of the incidents) ceased operation on 15 December 2011 and has been decommissioned. Santos has commenced rehabilitation of vegetation surrounding the Bibblewindi facility which was affected by the incidents. Alternative arrangements for managing existing produced water and produced water from recommencement of operations have been progressed, and approval has been granted for the construction and operation of new water storage ponds at Leewood. The ponds at the Leewood Produced Water Facility will be

double lined and will have a leak detection system. Refer to Section 3.2.1.2 of the EIS for further details of the Leewood ponds.

In addition, Santos has significant financial capital, and has many years of experience in undertaking exploration activities for CSG. As a result, it has developed an extensive understanding of the steps and measures that should be taken to prevent or minimise its impact on the environment, human health and safety when undertaking exploration activities. Santos seeks to conduct its activities in a way that avoids and minimises potential impacts on the environment.

2) Under the *Petroleum (Onshore) Act 1991*, a security deposit must be provided to the government. This covers the full rehabilitation costs of the proposed activity, and is not released until the proposed activity works (including rehabilitation) have been completed satisfactorily.

3) Santos supports operating in a robust regulatory framework that enables the sustainable and safe exploration and development of Australia's valuable and abundant reserves of gas for the benefit of all Australians.

4.10.2 Commonwealth referral

4.10.2.1 Issue description

1) The proposed activity and the broader E&A Program will have a significant impact on Matters of National Environmental Significances (MNES) (Water Resources) and should be referred to the Commonwealth Scientific Panel for assessment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

2) Concerned that the Federal Minister for Environment did not use the 'water trigger' and did not declare Santos' current activity in the Pilliga forest a 'controlled action'. Santos' proposed actions should have been referred to the Independent Expert Scientific Committee (IESC).

3) The referral was (artificially) restricted to exploration but should have included the future production activities. A study of the cumulative impacts of the entire proposed project should have been done by the IESC.

4.10.2.2 Response

1) Santos referred E&A Program activities within the Pilliga forest (including the proposed activity), to the Federal government for a decision under the EPBC Act in June 2013 (Section 6.3.1 of the EIS). On 1 October 2013, the Minister made the decision that the proposed action is not a controlled action if undertaken in a particular manner. The referral included an assessment of the potential cumulative impacts on the 'Water Resources from CSG development and large coal mining development'.

2) This is a matter for the Federal government. Santos' referral of the E&A Program under the EPBC Act included an assessment against the MNES 'water trigger' (water resource, in relation to coal seam gas development and large coal mining development). The Commonwealth Minister for the Environment assessed the E&A Program and concluded the Santos' E&A Program is not a CSG development that has or is likely to have, a significant impact on water resources, provided it is carried out in accordance with particular requirements.

3) CSG exploration, appraisal and production planning is an iterative process whereby the results of early stage activities are used to inform later stages of project development. As such, any future

exploration, appraisal or production activities beyond the E&A Program, including the Narrabri Gas Project, will be referred as considered necessary at the appropriate time.

4.10.3 Policy

4.10.3.1 Issue description

1) Concerns were raised over a number of NSW Government policy issues:
   - The adequacy of CSG exclusion zones that came into effect from 4 October 2013, which enforced a two kilometre buffer for new CSG activities across existing residential zones, as well as lands identified for future residential growth.
   - The domestic gas reservation policy does not protect against gas price increases. If the proposed activity is approved, the government will be at risk of litigation regarding property devaluation, impacts on water rights and legacy costs of contamination from well integrity risks.

2) It would be instructive for the proponent to undertake a detailed impact analysis against the *Namoi Catchment Action Plan 2010-2020* thresholds and targets, and requirements of the *Extractive Industries Policy 2009* for the Namoi Catchment and the *Namoi CMA Biodiversity Offsets Policy 2011*. Ideally this would be requested as part of the DGRs.

4.10.3.2 Response

1) These are policy issues for the NSW Government to consider.

2) The *Namoi Catchment Action Plan 2010-2020* (CAP) (NCMA, 2011) identifies biodiversity, land, water and people as the major natural resource management assets of the catchment. The proposed activity is located on existing cleared lease areas and is not expected to impact CAP thresholds and targets.

   The *Namoi CMA Biodiversity Offsets Policy 2011* identifies principles to be applied when offsets are implemented for a proposed development. A key principle is that offsets will be used as a last resort after consideration of alternatives to avoid and/or mitigate impacts. The proposed activity has been located on existing cleared lease areas to avoid any further vegetation clearing and is therefore consistent with this policy.

   An environmental risk assessment for the proposed activity has been undertaken as outlined in Chapter 7 of the EIS, in line with the *Extractive Industries Policy for the Namoi Catchment* (NCMA, 2009a).

4.10.4 Other regulatory comments

4.10.4.1 Issue description

1) NSW EPA needs to be adequately resourced to enable compliance monitoring.

2) All mining activities should go through an EIS process.

3) Concern that the Aquifer Interference Approvals have not come into effect. If the development does not require approval under section 91F of the *Water Management Act 2000* due to a technicality, the situation should be reviewed and remedied. Santos' development will clearly interfere with an aquifer.

4) Santos will need to ensure that appropriate WALs are in place to account for any take of groundwater.

5) Santos will need to submit a variation application to NSW EPA to add the proposed activity to the EPL application.

4.10.4.2 Response

1) This is a recommendation for the NSW Government to consider.

2) This is a recommendation for NSW Government to consider. However, Santos believes that consideration should be given to the nature and scale of the specific activity proposed as to whether it needs to go through an EIS process (as is already the case).

3) Section 9.4 and Appendix 3 of the EIS states that the proposed activity will constitute an aquifer interference. In addition, the NSW Office of Water undertakes an assessment of the proposed activity against the AIP as part of its review of the EIS. The requirement for an Aquifer Interference Approval is a policy matter for the NSW Government.

4) Santos has currently applied for a 600 megalitre WAL to account for all take of water for the proposed activity, and will continue to work with the NSW Office of Water to ensure that it obtains all the necessary licenses for the E&A Program.

5) Santos will submit a variation application to the NSW EPA to vary its application for an EPL if development consent for the proposed activity is granted.

4.11 Environmental risk assessment

4.11.1 Issue description

1) The risk assessment is insufficient as there is no mention of the 23 reported hazardous incidents involving the spilling of produced water, no detail on the management of weeds, the *NSW Coal Seam Gas Code of Practice Well Integrity* (DTIRIS, 2012) would not mitigate risk to stygofauna, the bushfire risk is underestimated and the heritage risk assessment is lacking.

4.11.2 Response

1) The risk assessment provided in the EIS is considered to be appropriate, given the nature and scale of the proposed activity (drilling of two additional wells on existing well pads, and operation of 14 wells for up to three years) and the mitigation measures that will be adopted. The risk assessment process inherently takes into account past pollution incidents. The potential for leakage or spills, weed invasion, risks to stygofauna and bushfires were identified during the preliminary environmental risk assessment, shown in Tables 7-1 and 7-2, and considered in further detail in the impact assessment chapters of the EIS. The mitigation measures are appropriate to manage the identified risks e.g. produced water will be managed in a purpose built gathering and storage system including double lined ponds with leak detection system.

4.12 Land resources

4.12.1 Issues raised by NSW Office of Agricultural Sustainability and Food Security

4.12.1.1 Issue description

The NSW Office of Agricultural Sustainability and Food Security considered that the EIS and AIS did not provide sufficient discussion of the following land resources aspects to fulfil the DGRs:

1) Detailed soils and land capability has not been conducted for the proposed activity.

2) Contamination has not been adequately addressed, and no information on soil contamination in relation to soil and land capability is provided.

3) Soil erosion and sediment transport has not been assessed; only a broad estimate based on one soil type (a Sodosol) has been made, mentioning sodicity and dispersion however not mentioning erosion.

4) Regional salinity has not been assessed.

4.12.1.2 Response

At the request of the NSW Office of Agricultural Sustainability and Food Security, further discussion on aspects of land resources are provided below.

1) *Soils and fertility*

Australian Soil Classification (ASC) soil order mapping (1:100,000) prepared by OEH (2012a) shows that the project area and the surrounding landscape is characterised by a single ASC soil order (Sodosols). Rudosols and Tenosols are also mapped approximately 1.5 kilometres south-east of the proposed activity. These soil orders are briefly described in Table 1**.**

Table 1 Australian Soils Classification

ASC Soil Order	Description
Sodosols	Soils with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2 horizon is sodic and not strongly acid.
Rudosols and Tenosols	These soils have weak (Tenosol) to negligible (Rudosol) pedological organisation.

Landscape unit mapping was prepared by DECC (2002) for the NSW (Mitchell) Landscapes. The landscape unit mapping shows that the project area is defined by a single landscape unit, Coghill Alluvial Plains, which is described in Table 2.

Table 2 Soil Landscape Units

Landscape Unit	Description
Coghill Alluvial Plains	Deep texture-contrast soils with harsh clay subsoils, grey clay with gilgai.

Ternary radiometric data images were sourced from Geoscience Australia using their Geophysical Archive Data Delivery System. The data was used to assist with delineating possible soil type boundaries by visual identification of broad patterns of radioactive isotope distribution in the landscape. The proposed activity area and nearby surrounds consist of weathered materials (green-blue) and quartz rich sandy materials (black). More importantly, the hue patterns are quite consistent across the Pilliga which supports the broadscale mapping of the dominant soil types (i.e. Sodosols and Rudosols/Tenosols) over this landscape.

ESG commissioned a soil survey of the proposed gas pipeline alignment from the Bibblewindi State Forest in the south to the Wilga Park Power Station in the north (GCNRC, 2008). The survey identified that the soils along the alignment in the Pilliga and Bibblewindi State Forests were dominated by deep texture contrast soils with a sub-dominant occurrence of deep sandy soils. The subsoil of the deep texture contrast soils was described as having a high to very high dispersion potential which is characteristic of Sodosol soils. The deep sandy soils observed in the Bibblewindi State Forest were light textured (sand to sandy loam) throughout the solum and are best classified as Rudosol/Tenosol soils.

The NSW Soil and Land Information Systems database identified three local soil observations within 5 to 10 kilometres of the proposed activity area to assist in validating broadscale mapping. Profiles 79, 80 and 81 were collected by random survey for the Southern Brigalow Western Regional Assessment to establish data for the Soil Landscapes of the Baan Baa 1:100,000 Map Sheet for Liverpool Plains (Pengelly, 2010). The texture contrast soil profile descriptions and pH data (pH greater than 5.5) reported was very similar to that previously encountered by RPS for Sodosols. Of particular note was the presence of a conspicuously bleached A2 horizon at all three sites which was also noted by RPS and is indicative of poor drainage due to the strongly sodic subsoils.

A site inspection of the proposed activity area was undertaken by RPS on 3 July 2013 which consisted of observations of vegetation types and noting features of the soil surface. The vegetation at the proposed activity area was consistent with the vegetation types previously observed by RPS associated with Sodosol soils in the Bibblewindi and Pilliga State Forests. The topsoil of the undisturbed area surrounding the project area was pale orange and of a coarse sandy texture. Hard-set clay subsoils with evidence of tunnelling and finely fretted erosion features were noted in soils exposed in nearby road cuttings. These soil surface features were consistent with properties of the Sodosol soils previously encountered by RPS at soil survey sites in the Bibblewindi and Pilliga State Forests.

A soil profile was extracted 13 kilometres north of the project area, within mapped Sodosols. Based on the physical and chemical properties, the soils within this region were considered to be Sodosols and defined as non-saline to moderately saline, with strongly sodic subsoils (>150 mm depth).

According to the *Draft Inherent Soil Fertility Mapping, Upper Hunter and New England North West Strategic Regional Landuse Areas* (OEH, 2012b), the inherent soil fertility of the proposed activity site and its surrounds is moderately low.

The vegetation associations and soil surface conditions noted during the site inspection confirmed that the likely soil type at the project area is a Sodosol. The soil survey previously conducted by RPS in the Pilliga and Bibblewindi State Forests found that Sodosol soils were the dominant soil type in the surveyed landscape. Considering the current inherent soil fertility mapping and the soil type (Sodosols) of the project area, the soils are likely to have moderately low to low fertility.

Land Capability and Agricultural Land Use Suitability

According to the NSW Agriculture Agricultural Land Classification (NSW, 2002) technical manual on agricultural land classification classes, lands that need not be evaluated include State forests. The proposed activity is located within the Bibblewindi State Forest. As the proposed activity is located within a State forest no Agricultural land classification has been undertaken. However, Agricultural land is largely classified by evaluating biophysical factors that may constrain the use of land for agricultural. A desktop assessment on other land and soil capability investigations and mapping which also largely considers biophysical factors is presented below.

In NSW, land and soil capability classes (LSC Classes) have been mapped for the New England - North West region (OEH, 2012c). The mapping is based on an eight class system with values ranging between 1 and 8 which represent a decreasing capability of the land to sustain land use. The site and surrounds have been mapped as LSC Class 4 and 5. Lands in LSC Class 4 are described as having moderate to severe limitations and are generally not capable of sustaining high impact land uses unless using specialised land management practices with high level of knowledge, expertise, inputs, investment and technology. Limitations are more easily managed for lower impact land uses (e.g. grazing). Lands in LSC Class 5 are described as having severe limitations and are not capable of sustaining high impact land uses except where resources allow for highly specialised land management practices to overcome limitations (e.g. high value crops). Lower impact land uses (e.g. grazing) can be managed by readily available practices.

The Soil Conservation Service (SCS) of NSW (Land and Water Conservation) uses 1:100,000 scale maps for evaluating rural land (Emery, 1986). Mapping is based on an assessment of the biophysical characteristics of the land, the extent that these will limit a particular land use and also includes assessments of soil erosion hazards. The SCS of NSW study classed the proposed site as a State forest and did not assign a land capability classification. Similar to the SCS mapping land capability mapping the NSW Department of Primary Industries land use assessment has not assigned the Bibblewindi State forest a land use suitability class.

Cropping history is a strong indicator of land use suitability for cropping. Cropping extent was mapped for the Border Rivers-Gwydir-Namoi CMAs using a process of manually digitising cropping paddock boundaries and attributing them with cropping history data established through field observations and Landsat TM imagery (NCMA, no date). The NSW OEH combined all cropping paddock boundaries digitised with a new set of polygons produced through automated image segmentation, adding further information to the digitised data. The Cropping History Assessment (1998-2008) indicates that no cropping has occurred on the proposed activity site during this period. No cropping has occurred at the site after 2008.

Considering the above information and soil limitations, the proposed activity area would not be considered appropriate for cropping, though low intensity grazing may be suited to the site.

2) The project area has not been identified as an existing contaminated site. Risk of soil contamination or reduction of land capability as a result of contamination are largely associated with fuel/oil spills, however risks will be mitigated by the measures identified in section 8.4 of the EIS.

During operation, the groundwater lifted from the coal seam will flow to the balance tank located at Bibblewindi 19H via a short section of pipe. The water transfer (or balance) tank at Bibblewindi 19H will be used for temporary storage of produced water. The water transfer tank will be bunded to 100 per cent capacity to minimise impacts of any spillage. Water from the balance tank will be transferred via the existing gathering system to the Bibblewindi Water Management Facility and then to the Leewood Produced Water Facility.

There is a risk that a line failure could occur within the gathering system that transfers lifted groundwater between the wells to the transfer tank at Bibblewindi 19H. Water pressure within the pipes is monitored remotely and should this occur, operation of the well will be suspended until the problem is rectified. The extent of the impact will also be small, localised and short term.

Impacts to structural integrity, land instability or subsidence are not expected.

Considering the low and minimal contamination risks and proposed mitigation measures it is unlikely that the proposed activity will reduce the low intensity grazing capacity of Land and Soil Capability Classes of 4 and 5.

3) *Sodicity*

Land Management Units mapping in the Namoi Catchment (NCMA, 2009b) was a project commissioned by the Namoi CMA and involved soil and land capability mapping (scale: 1:100,000) of the Namoi Catchment. Derivative maps were also created and included sodicity maps.

The sodicity mapping indicates that the location of the proposed activity is characterised by localised surface sodicity and widespread subsurface sodicity. Further, investigations undertaken by RPS have also found Sodosols within the Bibblewindi State Forest and Pilliga forest to contain strongly sodic subsoils.

Dispersion

The ESG survey (GCNRC, 2008) also analysed soil dispersion susceptibility. The nearest site, Profile 6, was located 5.9 kilometres north of the proposed Bibblewindi 32 site. Profile 6 was also identified as a Sodosol. The dispersion percentages identified that surface dispersions (0 – 0.14 m) was slightly dispersive (dispersion % = 6 – 30), while subsoils (<0.14 m) dispersion values were very high (dispersions % = >65). Surface dispersion potential is the most important consideration for a site with possible exposure of surface soil and minimal deep disturbance.

Erosion and sediment transport

The low slope of the landscape (1%) and moderate erosivity rainfall in the Narrabri region results in a relatively low erosion risk for the development. This assumes that the site will preclude on-site runoff and the disturbed area is relatively small. However, sodic and dispersive soils have been identified by both GCNRC (2008) and RPS (2013), therefore some management is required to minimise erosion risk (Section 8.4.1 of the EIS).

Soil texture has been identified as largely sandy with some clay content. Infiltration rates for this soil will be moderate to high. The transport of sediments should be minimal.

Erosion and sediment controls, such as silt fencing, will be implemented where necessary during site preparation activities in accordance with the Blue Book (Landcom, 2004). These controls will be maintained until disturbed areas of the site are stabilised. This measure is decribed in section 8.4 of the EIS.

4) The Australian Government's Department of Agriculture, Fisheries and Forestry compiled salinity risk and hazard mapping for 2000, 2020 and 2050 (NLWRA, 2001), showing the areas considered as having either a high salinity risk or a high salinity hazard. Groundwater data has been used and where this data is inadequate, salinity assessments have been based on the presence of geological, landscape, regolith, land use and climate attributes.

The Australian Dryland Salinity Assessment Spatial Data is at a scale of 1:2,500,000 and was created in 2001. There is no assessed dryland salinity within the proposed site or the surrounding area.

Conventionally saline soils are defined as those having an ECe value greater than 4ds/m. Profile assessment undertaken by RPS within Sodosols of the Pilliga Scrub indicated that 0 (0.28 ECe

ds/cm) to 460 millimetres (2.47 ECe ds/cm) are non-saline soils, while 460 to 760 millimetres depth is slightly saline.

4.12.2 Other issues raised

4.12.2.1 Issue description

1) The best food-producing lands and finest natural areas are at risk from CSG activity. The science tells us that CSG puts at risk the clean water and soil that is essential for food production.

2) The forest should remain as a resource enjoyed by the public for bushwalking, camping, tourism, birdwatching, forestry and cultural heritage practices.

3) Erosion and sediment controls should be implemented consistently with the guidelines, principles and recommended minimum design standards contained in *Managing Urban Stormwater: Soils and Construction – Volume 1* (the Blue Book).

4.12.2.2 Response

1) The site is located within the Bibblewindi State Forest. The site is not located on or near BSAL and/or a CIC as defined in the *New England North West Strategic Regional Land Use Plan* (DP&I, 2012). The nearest mapped BSAL is approximately 15 kilometres from the site and no CIC has been identified in DP&I (2012).

   The AIS that was undertaken for the EIS (Appendix 2) concluded that there would be no impact to agricultural land.

   Produced water from the wells is not from the productive aquifers accessed by farmers and the community. It comes from deep underground and is not used by farmers and the community due to its depth and high salinity. Santos has developed an extensive regional groundwater model that simulates groundwater flow and predicts groundwater drawdown. The Groundwater Impact Technical Report (Appendix 3 of the EIS) predicted the effect of the E&A Program on productive groundwater resources to be negligible.

   The proposed activity is located within areas that have been previously cleared for CSG activities. As outlined in the EIS, mitigation measures will be put in place to ensure the impact of the proposed activity is minimised.

2) The proposed activity is located within areas that have been previously cleared for CSG activities, with no additional area to be disturbed.

3) Santos agrees with this recommendation; the SoC has been updated accordingly.

4.13 Groundwater

4.13.1 Baseline monitoring

4.13.1.1 Issue description

1) The Director General requires baseline monitoring, however there is no baseline water study completed for the Pilliga groundwater systems. The aquifer monitoring bores required have not been constructed. The proposed deep and shallow bores should be installed and monitored to establish baseline conditions prior to further drilling.

2) Concern over the lack of information supplied by Santos for the Namoi Catchment Water Study.

4.13.1.2 Response

1) Baseline groundwater monitoring has been undertaken for bores (including at private water bores and NSW Office of Water bores) as part of the Santos Regional Bore Inventory and Monitoring Scheme. The collated data from a number of sources over a period of time provides a groundwater monitoring dataset for the region. The data is included in the *Bibblewindi Gas Exploration Pilot Baseline Surface and Groundwater Data Report*, attached as Appendix 2.

   The scheme was initiated for the Narrabri region in 2012, focusing on collecting groundwater samples and static water levels from landholder bores in close proximity to the CSG activities. As this data is collected and assessed, it expands on baseline data and understanding by providing greater spatial and temporal data resolution local to CSG activities. Seventy bores (mostly private farm bores) have been documented and groundwater samples analysed so far from within PEL 238.

   To support the development of a regional baseline dataset, Santos has collated historical data collected by ESG and publicly available information from the NSW Office of Water. Data gathered includes:

   - Produced water extraction rates from CSG pilot wells.
   - Groundwater elevations from available NSW Office of Water aquifer monitoring bores.
   - Produced water geochemical data from CSG pilot wells.
   - Groundwater geochemical data from landholder bores.

   As additional data is collected through Santos' ongoing environmental monitoring programs it will enable the expansion of this baseline dataset. The data will be used to assist in monitoring for any unexpected changes to overlying aquifers during the operation of the proposed activity.

2) Santos has provided sponsorship and geological & drill stem test (DST) data to the Namoi Water Catchment Study, which was finalised in August 2012.

   Santos was actively involved in providing review comments and feedback to the Namoi Catchment Water Study.

4.13.2 Model conceptualisation, development and calibration

4.13.2.1 Issue description

1) The Conceptual Hydrogeological Model in Figure 9-1 appears to be incorrect, based on Santos' own data and other published geological maps. The conceptualisation of the hydrostratigraphic beds and how they interact with each other, including the aquitards and aquicludes, appears to be incorrect.

   None of the confining beds have been positively identified. A number of beds are referred to as 'probable hydraulic barriers' or as an 'impedance to groundwater', but none have been recognised as barriers to groundwater movement.

2) The model layers used to build the Groundwater Numerical Model are not representative of the shallow hydrostratigraphy.

3) The model is considered to be based on insufficient hydraulic data. The lack of information on the assumptions required for model development, in particular basic hydrogeological or geological data,

is of concern. Without this data it is hard for technical reviewers to provide informed comments as to whether the conclusions reached in the EIS are justifiable or not.

The short comings of the model and the assumptions used give rise to concerns over the robustness of the results obtained, including the assessment of potential impacts of CSG activities on groundwater resources.

There should be thorough sampling and testing across the project area, including pump testing and water quality analysis, to enable modelling of regional groundwater flows and a comprehensive impact assessment of groundwater resources and GDEs in the Pilliga region. The additional data should be fed back into the numerical groundwater model, sensitivity analysis carried out and the model rerun.

4) The EIS acknowledges that 'the spatial coverage of groundwater measurement is sparse and as there are no targets for calibration over large areas of the model it is not possible to calibrate these areas'. The respondent would like to know what further data is required to calibrate the model.

5) The Maules Creek Formation is predicted to achieve 80 per cent recovery after ten years. This would appear to indicate hydraulic connectivity. Furthermore, rapid recovery after drawdown in both the Hoskissons and Maules Creek coal seams is shown, again appearing to indicate actual or potential hydraulic connectivity to aquifers. The Maules Creek Formation is listed as being a 'negligibly transmissive unit', an apparent contradiction to the rapid pressure recovery.

6) Narrabri Shire Council seeks further information on the conceptual groundwater model and the assumptions made in the groundwater modelling.

7) Insufficient information has been provided for the NSW Office of Water to assess the validity of the model and its suitability in making the required predictions. An additional detailed modelling report should be submitted to NSW Office of Water for review, including any peer review.

4.13.2.2 Response

1) Figure 9-1 in the EIS is a schematic cross section and reflects the current conceptual understanding of geology and hydrostratigraphy in the E&A Program area (based on Santos geological model data and agreed with Santos geologists). Further detail to support the schematic cross section and descriptions used is provided in the Groundwater Impact Technical Report (Appendix 3 of the EIS).

   Table 3-1 of the Technical Report presents the hydrogeological classification of each model layer, and therefore each hydrostratigraphic unit. The litho-stratigraphy has been classified into significant transmissive units (STU) and less significant transmissive units (LSTU), probable negligibly transmissive units (PNTU) (restricting the transmission of groundwater) and negligibly transmissive units (NTU) (impeding groundwater flow). The purpose of these definitions is to recognise the relative significance of hydraulic properties of different units to the hydrogeological response of the system without attributing labels that carry generally-accepted but potentially inappropriate connotations, such as 'aquifer', 'aquitard' and 'aquiclude'. Hence a highly conductive, high-yielding stratum would be considered a typical example of a STU and a low-yielding stratum would be considered a LSTU.

2) The model was developed as a regional model to assess the impact of depressurisation of the target coal seam on the overlying formations. The focus of the model was not on the shallow system, but the groundwater system as a whole and the potential propagation of drawdown as a result of coal seam depressurisation. The model design and development was based on all information available

at the time. The Bohena alluvium is modelled as Hydrostratigraphic Unit (HSU) 1 while the Pilliga Sandstone and Keelindi Beds are modelled as HSU10. Minimal information is available relating to the Keelindi Beds. On the basis of its characteristic lithologies, it has been subsumed into the underlying Pilliga Sandstone for the purpose of its inclusion in the hydrogeological conceptualisation and numerical groundwater flow model.

3) The model is a Level 1 model, developed in accordance with the *Australian Groundwater Modelling Guidelines* (Barnett *et al*., 2012), and is intended to provide the basis for an initial assessment of the responses of the system to hydraulic stress. Santos considers the level of data utilised in the model to be suitable for the level of assessment undertaken. As with the development of all scientific models, additional data will assist in model refinement.

   A conservative approach, consistent with the precautionary principle, has been taken to all aspects of the design of the model in order to ensure that the model is sensitive to the simulated hydraulic stress (CSG water extraction). The approach taken to construct and parameterise the model has been extensively peer reviewed by leading independent authorities. Model construction utilised all baseline data available. In the absence of measured parametric data, values derived from relevant calibrated models in the locality were used. Extensive and targeted sensitivity analysis has been conducted to determine the significance of aspects of the model design and the hydraulic parameterisation of the model and ensure adequate conservatism.

   By the end of 2013 Santos will have drilled and installed seventeen new groundwater monitoring bores, targeting the Upper and Lower Pilliga Sandstone, Orallo formation and Purlawaugh formation and one deep aquifer monitoring bore targeting strata surrounding the Black Jack and Maules Creek Coal measures. The data that will become available through the ongoing Regional Bore Inventory and Monitoring Scheme will be used to refine and validate the model, in accordance with the *Australian Groundwater Modelling Guidelines* (Barnett *et al*., 2012).

4) Santos has utilised data available at the time of model construction to calibrate the model. As more data becomes available, the model parameters will be refined to incorporate this new data. Santos has a detailed geological model covering the entire project area and therefore has detailed information on the depth of all formations, including aquifer units.

5) The fast initial recovery is mainly due to the minimal storativity of the Maules Creek Formation which means a small amount of water, during extraction or during recovery, yields a large change in head.

6) Santos has approached the Narrabri Shire Council with the offer to meet and discuss various groundwater matters including numerical model conceptualisation and the monitoring program.

7) Santos is currently liaising with the NSW Office of Water, and will provide the groundwater model and independent peer review reports for review. Santos will continue to work with the NSW Office of Water to seek clarification on the comments they have made in their review and to respond to their concerns and questions.

4.13.3 Potential impacts to groundwater resources

4.13.3.1 Issue description

1) Concerns raised over the potential contamination of groundwater resources through leakages of chemicals used during drilling and cross-contamination between aquifers. Contamination could impact on the health of the community and environment, as well as create flow-on effects to local industries reliant on the groundwater resource.

2) Concerns raised over the potential drawdown of aquifers due to the extraction of groundwater. The drawdown of groundwater levels could potentially cause these resources to become inaccessible to native plants, crops or bores, or disconnected to local streams.

3) The EIS has not provided an assessment of the impacts of the proposed activity (including drilling) on water quality. Sufficient water quality information should be provided to allow an assessment against the minimal impact consideration for water quality in the AIP for affected water sources.

4) Concerns raised that the potential impacts on groundwater due to CSG are not known. The development of a CSG industry threatens the local community as it risks impacting on the groundwater supply and quality. These impacts could be long-term. Santos cannot guarantee water supply will not be adversely affected as a result of CSG activities.

4.13.3.2 Response

1) It is considered highly unlikely that water quality from the deeper water sources would have a pathway to migrate upwards. This is confirmed in the groundwater flow model. Wells will be designed and constructed in accordance with the *NSW Coal Seam Gas Code of Practice Well Integrity* (DTIRIS, 2012), as stated in Section 9.3.1 of the EIS. This Code of Practice includes mandatory requirements for well design, casing, cementing, wellheads and drilling fluids. Further to this, Santos will adopt best practice site environmental management measures to minimise the likelihood of accidental spillage, and have appropriate management and mitigation plans in place should a spillage occur as outlined in Section 8.4 of the EIS, to contain and prevent environmental harm.

2) Groundwater modelling has been undertaken at a regional scale to predict the impact of depressurisation of deeper water bearing strata on locally utilised aquifers. The groundwater impact assessment (Appendix 3 to the EIS) concluded that there is unlikely to be a significant decline in the shallow aquifer system, and this will prevent impacts on GDEs, local bore users and watercourses (including perennial watercourses outside of the Pilliga forest). Surface water baseline monitoring within the Pilliga forest indicates that many of the creeks are ephemeral, and therefore flow during high rainfall events only (Section 9.1.1 of the EIS).

3) Section 9.1.4 of the EIS presents a summary of water quality, while further details of baseline groundwater water quality data is presented in the *Bibblewindi Gas Exploration Pilot Baseline Surface and Groundwater Data Report* (Appendix 2). Furthermore, groundwater quality is assessed as a construction impact in Section 9.3.1 of the EIS. The groundwater flow model confirms that during operation it is considered highly unlikely that the more saline water from the deeper water sources would have a pathway to migrate upwards. Potential impacts to surface water during both construction and operation of the proposed activity are provided in Section 10.2.2 of the EIS. Given the scale of the proposed activity, and the implementation of appropriate mitigation measures, these are considered to be minimal.

   During drilling, the circulating drilling fluid will establish a wall cake (a low permeability ‘skin’ around the wall of the hole) and maintain pressure on the various aquifers intercepted. This will prevent the ingress of groundwater to the pilot well, mixing of groundwater between aquifers and discharge of groundwater to the surface. It will also limit the ingress of drilling fluid into the aquifers in the immediate vicinity of the pilot well.

   The focus of the AIP with regard to water quality is the alluvial aquifer. The AIP sets minimal impact considerations for water quality. For deeper aquifers, including both Porous Rock Water Sources and the Fractured Rock Water Sources, the AIP states that changes in groundwater should not change the beneficial use category of the groundwater source beyond 40 metres from the activity.

The NSW GAB Groundwater Source WSP states a range of beneficial uses. Santos' monitoring program will identify if impacts to the groundwater quality system are occurring.

4) Santos acknowledges the sensitivity of the availability of groundwater as a resource within the region. A detailed monitoring program has commenced and will be continued throughout the duration of Santos' activities in the Narrabri region. The monitoring program will identify if impacts to the groundwater system are occurring. If impacts to groundwater are identified, Santos' groundwater extraction activities in the localised area of the impact will cease, the issue investigated and appropriate mitigation and management measures will be implemented. In the event that Santos' operations are found to have impacted the capacity or quality of a useable aquifer, Santos will adhere to 'make good provisions' under the AIP.

4.13.4 Great Artesian Basin

4.13.4.1 Issue description

1) The Pilliga forest is a recharge area for the GAB and contributes surface water flows to the Murray-Darling Basin. Concerns that the GAB is at risk from proposed intensive CSG drilling, with potential declines in water quantity or quality which could have flow on effects to other industries. These impacts may not be easily fixed or compensated.

4.13.4.2 Response

1) Santos acknowledges that the Pilliga Sandstone which outcrops in parts of the Pilliga forest acts as a recharge bed for the GAB, and the need for due care when operating in the outcrop area. This has been reflected in the sensitivity of the receptor within the impact assessment. The groundwater impact assessment (Section 9.4 and Appendix 3 of the EIS) indicates that there will be negligible impact to the GAB due to the cumulative effects of the E&A Program.

4.13.5 Drilling techniques and well integrity

4.13.5.1 Issue description

1) Concerns that there is a risk of leakage of produced water or drilling fluid into the freshwater aquifers as a result of poor bore construction, creating potential groundwater quality impacts. In particular, drilling through the casing of wells poses a risk to the GAB and other aquifers as it is very difficult, if not impossible, to seal the junction between the casing and the lateral.

2) Concerns that there is a risk of leakage of produced water to the freshwater aquifers as a result of improper site practices, operational procedures or fracturing of casing and grouting. Gas wells fail over time, with seven per cent leaking immediately and 50 per cent within 20 years.

3) The *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012) guidelines are being relied upon by the NSW Government to ensure Santos does not contaminate the water resource. Santos, however, is only required to adequately seal off 'producing aquifers' from each other. The Bohena alluvial aquifer might not be a 'producing aquifer' but it is still a lower quality aquifer that will be connected to the Pilliga during drilling activities and therefore poses a risk of leaking lower quality water into the GAB aquifer.

4.13.5.2 Response

1) The Bibblewindi 31 and 32 wells will be designed and constructed in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012) (Section 4.2.1 of the EIS). The Code of Practice established a best practice framework for the design, construction and maintenance of a

well, has undergone peer-review and been endorsed by the NSW Chief Scientist and Engineer. Complying with the Code of Practice is a condition of Santos' licence to explore in the Narrabri project area, to ensure the proposed activity is undertaken safely and the groundwater is protected.

During drilling, the circulating drilling fluid will establish a wall cake (a low permeability 'skin' around the wall of the hole) and maintain pressure on the various aquifers intercepted. This will prevent the ingress of groundwater to the pilot well, mixing of groundwater between aquifers and discharge of groundwater to the surface. It will also limit the ingress of drilling fluid into the aquifers in the immediate vicinity of the pilot well.

2) All Santos CSG wells are designed to ensure they are safe and prevent any interconnection between hydrocarbon bearing formations and aquifers and to ensure that gas is contained within the well and associated pipework and equipment without leaking. To achieve this, a completed well will consist of three layers of steel casing and cement. These casing strings and cement layers serve to maintain the well opening, isolate the coal seams from the overlying geologic formations and aquifers, and provide a conduit for fluids to flow from the formation to the ground surface.

   Santos conducts regular monitoring and maintenance of all its wells. Routine operational visits are also undertaken to monitor well-head pressure and inspect casing and well-head equipment.

3) The GAB is classified as a beneficial aquifer, based on the definitions within the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012), and will therefore be isolated with cement in accordance with the Code of Practice. Furthermore, the Bohena alluvium is an intermittent aquifer fed primarily by rainfall and therefore not considered to be of poor quality. In areas where the Bohena alluvium intercepts the Pilliga Sandstone, it provides a direct source of recharge to the GAB.

4.13.6 Cumulative impacts

4.13.6.1 Issue description

1) The cumulative groundwater impact modelling should incorporate the proposed 400 production wells. The EIS does not address cumulative risk of drilling and extraction of groundwater.

4.13.6.2 Response

1) The numerical groundwater model used for the EIS assesses the cumulative impact of the operation of the six pilots that form the E&A Program including the proposed activity. Any future exploration, appraisal or production activities beyond the E&A Program, including the Narrabri Gas Project, will be modelled and assessed cumulatively as part of the environmental assessment documentation which supports any applications for approval once they are made.

   In December 2013, Santos identified the proposed project area currently being considered for the Narrabri Gas Project. The project includes a gas field and a pipeline to transport the natural gas to the NSW market. The gas field will include:

   - Up to 850 production wells.
   - Monitoring of wells to provide continual information about water and gas volumes and well site security.
   - A central water management and treatment facility to store and treat produced water for reuse.
   - A central gas processing facility to treat and compress the natural gas.

Further details of the Narrabri Gas Project can be found at http://www.santos.com/exploration-acreage/new-south-wales/narrabri-gas-project.aspx.

4.13.7 Registered bores

4.13.7.1 Issue description

1) Bore census information is not presented in the EIS to verify the conclusion that there are no known bores extending into the Gunnedah-Oxley Basin groundwater source in the E&A Program area. A bore census covering all of the E&A Program area should be provided.

2) The EIS identifies that there are five registered extraction bores within five kilometres of the wells, however the predicted drawdown extends beyond this distance. All bores within the potential drawdown area should be identified and potential impacts quantified.

4.13.7.2 Response

1) Santos utilises groundwater data from registered bores which is publically available through the NSW Natural Resource Atlas (http://nratlas.nsw.gov.au/wmc/custom/homepage/home.html) or on the NSW Office of Water's *Pinneena 3.2 – New South Wales groundwater data archive*, the latest version of which was released in 2010.

   Baseline groundwater data collation and monitoring has been undertaken for bores (including accessible private water bores and NSW Office of Water bores) in the vicinity of the E&A Program area as part of the Santos Regional Bore Inventory and Monitoring Scheme. This information, including bore locality data, is presented in the *Bibblewindi Gas Exploration Pilot Baseline Surface and Groundwater Data Report* (Appendix 2).

2) The five kilometre buffer was used for assessing impacts to groundwater during construction. As stated in Section 4.6 of the Groundwater Impact Technical Report (Appendix 3 of the EIS), there are no known registered bores sourcing water from formations deeper than the Pilliga Sandstone in the E&A Program area. The predicted impact on registered water supply bores is stated in Section 4.6 of the Groundwater Impact Technical Report.

4.13.8 Groundwater monitoring program

4.13.8.1 Issue description

1) A hydrology and water quality baseline monitoring program should be implemented as part of the program that covers all aquifers potentially impacted by CSG production, including shallow aquifers.

2) One deep groundwater monitoring bore is considered inadequate to monitor the changes in the deep aquifer layers. Additional deep monitoring bores should be installed, or if they already exist, they need to be incorporated into the monitoring program. The bores should be installed with sufficient time to collect baseline data prior to the start of operations. The monitoring should continue over the life of the project as well as during recovery.

3) Inconsistent reporting of locations for the proposed groundwater monitoring bores between what is reported in the EIS and what was provided to the NSW Office of Water in the *Narrabri Gas Field Monitoring and Modelling Plan* should be clarified.

4) Narrabri Council requires further information to determine the adequacy of the monitoring program. The water quality monitoring program should include parameters indicative of contamination of groundwater by drilling fluids and vertical flow of groundwater. Council seeks that the monitoring suite includes: pH, EC, major ion, fluoride, silica, dissolved metals, nutrients, dissolved gases,

hydrocarbons and isotopic analysis. Monitoring must be undertaken using sampling protocols that have been approved by an appropriate agency e.g. NSW OCSG. It is essential that the monitoring program including isotope testing be implemented before any further wells are constructed. As part of this program the process to rehabilitate and repair the damage to the aquifers needs to be included.

5) Further information on the baseline monitoring results and the proposed trigger values when contingency measures will be implemented should be provided to Narrabri Council, as well as the proposed feasible contingencies.

6) Narrabri Council must be provided with an opportunity to review and comment on the proposed groundwater monitoring program.

7) The conclusion that there will be no significant impacts to groundwater pressure or flows will need to be confirmed as part of a rigorous groundwater monitoring program.

4.13.8.2 Response

1) Santos has baseline groundwater monitoring data for the E&A Program area, which is presented in the *Bibblewindi Gas Exploration Pilot Baseline Surface and Groundwater Data Report* (Appendix 2). Santos is continuing baseline surface water quality sampling across the wider project area, stretching from the foothills of the Liverpool Ranges to downstream of Wee Waa. Further to this, Santos has committed to drilling shallow and deep groundwater monitoring bores to act as sentinel monitoring locations against which any impacts can be identified, with appropriate mitigation and/or management measures to be adopted where necessary.

2) As part of the E&A Program Santos is installing and operating a groundwater monitoring network to detect any changes in groundwater levels.

   Over the appraisal program, Santos will install a regional deep aquifer monitoring bore (Dewhurst 8A) with pressure monitoring devices targeting the formations (Digby Formation, Arkarula Formation, Porcupine Formation and the top of the Maules Creek Formation) in the likely zones of depressurisation overlying the targeted coal seams. This bore is strategically located at the eastern periphery of the Narrabri Gas Project area within the Permo - Triassic strata from which depressurisation originates. Potential changes to fluxes due to vertical propagation between Triassic and Jurassic hydrostratigraphic units will be captured in this monitoring bore. The depressurisation data will complement existing depressurisation data derived from within the laterally extensive appraisal pilot wells.

   This monitoring will also act as a sentinel for impacts on Groundwater Dependent Ecosystem (GDE) recharge springs at the Pilliga/Purlawaugh junction. Baseline groundwater pressure and quality data for deep formations are also available from the existing pilot wells. The depressurisation of the coal seams will be constantly monitored with data being utilised to update and calibrate the groundwater model.

3) Indicative groundwater monitoring bore locations were presented and discussed with the NSW Office of Water in the development of the *Narrabri Gas Field Monitoring and Modelling Plan.* The final locations of the bores are determined based on a number of factors, including review of hydrogeological data and accessibility issues.

4) Santos has offered to meet with the Narrabri Shire Council and discuss various groundwater issues, including numerical model conceptualisation and the monitoring program. As part of its Regional Bore Inventory and Monitoring Scheme, Santos undertakes water quality testing using analytical

suites which include pH, EC, major ion, fluoride, silica, dissolved metals, nutrients, dissolved gases and hydrocarbons.

5) Water quality data from the surface water and groundwater monitoring network will be made available to the public via an internet portal http://www.santoswaterportal.com.au.

   The monitoring program discussed in Section 9.5.3 of the EIS has commenced and will continue throughout the duration of Santos' activities in the Narrabri region. The monitoring program will identify if impacts to the groundwater system are occurring. If impacts to groundwater are identified, Santos' groundwater extraction activities in the localised area of the impact will cease, the issue investigated and appropriate mitigation and management measures will be implemented. In the event that Santos' operations are found to have impacted the capacity or quality of a useable aquifer, Santos will adhere to 'make good provisions' under the AIP.

6) Santos has approached the Narrabri Shire Council with the offer to meet and discuss various groundwater issues, including numerical model conceptualisation and the monitoring program.

   Activities within the PAL must be carried out in accordance with the POP which has been approved by the Director-General of NSW Trade and Investment. Under the POP, a GMMP has been developed by Santos, and approved by the State government.

7) Santos is in agreement with this statement.

4.13.9 Protection of water resources

4.13.9.1 Issue description

1) The Water Catchment Authority's recommendations, which were in a report submitted to the government, should be followed in full. The protection of water supply should be the first priority.
2) A remedial action plan in the event of adverse impacts to the groundwater such as leakage and cross contamination between aquifers as a result of the drilling and well construction process, as well as possible well failure into the future, should be provided.

3) A remedial action plan in the event of accidental contamination from the Bibblewindi water transfer and Leewood produced water facilities should be prepared.

4.13.9.2 Response

1) Recommendations from both the Namoi Water and the Namoi Catchment Management Authority submissions have been considered, and are addressed within this submissions report as outlined in Appendix 1.

2) If impacts to groundwater are identified, Santos' groundwater extraction activities in the localised area of the impact will cease, the issue investigated and appropriate mitigation and management measures will be implemented. In the event that Santos' operations are found to have impacted the capacity or quality of a useable aquifer, Santos will adhere to 'make good provisions' under the AIP.

3) The tank at the Bibblewindi Water Transfer Facility and the ponds at the Leewood Produced Water Facility will be double lined and have a leak detection system (Section 3.2.1 of the EIS). In the event of any spills or leaks Santos will employ its emergency response plan to manage and mitigate the situation.

4.13.10 Report discrepancy

4.13.10.1 Issue description

1) The EIS states 'no decline in groundwater level or change in flux' in the GAB Surat Pilliga Sandstone in Section 9.4.2. However, it also states that the Pilliga Sandstone aquifer will not be significantly impacted by the proposed activity in Section 9.4.4.

4.13.10.2 Response

1) To clarify, there is negligible predicted impact (defined as less than 0.5 metres) in the Namoi alluvium and the Pilliga Sandstone from the E&A Program, as provided in Section 4.1.2 of the Groundwater Impact Technical Report (Appendix 3 of the EIS).

4.14 Surface water

4.14.1 Issue description

1) It is a misunderstanding to state that there is only intermittent water in the creeks. The water courses may be filled with sand but the water table is close to the surface. The ecosystems of the Pilliga forest depend on this water and contamination or depletion should not be risked. There is a risk of contamination of streams and rivers caused by spills of produced water due to interconnectivity of aquifers and their surface expressions.

2) The EIS assumes that there will be no impact to registered surface water users because there aren't any. There are licensed water holders that have legal water rights to these ephemeral streams. Regardless of whether their works are developed or not, these water licence holders have a licence that is recognised under the *Water Management Act 2000*.

4.14.2 Response

1) Section 9.1.1 of the EIS acknowledges the presence of perched aquifers in the alluvium (thin veneers associated with the more minor tributaries), which would have a level of interconnectivity with the ephemeral streams during periods of higher rainfall. Santos will adopt best practice site environmental management measures to minimise the likelihood of accidental spillage, and have appropriate management and mitigation plans in place should a spillage occur as outlined in Section 8.4 of the EIS, to contain and prevent environmental harm.

2) Potential impacts to surface water during both construction and operation of the proposed activity are provided in Section 10.2 of the EIS. Given the scale of the proposed activity, and the implementation of appropriate mitigation measures, impacts to surface waters and their users are considered to be minimal. Santos will adopt best practice site environmental management measures to minimise the likelihood of accidental spillage, and have appropriate management and mitigation plans in place should a spillage occur as outlined in Section 8.4 of the EIS, to contain and prevent environmental harm.

4.15 Biodiversity

4.15.1 Baseline monitoring

4.15.1.1 Issue description

1) Ecological surveys to establish parameters for maintaining the viability of threatened wildlife have not been carried out. There must be baseline ecological surveys to assess the population dynamics and status of threatened wildlife, including the Pilliga Mouse, Eastern Pygmy Possum and Barking Owl.

   Concern that there is a lack of sufficient scientific evidence and baseline studies on impacts to biodiversity.

4.15.1.2 Response

1) The proposed activity will not involve any clearing of vegetation as construction (including drilling) and operation is confined to existing lease areas, therefore negligible impacts to biodiversity are anticipated.

   More than 3,000 hours have been spent conducting ecological surveys in the north-east Pilliga forest since 2002. Surveys have been undertaken specifically for the purpose of establishing the baseline ecological values to assess the potential impact of CSG development.

4.15.2 Survey methodology

4.15.2.1 Issue description

1) The survey methodology has not been adequately explained, including the spatial coverage, search effort and effectiveness of measures employed.

2) The use of Biometric Vegetation Types is not appropriate as it does not discriminate between small scale vegetation structural and floristic characteristics and habitat attributes.

3) The area of impact is insufficient. It should be greater than the well lease pad plus 20 metres, particularly for indirect impacts.

4.15.2.2 Response

1) The proposed activity will not involve any clearing of vegetation as construction (including drilling) and operation is confined to existing lease areas, therefore negligible impacts to biodiversity are anticipated.

   However, detailed descriptions on methodology and results can be found in the ecological assessments prepared for the E&A Program (including the proposed activity) (RPS, 2012a-d; RPS, 2013b-e). These ecological assessments form the foundation of the Impact Assessment under the EPBC Act report (ELA, 2013a; refer to Appendix 3) for activities included in the E&A Program.

2) The proposed activity will not involve any clearing of vegetation as construction (including drilling) and operation is confined to existing lease areas.

   However, the vegetation classification system used in the Impact Assessment under the EPBC Act report (ELA, 2013a; refer to Appendix 3) follows the NSW OEH survey and assessment guideline for classifying native vegetation in NSW (OEH, 2013a).

At the time of the assessment, this was the best available mapping at a scale which effectively covered the E&A Program and existing exploration and appraisal activities, allowing a comparison of vegetation and habitat loss within the study area.

3) The proposed activity will not involve any clearing of vegetation as construction (including drilling) and operation is confined to existing lease areas, therefore negligible impacts to biodiversity are anticipated.

   Potential temporary indirect impacts such as weed invasion, disruption of breeding cycle, noise, dust, light and fauna/vehicle road iterations were considered in Section 5.2.9 - 5.2.15 of the Ecological Assessment for the proposed activity (RPS, 2013e).

4.15.3 Cumulative impacts

4.15.3.1 Issue description

1) CSG exploration in the Pilliga forest to date has resulted in substantial environmental damage, including clearing of vegetation, habitat loss and fragmentation. Continued CSG activity could result in further loss of habitat, fragmentation of continuous forest and edge effects which will have an impact on the territories, distribution and abundance of threatened species. There are also risks of impacts on biodiversity due to contamination and fugitive emissions. Need for a detailed description of the likely interactions between the development and existing, approved and proposed gas exploration and production.

2) Impact assessment under the EPBC Act is insufficient.

3) No description of how the measures to avoid, minimise and mitigate have been applied

4) The occurrence of the Critically Endangered Ecological Community (CEEC) *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland* needs to be considered.

5) There was no reference to findings in *The ecological values of the Pilliga East Forest and threats posed by Coal Seam Gas mining 2011-2012* (NICE and CUCCLG, 2012) report.

6) Roads and pipelines should be considered effective barriers to movement of fauna and are different to forestry roads as they will carry more consistent and higher volumes of traffic.

4.15.3.2 Response

1) A detailed assessment of the E&A Program (including the proposed activity) and existing exploration and appraisal activities has been undertaken through the preparation of cumulative impact assessments under the EPBC Act and the *NSW Threatened Species Conservation Act 1995* (TSC Act) (ELA, 2013a,b), attached as Appendices 3 and 4 respectively.

   CSG exploration, appraisal and production planning is an iterative process whereby the results of early stage activities are used to inform later stages of project development. As such, any future exploration, appraisal or production activities beyond the E&A Program, including the Narrabri Gas Project, will be assessed when the relevant applications are lodged. These assessments will continue to incorporate cumulative impact assessments, and additional approvals will be required by both State and Federal government.

   CSG exploration and appraisal activities in the Pilliga forest and north of the Pilliga from 2002 to present have resulted in the loss of approximately 175.5 hectares of vegetation. This includes

vegetation recently cleared for the E&A Program and represents a total loss of approximately 0.37 per cent of vegetation within the study area (defined as an area covering approximately 48,000 hectares and includes (in part) Pilliga East State Forest, Bibblewindi State Forest, Jacks Creek State Forest and Pilliga East State Conservation Area as well as Crown Land and privately owned land).

While there has been clearing of vegetation and loss to fauna habitats as a result of the exploration and appraisal activities, the total loss is not considered significant in relation to the amount of available habitat within the study area and region.

Given the relatively small amount of clearing as a proportion of available habitat, the current land uses and extent of rehabilitation (completed and proposed), exploration and appraisal activity impacts are not expected to significantly fragment or reduce the availability of habitat in a way which will adversely affect species within the study area.

A detailed fragmentation analysis was undertaken as part of the cumulative impact assessment for the EPBC Act report including the proposed activity which is included at Appendix 3. The analysis concluded that small number of additional short-term breaks across potential movement pathways was unlikely to significantly affect threatened species.

2) The proposed activity involves no clearing and is highly unlikely to significantly impact any EPBC Act listed threatened species, populations or communities, or their habitats. The level of assessment provided in the Appendix 4 of the EIS is therefore considered adequate. Santos separately referred E&A Program activities, including the proposed activity, to the Commonwealth government for assessment under the EPBC Act in July 2013.The Impact Assessment under the EPBC Act report (ELA, 2013a included as Appendix 3) which accompanied that referral is based on the results of more than 3,000 hours of ecological surveys in the north-east Pilliga forest since 2002.

   Targeted surveys were undertaken for the E&A Program (including the proposed activity) by RPS (2012a-d, 2013b-e) which address the potential impacts of the E&A Program on MNES.

   The purpose of the cumulative impact assessment (Appendix 3) was to assess the impact of the E&A Program on MNES and provide a cumulative assessment as to whether the E&A Program, when added to the existing exploration and appraisal activities, would be likely to have a significant impact on MNES.

3) Details on measures taken to avoid, minimise and mitigate impacts are contained within the ecological assessments (RPS, 2012a-d; RPS, 2013b-e) which support the Impact Assessment under the EPBC Act report (ELA, 2013a; refer to Appendix 3).

4) The E&A Program (including the proposed activity) does not require clearing of any vegetation which could be considered to constitute *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland*.

5) More than 3,000 hours have been spent conducting ecological surveys in the north-east Pilliga forest since 2002. Surveys have been undertaken specifically for the purpose of establishing the baseline ecological values to assess the potential impact of the E&A Program and the proposed Narrabri Gas Project. These surveys form the foundation of the Impact Assessment under the EPBC Act report (ELA, 2013a; refer to Appendix 3).

   The NICE and CUCCLG (2012) report information has informed the preparation of, and is directly cited in, the cumulative impact assessment report prepared for the EPBC Act Referral in relation to

determining the presence and potential significance of the species *Pseudomys pilligaensis* (Pilliga Mouse) and included as Appendix 3.

While the NICE and CUCCLG (2012) report is not directly cited in relation to all species, a range of other studies (e.g. NPWS, 2000; NPA, 2002; Ecotone, 2009) including threatened species data from NSW Bionet (Atlas of NSW Wildlife) have been included and are considered adequate for determining the significance of impacts to threatened species.

6) There are no roads or pipelines to be installed as part of the proposed activity. However in response to the comment made, as stated in the cumulative impact assessment (ELA, 2013a; refer to Appendix 3), up to 60 per cent of the clearing associated with flow lines and water and gas gathering systems, other components of the E&A Program, will be rehabilitated following installation. This effectively reduces a short-term width of 10 metres for flow lines and water and gas gathering systems down to four metres for an access track following construction.

   These access tracks will carry increased volumes of traffic during construction with reduced volumes during operation and are considered unlikely to be long-term barriers to movement of fauna.

   A detailed fragmentation analysis was undertaken as part of the cumulative impact assessment for the E&A Program under the EPBC Act report (including the proposed activity) (Appendix 3). The analysis concluded that a small number of additional short-term breaks across potential movement pathways are unlikely to significantly affect threatened species.

4.15.4 Threatened species

4.15.4.1 Issue description

1) Potential impacts (including cumulative) to threatened species, such as *Pseudomys pilligaensis* (Pilliga Mouse), *Cercartetus nanus* (Eastern Pygmy Possum), *Macropus dorsalis* (Black-striped Wallaby), *Nyctophilus corbeni* (South-eastern Long-eared Bat) and *Phascolarctos cinereus* (Koala) need to be considered.

2) A Species Impact Statement (SIS) should be undertaken.

4.15.4.2 Response

1) The proposed activity does not require any additional clearing of vegetation and therefore no threatened species will be directly affected by the proposed activity.

   Cumulative impact assessments, considering both direct and indirect impacts, have been completed for the E&A Program for threatened species and communities listed under the TSC Act and the EPBC Act including *Pseudomys pilligaensis* (Pilliga Mouse), *Cercartetus nanus* (Eastern Pygmy Possum), *Macropus dorsalis* (Black-striped Wallaby), *Nyctophilus corbeni* (South-eastern Long-eared Bat) and *Phascolarctos cinereus* (Koala) (ELA 2013a,b) These are provided as Appendices 3 and 4 to this report.

   The cumulative impact assessments concluded that given the relatively small extent of clearing as a proportion of available habitat (both within the study area and the Namoi CMA region), minimisation of fragmentation impacts by locating linear infrastructure (flow lines) along existing tracks wherever possible, and measures proposed to avoid, minimise and mitigate impacts, the E&A Program (including the proposed activity) and existing exploration and appraisal activities are not expected to significantly fragment or reduce the availability of habitat in a way which will adversely affect ecological values listed under the TSC Act or EPBC Act within the study area.

2) Species Impact Statements (SIS) are not required for SSD - Schedule 1, clause 2 (1)(f) of the *Environmental Planning and Assessment Regulation 2000*, however cumulative impact assessments have been completed for threatened species and communities listed under the EPBC Act and the TSC Act (ELA, 2013a,b; refer to Appendices 3 and 4).

4.15.5 Pilliga Mouse

4.15.5.1 Issue description

1) Targeted surveys for the Pilliga Mouse have not targeted breeding habitat or habitat characterised by vegetation regenerating after relatively recent fire with a dense, floristically diverse, low shrubby understorey, a sparsely vegetated ground layer and a well-developed leaf litter layer.

2) It is incorrect to link the Pilliga Mouse with the widespread *Pseudomys delicatulus* (Delicate Mouse).

3) Santos has admitted that their CSG exploration will destroy habitat for the Pilliga Mouse. The safety of the Pilliga Mouse cannot be assured under this proposed activity.

4.15.5.2 Response

1) Surveys were not undertaken as the proposed activity will not involve any clearing of vegetation as construction (including drilling) and operation is confined to existing lease areas. Therefore, the Pilliga Mouse is unlikely to be directly affected by the proposed activity.

   However, surveys for the E&A Program specifically targeted *Pseudomys pilligaensis* (Pilliga Mouse) breeding habitat using appropriate methodology (RPS 2012a, 2012c, 2013b) and resulted in the detection of this species.

2) The cumulative impact assessment prepared for the EPBC Act referral (ELA, 2013a; refer to Appendix 3) does not attempt to 'downgrade' the status of Pilliga Mouse, rather it presents currently accepted information presented in both the Department of Environment's (DoE) threatened species guidelines (SEWPaC, 2012) and other recent publications (Breed and Ford, 2007; Ford, 2008) regarding the uncertainty surrounding the presence of a distinct *Pseudomys* species in the Pilliga.

   The cumulative impact assessment (Appendix 3) goes further to comment that 'this taxonomic change has not yet been formally recognised under the EPBC Act, hence this report considers the Pilliga Mouse as currently listed'. This recognises that although there is uncertainty in respect to the status of the Pilliga Mouse, the assessment has proceeded on the basis that the Pilliga Mouse is a distinct taxa as listed under the EPBC Act.

3) The proposed activity will not involve any clearing of vegetation as construction (including drilling) and operation is confined to existing lease areas. Therefore, the Pilliga Mouse is unlikely to be directly affected by the proposed activity.

   Full consideration of the impact of the E&A Program (including the proposed activity) and existing exploration and appraisal activities on the Pilliga Mouse is contained within the cumulative impact assessments completed for threatened species and communities listed under the EPBC Act and the TSC Act (ELA, 2013a,b; refer to Appendices 3 and 4) and within the ecological assessments (RPS, 2012a-c; RPS, 2013b-d) which support the cumulative impact assessments.

4.15.6 South-eastern Long-eared Bat

4.15.6.1 Issue description

1) No assessment of high frequency noise on the South-eastern Long-eared Bat.

2) No assessment of the potentially damaging effects that drinking water from holding ponds is likely to have on the South-eastern Long-eared Bat.

3) No assessment of loss of foraging habitat and increased fragmentation on the South-eastern Long-eared Bat.

4) Detail required on targeted surveys undertaken for South-eastern Long-eared Bat. Assumptions made about Pilliga forest representing a stronghold for the species. Inadequate assessment of impact to hollow bearing trees required for roost and maternity sites, noise, impact on foraging habitat and vegetation gaps.

4.15.6.2 Response

1) The potential impacts of noise have been considered in the Section 5.2.11 of the Ecological Assessment for the proposed activity (RPS, 2013e).

   The proposed activity may result in short-term increased noise pollution, which has the potential to temporarily disrupt foraging and roosting behaviour of some native fauna species (including the South-eastern Long-eared Bat). However, considering the paucity of intact overstorey vegetation, including a general lack of hollow bearing trees, the habitat surrounding the proposed activity is considered unlikely to contain large numbers of this species.

   Considering the lack of suitable habitat resources and the short-term duration of the proposed activity, it is considered unlikely that the proposed activity will have a significant impact on the South-eastern Long-eared Bat.

2) The storage ponds at Leewood are located to the north of the Pilliga Forest and are unlikely to pose a significant risk to the South-eastern Long-eared Bat population. Bats are drawn to natural systems which are surrounded by native vegetation, have good flyways and good habitat structure in wetland areas which provides habitat for their prey. The location, lining and maintenance of the storage ponds is likely to minimise the potential for the development of a food resource for the South-eastern Long-eared Bat. As such the storage ponds would be considered relatively low risk for any potential impacts on the South-eastern Long-eared Bat.

3) The proposed activity does not require any additional clearing of vegetation and therefore no threatened species will be directly affected by the proposed activity.

   A detailed fragmentation analysis was undertaken as part of the Impact Assessment under the EPBC Act report (including the proposed activity) (ELA, 2013a; refer to Appendix 3). The analysis concluded that a small number of additional short-term breaks across potential movement pathways was unlikely to significantly affect threatened species.

4) The proposed activity does not require any vegetation clearing and will not impact on any hollow-bearing trees.

   Surveys for *Nyctophilus corbeni* (South-eastern Long-eared Bat) have been previously undertaken as part of ecological studies into the biodiversity values of the north-east Pilliga Forest for the

purpose of establishing the baseline ecological values to assess the potential impact of CSG development.

The Pilliga forest region is known to be the distinct stronghold for the South-eastern Long-eared Bat (OEH, 2013b). There are numerous records for this species within the study area and Pilliga Forest region.

Surveys by NICE and CUCCLG (2012) captured 21 individuals at eight sites over 20 trap nights within and adjoining the study area, suggesting a relatively large population of South-eastern Long-eared Bat occurs in the north-east Pilliga Forest.

An assessment of the impact to hollow bearing trees is contained within the ecological assessments (RPS, 2012a-c; RPS, 2013b-d) which support the Impact Assessment under the EPBC Act report (ELA, 2013a; refer to Appendix 3).

This information has informed the preparation of the Impact Assessment under the EPBC Act report (Appendix 3) in determining the presence and potential significance of this species. Whilst the NICE and CUCCLG (2012) report is not directly cited in relation to the South-eastern Long-eared Bat, a range of other studies (NPWS, 2000; NPA, 2002; Ecotone, 2009) including threatened species data from NSW Bionet (Atlas of NSW Wildlife) have been included and are considered adequate for determining the significance of impacts to this species.

4.15.7 Invasive species and pathogens

4.15.7.1 Issue description

1) Impacts of invasive species (feral animals) are likely to increase with CSG development.

2) *Phytophthera* is already present at drilling sites.

3) Increased potential for weeds and *phytophthera* as a result of additional traffic. Mitigation measure of vehicles to be washed down where they have been exposed is not sufficient. Washdown should occur for all vehicles.

4.15.7.2 Response

1) Populations of invasive species such as the *Vulpes vulpes* (European Red Fox) and *Felis catus* (Feral Cat) are already well established and move freely through the study area.

   Studies undertaken in 2013 detected significant numbers of invasive species including the European Red Fox and Feral Cat with remote cameras.

   The E&A Program (including the proposed activity) is unlikely to exacerbate the impacts of invasive species as it has been designed to minimise fragmentation impacts by locating linear infrastructure (flow lines) along existing tracks wherever possible which limits the creation of new pathways for invasive species.

2) *Phytophthora* has not been identified on any current Santos drilling sites.

3) The Ecological Assessment for the proposed activity (Appendix 4 of the EIS) includes a procedure to wash down all plant and machinery (including vehicles) prior to being transported to the site to prevent the spread of weeds and importation of *Phytophthora cinnamomi*. This is considered appropriate.

4.15.8 Stygofauna

4.15.8.1 Issue description

1) The EIS states that no stygofauna has been found within the sampled groundwater however, a study by Serov in 2012 shows that there are unique stygofauna populations within the alluvial groundwater of the Pilliga East State forest area.

2) Stygofauna must be studied to determine and describe the species and community present and identify their conservation significance. There must be comprehensive baseline assessment of GDEs (including stygofauna), including the potential impacts of any drawdown.

4.15.8.2 Response

1) Section 5.2.1 of the Ecological Assessment (Appendix 3 of the EIS) states that '*Recent investigation by Eco Logical has not identified significant stygofauna populations within groundwater sampled from monitoring wells located in similar groundwater sources.'* This references monitoring undertaken from groundwater sources of similar nature to the target coal seam aquifers.

   Section 11.3.5 of the EIS report acknowledges that stygofauna are known to occur within the Namoi River alluvial aquifer, with limited potential for their presence in the shallower GAB sandstone aquifers present within the proposed activity area.

2) Stygofauna is unlikely to be present in the shallower GAB sandstone aquifers located within the proposed activity area, such as the Pilliga Sandstone (Section 11.3.5 of the EIS). For these to be suitable for stygofauna, they would have to be highly fractured or weathered enough to allow stygofauna movement and a sufficient flux of water, oxygen and organic matter. The suitability of these rock aquifers as stygofauna habitat diminishes with depth from the surface.

   The deeper target coal seam aquifers are unlikely to contain stygofauna as:

   - the space available for movement is reduced significantly with increasing depth
   - there is an overall decline in water quality as depth from surface increases.

   The proposed activity potentially poses the following threats to stygofauna:

   - Penetrating suitable habitat during drilling and the subsequent draining of the aquifer or contamination through trans-boundary flow between aquifers
   - Depressurisation of underlying aquifers causing a change in the physical structure of stygofauna habitat that may result in drainage or contamination from more saline water.

   Further details are provided in *Pilliga Stygofauna Review – Santos Energy NSW Coal Seam Gas Exploration and Extraction Activities*, prepared by Eco Logical Australia (attached as Appendix 5).

   Neither of the proposed wells requires drilling through alluvial aquifers, significantly reducing the potential for impact to stygofauna.

   Provided drilling, operation and closure activities are undertaken in accordance with the relevant guidelines and legislation, the proposed CSG drilling and extraction activities are unlikely to pose a significant threat to any known or likely stygofauna habitat.

4.15.9 Pilliga conservation

4.15.9.1 Issue description

1) The Pilliga forest has significant biodiversity values which are threatened by CSG development and should be protected.

2) The E&A Program area in the Pilliga East Forest was identified as Tier 1 biodiversity in the NSW Government Draft Strategic Regional Land Use Policy.

4.15.9.2 Response

1) In recognition of the high ecological and landscape value of the Pilliga forest, over 240,000 hectares of conservation reserve have been gazetted under the NPW Act since the 1960s. The Pilliga Nature Reserve (83,000 hectares) was first reserved in 1968. Thirty years later, regional assessments of the Brigalow and Nandewar Bioregions (NPWS, 2000) culminated in the NSW Government's decision in 2005 to conserve an additional 160,000 hectares of CCA in the Pilliga region under the BNCCA Act. This area focuses on the central, southern and western extents of the Pilliga forest. Today, approximately half of the Pilliga forest is now reserved under the NPW Act, with the other half retained as State forest for commercial timber production, recreation and mineral extraction.

   As part of the BNCCA Act, four CCA zones have been defined:

   - Zone 1: Conservation and recreation (National Park)
   - Zone 2: Conservation and Aboriginal culture (Aboriginal Area)
   - Zone 3: Conservation, recreation and mineral extraction (State Conservation Area)
   - Zone 4: Forestry, recreation and mineral extraction (State Forests)

   Of the 240,00 hectares of reserve, a total of 146,000 hectares, including Pilliga Nature Reserve, four CCA Zone 1 reserves (National Parks) and two CCA Zone 2 reserves (Aboriginal Areas) are precluded from logging and mineral/petroleum exploration. Three CCA Zone 3 reserves (State Conservation Areas) totalling 94,000 hectares, were created to 'protect important conservation values in western NSW and ensure the long-term sustainability of the region's important timber, gas, minerals and apiary sectors'.

   The area within which the proposed activity is located is entirely within 'Zone 4' (Forestry, recreation and mineral extraction (State Forests)) under the BNCCA Act. As mineral extraction is a permitted use in Zone 4, the proposed activity is considered consistent with the BNCCA Act.

2) An overview of the NSW Government's Strategic Regional Land Use Plan (SRLUP) is included in Section 2.2.3 of the EIS. The final SRLUP does not include mapping for biodiversity values.

4.15.10 Other biodiversity concerns raised

4.15.10.1 Issue description

1) Potential for work to extend outside area investigated – conflicting information presented in the ecological assessment.

2) Indirect impacts such as noise and light impacts on fauna during operation have not been assessed.

3) Offsets are inadequate in protecting threatened species.

4) No data on the presence of hollow bearing trees has been included.

4.15.10.2 Response

1) All work will be contained within the existing cleared footprints associated with the Bibblewindi 14 and 19H lease areas (refer to section 3.1.1 of the EIS). There is no proposal to extend work outside of the existing cleared area. Any future proposal to extend works outside of the lease areas and access tracks would require additional ecological assessment and government approvals.

2) Potential temporary indirect impacts such as weed invasion, disruption of breeding cycle, noise, dust, light and fauna/vehicle road iterations were considered in Section 5.2.9 - 5.2.15 of the Ecological Assessment (Appendix 4 of the EIS).

3) The NSW Government has developed a set of principles that apply in determining the impacts of SSD on biodiversity in NSW. These principles set out a hierarchy of control to deal with impacts upfront, the methods to calculate impacts, legal context and the types of offsets that may apply.

   The proposed activity does not require any additional clearing of vegetation and therefore no threatened species will be directly affected by the proposed activity. As such no offsets are required for this proposed activity.

4) The proposed activity will not involve any clearing of vegetation, including hollow-bearing trees, as construction (including drilling) and operation is confined to existing lease areas.

   However, cumulative hollow-bearing tree data for the E&A Program is presented in the ecological assessments (RPS, 2012a-c; RPS, 2013b-d) which support the cumulative impact assessment for the E&A Program (ELA, 2013a; included as Appendix 3).

4.16 Air quality

4.16.1 General concerns raised

4.16.1.1 Issue description

1) Concerns about the potential negative impact this exploration will have on air quality.
2) Recommendation of a peer review of the modelling used to ascertain the Nitrous Oxide conversions and modelling methodology described on page 13 of the Air Quality Impact Assessment (Appendix 5 of the EIS) to ensure these calculations are correct.
3) The EIS does not include an assessment of potential fugitive emissions from the project, which could include VOCs and PAHs. It is recommended that the proponent considers the potential for fugitive emissions and the impact of these emissions at the nearest receptors.

4.16.1.2 Response

1) An Air Quality Impact Assessment was undertaken as part of the EIS (Appendix 5). The assessment concluded that the additional air quality impacts arising from the proposed activity would be minor at the surrounding sensitive receptors. It also concluded that changes in air quality due to the proposed activity is unlikely to be detectable, with results showing that the levels would be well below the relevant criteria for the pollutants assessed.

2) The DP&I and NSW EPA will review the Air Quality Impact Assessment in conjunction with the EIS.

3) To safeguard against fugitive emissions there will be sensors at transitional points across the well head and pipe network that will trigger automatic shutdown of wells in the event of a leak, until it is found and repaired. Further, the nearest sensitive receptor is located 7.5 kilometres from the proposed activity and is unlikely to be affected by any fugitive emissions.

4.16.2 Baseline data and monitoring

4.16.2.1 Issue description

1) The DGRs state that an assessment of the risk of fugitive emissions on environmental and human health should be undertaken. The baseline atmospheric methane data collection against which to assess any future potential fugitive emissions and Independent Health Impact Assessment (HIA) of north-west NSW to establish baseline health data and air quality information has not yet been conducted. One of the DGRs is to assess the risk of these emissions and their effect on the environment and human health, therefore it is imperative that HIAs be a compulsory part of any planning of major works and industry that could cause long and short term health issues for communities. Determining these methane baselines should be the first priority, and no development should occur before baseline data is collected.

2) A Leak Detection and Repair program should be incorporated into the fugitive emissions monitoring program, conducted in accordance with *US EPA Method 21 - Determination of Volatile Organic Compound Leaks*.

3) Concern about the lack of suitable site-specific nitrogen dioxide (NO_2) data being available to quantify the existing ambient levels at the site. Using data from the Muswellbrook NSW EPA monitoring site is inappropriate. The air quality in the heavily industrialised Muswellbrook and the forest ecosystem of the Pilliga are completely different. A suitable ambient monitoring station should be set up in the vicinity of the proposed activity before drilling commences.

   Suitable site-specific carbon monoxide (CO) data collection points to quantify the existing ambient levels at the site are also required. Without these baselines, there will be no way to accurately measure or prove increasing levels as a result of the CSG drilling in the Pilliga forest.

4.16.2.2 Response

1) Santos and the University of Adelaide have been undertaking baseline atmospheric methane sampling with a Picarro Cavity Ring Down Spectrometer. The device is accurate to less than one part per million and takes a sample approximately every second. Sampling has been undertaken at existing and proposed CSG exploration and appraisal sites in PEL 238 and PAL 2 to gather baseline data. Samples have been taken while existing pilot wells have been shut in and before any drilling for the E&A Program had commenced. Santos is committed to continuing these studies to include sampling while the pilots are being operated. In the Gunnedah Basin more broadly the baseline sampling has been undertaken in proximity to a number of land uses and most intensively throughout PEL 238.

2) Santos is aware that US EPA Method 21 has been used elsewhere in NSW for leak detection and repair programs in association with CSG operations. The US EPA Method 21 was developed prior to the availability of the current mobile Cavity Ring Down Spectrometer devices. A more robust and effective leak detection and repair program for pilot wells would be based on the use of this new technology, taking full advantage of the sensitivity of the device and its mobility. The SoC have been amended accordingly.

3) The Muswellbrook NSW EPA monitoring site is the closest available site for background ambient NO_2 data. Due to the presence of human activity, including residential areas, traffic, major highways and industry, the Muswellbrook monitoring location is likely to experience higher levels of NO_2 pollutants than the areas in the vicinity of the site, which is largely rural and undeveloped. Therefore the use of the Muswellbrook data to represent local ambient NO_2 levels in the air quality analysis for the proposed activity will be conservative as it would overestimate the likely levels of air pollutants.

   Suitable site-specific CO data was not available to quantify the existing ambient levels at the site. Combustion activities are the cause of CO emissions and spatially there is very little such activity in the area apart from power generation, motor vehicles and wood heaters. Therefore, ambient concentrations of CO are expected to be low (i.e. <0.02 µg/m³ (8hour average)).

   The air quality assessment for the proposed activity has been conducted using the best available information currently available and represents a conservative estimate of air quality impacts. The air quality assessment (Appendix 5 of the EIS) concluded that the additional air quality impacts arising from the proposed activity would be minor at the surrounding sensitive receptors and that change in air quality due to the proposed activity is unlikely to be detectable with the results showing that the levels would be well below the relevant criteria for the pollutants assessed. Therefore air quality monitoring at the site, which would necessitate localised baseline monitoring, has not been considered necessary as a mitigation measure for the proposed activity.

4.17 Greenhouse gases

4.17.1 Issue description

1) The flare and vent stack impacts should have been assessed as part of this EIS, despite being stated as an unlikely occurrence. If venting or flaring does take place, there should be exact measuring and reporting of the emissions.

2) Concerns about cumulative effects of climate change from the carbon emissions of the E&A Program, particularly methane.

3) Fugitive emissions from the expected expansion of this industry, including future production of natural gas by Santos in the Pilliga forest is considered unacceptable. As a greenhouse gas (GHG), methane, which is the major component of natural gas, is 105 times more potent than carbon dioxide (CO_2) over a 20 year period and 33 times more potent over a 100 year period with an uncertainty of 23 per cent. These statistics indicate the importance of assessing even small leaks of methane and ensuring that an independent body assesses and monitors emissions prior to drilling, as well as ongoing.

   The EIS states that '*The beneficial aspects of the proposed activity provides significant GHG mitigation potential through the supply of CSG for power generation, which represents a 58 per cent emissions saving (per gigajoule) over more traditional large-scale energy sources such as coal*'. However, emissions per unit of electricity produced by burning CSG are not less than that for burning coal when emissions for the whole CSG production cycle, including mining, liquefaction and transport, are included in the calculations.

4) The loss of carbon sequestering woodland and bushland cleared for the development of the drill sites, pipes, gas field infrastructure and roads must be considered.

4.17.2 Response

1) The GHG profile presented in Section 13.2 of the EIS included both direct emissions from the extraction of the gas (such as leakage, mud degassing, flaring and onsite power generation), and indirect emissions from the use of plant and equipment to establish the wells and transport personnel.

   Santos will record each vent and flare event, which will inform both the voluntary (Annual Sustainability Reporting) and mandatory (National Greenhouse and Energy Reporting) GHG profiles.

2) The cumulative impacts of the E&A Program were addressed in Section 13.4 of the EIS, in line with the certainty of the available data and within the bounds of commercially sensitive information. This will be revisited as the confidence in the extractable-gas reserves and project certainty increases. Any future exploration, appraisal or production activities beyond the E&A Program, including any application for the Narrabri Gas Project, will be assessed when the relevant applications are lodged. These assessments will continue to incorporate cumulative impact assessments.

3) The Emission Factors provided in the National Greenhouse Account Factors (NGA Factors) (DCCEE, 2012) were applied, as shown in Table 13-1 of the EIS. DCCEE (2012) specifies a leakage factor for CSG which has been applied, and accounts for the Global Warming Potential (GWP) of both methane and nitrous oxide as recognised by the Federal Government and the United Nations Framework Convention on Climate Change for reporting.

   Santos believes that, if done correctly, CSG has an important part to play in the transition to a low-carbon economy. This means controlling leakage, understanding and responding to the geology of the area and properly sealing and rehabilitating the sites at the end of their productive life.

   The established emission intensity from the combustion of CSG has been calculated to be 51.33 kilograms of CO_2^e per gigajoule (GJ) of gas (NGA Factors). Bituminous coal is calculated to be 88.43 kilograms of CO_2^e per GJ. Based on this gigajoule for gigajoule, CSG is approximately 40 per cent cleaner than coal (or 45 per cent when compared to brown coal). This is additional to any benefit gained from higher efficiency equipment used in the combustion process (where less gigajoule are needed to do the same amount of work or produce the same amount of power).

   Table 21-1 of the EIS states "*The beneficial aspects of the proposed activity provides significant GHG mitigation potential through the supply of CSG for power generation, which represents a 58 per cent emissions saving (per GJ) over more traditional large-scale energy sources such as coal.*" The emissions savings percentage is incorrectly detailed in this table. It should state a 42 per cent emissions saving (per GJ); as it represents 58 per cent of the coal emission profile, based on the established emission intensity profile (DCCEE, 2012).

   There is no consistent comparison of the extraction of CSG to coal in DCCEE (2012). RPS estimates the process to be in the range of five to six kilograms of CO_2^e per GJ of gas.

4) No vegetation clearing is required for the proposed activity.

   Approximately 36.5 hectares of eucalyptus woodland will be cleared for the E&A Program to allow for well pads, flow lines and access tracks. Pipework will be co-located with access tracks wherever possible to minimise clearing.

   This clearing is estimated to impact approximately 9,890 T CO_2^e of carbon sink, calculated using the Federal Government's FullCAM model. Following construction, well pads will be reduced from one hectare to 0.04 hectares each. This revegetation may recapture a small portion of the lost carbon sink.

4.18 Traffic and transport

4.18.1 Recommendations from Roads and Maritime Services

4.18.1.1 Issue description

1) The following conditions of approval are recommended:

- The intersection of X-Line Road and the Newell Highway should be upgraded to include an Auxiliary Left Turn Treatment Short and Channelised Right Turn Treatment Short on a major road in accordance with Figures 8.3 and 7.6 Part 4A Austroads 2010 respectively and RMS supplements. The intersection works should be designed and constructed to accommodate the largest vehicle accessing the intersections. Such designs shall be appropriate for the current speed zone of 110km/h.
- X-Line Road and Westport Road should be sealed a minimum of 30 metres from the edge of the southbound travel lane on the Newell Highway.
- As road works are required on a State road, the developer will be required to enter into a Works Authorisation Deed (WAD) with Roads and Maritime Services prior to the commencement of roads. Roads and Maritime Services will exercise its power under Section 87 of the *Roads Act 1993* (the Act) and/or the functions of the roads authority, to undertake road works in accordance with Sections 64 and 71 and/or Sections 72 and/or 73 of the Act, as applicable, for all works under the WAD.
- Upgrades of the intersection of X-Line Road and the Newell Highway and the intersection of Westport Road and the Newell Highway should be completed prior to the commencement of construction works associated with the proposed activity.
- A Road Occupancy Licence is required prior to any works commencing within three metres of the travel lanes in the Newell Highway.
- All access to the pilot should be via the intersection of X-Line Road and the Newell Highway. All access to Westport Drillers Camp should be via the intersection of Westport Road and the Newell Highway. No other access from/to the state road network (Newell and Kamilaroi Highways) from/to the project area is permitted.

4.18.1.2 Response

1) Since the EIS was prepared Santos has undertaken a revised cumulative traffic assessment for the E&A Program based on more current information provided by the construction and drilling contractors and in consultation with the Roads and Maritime Services. The E&A Program will be conducted over the next two to three years and will include an overlap of several construction activities. Works associated with the E&A Program includes site preparation, drilling and surface facilities at pilot wells, with access generally via X-Line Road. Traffic generation will be higher in the earlier years while pilot wells for the E&A Program are drilled. In the latter years, the pilots will be in operation and traffic will reduce.

   Access to the forest via Westport Road will be discouraged to reduce impacts to sensitive receivers along this road. It is also noted that workers accommodated at the drillers camp will be fly in-fly out and would arrive in mini buses rather than private vehicles as assumed in the Traffic and Transport Assessment report (Appendix 7 of the EIS). Movements associated with relocating the drill rig between sites and drillers travelling between the drillers' camp and site will all occur within the Pilliga forest.

   For the E&A Program, the X-Line Road/ Newell Highway intersection will need to accommodate up to 84 vehicles per day (two-way) and up to 28 vehicles during a site activity peak hour throughout

construction works. This includes approximately 14 vehicles turning left into X-Line Road and 14 vehicles turning right out of X-Line Road (refer Figure 1).

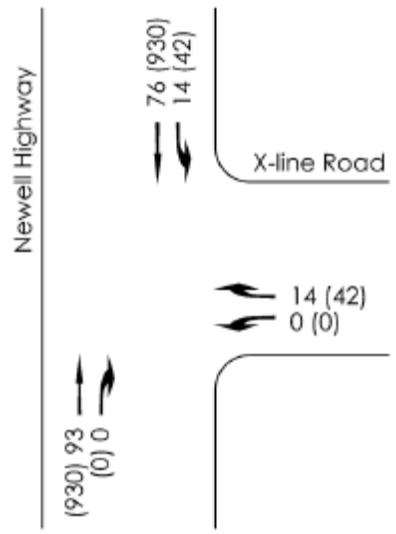

Figure 1 Daily (Peak hour) construction traffic generation at X-Line Road / Newell Highway intersection

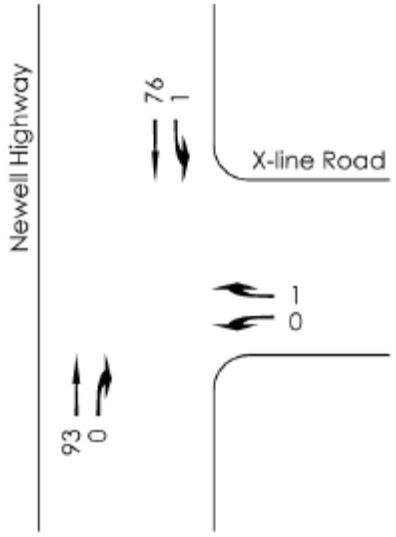

Figure 2 Peak hour operational traffic generation at X-Line Road / Newell Highway

The maximum projected 84 vehicles per day will only occur when equipment is delivered to well lease areas immediately after drilling. This will occur on approximately 10 to 15 occasions in the six month period to June 2014, with less than 60 vehicles anticipated on a typical day during the same period. Once works associated with the Leewood site and the Bibblewindi Water Transfer Facility are complete, approximately 46 vehicles per day will use the X-Line Road/Newell Highway intersection, with 26 vehicles on a typical day.

During operation (from Q4 2014 to Q1 2015) of the E&A Program, traffic volumes will significantly decrease (refer Figure 2).

It has been agreed with Roads and Maritime Services that the 169 vehicles per hour (two-way) as collected by Roads and Maritime Services in April 2012 is representative of current Newell Highway traffic volumes and has been adopted for the purposes of this assessment.

With the highest average peak hour of 169 vehicles on the Newell Highway, and 76 northbound vehicles, The Austroads *Guide to Road Design Part 4A: Unsignalised and Signalised Intersections* determines a range for an appropriate left turn treatment as follows:

- 0-80+ left turning vehicles per hour - Basic Left Turn Treatment
- 80+ left turning vehicles per hour - Auxiliary Left Turn Treatment Short.

Based on the estimate of 14 left turning vehicles in any peak hour, the cumulative traffic generation at X-Line Road would not trigger the requirement for an auxiliary left turn treatment.

No vehicles would be required to turn right into X-Line Road from the Newell Highway. As such, a channelised right turn treatment would also not be required.

Accordingly, Santos does not propose to upgrade the intersection of X-Line Road/Newell Highway apart from sealing the first 30 metres. As construction traffic will be required to use X-Line Road in preference to Westport Road, Santos also does not propose to upgrade Westport Road.

Santos confirms that access to the pilot shall primarily be via the intersection of X-Line Road and the Newell Highway. All access to Westport Drillers Camp shall be via the intersection of Westport Road and the Newell Highway. No other access from/to the state road network (Newell and Kamilaroi Highways) from/to the project area is proposed. The SoC have been amended accordingly.

4.18.2 Other issues raised

4.18.2.1 Issue description

1) The unsealed road network associated with the proposed activity should be managed and maintained consistent with the guidelines, principles and recommended minimum design standards contained in:
   - *Managing Urban Stormwater: Soils and Construction – Volume 2C Unsealed Roads*
   - *Erosion and sediment control on unsealed roads – A field guide for erosion and sediment control maintenance practices.*

2) Traffic speeds are currently higher than 20 kilometres per hour and there is an increased potential for roadkill.

3) There will be a significant, long term increase in the number of traffic movements once the project restarts, far more than the stated 'minor increase' of 16 vehicles movements per day. It's the longer operation phase that brings the average down.

4.18.2.2 Response

1) Santos will manage and maintain the unsealed road network in line with the Permit to Occupy issued by Forestry NSW. As stated in Table 20-1 of the EIS, Santos' SoC for the proposed activities includes that '*any damage to roads caused by construction activities would be repaired at Santos cost in accordance with the Permit to Occupy*'.

2) Santos' SoC for the proposed activities include the following to assist in monitoring speed limits of employees and reducing fauna strike (Table 20-1 of the EIS):
   - Construction and operational vehicles/plant will only travel on the designated access tracks. Site speed limits will be imposed to reduce the potential of fauna strike and to reduce dust generation.
   - An in-vehicle monitoring system (IVMS) will be fitted to all Santos vehicles.

3) The estimated traffic volumes for the construction and operational phases of the proposed activity were modelled separately, as outlined in the Traffic and Transport Assessment report (Appendix 7 of the EIS). Section 4.5 of this report states that '*for the construction of the two pilot wells, the estimated traffic generation has been calculated based on the site supporting up to 40 workers at any one time, anticipated to occur during drilling activities*.' The anticipated construction vehicle volumes, as well as the underlying calculation assumptions, are provided in Section 4.5.3 of the Traffic and Transport Assessment report.

4.19 Waste

4.19.1 Issue description

1) The gas field will produce vast quantities of waste that cannot be properly disposed of. The surface works, and storage and disposal of water and chemicals will increase the risk of damage to the surrounding environment and surface waters.

4.19.2 Response

1) Prior to commencement of the proposed activity, a waste management plan will be developed based on the waste reduction hierarchy of avoid, reduce, reuse, recycle, recover, treat and dispose outlined in the *NSW Waste Avoidance and Resource Recovery Strategy 2007* (DECC, 2007). During construction, the management of the drilling fluid and drill cuttings will be undertaken as outlined in Section 16.4.1 of the EIS. Throughout the proposed activity, Santos will adopt best practice site environmental management measures in compliance with the POEO Act and *Protection of the Environment Operations (Waste) Regulation 2005* to minimise waste and potential impacts associated with waste generation and disposal.

   The produced water abstracted from the aquifer will be captured at the wellhead and transferred through the water gathering system to Bibblewindi 19H. As outlined in Section 4.4.2 of the EIS, the water will then be stored in a transfer tank and transferred by the existing pipeline to the Bibblewindi Water Transfer Facility, and then on to the Leewood Produced Water Facility.

4.20 Hazards

4.20.1 Bushfire risk

4.20.1.1 Issue description

1) Bushfire is a major concern in this area as the Pilliga forest is highly susceptible to fires. Activities associated with CSG could increase the risk of bushfires. Santos does not appear to have a clear bushfire strategy.

2) Concerns that Santos is allowed to operate in such a vulnerable area with a large risk of fire from flaring, particularly as flares are exempt from fire ban. It is understood that they cannot be shut down in the event of catastrophic fire conditions, or that if they are that the gas will explode.

   An industry insider has advised that the knowledge on how to shut down the attached infrastructure of a well that contains an operating gas flare that catches alight is not available in Australia and that an individual would need to be brought from the USA to carry out this work.

3) Santos is closing off areas of the Pilliga forest, endangering lives and potentially hampering RFS access.

4.20.1.2 Response

1) Santos has a Bushfire Management Plan that provides direction for Santos' operations on how to prepare for, manage and respond to the risk of bushfire in the area of operations. It outlines the statutory requirements of occupiers of land to prevent bushfires and provides information about Santos' bushfire season preparedness tasks that includes hazard reduction, potential ignition source management, establishment and maintenance of asset protection zones, permit requirements for

high risk activities and staff and contractor education. Santos also has an Emergency Response Plan that details actions required in the event of a bushfire incident or emergency.

Santos continues to consult and work with RFS and Forestry NSW on best practice bushfire management practices, shared learnings and implement agreed practices.

2) The pilot infrastructure does allow for the ability to remotely shut in wells at the well head, while the gas pipelines are buried at least half a metre below ground.

3) Santos continues to consult and work with RFS and Forestry NSW to ensure the safety of all users of the Pilliga forest.

   Forestry NSW was requested to enact a temporary exclusion area immediately surrounding one of Santos' work sites, under the provisions of the *Forestry Regulation 2012* (Part 2, Division 1, Clause 7), to ensure the safety of Santos staff, contractors and members of the public.

4.20.2 Chemical risks

4.20.2.1 Issue description

1) The EIS does not explore the impact that the loss of chemicals through lost circulation fluid will have on the aquifers. While many CSG companies state they use food based polymers, these are often removed or cleaned up using acid-based products which also has potential for increased risks.

2) The EIS states 'all chemicals used during drilling will be non-toxic'. This is incorrect. The ecotoxicity of a chemical will depend on its concentration in the environment. An assessment of the impacts of drilling on groundwater quality needs to be undertaken to determine whether drilling fluids will be released to the environment at toxic concentrations.

3) The list of chemicals is different to that provided as part of the DA Application (DA 546/2013) for the drilling fluid treatment facility.

4) Query raised as to what chemicals are used in place of benzene, toluene, ethylbenzene, and xylenes (BTEX) chemicals.

4.20.2.2 Response

1) During drilling, the circulating drilling fluid will establish a wall cake (a low permeability 'skin' around the wall of the hole) and maintain pressure on the various aquifers intercepted. This will prevent the ingress of groundwater to the pilot well and discharge of groundwater to the surface. It will also limit the ingress of drilling fluid into the aquifers in the immediate vicinity of the pilot well.

   As noted in the submission, drilling fluids use primarily food products such as sugar and starch-based products. These compounds are biodegradable in the formation and surplus drilling fluid (prior to cementing) is generally flushed to surface with water.

2) The chemicals used in drilling have been assessed and determined to pose no long term risks to the environment. In accordance with Australian and International standards, a hazard assessment has been conducted on the chemicals used in drilling. This hazard assessment methodology assesses the persistence, bioaccumulation and toxicity (PBT) of chemicals to determine if chemicals could persist or accumulate in the environment at concentrations that could pose risks to receptors. None of the chemicals used in drilling have been identified as PBT chemical.

3) The DA for the chemical storage facility at Santos' Narrabri Operations Centre included chemicals to be used in fluid treatment processes. Therefore, not all chemicals identified in the storage facility DA will be present at the drilling site. Since preparation of the EIS, it has been identified that some additional chemicals may be required for use in drilling. These are identified in Table 3.

Table 3 Drilling chemical additives in addition to those listed in the EIS (RPS, 2013)

Chemical trade name	Description	Purpose
Rheoben NT (Bentonite, Maxigel, Aus-Gel, Trugel 13A. Gel)	Water absorbent clay. Montmorillonite. Naturally occurring clay mineral in Australia.	Thickens the mud so it can carry the drilled rock out of the hole. Also forms a 'wall cake' on the side of the hole to prevent mud from leaching into the ground.
SAPP (Disodium Pyrophosphate)	Sodium Acid Pyro Phosphate	Used with Citric Acid to free pipe from side of the hole. Also used to clean bentonite from the hole when finished.
STARCH-B	Natural corn or potato starch	Reduces the amount of fluid seepage from the mud into the ground which can cause the hole to become sticky, unstable and less productive.
Potassium Chloride	KCl	Helps to keep the drilled clays dry and less sticky. Used if potassium sulphate not available.
RHEOLUBE	Vegetable oil-based surfactants	Improves drilling Rate of Penetration and prevents stuck pipe and twist-offs.
Salt	Sodium Chloride (NaCl)	Prevents hole collapsing and high pressure gas or water from escaping (i.e. 'Blowout'). Legal requirement for well control.

4) Chemicals that may be used in the drilling process or held on site during the drilling process and their purposes are summarised in Table 4-3 of the EIS and Table 3 above.

4.21 Social and economic

4.21.1 Employment

4.21.1.1 Issue description

1) The EIS identifies that during construction 5.6 Full Time Equivalent (FTE) positions (of which it is proposed that 4.2 are fly-in-fly-out) during construction and only two FTE positions during operations. The EIS then applies an economic multiplier to create a further 16 indirect jobs. However as the EIS states that the employees to be housed at the Drillers Camp at Westport (for the 15 weeks of the construction phase and are likely to be specialised personnel) this multiplier effect will be reduced. It is therefore unlikely that a significant portion of the identified benefits of the project will be accrued in the local community.

2) The industry is needed for the economic benefit of the state, and to create employment, but there is concern over the potential environmental and social impacts that arise from a short term gain.

4.21.1.2 Response

1) The economic benefit of the proposed activity was calculated using an Input-Output model calculating economic and employment multipliers for different industries. The multipliers have been calculated in line with the methodology proscribed by the Australian Bureau of Statistics in *Information Paper Australian National Accounts Introduction to Input-Output Multipliers* (Cat No 5246.0). The calculations utilise data from *Australian National Accounts: Input-Output Tables - Electronic Publication, 2007/08 Final* (Cat No. 5209.0.55.001), namely Tables 5 and 20.

2) Santos will manage the risks with the proposed mitigation strategies outlined in the SoCs, and compliance with relevant legislation and policy.

4.21.2 Impacts on the community

4.21.2.1 Issue description

1) Developing industrial gas fields within the rural landscape will potentially damage rural areas, impact on long-term sustainable farming and force unwanted change onto communities. It is in direct conflict with farming and rural life, and land values will decline in the area.

2) There is community opposition to CSG by farmers. The Narrabri community has not given Santos a social license to operate. A number of communities across the Liverpool Plains have been surveyed with results showing that greater than 90 per cent of residents do not want CSG, particularly in such important ecosystems as the Pilliga forest.

3) Santos approached Forestry NSW to obtain closure of the Pilliga forest in order to deter peaceful protest.

4) The SoC should explicitly include the measures described in Chapter 18 of the EIS i.e. ongoing contributions to the local sponsorship program; ongoing provision of four rental properties in Narrabri to project workers; and implementation of a buy local program seeking to promote local contractors, services, equipment and products.

5) Ongoing contractor forums to inform local businesses of opportunities associated with the project are encouraged.

   Santos should seek to procure at least 50 per cent of goods and services from local, and in particular locally owned, businesses.

6) A social impact assessment is essential and must be completed for full consideration before any more CSG extraction is undertaken in the Pilliga forest.

4.21.2.2 Response

1) The proposed activity is being undertaken within a State forest, and will have negligible impacts to agricultural land as discussed in section 8.2.1 of the EIS and the accompanying AIS (Appendix 2 of the EIS). Based on groundwater modelling, with best practice mitigation measures in place the proposed activity should have negligible impacts on groundwater resources. The cumulative E&A Program is also predicted to have minimal impact on land resources, being predominantly located within State forest, and not located on land classified as BSAL or CIC.

2) Santos continues to work hard to maintain a social licence, with a commitment to transparent communication and ongoing engagement with the community. Santos has a long history of working with regional communities and understands that the community has concerns about the industry. Issues raised are addressed through the community engagement and consultation framework, and by making information about the E&A Program readily available through:
   - Community shopfronts in both Narrabri and Gunnedah
   - Conducting regular site tours of the operations and holding regular information sessions throughout the assessment process.

3) Forestry NSW was requested to enact a temporary exclusion area immediately surrounding one of Santos' work sites, under the provisions of the *Forestry Regulation 2012* (Part 2, Division 1, Clause 7), to ensure the safety of Santos staff, contractors and members of the public.

4) Santos is in general agreement with this recommendation; the SoC has been updated accordingly.

5) Santos acknowledges this support, and will continue operating ongoing contractor forums to inform local businesses of opportunities associated with the E&A Program, wherever the opportunity arises to ensure that local contractors, businesses and community groups can benefit from the E&A Program where possible.

6) A social impact assessment was undertaken for this proposed activity, and was incorporated into Section 18.3 of the EIS.

4.21.3 Impact on other industries

4.21.3.1 Issue description

1) The economic assessment has not adequately considered loss of revenue from tourism and the potential impacts on the agriculture industry from groundwater impacts. The benefits have not been demonstrated to outweigh the costs. Other industries such as agriculture and tourism face labour shortages and rising costs whilst losing land and assets to mining. It will industrialise an agricultural area and destroy the tourist industry.

2) Questions why the mining industry is given preference over industries such as farming, thoroughbred /horse racing and wineries (particularly in the Hunter Valley).

3) Mining and extractive industries are unsustainable in the long term, whereas farming and agriculture has the ability to support the region indefinitely. The sustainability of the forestry industry should be assessed for a CSG field involving hundreds of cleared pads.

4.21.3.2 Response

1) The proposed activity is being undertaken within a State forest, and will have negligible impacts to agricultural land as discussed in section 8.2.1 of the EIS and the accompanying AIS (Appendix 2 of the EIS). Based on groundwater modelling, with best practice mitigation measures in place the proposed activity should have negligible impacts on groundwater resources. The cumulative E&A Program is also predicted to have minimal impact on land resources, being predominantly located within State forest, and not being located on land classified as BSAL or CIC.

   The AIS concluded that there would be no change to existing recreational tourism opportunities in Bibblewindi State Forest such as hiking, camping and bird watching as a result of the proposed activity, particularly as the proposed activity will be confined to an existing lease area. The presence of equipment and small stockpiles during the construction stage of the proposed activity will result in some visual clutter however this is unlikely to be noticeable other than by users of the forest in the immediate area.

2) The proposed activity will not affect any farming, thoroughbred/horse racing or viticulture/winery industries.

3) The proposed activity is being undertaken within a State forest, and should have negligible impacts to agricultural land as discussed in section 8.2.1 of the EIS and the accompanying AIS (Appendix 2 of the EIS). The cumulative E&A Program is also predicted to have minimal impact on land

resources, being predominantly located within State forest, and not being located on land classified as BSAL or CIC.

Although production forestry is mapped within PEL 238 and PAL 2, there are minimal exotic plantations. Rather, these areas include State forest used for timber harvesting and nature reserves. Timber harvesting within the Pilliga forest has been reduced largely due to conservation efforts; therefore any impact on such enterprises are not considered significant. Additional clearance due to the E&A Program has a very small extent within the State forest (less than 50 hectares), when compared to the extent of the State forest in the Pilliga region (over 190,000 hectares).

4.22 Cultural heritage

4.22.1 Issue description

1) Respondents were disappointed that Aboriginal Heritage requirements were taken out of the DGRs.

2) Gomeroi Traditional Owners have a strong connection to the Pilliga, as it is considered to have a high Aboriginal cultural significance. The area has many sacred sites, including rock shelters, burials, grinding grooves and scarred trees that are not included on the Aboriginal Heritage Information Management System (AHIMS) register. There is concern that the proposed activity will damage this cultural heritage.

3) It is important that a full Aboriginal cultural heritage impact assessment is conducted in consultation with Coonamble Shire Council and the local Aboriginal community.

4.22.2 Response

1) This was a decision based on the inherent risk to Aboriginal heritage acknowledging that the proposed activity is contained within existing lease pads and access tracks that were previously cleared and the ground prepared for CSG activity.

2) Prior to the establishment of the Bibblewindi 14 and 19H lease areas, on which the proposed activity will be located, a cultural heritage survey was completed with local Indigenous community participation. Despite the proposed activity's location on these existing disturbed areas, an archaeological inspection of the existing well leases and surrounding area was undertaken by RPS on 27 November 2012, as stated in Section 19.1.2 of the EIS. The inspection was consistent with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales*.

   No Aboriginal objects, sites, places of significance or culturally modified trees were identified within the site or immediate surrounds. No evidence of Aboriginal objects or sites were identified along the tributary of Cowallah Creek. The potential for any previously unidentified Aboriginal objects or sites to be located within the site or immediate surrounds is considered to be nil to low.

   Despite the perceived low potential for impact, a number of mitigation measures were provided in the SoC (Table 20-1 of the EIS) to reduce the potential for any impacts on Aboriginal cultural heritage.

3) The sites of proposed activities within the E&A Program have been assessed for potential to impact Aboriginal cultural heritage. Ongoing dialogue has been established between Narrabri LALC and all future works will be completed with local participation. The proposed activity and other activities as part of the E&A Program are not located within the Coonamble Shire LGA, therefore it is considered more appropriate to consult with the local Aboriginal community in regards to cultural heritage matters at this time.

4.23 Health

4.23.1 Issue description

1) Concerns about the health impact to the Coonamble community when Santos expands the gas field to Coonamble (as Santos has stated their intention but not assessed in cumulative impacts of in their EIS).

2) Concerns about the risk of emissions impacting on the health and wellbeing of humans and wildlife. There are reportedly cancer clusters forming around the gas fields on the Darling Downs, as well as other noticeable health effects. A study by Dr McCarron suggests that they are from airborne BTEX chemicals. But as the gas industry does not disclose the chemicals used, it is hard to test for them.

   CSG can have a negative health impact and is a source of major social disruption to the local residents and the wider regional communities. Spraying produced water on the dirt roads has caused terrible skin reactions on the people of Tara (Qld) and there is no research on wildlife health.

3) The EIS conclusions that the proposed activity is relatively minor in scale to negatively impact on the psychological wellbeing of individuals may be too generalised and an independent assessment should be considered to provide reassurance of the applicant's assertions.

4.23.2 Response

1) The proposed activity and other activities as part of the E&A Program are not located within the Coonamble Shire LGA. Further, the proposed project area currently under investigation for the Narrabri Gas Project is also not within Coonamble Shire LGA.

2) Adverse health related issues are not anticipated.

   The scale of the proposed activity is small and it is located well away from public facilities. The nearest residence is located 7.5 kilometres from the proposed activity. Due to these reasons, the air quality impact assessment (Appendix 5 of the EIS) determined that air quality issues during both construction and operation were negligible. Produced water will not be used for dust suppression during the proposed activity.

   The drilling fluids do not contain petroleum oil or chemicals with BTEX constituents as ingredients. In accordance with the standard drilling process, wells are constructed with the aquifer systems isolated by casings and cement from the underlying target coal sequences. A surface casing (extending through any shallow aquifers) is established and cemented prior to advancement of drilling into the deeper coal units. This surface casing eliminates the potential for impact from constituents present within the coal during drilling or operation of the well.

   Unlike conventional petroleum reservoirs, which contain heavier petroleum hydrocarbon fractions, CSG is primarily methane and does not contain heavier petroleum gases such as BTEX. Sampling and analysis of the CSG in the area has confirmed that the gas is dominated by methane (approximately 96 per cent by weight) and does not contain heavy petroleum gases.

   Reference has been made in submissions to allegations of health impacts from CSG operations located near Tara in Queensland in respect of emissions and the use of produced water for dust suppression.

   Queensland Health investigated these allegations and its report found no evidence of any link between CSG operations and claimed health impacts from residents. ‘Based on the clinical and

environmental monitoring data available for this community risk assessment, a clear link cannot be drawn between health complaints by some residents of the Tara region and impacts of the local CSG industry on air, water and soil within the community' (Queensland Health, 2013). A copy of the report is available at http://www.health.qld.gov.au/publications/csg/documents/report.pdf.

An independent medical practitioner has also carried out an investigation with similar results. The report of the investigation noted 'CSG is also released during coal mining, thus coal miners have been and are regularly exposed to CSG in the course of their work. Despite regular monitoring of the health of coal miners both in Queensland and internationally, no health effect from potential exposure to methane has been recognised… The relationship between symptoms and potential exposure to chemicals involved in the production of CSG remains unclear' (Adam, 2013). A copy of the report is available at http://www.health.qld.gov.au/publications/csg/documents/appx2.pdf.

3) According to Carey (2012), mental health issues may arise when the basic needs of a community are not met due to the cumulative impacts of water and air pollution, degradation of agricultural land and loss of amenity and landscape. Mental health issues (anxiety, depression and paranoia) may also manifest when there is a lack of empowerment and people's environment change beyond their control.

   The nature and scale of the proposed activity, and the broader E&A Program, as well as its location within the State forest ensures that potential cumulative impacts to the community are minimised. In addition, Santos will adopt best practice site environmental management measures during both construction and operation to minimise the likelihood of potential impacts to land and water resources, as outlined in the SoC within Table 20-1 of the EIS.

   In terms of ensuring that landholders maintain a sense of empowerment, Santos has a long standing commitment to work in partnership with landholders, to ensure that CSG activities do not impact on their lifestyle or the sustainability of their land. Gas exploration or development activities are only undertaken on the property of landholders who agree to host the operations. A mutually agreeable land access agreement is put in place prior to carrying out any exploration work or developing well sites on a landholder's property.

   Santos has developed a community engagement and consultation framework to specifically target the different needs and requirements of stakeholders and the community to inform and consult on the E&A Program and the CSG industry more broadly. Santos is committed to undertaking ongoing community engagement and consultation, including a presence in the local community in the form of a project information centre at 125 Maitland Street, Narrabri, which members of the community can visit and request information about the E&A Program.

5.0 Revised Statement of Commitments

The EIS for the Bibblewindi Gas Exploration Pilot Expansion identified a range of environmental outcomes and management measures that would be required to avoid or reduce the environmental impacts of the proposed activity.

After consideration of the issues raised in the public submissions, the draft Statement of Commitments for the project (refer to Chapter 20 of the EIS) has been revised. Should the proposed activity be approved, the revised commitments will guide the subsequent phases of the associated works.

The revised Statement of Commitments, including commitments relating to the key issues described in the Director-General's Requirements is provided in Table 4. Modified commitments are shown in **bold** and *italics*.

Table 4 Statement of Commitments

Item	Commitment
Activity type	The Bibblewindi Gas Exploration Pilot Expansion (proposed activity) includes the construction and drilling of Bibblewindi 31 and 32 on the existing Bibblewindi 14 and Bibblewindi 19H well leases respectively, installation of surface infrastructure to connect the two wells to the existing Bibblewindi Multi-Lateral Pilot and operation of the Bibblewindi 31 and 32 wells as part of the Bibblewindi Multi-Lateral Pilot.
Location	The proposed activity is within PAL2, within the Bibblewindi State Forest.
Hours of operation	Hours of operation will be up to 24 hours a day, seven days a week.
Activity duration	Approximately 15 weeks construction and up to 3 years for operation of the wells.
Proposed commencement date	Works are scheduled to commence in Q2 2014.
Maximum area of disturbance	Nil. The activity includes the construction and drilling of Bibblewindi 31 and 32 on the existing Bibblewindi 14 and Bibblewindi 19H well leases and access tracks.
Rehabilitation commitments and timeframes	Pilot well decommissioning and rehabilitation of the well lease areas and access tracks will occur within 6 months of abandonment. Pilot wells and ancillary infrastructure would be decommissioned and lease areas rehabilitated as outlined in Section 4.5.1 of the EIS.
Stakeholder consultation	▪ Community consultation will be undertaken in accordance with Chapter 5 of the EIS. ▪ Advice will be provided to relevant landholders that may be impacted by the activity 14 days prior to the proposed activity commencing. ▪ Narrabri Shire Council will be consulted on a monthly basis where appropriate. ▪ Updates on the proposed activity will be provided to the Narrabri Community Consultation Committee. ▪ Advertisements will be placed in the local media of the upcoming exploration and drilling activities. ▪ The local police will be notified of the proposed drilling activities and provided with a road traffic plan specifying the route, time and location of the drilling rig 14 days prior to the drilling rig mobilising to site.
Land resources	Construction ▪ Excess topsoil and subsoil generated during site preparation activities will be stockpiled onsite and used as backfill following completion of drilling. ▪ Erosion and sediment controls will be implemented where necessary during site preparation activities, in accordance with ***the guidelines, principles and recommended minimum design standards contained in Managing Urban Stormwater: Soils and Construction – Volume 1 (the Blue Book)***. These controls will be maintained until disturbed areas of the site are stabilised. ▪ The quantity of chemicals, fuels and oils stored onsite will be minimised, where practicable. ▪ All additives, chemicals, fuels and oils stored onsite will be kept in an appropriately secured, bunded storage shed in accordance with the relevant Safety Data Sheet (SDS). ▪ Where there is a risk of contamination pits will be lined or material will be stored in surface tanks or metal bins. ▪ An SDS register of all chemicals used or stored onsite will be maintained. ▪ Maintenance of vehicles, plant and equipment will occur offsite at an appropriately licensed facility unless deemed necessary and appropriate to conduct such maintenance onsite.

Item	Commitment
	▪ Refuelling of plant and equipment will occur in a designated, bunded area, at least 40 metres from the nearest waterway. ▪ Any spills or leaks will be contained and cleaned up immediately using the spill kit. Contaminated material (such as contaminated soil or absorbent materials) will be placed in a bag and removed from site for disposal at a licensed waste facility. ▪ Plant and equipment will be inspected daily to ensure these are properly maintained. Operation ▪ Ongoing management and maintenance of remaining infrastructure onsite will occur, including water transfer area and well heads. ▪ The gathering system water pressure will be monitored. Should line failure occur between the wells to the transfer tank at Bibblewindi Water Transfer Facility, operation of the well will be suspended until the problem is rectified. ▪ The site will be rehabilitated in accordance with Section 4.5.1 of the EIS.
Groundwater	Construction ▪ The wells will be designed and constructed in accordance with the *NSW Coal Seam Gas Code of Practice Well Integrity* (DTIRIS, 2012). ▪ Drilling and installation operations, well control, waste management and abandonment procedures for the pilot wells will be in accordance with accepted industry practices and in accordance with the processes outlined in the EIS. ▪ A driller that holds the relevant qualifications as defined by the NSW Office of Water will be onsite during drilling of the top hole until the surface casing is set, cemented, and pressure tested. During this time, there will be 24 hour coverage by one person working the day shift and on call at site during the night. This will ensure that the appropriate knowledge of water legislation and regulation in NSW and technical skills are employed to avoid impacts to surface and groundwater sources. ▪ Excessive drilling fluid losses will be cured by loss circulation material (cellulose material such as sawdust or other benign naturally occurring substances, as required) to ensure most fluids return to the surface. ▪ Santos will make reasonable endeavours to seek permission (from landowners) to access registered groundwater bores within 2 km of the site to undertake groundwater monitoring prior to drilling, to establish baseline conditions, and on completion of drilling, to determine if there are any impacts. Where access to bores is granted (and the bore is functioning), monitoring will include water level measurements and water quality observations in the field, and sampling for analysis by an accredited laboratory. Operation ▪ The volume of water extracted from the pilot wells will be monitored. ▪ Pressure gauges will be fitted to the pilot wells and monitored remotely through a Supervisory Control and Data Acquisition (SCADA) system. Should pressure change due to a leak, the pilot wells will be shut down immediately and the affected area investigated. ▪ The groundwater monitoring program will be implemented. ▪ In line with monitoring during drilling, Santos will make reasonable endeavours to seek permission (from landowners) to continue monitoring of registered groundwater bores within 2 km of the site to determine if there are any impacts to aquifers. ▪ The wells will be decommissioned as soon as they are no longer required.

Item	Commitment
Surface water	Construction ▪ Water will not be extracted from nearby watercourses, including Cowallah Creek or Mount Pleasant Creek. ▪ The existing diversion bund will be maintained on the up-slope side of the lease areas to divert clean water around the work area. ▪ Drilling fluids will be contained in surface tanks which will be regularly inspected and maintained. ▪ Water that drains to the cellar pit will be circulated with the drilling fluid throughout the drilling process. ▪ Should any formation fluid rise through the well, it will be captured in the waste fluid tank and will be removed to a licensed waste facility that is able to accept liquid waste for disposal or treatment. ▪ Drilling fluids will be transported to and from site by an appropriately licensed contractor. ▪ Fuel and lubricants will be stored onsite only when necessary and maintained offsite whenever possible. ▪ Wastewater generated through general site activities will be removed by an appropriately licensed contractor for disposal at a licensed facility or treated to an appropriate quality prior to discharging. ▪ All areas storing or handling fuel, fuel using equipment, and chemicals will be bunded in accordance with *Australian Standard 1940-2004; The Storage and Handling of Flammable and Combustible Liquids* or other relevant guidelines. ▪ Weather forecast will be monitored and in the event that prolonged, severe wet weather of flooding is predicted, works will cease and plant, machinery and any chemicals will be secured and bunded. ▪ A minimum freeboard of 300 mm will be maintained for any tanks or pits containing liquid waste. Operation ▪ The surface infrastructure at the lease areas will be regularly inspected. ▪ The surface water monitoring program will be implemented.
Biodiversity	▪ The site boundary will be clearly demarcated to ensure that plant and vehicles keep within the approved area of disturbance. ▪ The site will be rehabilitated in accordance with Section 4.5 of the EIS. ▪ Construction and operational vehicles/plant will only travel on the designated access tracks. Site speed limits will be imposed to reduce the potential of fauna strike and to reduce dust generation. ▪ Weed management measures will be undertaken, ***including wash down of all plant and machinery (including vehicles) in accordance with legislative requirements to prevent the spread of weeds and pathogens.*** ▪ Weed monitoring will occur throughout all phases of the proposed activity. Weed removal will be carried out as necessary.
Air quality	▪ Dust will be suppressed as required by spraying water along the access tracks and lease areas. ▪ Site speed limits will be imposed to minimise dust generated by vehicle movements. ▪ Vehicles, plant and equipment will be regularly maintained to ensure they are in good operating condition. ▪ Vehicles, plant and machinery will be turned off when not in use rather than left idling. ▪ Rehabilitation works, including landform establishment, will occur within 6 months of abandonment.

Item	Commitment
Greenhouse Gases	Construction ▪ Energy efficient equipment and processes will be used where possible. ▪ Water based drilling fluid will be used. ▪ Appropriate monitoring of emissions and consumables will be undertaken for legislative reporting requirements (such as to inform National Greenhouse Energy Reporting Scheme (NGERS) calculations). Operation ▪ Regular monitoring and maintenance of equipment and pipes to minimise fugitive emissions. ▪ A fugitive emissions monitoring program will be implemented in the Energy NSW CSG Exploration and Appraisal Program (E&A Program) area, ***incorporating a leak detection and repair program using the Picarro Cavity Ring Down Spectrometer.*** ▪ Appropriate monitoring of emissions and consumables will be undertaken for legislative reporting requirements (such as to inform NGERS calculations).
Noise	▪ Forestry Corporation of NSW (Forestry NSW) to be notified prior to the proposed activity commencing. This will include details of the timing and duration of noise generating activities. ▪ In the event of a noise complaint, the source of the noise will be investigated. Where necessary, Santos will offer to conduct noise monitoring from the proposed activity at the affected receiver. If it is determined that noise levels are unacceptable, further feasible and reasonable work practices or mitigation measures will be implemented.
Traffic and Transport	▪ Vehicles within the forest will not travel at speeds greater than 80 kilometres per hour unless otherwise signed. ▪ An in-vehicle monitoring system (IVMS) will be fitted to all Santos vehicles. ▪ Construction vehicle movements will be restricted to designated routes to/ from site via the Newell Highway. ▪ Construction vehicle activity will be managed and controlled in the vicinity of the site. ▪ Any damage to roads caused by construction activities would be repaired at Santos cost in accordance with the Permit to Occupy. ▪ ***Access to the pilot shall primarily be via the intersection of X-Line Road and the Newell Highway.***
Waste	▪ Management of waste, including its transport, will comply with the *Protection of the Environment Operations Act* 1997 (POEO Act) and *Protection of the Environment Operations (Waste) Regulation* 2005. ▪ A Waste Management Plan will be implemented, that will be based on the waste reduction hierarchy of avoid, reduce, reuse, recycle, recover, treat and dispose. ▪ General site waste will be segregated according to their classifications under the Waste Classification Guidelines (DECCW, 2009) and stored in bins or skips within a designated waste transfer point within the lease area prior to transportation for disposal. ▪ Drill cuttings will be used for backfilling or site shaping during rehabilitation of the site, to reduce material which may otherwise go to landfill ▪ Regulated waste will be collected by licensed contractors for offsite disposal. General and recyclable waste will be transported to local council landfill and recycling facilities. ▪ Following completion of cementing, excess fluids and cement slurries will be segregated in steel waste tanks and removed and disposed of by a licensed waste disposal company.

Item	Commitment
	▪ Sewage waste will be removed from site by a licensed contractor for treatment and disposal, as required. ▪ Appropriate waste receptacles will be provided onsite including covered rubbish bins for disposal of domestic wastes. These will remain during drilling activities. ▪ The type and volume of all waste removed from site will be recorded. ▪ All staff and contractors will be made aware of waste management procedures during site induction and through toolbox talks. ▪ Chemical, fuel and oil containers will be managed according to the SDS or manufacturers' directions to avoid potential impacts to the environment or human health.
Hazards	Construction ▪ Site safety protocols, incident management and emergency procedures will be implemented during the construction and drilling works. ▪ The site will be kept in a clean and tidy manner during site preparation, drilling activities and operation of the pilot wells. ▪ Chemicals and potentially hazardous substances will be used and stored according to regulatory requirements including the *Work Health and Safety Act 2011*. ▪ Any dangerous goods will be transported according to regulatory requirements under the *Dangerous Goods (Road and Rail Transport) Act 2008*. ▪ Chemical, fuel and oil containers will be managed according to the SDS or manufacturers' directions to avoid potential impacts to the environment or human health. Operation ▪ Where feasible best practice bushfire risk management will be implemented. ▪ All statutory obligations for bushfire management will be met. ▪ An education program for staff and contractors regarding the risks from bushfires in consultation and collaboration with the NSW Rural Fire Service, Fire & Rescue NSW and Forestry NSW will be implemented.
Social and Economic	▪ Consultation activities will occur in accordance with Chapter 5 of the EIS. ▪ ***Ongoing contributions will be made to the local sponsorship program throughout the E&A Program.*** ▪ ***Santos will continue to rent properties in Narrabri for the use of project workers throughout the E&A Program.***

Item	Commitment
Other	▪ Project staff and contractors will be made aware of their statutory obligations to protect Aboriginal cultural heritage objects under the *National Parks and Wildlife Act* 1974 (NPW Act), through site induction and toolbox talks. ▪ All works will be undertaken to comply with Part 6 of the NPW Act. ▪ If any previously unidentified Aboriginal cultural heritage objects are identified during works, then such in the immediate area will cease, the area will be cordoned off and the NSW Office of Environment and Heritage (NSW OEH) Enviroline 131 555 will be contacted. A suitably qualified archaeologist will be contacted so that the site can be assessed and managed in accordance with relevant legislative and policy requirements. ▪ In the event that skeletal remains are uncovered, then works in the immediate area will cease, the area will be cordoned off and the NSW Police will be contacted. Should the NSW Police determine that the material is not recent, the OEH Enviroline 131 555 and relevant Aboriginal stakeholders will be contacted to determine an action plan for the management of the skeletal remains prior to works re-commencing. ▪ If any previously unidentified potential non-Aboriginal cultural heritage material is identified during construction or drilling, then works in the immediate area will cease, the area will be cordoned off and the OEH Heritage Branch will be contacted. A suitably qualified archaeologist will be contacted so that the site can be assessed and managed.

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7.0 Terms and abbreviations

ABS	Australian Bureau of Statistics
AHIMS	Aboriginal Heritage Information Management System
AIP	Aquifer Interference Policy
AIS	Agricultural Impact Statement
ASC	Australian Soils Classification
BNCCA Act	*Brigalow and Nandewar Community Conservation Area Act* 2005 (NSW)
BSAL	Biophysical Strategic Agricultural Land
BTEX	Benzene, toluene, ethylbenzene, and xylenes
CAP	*Namoi Catchment Action Plan 2010-2020* (NCMA, 2011)
CCA	Community Conservation Area
CEEC	Critically Endangered Ecological Communities
CIC	Critical Industry Cluster
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2^e	Carbon dioxide equivalent
CSG	Coal seam gas
CUCCLG	Coonabarabran and Upper Castlereagh Catchment and Landcare Group
DA	Development application
DAMB	Deep aquifer monitoring bore
DCCEE	Commonwealth Department of Climate Change and Energy Efficiency
DECC	NSW Department of Environment and Climate Change
DECCW	NSW Department of Environment, Climate Change and Water
DGRs	Director-General's Requirements
DoE	Commonwealth Department of the Environment
DP&I	NSW Department of Planning and Infrastructure
ds/cm	Decisiemens per centimetre
ds/m	Decisiemens per metre
DST	Drill stem test
DTIRIS	NSW Department of Trade and Investment, Regional Infrastructure and Services
E&A Program	Energy NSW CSG Exploration and Appraisal Program
EC	Electrical conductivity
EIS	Environmental Impact Statement
EFT	Equivalent Full Time
ELA	Eco Logical Australia
EP&A Act	*Environmental Planning and Assessment Act* 1979 (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999 (Cth)
EPL	Environment Protection Licence
ESG	Eastern Star Gas
Forestry NSW	Forestry Corporation of New South Wales
FTF	Fluids treatment facility
GAB	Great Artesian Basin

GDE	Groundwater Dependent Ecosystem
GHG	Greenhouse gas
GJ	Gigajoule
GMMP	Groundwater Monitoring and Modelling Plan
GWP	Global warming potential
HIA	Health Impact Assessment
HSU	Hydrostratigraphic Unit
IECA	International Erosion Control Association
IESC	Independent Expert Scientific Committee
IVMS	In vehicle monitoring system
LGA	Local government area
LSC Class	Land and soil capability class
LSTU	Less significant transmissive unit
MNES	Matter of National Environmental Significance
Namoi CMA	Namoi Catchment Management Authority
Narrabri CCC	Narrabri Community Consultation Committee
Narrabri LALC	Narrabri Local Aboriginal Land Council
NGA Factors	*National Greenhouse Accounts Factors* (DCCEE, 2012)
NGERS	National Greenhouse Energy Reporting Scheme
NICE	Northern Inland Council for the Environment
NOW	NSW Office of Water
NO_2	Nitrogen dioxide
NPA	National Parks Association
NPW Act	*National Parks and Wildlife Act* 1974 (NSW)
NPWS	National Parks and Wildlife Service
NSW	New South Wales
NSW EPA	NSW Environment Protection Authority
NSW Health	NSW Health – Hunter New England Local Health District
NSW OCSG	NSW Office of Coal Seam Gas
NSW OEH	NSW Office of Environment and Heritage
NTU	Negligibly transmissive unit
PAC	Planning Assessment Committee
PAH	Polycyclic aromatic hydrocarbons
PAL	Petroleum Assessment Lease
PBT	Persistence, bioaccumulation and toxicity
PEA	Preliminary environmental assessment
PEL	Petroleum Exploration Licence
PIN	Penalty infringement notice
PNTU	Probable negligibly transmissive unit
POEO Act	*Protection of the Environment Operations Act* 1997 (NSW)
POP	Petroleum Operations Plan
PPL	Petroleum Production Licence
PWMP	Produced Water Management Plan

REF	Review of Environmental Factors
RFS	NSW Rural Fire Service
RO	Reverse osmosis
RPS	RPS Australia East Pty Ltd
SAMB	Shallow aquifer monitoring bore
Santos	Santos NSW (Eastern) Pty Ltd
SCADA	Supervisory control and data acquisition
SCS	Soil Conservation Service
SDS	Safety Data Sheet
SIS	Species Impact Statement
SoC	Statement of Commitments
SRD SEPP	*State Environmental Planning Policy (State and Regional Development*) 2011
SRLUP	Strategic Regional Land Use Policy
SSD	State Significant Development
STU	Significant transmissive unit
TSC Act	*Threatened Species Conservation Act* 1995 (NSW)
VOCs	Volatile organic compounds
WAD	Works Authorisation Deed
WAL	Water access licence
Wall cake	Low permeability ‘skin’ around the wall of the hole.

Appendix 1

List of submissions received

Submission number	Response from	Key areas of concern	Submissions Report reference
Government Agency			
	NSW Environmental Protection Agency	▪ Regulatory requirements ▪ Land resources ▪ Air quality ▪ Traffic and transport	▪ Section 4.10.4 ▪ Section 4.12.2 ▪ Section 4.16.2 ▪ Section 4.18.2
	NSW Office of Coal Seam Gas	▪ No issues raised	▪ Section 3.3.1.6
	NSW Office of Water	▪ CSG infrastructure ▪ Regulatory requirements ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – groundwater monitoring program ▪ Groundwater – protection of water resources	▪ Section 4.8.4 ▪ Section 4.10.4 ▪ Section 4.13.2 ▪ Section 4.13.3 ▪ Section 4.13.8 ▪ Section 4.13.9
	NSW Office of Environment and Heritage	▪ No issues raised	▪ Section 3.3.1.8
	NSW Health – Hunter New England Local Health District	▪ Community and stakeholder consultation ▪ Air quality ▪ Health	▪ Section 4.9.2 ▪ Section 4.16.1 ▪ Section 4.23
	Heritage Council of NSW	▪ No issues raised	▪ Section 3.3.1.2
	NSW Agricultural Sustainability and Food Security	▪ Land resources	▪ Section 4.12.1
	Fisheries NSW	▪ No issues raised	▪ Section 3.3.1.1
	NSW Roads and Maritime Services	▪ Traffic and transport	▪ Section 4.18.1
	Namoi Catchment Management Authority	▪ Community and stakeholder consultation ▪ Policy	▪ Section 4.9.1 ▪ Section 4.10.3
Council			
	Narrabri Shire Council	▪ Hydraulic fracturing (fracking) ▪ CSG infrastructure	▪ Section 4.8.1 ▪ Section 4.8.4

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – registered bores ▪ Groundwater – groundwater monitoring program ▪ Groundwater – report discrepancy ▪ Hazards – chemical risks ▪ Social and economic	▪ Section 4.9.2 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.3 ▪ Section 4.13.7 ▪ Section 4.13.8 ▪ Section 4.13.10 ▪ Section 4.20.2 ▪ Section 4.21
	Coonamble Shire Council	▪ Future development ▪ Produced water management ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Groundwater – groundwater monitoring program ▪ Hazards – bushfire risk ▪ Cultural heritage ▪ Health	▪ Section 4.5.1 ▪ Section 4.8.2 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.13.8 ▪ Section 4.20.1 ▪ Section 4.22 ▪ Section 4.23
Special Interest Group			
82073	NSW Artesian BoreWater Users Association	▪ Scientific uncertainty ▪ Future development ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Health	▪ Section 4.4 ▪ Section 4.5.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.23
82045	Armidale Branch National Parks Association	▪ Scientific uncertainty ▪ Future development ▪ Cumulative impacts	▪ Section 4.4 ▪ Section 4.5.1 ▪ Section 4.5.2

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Adequacy of the EIS ▪ Need and justification ▪ Produced water management ▪ Community and stakeholder consultation ▪ Commonwealth referral ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – cumulative impacts ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – invasive species ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Greenhouse gases ▪ Hazards – bushfire risk ▪ Social and economic ▪ Cultural heritage	▪ Section 4.6 ▪ Section 4.7.1 ▪ Section 4.8.2 ▪ Section 4.9.1 ▪ Section 4.10.2 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.3 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.7 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.17 ▪ Section 4.20.1 ▪ Section 4.21.2 ▪ Section 4.22.1
81892	Friends of the Pilliga	▪ Cumulative impacts ▪ Produced water management ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – drilling techniques and well integrity ▪ Surface water ▪ Biodiversity – invasive species ▪ Biodiversity – other concerns ▪ Air quality ▪ Traffic and transport	▪ Section 4.5.2 ▪ Section 4.8.2 ▪ Section 4.9.2 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.5 ▪ Section 4.14 ▪ Section 4.15.7 ▪ Section 4.15.10 ▪ Section 4.16.2 ▪ Section 4.18.2

Submission number	Response from	Key areas of concern	Submissions Report reference
82612	Namoi Water	▪ Need and justification ▪ Produced water management ▪ Rehabilitation ▪ Regulatory compliance ▪ Policy ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Groundwater – registered bores ▪ Groundwater – groundwater monitoring program ▪ Surface water ▪ Hazards – chemical risks ▪ Social and economic	▪ Section 4.7.1 ▪ Section 4.8.2 ▪ Section 4.8.3 ▪ Section 4.10.1 ▪ Section 4.10.3 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.13.7 ▪ Section 4.13.8 ▪ Section 4.14 ▪ Section 4.20.2 ▪ Section 4.21
82892	The Wilderness Society Newcastle	▪ Future development ▪ Cumulative impacts ▪ Adequacy of the EIS ▪ Need and justification ▪ Produced water management ▪ Rehabilitation ▪ Community and stakeholder consultation ▪ Regulatory requirements ▪ Environmental risk assessment ▪ Land resources ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Groundwater – cumulative impacts ▪ Biodiversity – cumulative impacts ▪ Biodiversity – threatened species	▪ Section 4.5.1 ▪ Section 4.5.2 ▪ Section 4.6 ▪ Section 4.7.1 ▪ Section 4.8.2 ▪ Section 4.8.3 ▪ Section 4.9.1 ▪ Section 4.10.4 ▪ Section 4.11 ▪ Section 4.12.2 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.13.6 ▪ Section 4.15.3 ▪ Section 4.15.4

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – South-eastern Long-eared Bat ▪ Biodiversity – invasive species ▪ Biodiversity – stygofauna ▪ Biodiversity – Pilliga conservation ▪ Biodiversity – other concerns ▪ Air quality ▪ Greenhouse gases ▪ Hazards – bushfire risk ▪ Hazards – chemical risks ▪ Social and economic ▪ Cultural heritage	▪ Section 4.15.5 ▪ Section 4.15.6 ▪ Section 4.15.7 ▪ Section 4.15.8 ▪ Section 4.15.9 ▪ Section 4.15.10 ▪ Section 4.16 ▪ Section 4.17 ▪ Section 4.20.1 ▪ Section 4.20.2 ▪ Section 4.21.3 ▪ Section 4.22
82049	Upper Mooki Landcare Group	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Social and economic ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.21.2 ▪ Section 4.22.1
82079	Northern Inland Council for the Environment Inc.	▪ Future development ▪ Cumulative impacts ▪ Hydraulic fracturing (fracking) ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration	▪ Section 4.5.1 ▪ Section 4.5.2 ▪ Section 4.8.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – cumulative impacts ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – stygofauna ▪ Air quality ▪ Hazards – bushfire risk ▪ Social and economic ▪ Cultural heritage	▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.3 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.8 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.21.2 ▪ Section 4.22.1
82053	North Coast Environment Council	▪ Future development ▪ Community and stakeholder consultation ▪ Regulatory compliance ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.10.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
Community			
79536	Public	▪ General objections ▪ Objections to the CSG industry ▪ Groundwater – Great Artesian Basin	▪ Section 4.1 ▪ Section 4.2 ▪ Section 4.13.4
81224	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81228	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81232	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.20.1 ▪ Section 4.22.1
81234	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81237	Public	▪ Objections to the CSG industry ▪ Commonwealth referral ▪ Biodiversity – Pilliga conservation	▪ Section 4.2 ▪ Section 4.10.2 ▪ Section 4.15.9
81243	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81245	Public	▪ Future development ▪ Community and stakeholder consultation	▪ Section 4.5.1 ▪ Section 4.9.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – cumulative impacts ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Waste ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.3 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.19 ▪ Section 4.20.1 ▪ Section 4.22.1
81247	Public	▪ Commonwealth referral ▪ Groundwater – Great Artesian Basin ▪ Hazards – bushfire risk ▪ Social and economic	▪ Section 4.10.2 ▪ Section 4.13.4 ▪ Section 4.20.1 ▪ Section 4.21.2
81249	Public	▪ Biodiversity – Pilliga conservation	▪ Section 4.15.9
81252	Public	▪ Biodiversity – Pilliga conservation	▪ Section 4.15.9
81254	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1

Submission number	Response from	Key areas of concern	Submissions Report reference
81256	Public	▪ Groundwater – Great Artesian Basin ▪ Biodiversity – baseline monitoring ▪ Hazards – bushfire risk	▪ Section 4.13.4 ▪ Section 4.15.1 ▪ Section 4.20.1
81258	Public	▪ Regulatory compliance ▪ Biodiversity – Pilliga conservation	▪ Section 4.10.1 ▪ Section 4.15.9
81263	Public	▪ Objections to the CSG industry ▪ Biodiversity – Pilliga conservation	▪ Section 4.2 ▪ Section 4.15.9
81265	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81267	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Cultural heritage	▪ Section 4.22.1
81269	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81273	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81276	Public	▪ Future development ▪ Cumulative impacts ▪ Community and stakeholder consultation ▪ Regulatory compliance ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration	▪ Section 4.5.1 ▪ Section 4.5.2 ▪ Section 4.9.1 ▪ Section 4.10.1 ▪ Section 4.13.1 ▪ Section 4.13.2

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81278	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81280	Public	▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Hazards – bushfire risk	▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.20.1
81286	Public	▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring	▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1
81288	Public	▪ Objections to fossil fuel development	▪ Section 4.3

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Need and justification ▪ Biodiversity – Pilliga conservation	▪ Section 4.7.2 ▪ Section 4.15.9
81290	Public	▪ Hydraulic fracturing (fracking) ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga conservation ▪ Biodiversity – Other concerns	▪ Section 4.8.1 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.9 ▪ Section 4.15.10
81292	Public	▪ Biodiversity – Pilliga conservation	▪ Section 4.15.9
81294	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81296	Public	▪ Biodiversity – Pilliga conservation ▪ Social and economic	▪ Section 4.15.9 ▪ Section 4.21.3
81298	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81302	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81304	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81306	Public	▪ Objections to the CSG industry	▪ Section 4.2

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Objections to fossil fuel development	▪ Section 4.3
81308	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81312	Public	▪ Objections to fossil fuel development ▪ Future development ▪ Need and justification ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.3 ▪ Section 4.5.1 ▪ Section 4.7.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81316	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81318	Public	▪ Biodiversity – Pilliga conservation	▪ Section 4.15.9
81320	Public	▪ Land resources	▪ Section 4.12.2
81322	Public	▪ Objections to the CSG industry ▪ Biodiversity – Pilliga conservation ▪ Hazards – bushfire risk ▪ Health	▪ Section 4.2 ▪ Section 4.15.9 ▪ Section 4.20.1 ▪ Section 4.23
81326	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81328	Public	▪ Future development ▪ Need and justification ▪ Community and stakeholder consultation	▪ Section 4.5.1 ▪ Section 4.7.1 ▪ Section 4.9.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Regulatory compliance ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.10.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81332	Public	▪ General objections ▪ Groundwater – baseline monitoring ▪ Groundwater – Great Artesian Basin ▪ Groundwater –groundwater monitoring program	▪ Section 4.1 ▪ Section 4.13.1 ▪ Section 4.13.4 ▪ Section 4.13.8
81336	Public	▪ Biodiversity – cumulative impacts ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Cultural heritage	▪ Section 4.15.3 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.22
81338	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Cultural heritage	▪ Section 4.22.1
81340	Public	▪ Need and justification ▪ Biodiversity – Pilliga conservation	▪ Section 4.7.2 ▪ Section 4.15.9
81342	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81344	Public	▪ General objections ▪ Need and justification ▪ Biodiversity – Pilliga conservation	▪ Section 4.1 ▪ Section 4.7.1 ▪ Section 4.15.9
81346	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1

Submission number	Response from	Key areas of concern	Submissions Report reference
81350	Public	▪ Biodiversity – Pilliga conservation	▪ Section 4.15.9
81352	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81354	Public	▪ Scientific uncertainty ▪ Hydraulic fracturing (fracking)	▪ Section 4.4 ▪ Section 4.8.1
81356	Public	▪ Groundwater – drilling techniques and well integrity	▪ Section 4.13.5
81360	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81362	Public	▪ Need and justification	▪ Section 4.7.2

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Regulatory compliance ▪ Biodiversity – Pilliga conservation	▪ Section 4.10.1 ▪ Section 4.15.9
81364	Public	▪ General objections	▪ Section 4.1
81366	Public	▪ Need and justification ▪ Groundwater – baseline monitoring ▪ Groundwater – Great Artesian Basin ▪ Biodiversity – Pilliga conservation	▪ Section 4.7.2 ▪ Section 4.13.1 ▪ Section 4.13.4 ▪ Section 4.15.9
81368	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81370	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1

Submission number	Response from	Key areas of concern	Submissions Report reference
81372	Public	▪ General objections	▪ Section 4.1
81375	Public	▪ General objections ▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.1 ▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81378	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81380	Public	▪ Groundwater – potential impacts to groundwater resources ▪ Biodiversity – Pilliga conservation	▪ Section 4.13.3 ▪ Section 4.15.9
81382	Public	▪ Objections to the CSG industry ▪ Regulatory compliance	▪ Section 4.2 ▪ Section 4.10.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – Great Artesian Basin ▪ Biodiversity – Pilliga conservation ▪ Social and economic	▪ Section 4.13.4 ▪ Section 4.15.9 ▪ Section 4.21.2
81384	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81390	Public	▪ General objections ▪ Groundwater – potential impacts to groundwater resources	▪ Section 4.1 ▪ Section 4.13.3
81392	Public	▪ Need and justification ▪ Social and economic	▪ Section 4.7.1 ▪ Section 4.21.2
81394	Public	▪ Need and justification ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Biodiversity – Pilliga conservation ▪ Hazards – bushfire risk ▪ Social and economic ▪ Cultural heritage	▪ Section 4.7.1 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.15.9 ▪ Section 4.20.1 ▪ Section 4.21.2 ▪ Section 4.22
81396	Public	▪ Biodiversity – Pilliga conservation	▪ Section 4.15.9
81402	Public	▪ Objections to the CSG industry ▪ Hydraulic fracturing (fracking)	▪ Section 4.2 ▪ Section 4.8.1
81404	Public	▪ Objections to the CSG industry	▪ Section 4.2

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Objections to fossil fuel development ▪ Need and justification ▪ Hydraulic fracturing (fracking) ▪ Health	▪ Section 4.3 ▪ Section 4.7.2 ▪ Section 4.8.1 ▪ Section 4.23
81406	Public	▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – cumulative impacts ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Greenhouse gases ▪ Hazards – bushfire risk	▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.3 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.17 ▪ Section 4.20.1
81408	Public	▪ General objections	▪ Section 4.1
81412	Public	▪ Groundwater – baseline monitoring ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga conservation ▪ Hazards – bushfire risk	▪ Section 4.13.1 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.9 ▪ Section 4.20.1
81414	Public	▪ Objections to fossil fuel development ▪ Future development ▪ Need and justification ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse	▪ Section 4.3 ▪ Section 4.5.1 ▪ Section 4.7.2 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81416	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81418	Public	▪ Objections to fossil fuel development ▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – cumulative impacts ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.3 ▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.3 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81422	Public	▪ Objections to the CSG industry ▪ Objections to fossil fuel development	▪ Section 4.2 ▪ Section 4.3

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Future development ▪ Need and justification ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.7.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81424	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81436	Public	▪ Objections to the CSG industry ▪ Hydraulic fracturing (fracking) ▪ Social and economic	▪ Section 4.2 ▪ Section 4.8.1 ▪ Section 4.21.2
81438	Public	▪ Objections to the CSG industry	▪ Section 4.2
81446	Public	▪ Future development ▪ Community and stakeholder consultation	▪ Section 4.5.1 ▪ Section 4.9.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Social and economic ▪ Cultural heritage	▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.21.2 ▪ Section 4.22.1
81450	Public	▪ Need and justification	▪ Section 4.7.1
81452	Public	▪ Objections to the CSG industry	▪ Section 4.2
81454	Public	▪ Biodiversity – Pilliga conservation	▪ Section 4.15.9
81460	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81466	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81476	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Regulatory compliance ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.10.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81478	Public	▪ General objections	▪ Section 4.1
81484	Public	▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity	▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5
81506	Public	▪ Objections to the CSG industry ▪ Future development ▪ Need and justification ▪ Community and stakeholder consultation	▪ Section 4.2 ▪ Section 4.5.1 ▪ Section 4.7.1 ▪ Section 4.9.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Social and economic ▪ Cultural heritage	▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.21.2 ▪ Section 4.22.1
81510	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81512	Public	▪ Objections to the CSG industry ▪ Need and justification ▪ Biodiversity – Pilliga conservation	▪ Section 4.2 ▪ Section 4.7.2 ▪ Section 4.15.9
81518	Public	▪ Scientific uncertainty ▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring	▪ Section 4.4 ▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81526	Public	▪ Community and stakeholder consultation ▪ Groundwater – Great Artesian Basin ▪ Biodiversity – Pilliga conservation	▪ Section 4.9.1 ▪ Section 4.13.4 ▪ Section 4.15.9
81538	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81548	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81552	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81556	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81560	Public	▪ Future development ▪ Community and stakeholder consultation	▪ Section 4.5.1 ▪ Section 4.9.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81564	Public	▪ Scientific uncertainty ▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.4 ▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81574	Public	▪ Objections to the CSG industry ▪ Scientific uncertainty ▪ Groundwater – potential impacts to groundwater resources ▪ Social and economic	▪ Section 4.2 ▪ Section 4.4 ▪ Section 4.13.3 ▪ Section 4.21.2
81586	Public	▪ Future development ▪ Hydraulic fracturing (fracking) ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring	▪ Section 4.5.1 ▪ Section 4.8.1 ▪ Section 4.9.1 ▪ Section 4.13.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Greenhouse gases ▪ Hazards – bushfire risk ▪ Cultural heritage ▪ Health	▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.17 ▪ Section 4.20.1 ▪ Section 4.22.1 ▪ Section 4.23
81602	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Regulatory compliance ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.10.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81606	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Greenhouse gases ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.17 ▪ Section 4.20.1 ▪ Section 4.22.1
81608	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81612	Public	▪ Scientific uncertainty ▪ Groundwater – baseline monitoring ▪ Biodiversity – cumulative impacts ▪ Biodiversity – threatened species ▪ Hazards – bushfire risk ▪ Health	▪ Section 4.4 ▪ Section 4.13.1 ▪ Section 4.15.3 ▪ Section 4.15.4 ▪ Section 4.20.1 ▪ Section 4.23
81614	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81616	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81627	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Air quality ▪ Hazards – bushfire risk	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.16.2 ▪ Section 4.20.1
81635	Public	▪ Biodiversity – Pilliga conservation ▪ Social and economic	▪ Section 4.15.9 ▪ Section 4.21.2
81637	Public	▪ Objections to the CSG industry	▪ Section 4.2
81647	Public	▪ Objections to the CSG industry ▪ Need and justification	▪ Section 4.2 ▪ Section 4.7.1

Submission number	Response from	Key areas of concern	Submissions Report reference
81649	Public	▪ Objections to the CSG industry ▪ Health	▪ Section 4.2 ▪ Section 4.23
81655	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81666	Public	▪ Objections to the CSG industry ▪ Need and justification ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Biodiversity – Pilliga conservation ▪ Cultural heritage	▪ Section 4.2 ▪ Section 4.7.2 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.15.9 ▪ Section 4.22
81674	Public	▪ Objections to the CSG industry ▪ Scientific uncertainty ▪ Groundwater – baseline monitoring ▪ Biodiversity – baseline monitoring	▪ Section 4.2 ▪ Section 4.4 ▪ Section 4.13.1 ▪ Section 4.15.1
81687	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81691	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81707	Public	▪ Objections to the CSG industry ▪ Need and justification ▪ Hydraulic fracturing (fracking)	▪ Section 4.2 ▪ Section 4.7.2 ▪ Section 4.8.1
81711	Public	▪ General objections ▪ Biodiversity – Pilliga conservation	▪ Section 4.1 ▪ Section 4.15.9
81752	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81793	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81795	Public	▪ Objections to the CSG industry ▪ Scientific uncertainty ▪ Future development ▪ Hydraulic fracturing (fracking) ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species	▪ Section 4.2 ▪ Section 4.4 ▪ Section 4.5.1 ▪ Section 4.8.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81797	Public	▪ General objections	▪ Section 4.1
81800	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81812	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – cumulative impacts ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.3 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81814	Public	▪ Objections to the CSG industry	▪ Section 4.2

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Future development ▪ Cumulative impacts ▪ Produced water management ▪ Community and stakeholder consultation ▪ Regulatory compliance ▪ Policy ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Groundwater – protection of water resources ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Hazards – chemical risk ▪ Social and economic ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.5.2 ▪ Section 4.8.2 ▪ Section 4.9.1 ▪ Section 4.10.1 ▪ Section 4.10.3 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.13.9 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.20.2 ▪ Section 4.21 ▪ Section 4.22.1
81816	Public	▪ General objections ▪ Objections to the CSG industry ▪ Hydraulic fracturing (fracking) ▪ Produced water management ▪ Land resources ▪ Groundwater – potential impacts to groundwater resources ▪ Biodiversity – cumulative impacts ▪ Greenhouse gases ▪ Social and economic ▪ Health	▪ Section 4.1 ▪ Section 4.2 ▪ Section 4.8.1 ▪ Section 4.8.2 ▪ Section 4.12.2 ▪ Section 4.13.3 ▪ Section 4.15.3 ▪ Section 4.17 ▪ Section 4.21 ▪ Section 4.23
81824	Public	▪ Future development	▪ Section 4.5.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81840	Public	▪ Scientific uncertainty ▪ Community and stakeholder consultation ▪ Groundwater – Great Artesian Basin ▪ Biodiversity – cumulative impacts ▪ Social and economic	▪ Section 4.4 ▪ Section 4.9 ▪ Section 4.13.4 ▪ Section 4.15.3 ▪ Section 4.21.2
81846	Public	▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin	▪ Section 4.13.3 ▪ Section 4.13.4
81860	Public	▪ Future development ▪ Need and justification ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.7.2 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1

Submission number	Response from	Key areas of concern	Submissions Report reference
81866	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81876	Public	▪ General objections ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Biodiversity – cumulative impacts ▪ Air quality ▪ Hazards – bushfire risk	▪ Section 4.1 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.15.3 ▪ Section 4.16.1 ▪ Section 4.20.1
81882	Public	▪ Scientific uncertainty ▪ Cumulative impacts ▪ Adequacy of the EIS ▪ Produced water management ▪ Rehabilitation ▪ Regulatory requirements ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Groundwater – cumulative impacts ▪ Surface water	▪ Section 4.4 ▪ Section 4.5.2 ▪ Section 4.6 ▪ Section 4.8.2 ▪ Section 4.8.3 ▪ Section 4.10.4 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.13.6 ▪ Section 4.14
81896	Public	▪ Need and justification	▪ Section 4.7

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – potential impacts to groundwater resources ▪ Biodiversity – Pilliga conservation	▪ Section 4.13.3 ▪ Section 4.15.9
81903	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81907	Public	▪ General objections ▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.1 ▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81916	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81930	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
81932	Public	▪ Objections to the CSG industry ▪ Future development ▪ Cumulative impacts ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity	▪ Section 4.2 ▪ Section 4.5.1 ▪ Section 4.5.2 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.13.5

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – cumulative impacts ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Social and economic ▪ Cultural heritage	▪ Section 4.13.6 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.21.2 ▪ Section 4.22.1
82040	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
82047	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Cultural heritage	▪ Section 4.22.1
82061	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
82067	Public	▪ Groundwater – model conceptualisation, development and calibration	▪ Section 4.13.2
82071	Public	▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga conservation ▪ Hazards – bushfire risk	▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.15.4 ▪ Section 4.15.9 ▪ Section 4.20.1
82081	Public	▪ General objections ▪ Objections to the CSG industry ▪ Scientific uncertainty ▪ Cumulative impacts ▪ Regulatory compliance ▪ Groundwater – baseline monitoring ▪ Groundwater – cumulative impacts ▪ Biodiversity – Pilliga conservation	▪ Section 4.1 ▪ Section 4.2 ▪ Section 4.4 ▪ Section 4.5.2 ▪ Section 4.10.1 ▪ Section 4.13.1 ▪ Section 4.13.6 ▪ Section 4.15.9
82114	Public	▪ Commonwealth referral ▪ Groundwater – baseline monitoring	▪ Section 4.10.2 ▪ Section 4.13.1

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Groundwater – groundwater monitoring program	▪ Section 4.13.2 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.13.8
82147	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – stygofauna ▪ Biodiversity – Pilliga conservation ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.8 ▪ Section 4.15.9 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
82149	Public	▪ Scientific uncertainty ▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality	▪ Section 4.4 ▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Hazards – bushfire risk ▪ Social and economic ▪ Cultural heritage	▪ Section 4.20.1 ▪ Section 4.21 ▪ Section 4.22
82151	Public	▪ Scientific uncertainty ▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Social and economic ▪ Cultural heritage	▪ Section 4.4 ▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.21 ▪ Section 4.22
82157	Public	▪ Objections to the CSG industry ▪ Need and justification ▪ Policy ▪ Social and economic ▪ Health	▪ Section 4.2 ▪ Section 4.7.1 ▪ Section 4.10.3 ▪ Section 4.21.3 ▪ Section 4.23
82165	Public	▪ Hydraulic fracturing (fracking) ▪ Rehabilitation ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – groundwater monitoring program ▪ Biodiversity – cumulative impacts ▪ Biodiversity – Pilliga conservation ▪ Social and economic	▪ Section 4.8.1 ▪ Section 4.8.3 ▪ Section 4.13.3 ▪ Section 4.13.8 ▪ Section 4.15.3 ▪ Section 4.15.9 ▪ Section 4.21.3
82167	Public	▪ Scientific uncertainty	▪ Section 4.4

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
82172	Public	▪ Produced water management ▪ Regulatory compliance ▪ Commonwealth referral ▪ Groundwater – baseline monitoring ▪ Groundwater – Great Artesian Basin	▪ Section 4.8.2 ▪ Section 4.10.1 ▪ Section 4.10.2 ▪ Section 4.13.1 ▪ Section 4.13.4
82178	Public	▪ Community and stakeholder consultation	▪ Section 4.9.1
82190	Public	▪ Community and stakeholder consultation	▪ Section 4.9.1
82194	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1

Submission number	Response from	Key areas of concern	Submissions Report reference
82196	Public	▪ Groundwater – potential impacts to groundwater resources ▪ Biodiversity –Pilliga conservation ▪ Greenhouse gases ▪ Cultural heritage	▪ Section 4.13.3 ▪ Section 4.15.9 ▪ Section 4.17 ▪ Section 4.22
82219	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
82222	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
82230	Public	▪ Objections to the CSG industry ▪ Objections to fossil fuel development ▪ Scientific uncertainty	▪ Section 4.2 ▪ Section 4.3 ▪ Section 4.4

Submission number	Response from	Key areas of concern	Submissions Report reference
		▪ Cumulative impacts ▪ Need and justification ▪ Groundwater – baseline monitoring ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – cumulative impacts ▪ Biodiversity –Pilliga conservation ▪ Hazards – bushfire risk ▪ Social and economic	▪ Section 4.5.2 ▪ Section 4.7 ▪ Section 4.13.1 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.3 ▪ Section 4.15.9 ▪ Section 4.20.1 ▪ Section 4.21.2
82235	Public	▪ Objections to the CSG industry ▪ Hydraulic fracturing (fracking)	▪ Section 4.2 ▪ Section 4.8.1
82255	Public	▪ Objections to the CSG industry ▪ Objections to fossil fuel development ▪ Scientific uncertainty ▪ Cumulative impacts ▪ Need and justification ▪ Produced water management ▪ Regulatory compliance ▪ Regulatory requirements ▪ Groundwater – potential impacts to groundwater resources ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – cumulative impacts ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity –Pilliga conservation ▪ Greenhouse gases ▪ Waste ▪ Hazards – bushfire risk	▪ Section 4.2 ▪ Section 4.3 ▪ Section 4.4 ▪ Section 4.5.2 ▪ Section 4.7.1 ▪ Section 4.8.2 ▪ Section 4.10.1 ▪ Section 4.10.4 ▪ Section 4.13.3 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.3 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.9 ▪ Section 4.17 ▪ Section 4.19 ▪ Section 4.20.1

Submission number	Response from	Key areas of concern	Submissions Report reference
82267	Public	▪ Future development ▪ Community and stakeholder consultation ▪ Groundwater – baseline monitoring ▪ Groundwater – model conceptualisation, development and calibration ▪ Groundwater – Great Artesian Basin ▪ Groundwater – drilling techniques and well integrity ▪ Biodiversity – baseline monitoring ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Air quality ▪ Hazards – bushfire risk ▪ Cultural heritage	▪ Section 4.5.1 ▪ Section 4.9.1 ▪ Section 4.13.1 ▪ Section 4.13.2 ▪ Section 4.13.4 ▪ Section 4.13.5 ▪ Section 4.15.1 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.16.2 ▪ Section 4.20.1 ▪ Section 4.22.1
82263/82265	Public	▪ Future development ▪ Cumulative impacts ▪ Biodiversity – survey methodology ▪ Biodiversity – cumulative impacts ▪ Biodiversity – threatened species ▪ Biodiversity – Pilliga Mouse ▪ Biodiversity – South-eastern Long-eared Bat ▪ Biodiversity – invasive species ▪ Biodiversity – other concerns	▪ Section 4.5.1 ▪ Section 4.5.2 ▪ Section 4.15.2 ▪ Section 4.15.3 ▪ Section 4.15.4 ▪ Section 4.15.5 ▪ Section 4.15.6 ▪ Section 4.15.7 ▪ Section 4.15.10

Appendix 2

Bibblewindi Gas Exploration Pilot Baseline Surface and Groundwater Data Report

Bibblewindi Gas Exploration Pilot Baseline Surface Water and Groundwater Data Report

Revision 1 13 February 2014

1. Bibblewindi Gas Exploration Pilot Baseline Environmental Monitoring Data

The following document describes the attached baseline environmental data collected by Santos for the Bibblewindi 31 and 32 Gas Exploration Pilot (Pilot). Specifically this submittal is intended to satisfy the following Amended Director General's Environmental Assessment Requirement to provide "*adequate baseline monitoring for all surface water and groundwater sources and dependent ecosystems within and adjacent to the development.*

The following sections discuss the environmental media monitored, monitoring infrastructure utilized, and summary of data collected.

2. Environmental Media Monitored and Types of Data Collected

Baseline environmental monitoring activities have been undertaken on groundwater and surface water resources proximal to the Pilot as shown on **Figure 1**. While expanded analytical sampling has been undertaken at some locations, this baseline dataset includes the following primary monitoring data and analyte groups:

- Groundwater elevation data (both continuous and discrete water level measurements);
- Groundwater quality data (physiochemical parameters, major ion species and dissolved metals);
- Surface water flow data (stage and daily discharge measurements); and
- Surface water quality data (physiochemical parameters, major ion species and dissolved and total metals).

Note that the analyte groups summarized above are presented by individual constituent on the data summary tables discussed in further detail below.

Baseline groundwater data collection activities have focused primarily on shallow groundwater resources within the Namoi Alluvium, Orallo Formation and Pilliga Sandstone as these aquifers represent the primary beneficial aquifers for non-CSG activities (e.g., drinking water, irrigation, stock-watering, municipal use) and groundwater dependent ecosystems. Baseline surface water data collection activities have focused on the Namoi River, Bohena Creek, Jacks Creek, Bibblewindi Creek, and other minor tributaries and water bodies proximal to the Pilot.

3. Environmental Monitoring Infrastructure and Summary of Data Collected

The baseline environmental monitoring dataset was compiled utilising data collected from Santos monitoring infrastructure and private landholder bores as well as data sourced from publically available NSW Office of Water infrastructure. This monitoring infrastructure is described further by the media monitored and the type of infrastructure utilised. Refer to **Figure 1** for the spatial distribution of these monitoring networks.

Santos Groundwater Monitoring Infrastructure (dark green circles): These locations include shallow aquifer monitoring bores (SAMBs), in-stream monitoring bores, and groundwater supply bores installed by Santos. A brief description of these monitoring sites and data collected is provided below. Summary statistics for this dataset is included in **Table 1** and data by sampling location is provided in **Table 2**.

- SAMBS: Shallow aquifer monitoring bores have recently been (and are currently being) installed to collect baseline groundwater quality, pressure (i.e. groundwater level), and flow direction within the shallow aquifer systems and to confirm the low permeability nature of the underlying units. Some individual SAMBs are actually a nest of several bores, with each targeting different strata. Santos currently has a total of 19 individual bores that have been

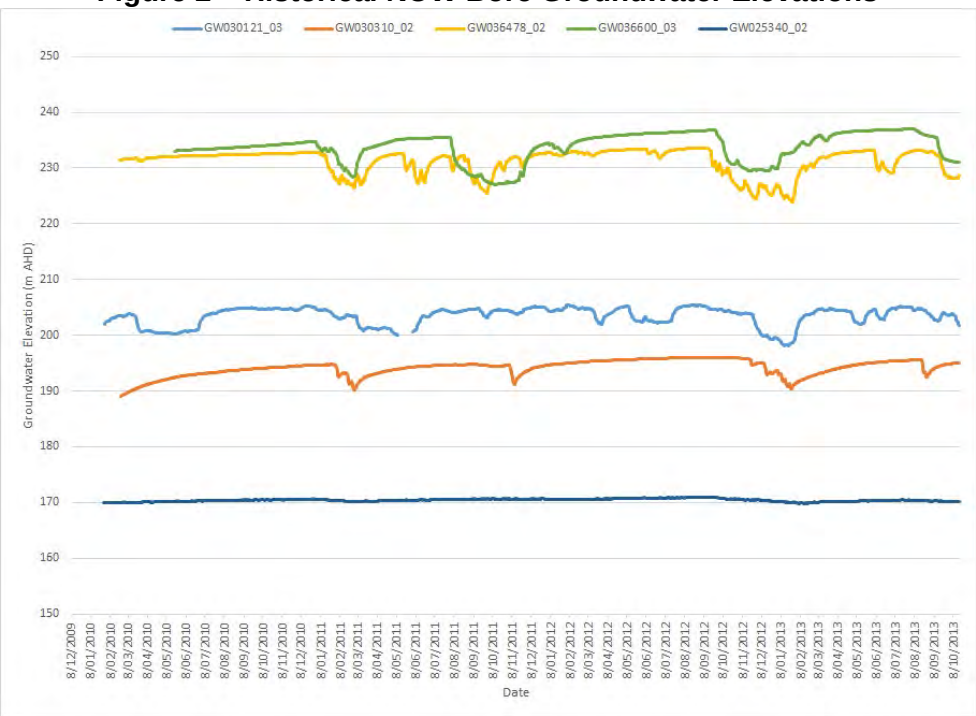
installed as part of the SAMB program. From these 25 groundwater samples have been collected to characterise baseline groundwater conditions in the Narrabri area.

- In-stream Monitoring Bores: Four (4) groundwater monitoring bores are located within the stream bed of Bohena Creek and screened in the underlying shallow aquifer to evaluate the interactions between shallow groundwater and surface water (when present) within Bohena Creek. To date, eight (8) groundwater samples have been collected from these in-stream monitoring bores.
- Groundwater Supply Bores: Three supply bores are screened within the shallow aquifer units and utilised by Santos to support operations at the Leewood and Bibblewindi facilities. To date, seven (7) groundwater samples have been collected from these supply bores.

Private Landholder Bores (purple circles): These bores are located on privately-held land and utilised by landholders for a range of uses including irrigation and stock-watering. To date Santos has collected samples from 53 landholder bores proximal to the Pilot as part of Regional Bore Inventory efforts. Summary statistics for this dataset is included in **Table 3** and data for each sampling location is provided in **Table 4**. Note that due to confidentiality agreements with the landholders the bore identification numbers cannot be disclosed and are therefore not provided on **Figure 1** or in **Table 4**.

NOW Monitoring Bores (light green circles): These monitoring bores are maintained by NOW and equipped with continuous water level monitoring transducers providing an independent dataset to evaluate groundwater levels. These bores have been collecting data from the aquifers that are the primary targets for the beneficial use for many years thereby establishing a detailed baseline for the major beneficial use aquifers in the district. As shown on **Figure 1**, five (5) NOW monitoring bores equipped with transducers are located proximal to the Pilot. **Figure 2**, provided below, depicts groundwater elevations at these bore locations between 2009 and 2013 utilising data sourced from the NSW Office of Water's Real-Time Data website (http://www.water.nsw.gov.au/realtime-data/default.aspx) and PINNEENA database.

Figure 2 – Historical NOW Bore Groundwater Elevations



Santos Surface Water Monitoring Infrastructure (orange triangles): 38 surface water monitoring locations were established by Santos within primary surface water resources following extensive desktop and field evaluation to collect water quality samples for baseline characterisation. To date Santos has collected over 260 samples from these surface water monitoring locations as part of surface water characterisation efforts. Summary statistics for this dataset is included in **Table 5** and data for each sampling location is provided in **Table 6**.

NOW Surface Water Monitoring Infrastructure (yellow triangles): Four (4) surface water stations maintained by NOW for daily flow monitoring are located proximal to the Pilot as shown on **Figure 1**. **Table 7**, provided below, summarises median daily discharge at these locations between 2003 and 2013 utilising data sourced from the NSW Office of Water's Real-Time Data website (http://www.water.nsw.gov.au/realtime-data/default.aspx) and PINNEENA database. These NOW surface water monitoring sites have large data sets of monitoring for this region establishing a long period of baseline.

Table 7 – Median Daily Discharge Summary for Area Stream Gauges (2003-2013 Data)

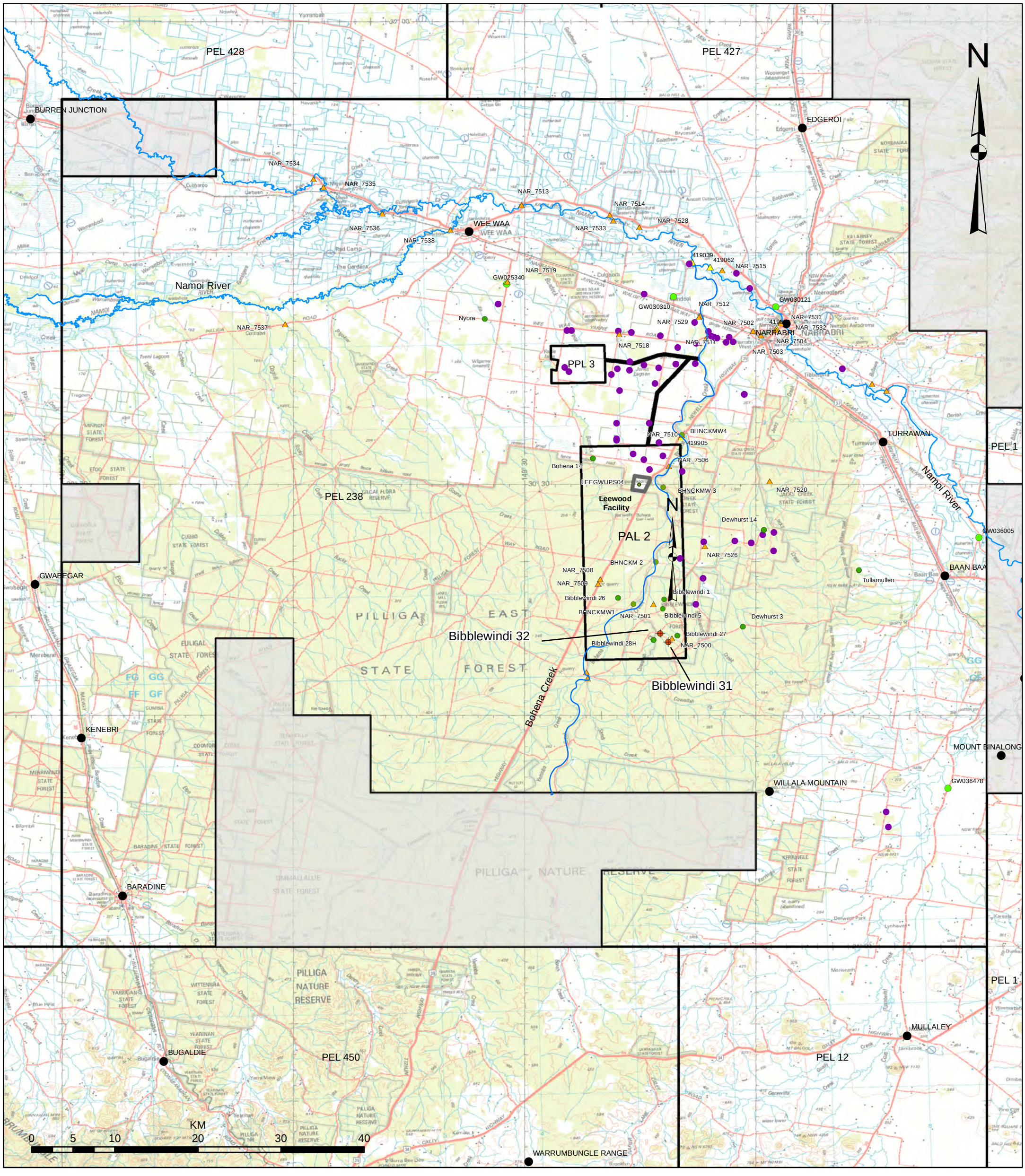
Gauge Number	Gauge Name	Maximum Medium Daily Discharge		Minimum Medium Monthly Discharge		Predicted Flow Regime
		ML/d	Month	ML/d	Month(s)	
419905	Bohena Creek at Newell Highway	-	All			Highly episodic
419003	Narrabri Creek at Narrabri	2,402	January	24	April	Perennial
419039	Namoi River at Mollee	2,270	January	66	April	Perennial
419063	Gunidgera-Pian Cutting at Merah North	198	January	0	April, May, June	Ephemeral

4. Closing

Following approval of the Bibblewindi 31 and 32 Pilot, Santos will continue to:

- Review and scrutinise the ongoing NOW data being collected,
- Collect additional data,
- Undertaking assessment on this growing baseline dataset and
- Undertake further calibrating the groundwater model.

It should be noted that some of the data provided in this memorandum is already publically available on the Santos Water Portal (http://www.santoswaterportal.com.au/water-monitoring-map.aspx?extent=16561000,-3600000,16787000,-3491000). As additional data monitoring sites are included into Santos' monitoring programs these and additional data will be presented on this water Portal.



Legend

- Proposed Pilot Hole Locations
- Santos Surface Water Sample Locations
- Santos Groundwater Monitoring Infrastructure
- NOW Surface Water Monitoring Infrastructure
- NOW Groundwater Monitoring Infrastructure
- Private Landholder Bore Locations
- Towns

Figure 1. Baseline Surface Water and Groundwater Locations

EHS Support consider it done

Whilst every care is taken by EHS Support to ensure the accuracy of the digital data, EHS Support makes no representation or warranties about its accuracy, reliability, completeness, suitability for any particular purpose and disclaims all responsibility and liability (including without limitation, liability in negligence) for any expenses, losses, damages (including indirect or consequential damage) and costs which may be incurred as a result of data being inaccurate in any way for any reason. Electronic files are provided for information only. The data in these files is not controlled or subject to automatic updates for users outside of EHS Support.

Santos We have the energy.

Table 1 – Santos Groundwater Monitoring Infrastructure – Groundwater Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

Analyte	Units	Minimum	Mean	Maximum	Number of Samples
Physiochemical					
pH	pH Unit	5.6	7.1659	11.9	39
Electrical Conductivity	µS/cm	122	419.07	2020	39
Total Dissolved Solids @180 °C	mg/L	66	404.41	5630	39
Dissolved Anions					
Hydroxide alkalinity as $CaCO_3$	mg/L	ND	ND	ND	39
Carbonate alkalinity as $CaCO_3$	mg/L	2	57.3333	138	39
Bicarbonate alkalinity as $CaCO_3$	mg/L	6	119.77	594	39
Total alkalinity as $CaCO_3$	mg/L	6	129.74	622	39
Residual alkalinity	meq/L	-0.09	1.3118	11.4	39
Chloride	mg/L	18	36.538	61	39
Sulphate as SO_4 2-	mg/L	1	3.1538	20	39
Fluoride	mg/L	0.1	0.4929	1.1	39
Dissolved Cations					
Calcium	mg/L	1	6.16	42	39
Magnesium	mg/L	1	3.5517	9	39
Sodium	mg/L	12	71.8205	352	39
Potassium	mg/L	1	7	30	39
Total hardness as $CaCO_3$	mg/L	2	24.424242	142	39
Sodium absorption ratio (calc)	-	0.9	12.4615	86.4	39
Ionic balance	%	0.56	4.7344	17.5	39
Dissolved Metals					
Aluminium	mg/L	0.01	0.13871	1.67	39
Arsenic	mg/L	0.001	0.0015	0.003	39
Beryllium	mg/L	ND	ND	ND	39
Boron	mg/L	0.11	0.2357	0.3	39
Cadmium	mg/L	ND	ND	ND	39
Chromium	mg/L	0.001	0.0019	0.004	39
Cobalt	mg/L	0.001	0.0024	0.008	39
Copper	mg/L	0.001	0.0091	0.036	39
Iron	mg/L	0.05	6.8524	29.8	39
Lead	mg/L	0.001	0.0014	0.002	39
Lithium	mg/L	0.001	0.0123	0.044	39
Manganese	mg/L	0.001	0.1507	0.82	39
Mercury	mg/L	ND	ND	ND	39
Molybdenum	mg/L	0.001	0.0113	0.075	39
Nickel	mg/L	0.001	0.0046	0.033	39
Selenium	mg/L	ND	ND	ND	39
Strontium	mg/L	0.011	0.0929	0.533	39
Tin	mg/L	ND	ND	ND	39
Uranium	mg/L	ND	ND	ND	39
Vanadium	mg/L	0.01	0.01	0.01	39
Zinc	mg/L	0.006	0.0562	0.327	39

Table 2 – Santos Groundwater Monitoring Infrastructure – Summary of Groundwater Analytical Data

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Type of Monitoring	SAMB	SAMB	SAMB	SAMB	SAMB
	Site ID	Dewhurst #3	Bibblewindi #27	Bibblewindi #27	Bibblewindi #27	Bibblewindi #27
	Bore ID	DWH3PRLPS02	BWD27PRUPS02	BWD27PRUPS02	BWD27PRLPS03	BWD27PRLPS03
	Sample ID	130930_DWH3PRLPS02	BBD27PRUPS02_WG_ 20131113_0900	BBD27PRUPS02_WG_ 20131114_0800	BBD27PRLPS03_WG_ 20131115_0800	BBD27PRLPS03_WG_ 20131117_0715
	Sample Date	30/09/2013	13/11/2013	14/11/2013	15/11/2013	17/11/2013
Analyte	**Units**					
Physiochemical						
pH	pH Unit	7.14	5.79	5.76	5.83	5.74
Electrical Conductivity	µS/cm	122	130	129	189	182
Total Dissolved Solids @180 °C	mg/L	112	92	98	140	140
Dissolved Anions						
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	15	8	8	12	10
Total alkalinity as $CaCO_3$	mg/L	15	8	8	12	10
Residual alkalinity	meq/L	0.3	0.16	0.16	0.24	0.2
Chloride	mg/L	23	33	32	46	46
Sulphate as SO_4 2-	mg/L	1	< 1	< 1	1	< 1
Fluoride	mg/L	0.1	< 0.1	< 0.1	< 0.1	< 0.1
Dissolved Cations						
Calcium	mg/L	< 1	< 1	< 1	< 1	< 1
Magnesium	mg/L	< 1	< 1	< 1	< 1	< 1
Sodium	mg/L	21	17	17	30	27
Potassium	mg/L	3	6	6	4	3
Total hardness as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1
Sodium absorption ratio (calc)	-					
Ionic balance	%					
Dissolved Metals						
Aluminium	mg/L	0.25	0.02	0.02	0.04	0.07
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.001
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.001	0.001	0.002	0.002	0.003
Cobalt	mg/L	< 0.001	< 0.001	0.001	0.002	0.002
Copper	mg/L	< 0.001	0.006	0.004	0.006	0.005
Iron	mg/L	0.06	< 0.05	< 0.05	0.14	< 0.05
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Lithium	mg/L	0.002	0.002	0.002	0.001	0.001
Manganese	mg/L	0.013	0.014	0.004	0.07	0.02
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.003	0.002	0.002	0.004	0.002
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	mg/L	0.011	0.021	0.023	0.024	0.015
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	< 0.005	0.015	0.011	0.028	0.026

Table 2 – Santos Groundwater Monitoring Infrastructure – Summary of Groundwater Analytical Data

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

Type of Monitoring		SAMB	SAMB	SAMB	SAMB
Site ID		Bohena #14	Bohena #14	Bibblewindi #26	Bibblewindi #26
Bore ID		BHN14PRORA01	BHN14PRUPS02	BWD26PRLPS02	BWD27PRUPS02
Sample ID		BHN14PRORA01_WG_201312141300	BHN14PRUPS02_WG_201312121700	BWD26PRLPS02_WG_201309191605	BWD27PRUPS02_WG_201308021655
Sample Date		14/12/2013	12/12/2013	19/09/2013	2/08/2013
Analyte	**Units**				
Physiochemical					
pH	pH Unit	8.34	8.33	7.48	7.19
Electrical Conductivity	µS/cm	474	459	156	134
Total Dissolved Solids @180 °C	mg/L	330	355	251	66
Dissolved Anions					
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	2	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	178	197	36	11
Total alkalinity as $CaCO_3$	mg/L	178	199	36	11
Residual alkalinity	meq/L	1.9	1.1	0.59	0.14
Chloride	mg/L	34	22	27	30
Sulphate as SO_4 2-	mg/L	< 1	< 1	2	1
Fluoride	mg/L	< 0.1	< 0.1	0.1	< 0.1
Dissolved Cations					
Calcium	mg/L	21	42	1	< 1
Magnesium	mg/L	7	9	1	1
Sodium	mg/L	62	48	21	18
Potassium	mg/L	5	7	13	7
Total hardness as $CaCO_3$	mg/L	81	142	7	4
Sodium absorption ratio (calc)	-	2.99	1.75	3.55	3.86
Ionic balance	%	0.77	0.56		
Dissolved Metals					
Aluminium	mg/L	0.06	< 0.01	1.67	0.11
Arsenic	mg/L	< 0.001	0.002	< 0.001	< 0.001
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	< 0.001	< 0.001	0.001	< 0.001
Cobalt	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Copper	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Iron	mg/L	0.14	< 0.05	0.4	0.05
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Lithium	mg/L	0.016	0.026	0.003	0.002
Manganese	mg/L	0.054	0.009	0.008	0.005
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	0.002	< 0.001	< 0.001
Nickel	mg/L	< 0.001	< 0.001	0.001	< 0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	mg/L	0.533	0.492	0.044	0.022
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	0.01	< 0.005	< 0.005	< 0.005

Table 2 – Santos Groundwater Monitoring Infrastructure – Summary of Groundwater Analytical Data
Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

Type of Monitoring		SAMB	SAMB	SAMB	SAMB
Site ID		Dewhurst #14	Dewhurst #14	Dewhurst #14	Dewhurst #14
Bore ID		DWH14PRUPS01	DWH14PRLPS02	DWH14PRLPS02	DWH14PRLPS02
Sample ID		DW14PRUPS01_WG_201311070935	DWH14PRLPS02_GW_201310271415	DWH14PRLPS02_WG_201311090900	DWH14PRLPS02_WG_201311110745
Sample Date		7/11/2013	27/10/2013	9/11/2013	11/11/2013
Analyte	**Units**				
Physiochemical					
pH	pH Unit	5.63	7.49	6.16	6.11
Electrical Conductivity	µS/cm	192	187	193	181
Total Dissolved Solids @180 °C	mg/L	126	147	170	122
Dissolved Anions					
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	10	31	22	14
Total alkalinity as $CaCO_3$	mg/L	10	31	22	14
Residual alkalinity	meq/L	0.04	0.39	0.26	0.2
Chloride	mg/L	39	37	42	42
Sulphate as SO_4 2-	mg/L	< 1	< 1	< 1	< 1
Fluoride	mg/L	< 0.1	0.1	< 0.1	< 0.1
Dissolved Cations					
Calcium	mg/L	< 1	3	2	< 1
Magnesium	mg/L	2	1	1	1
Sodium	mg/L	25	36	29	27
Potassium	mg/L	7	6	5	5
Total hardness as $CaCO_3$	mg/L	8	12	9	4
Sodium absorption ratio (calc)	-	3.79	4.6	4.18	5.79
Ionic balance	%				
Dissolved Metals					
Aluminium	mg/L	< 0.01	0.08	0.01	0.02
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	< 0.001	0.002	0.002	0.004
Cobalt	mg/L	0.001	0.001	0.002	0.002
Copper	mg/L	0.036	< 0.001	0.004	0.003
Iron	mg/L	< 0.05	< 0.05	0.07	0.05
Lead	mg/L	0.002	< 0.001	0.001	< 0.001
Lithium	mg/L	0.005	0.005	0.004	0.003
Manganese	mg/L	0.007	0.03	0.038	0.011
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.003	0.002	0.002	0.002
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	mg/L	0.019	0.045	0.031	0.02
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	0.121	< 0.005	0.029	0.011

Table 2 – Santos Groundwater Monitoring Infrastructure – Summary of Groundwater Analytical Data

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Type of Monitoring	SAMB	SAMB	SAMB	SAMB
	Site ID	Dewhurst #14	Dewhurst #14	Dewhurst #14	Dewhurst #14
	Bore ID	DWH14PRLPS02	DWH14PRPUR03	DWH14PRUPS01	DWH14PRUPS01
	Sample ID	DWH14PRLPS02_WG_201320271415	DWH14PRPUR03_GW_201320291340	DWH14PRUPS01_WG_201310281605	DWH14PRUPS01_WG_201311061110
	Sample Date	27/10/2013	29/10/2013	28/10/2013	6/11/2013
Analyte	**Units**				
Physiochemical					
pH	pH Unit	7.49	9.57	9.49	5.8
Electrical Conductivity	µS/cm	187	700	236	193
Total Dissolved Solids @180 °C	mg/L	147	584	165	133
Dissolved Anions					
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	138	32	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	31	159	17	11
Total alkalinity as $CaCO_3$	mg/L	31	296	49	11
Residual alkalinity	meq/L	0.39	5.88	0.81	0.06
Chloride	mg/L	37	32	41	40
Sulphate as SO_4 2-	mg/L	< 1	20	< 1	< 1
Fluoride	mg/L	0.1	0.4	< 0.1	< 0.1
Dissolved Cations					
Calcium	mg/L	3	1	< 1	< 1
Magnesium	mg/L	1	< 1	2	2
Sodium	mg/L	36	98	34	26
Potassium	mg/L	6	30	8	7
Total hardness as $CaCO_3$	mg/L	12	2	8	8
Sodium absorption ratio (calc)	-	4.6	27	5.15	3.94
Ionic balance	%		17.5		
Dissolved Metals					
Aluminium	mg/L	0.08	0.81	0.09	0.03
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	0.11	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.002	0.002	< 0.001	< 0.001
Cobalt	mg/L	0.001	< 0.001	0.002	0.001
Copper	mg/L	< 0.001	< 0.001	< 0.001	0.017
Iron	mg/L	< 0.05	0.71	< 0.05	< 0.05
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Lithium	mg/L	0.005	0.034	0.006	0.005
Manganese	mg/L	0.03	0.012	0.013	0.028
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	0.075	< 0.001	< 0.001
Nickel	mg/L	0.002	< 0.001	0.002	0.004
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	mg/L	0.045	0.075	0.075	0.047
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	< 0.005	0.01	< 0.005	0.15

Table 2 – Santos Groundwater Monitoring Infrastructure – Summary of Groundwater Analytical Data

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Type of Monitoring	SAMB	SAMB	SAMB	SAMB	SAMB
	Site ID	Dewhurst #14	Dewhurst #14	Nyora	Nyora	Nyora
	Bore ID	DWH14PRUPS01	DWH3PRUPS01	NYOPRORA01	NYOPRORA01	NYOPRORA01
	Sample ID	DWH14PRUPS01_WG_201311070935	DWH3PRUPS01_GW_201310021510	NYOPRORA01_WG_201311301500	NYOPRORA01_WG_201312040750	NYOPRORA01_WG_201312040940
	Sample Date	7/11/2013	2/10/2013	30/11/2013	4/12/2013	4/12/2013
Analyte	**Units**					
Physiochemical						
pH	pH Unit	5.63	9.31	8.46	8.57	8.44
Electrical Conductivity	µS/cm	192	721	1360	1340	1310
Total Dissolved Solids @180 °C	mg/L	126	92	682	826	802
Dissolved Anions						
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	89	28	40
Bicarbonate alkalinity as $CaCO_3$	mg/L	10	10	420	594	572
Total alkalinity as $CaCO_3$	mg/L	10	10	509	622	612
Residual alkalinity	meq/L	0.04	0.2	11.1	11.4	11
Chloride	mg/L	39	22	56	58	57
Sulphate as SO_4 2-	mg/L	< 1	2	1	< 1	< 1
Fluoride	mg/L	< 0.1	< 0.1	1.1	1	1
Dissolved Cations						
Calcium	mg/L	< 1	< 1	9	4	6
Magnesium	mg/L	2	< 1	4	1	1
Sodium	mg/L	25	20	266	342	335
Potassium	mg/L	7	2	12	2	6
Total hardness as $CaCO_3$	mg/L	8	< 1	39	14	19
Sodium absorption ratio (calc)	-	3.79		18.5	39.6	33.3
Ionic balance	%			3.57	3.85	4.33
Dissolved Metals						
Aluminium	mg/L	< 0.01	0.07	0.02	0.08	0.03
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.001
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	0.29	0.3	0.28
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	< 0.001	< 0.001	0.002	< 0.001	0.002
Cobalt	mg/L	0.001	0.002	< 0.001	< 0.001	< 0.001
Copper	mg/L	0.036	< 0.001	< 0.001	0.008	0.004
Iron	mg/L	< 0.05	< 0.05	< 0.05	0.07	< 0.05
Lead	mg/L	0.002	< 0.001	< 0.001	0.001	< 0.001
Lithium	mg/L	0.005	0.002	0.044	0.035	0.042
Manganese	mg/L	0.007	0.008	0.003	0.029	0.016
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	0.003	0.002	0.003
Nickel	mg/L	0.003	0.002	< 0.001	0.003	0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	mg/L	0.019	0.014	0.136	0.159	0.168
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	0.121	0.006	0.008	0.066	0.013

Table 2 – Santos Groundwater Monitoring Infrastructure – Summary of Groundwater Analytical Data

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Type of Monitoring	SAMB	SAMB	SAMB	Bohena Creek In-Stream	Bohena Creek In-Stream
	Site ID	Nyora	Nyora	Nyora	Bohena Creek MW-1	Bohena Creek MW-1
	Bore ID	NYOPRORA01	NYOPRUPS02	NYOPRUPS02	BHNCKMW1	BHNCKMW1
	Sample ID	NYOPRORA01_WG_201312060800	NYOPRUPS02_WG_201312011130	NYOPRUPS02_WG_201312080700	BHNCKMW1_WG_201307171305	BHNCKMW1_WG_201310250845
	Sample Date	6/12/2013	1/12/2013	8/12/2013	17/07/2013	25/10/2013
Analyte	**Units**					
Physiochemical						
pH	pH Unit	11.9	8.56	8.27	6.6	6.74
Electrical Conductivity	µS/cm	2020	1270	1320	200	207
Total Dissolved Solids @180 °C	mg/L	744	785	728	108	159
Dissolved Anions						
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	18	43	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	540	562	555	42	50
Total alkalinity as $CaCO_3$	mg/L	558	605	555	42	50
Residual alkalinity	meq/L	0.03	0.01	0.44	-0.09	0.07
Chloride	mg/L	58	61	57	28	34
Sulphate as SO_4 2-	mg/L	< 1	< 1	< 1	< 1	< 1
Fluoride	mg/L	0.9	0.9	0.9	0.1	0.1
Dissolved Cations						
Calcium	mg/L	1	4	1	7	7
Magnesium	mg/L	< 1	< 1	< 1	7	7
Sodium	mg/L	310	352	314	16	14
Potassium	mg/L	3	2	2	2	2
Total hardness as $CaCO_3$	mg/L	2	10	2	46	46
Sodium absorption ratio (calc)	-	85.3	48.4	86.4	1.02	0.9
Ionic balance	%	3.06	5.02	3.95		
Dissolved Metals						
Aluminium	mg/L	0.05	0.03	0.03	0.01	< 0.01
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.001
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	0.22	0.23	0.22	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	< 0.001	< 0.001	< 0.001	0.006	0.006
Copper	mg/L	0.001	< 0.001	0.002	< 0.001	< 0.001
Iron	mg/L	< 0.05	< 0.05	< 0.05	7.2	12
Lead	mg/L	< 0.001	< 0.001	0.001	< 0.001	< 0.001
Lithium	mg/L	0.034	0.032	0.03	< 0.001	< 0.001
Manganese	mg/L	0.009	0.001	0.002	0.478	0.543
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	0.002	0.002	0.001	< 0.001	< 0.001
Nickel	mg/L	< 0.001	< 0.001	< 0.001	0.004	0.003
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	mg/L	0.11	0.06	0.103	0.142	0.163
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	0.014	0.009	0.013	0.02	0.223

Table 2 – Santos Groundwater Monitoring Infrastructure – Summary of Groundwater Analytical Data

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Type of Monitoring	Bohena Creek In-Stream	Bohena Creek In-Stream	Bohena Creek In-Stream	Bohena Creek In-Stream	Bohena Creek In-Stream
	Site ID	Bohena Creek MW-2	Bohena Creek MW-2	Bohena Creek MW-3	Bohena Creek MW-3	Bohena Creek MW-4
	Bore ID	BHNCKMW2	BHNCKMW2	BHNCKMW3	BHNCKMW3	BHNCKMW4
	Sample ID	BHNCKMW2_WG_201307171550	BHNCKMW2_WG_201310251100	BHNCKMW3_WG_201307171115	BHNCKMW3_WG_201310251245	BHNCKMW4_WG_201307171710
	Sample Date	17/07/2013	25/10/2013	17/07/2013	25/10/2013	17/07/2013
Analyte	**Units**					
Physiochemical						
pH	pH Unit	6.62	6.42	6.23	6.41	6.74
Electrical Conductivity	µS/cm	171	137	186	146	236
Total Dissolved Solids @180 °C	mg/L	5630	300	333	166	172
Dissolved Anions						
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	52	40	54	41	56
Total alkalinity as $CaCO_3$	mg/L	52	40	54	41	56
Residual alkalinity	meq/L	0.38	0.4	0.39	0.34	0.16
Chloride	mg/L	18	20	20	20	32
Sulphate as SO_4 2-	mg/L	2	< 1	< 1	< 1	< 1
Fluoride	mg/L	< 0.1	< 0.1	< 0.1	0.1	< 0.1
Dissolved Cations						
Calcium	mg/L	5	3	4	3	6
Magnesium	mg/L	5	3	6	4	8
Sodium	mg/L	18	12	22	16	31
Potassium	mg/L	3	2	2	1	3
Total hardness as $CaCO_3$	mg/L	33	20	35	24	48
Sodium absorption ratio (calc)	-	1.36	1.17	1.62	1.42	1.95
Ionic balance	%					
Dissolved Metals						
Aluminium	mg/L	0.24	0.03	0.09	0.01	0.14
Arsenic	mg/L	0.002	0.001	0.003	0.002	0.002
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	< 0.001	< 0.001	0.001	< 0.001	< 0.001
Cobalt	mg/L	0.002	0.002	0.008	0.004	0.004
Copper	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Iron	mg/L	16.2	10.6	29.8	15.2	11.8
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Lithium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Manganese	mg/L	0.554	0.485	0.466	0.188	0.82
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.003	0.003	0.01	0.008	0.004
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	mg/L	0.099	0.093	0.09	0.073	0.129
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	0.01	< 0.01	< 0.01
Zinc	mg/L	0.024	0.232	0.013	0.115	0.009

Table 2 – Santos Groundwater Monitoring Infrastructure – Summary of Groundwater Analytical Data

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

Type of Monitoring		Bohena Creek In-Stream	Supply Bore	Supply Bore	Supply Bore	Supply Bore
Site ID		Bohena Creek MW-4	Bibblewindi MW-1	Bibblewindi 5	Leewood 4	Leewood 4
Bore ID		BHNCKMW4	BWDMW1	BWDMW5	LEEGWUPS04	LEEGWUPS04
Sample ID		BHNCKMW4_WG_201310221414	BWDMW1_WG_201310231130	BWDMW5_WG_201310231004	LEEGWUPS04_GW_201307190845	LEEGWUPS04_GW_201307191100
Sample Date		22/10/2013	23/10/2013	23/10/2013	19/07/2013	19/07/2013
Analyte	**Units**					
Physiochemical						
pH	pH Unit	6.68	5.79	5.6	6.83	6.75
Electrical Conductivity	µS/cm	290	124	124	239	235
Total Dissolved Solids @180 °C	mg/L	185	86	89	144	147
Dissolved Anions						
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	88	6	7	45	44
Total alkalinity as $CaCO_3$	mg/L	88	6	7	45	44
Residual alkalinity	meq/L	0.62	0.04	0.06	0.4	0.46
Chloride	mg/L	35	31	30	37	37
Sulphate as SO_4 2-	mg/L	< 1	< 1	2	2	2
Fluoride	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Dissolved Cations						
Calcium	mg/L	8	< 1	< 1	4	3
Magnesium	mg/L	9	1	1	4	4
Sodium	mg/L	27	17	16	20	19
Potassium	mg/L	3	5	5	21	21
Total hardness as $CaCO_3$	mg/L	57	4	4	26	24
Sodium absorption ratio (calc)	-	1.56	3.64	3.43	1.69	1.69
Ionic balance	%					
Dissolved Metals						
Aluminium	mg/L	0.06	< 0.01	< 0.01	0.02	0.03
Arsenic	mg/L	0.001	0.001	< 0.001	< 0.001	< 0.001
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	< 0.001	0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	0.002	0.002	0.001	0.001	< 0.001
Copper	mg/L	< 0.001	0.001	0.004	< 0.001	< 0.001
Iron	mg/L	8.64	< 0.05	< 0.05	6.78	7.44
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Lithium	mg/L	< 0.001	0.003	0.003	0.007	0.007
Manganese	mg/L	0.629	< 0.001	0.003	0.275	0.273
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.003	0.015	0.033	0.005	0.003
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	mg/L	0.112	0.016	0.019	0.093	0.093
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	0.327	0.008	0.012	0.079	0.039

Table 2 – Santos Groundwater Monitoring Infrastructure – Summary of Groundwater Analytical Data
Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Type of Monitoring	Supply Bore	Supply Bore
	Site ID	Leewood 4	Leewood 4
	Bore ID	LEEGWUPS04	LEEGWUPS04
	Sample ID	LEEGWUPS04_GW_201307201430	LEEGWUPS04_WG_201310230842
	Sample Date	20/07/2013	23/10/2013
Analyte	**Units**		
Physiochemical			
pH	pH Unit	6.87	6.71
Electrical Conductivity	µS/cm	238	234
Total Dissolved Solids @180 °C	mg/L	145	145
Dissolved Anions			
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	47	66
Total alkalinity as $CaCO_3$	mg/L	47	66
Residual alkalinity	meq/L	0.84	0.05
Chloride	mg/L	38	34
Sulphate as SO_4 2-	mg/L	2	3
Fluoride	mg/L	< 0.1	< 0.1
Dissolved Cations			
Calcium	mg/L	3	3
Magnesium	mg/L	4	4
Sodium	mg/L	19	18
Potassium	mg/L	21	18
Total hardness as $CaCO_3$	mg/L	24	24
Sodium absorption ratio (calc)	-	1.69	1.6
Ionic balance	%		
Dissolved Metals			
Aluminium	mg/L	< 0.01	< 0.01
Arsenic	mg/L	< 0.001	< 0.001
Beryllium	mg/L	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001
Chromium	mg/L	< 0.001	< 0.001
Cobalt	mg/L	< 0.001	< 0.001
Copper	mg/L	< 0.001	< 0.001
Iron	mg/L	8.04	8.51
Lead	mg/L	< 0.001	< 0.001
Lithium	mg/L	0.007	0.008
Manganese	mg/L	0.272	0.301
Mercury	mg/L	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001
Nickel	mg/L	0.003	0.006
Selenium	mg/L	< 0.01	< 0.01
Strontium	mg/L	0.093	0.096
Tin	mg/L	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01
Zinc	mg/L	0.018	0.018

Table 3 – Private Landholder Bores – Groundwater Analytical Data Summary Statistics
Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

Analyte	Units	Minimum	Mean	Maximum	Number of Samples
Physiochemical					
pH	pH Unit	5.5	7.56	8.65	53
Electrical Conductivity	µS/cm	50	1103.45	6240	53
Total Dissolved Solids @180 °C	mg/L	62	672.55	3440	53
Dissolved Anions					
Hydroxide alkalinity as $CaCO_3$	mg/L	ND	ND	ND	53
Carbonate alkalinity as $CaCO_3$	mg/L	15	28.88	46	53
Bicarbonate alkalinity as $CaCO_3$	mg/L	6	333.23	1010	53
Total alkalinity as $CaCO_3$	mg/L	6	337.60	1010	53
Residual alkalinity	meq/L	-0.04	6.09	17.8	53
Chloride	mg/L	4	146.68	1600	53
Sulphate as SO_4 2-	mg/L	1	22.63	86	30
Fluoride	mg/L	0.1	0.60	1.5	42
Dissolved Cations					
Calcium	mg/L	1	10.86	42	43
Magnesium	mg/L	1	6.29	45	48
Sodium	mg/L	5	226.19	1260	53
Potassium	mg/L	1	14.09	382	53
Total hardness as $CaCO_3$	mg/L	5	47.27	258	49
Sodium absorption ratio (calc)	-	1.31	17.58	56.6	51
Ionic balance	%	0.26	2.57	4.97	41
DISSOLVED Metals (by ICP / MS)					
Aluminium	mg/L	0.01	0.16	0.45	53
Arsenic	mg/L	0.001	0.00	0.018	53
Barium	mg/L	0.006	0.13	0.463	53
Beryllium	mg/L	ND	ND	ND	53
Boron	mg/L	0.06	0.18	0.3	53
Cadmium	mg/L	ND	ND	ND	53
Chromium	mg/L	0.001	0.00	0.001	53
Cobalt	mg/L	0.001	0.00	0.003	53
Copper	mg/L	0.001	0.00	0.023	53
Iron	mg/L	0.05	0.66	8.67	53
Lead	mg/L	ND	ND	ND	53
Lithium	mg/L	0.001	0.01	0.036	53
Manganese	mg/L	0.001	0.03	0.318	53
Mercury	mg/L	ND	ND	ND	53
Molybdenum	mg/L	0.001	0.00	0.005	53
Nickel	mg/L	0.001	0.00	0.003	53
Selenium	mg/L	ND	ND	ND	53
Strontium	mg/L	0.002	0.15	0.794	53
Tin	mg/L	ND	ND	ND	53
Uranium	mg/L	0.001	0.00	0.006	53
Vanadium	mg/L	0.01	0.02	0.04	53
Zinc	mg/L	0.005	0.05	0.691	53

Table 4 – Private Landholder Bores – Summary of Groundwater Analytical Data

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample Date	24/05/2012	24/05/2012	28/05/2012	25/05/2012	25/05/2012	25/05/2012	28/05/2012	28/06/2012	20/06/2012	21/06/2012	21/06/2012	21/06/2012
Analyte	**Units**												
Physiochemical													
pH	pH Unit	8.65	8.61	8.13	7.83	7.6	7.99	8.29	8.14	7.93	7.7	7.96	7.97
Electrical Conductivity	µS/cm	1260	1280	954	2980	1140	471	1240	2500	3650	3510	1950	2360
Total Dissolved Solids @180 °C	mg/L	771	779	584	1800	761	337	799	1530	2260	2240	1250	1500
Dissolved Anions													
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	46	40	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	563	568	429	432	327	222	596	1010	984	930	887	934
Total alkalinity as $CaCO_3$	mg/L	608	609	429	432	327	222	596	1010	984	930	887	934
Residual alkalinity	meq/L	11.8	6.86	6.24	5.11	1.83	11.4	17.8	15.7	13.7	16.9	17.2	13.3
Chloride	mg/L	53	55	52	721	175	25	55	246	623	633	124	240
Sulphate as SO_4 2-	mg/L	12	7	< 1	57	37	< 1	< 1	39	83	60	8	45
Fluoride	mg/L	1	1	0.6	0.6	0.4	< 0.1	1	1	1.1	0.5	1.4	1.5
Dissolved Cations													
Calcium	mg/L	4	4	26	20	12	39	6	20	30	42	6	12
Magnesium	mg/L	2	2	5	17	10	8	2	17	30	34	6	11
Sodium	mg/L	296	302	202	586	220	54	321	532	760	684	445	522
Potassium	mg/L	2	1	6	12	8	6	2	12	16	12	8	9
Total hardness as $CaCO_3$	mg/L	18	18	86	120	71	130	23	120	198	245	40	75
Sodium absorption ratio (calc)	-	30.2	30.8	9.5	23.3	11.3	2.06	29	21.2	23.3	19	29.9	25.9
Ionic balance	%	2.28	1.3	2.9	3.39	4.5	0.34	3.58	3.93	2.04	3.8	2.53	3.85
Dissolved Metals													
Aluminium	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.001	0.002	0.004	0.003
Barium	mg/L	0.204	0.178	0.163	0.082	0.099	0.249	0.072	0.3	0.215	0.179	0.048	0.044
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	0.24	0.24	0.14	0.08	< 0.05	< 0.05	0.24	0.24	0.2	0.15	0.25	0.18
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001
Copper	mg/L	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001	0.006	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Iron	mg/L	0.2	0.09	0.05	1.02	0.23	0.14	0.08	< 0.05	< 0.05	< 0.05	< 0.05	0.06
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Lithium	mg/L	0.035	0.033	0.036	< 0.001	< 0.001	0.026	0.03	0.004	0.004	0.004	0.003	0.002
Manganese	mg/L	0.002	< 0.001	0.004	0.03	0.013	0.045	0.002	< 0.001	0.158	< 0.001	< 0.001	0.004
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	0.003	0.002	0.001	0.005	0.005
Nickel	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	mg/L	0.208	0.213	0.186	0.488	0.215	0.27	0.083	0.367	0.583	0.794	0.191	0.266
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	0.001	0.005	0.006	< 0.001	0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	0.03	0.02	0.03	0.04	0.04
Zinc	mg/L	< 0.005	< 0.005	0.018	0.006	0.007	0.006	< 0.005	0.006	0.166	0.006	< 0.005	0.03

Table 4 – Private Landholder Bores – Summary of Groundwater Analytical Data

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample Date	28/06/2012	29/06/2012	29/06/2012	17/10/2012	18/10/2012	15/10/2012	20/08/2012	5/02/2013	5/02/2013	6/02/2013	6/02/2013	6/02/2013
Analyte	**Units**												
Physiochemical													
pH	pH Unit	8.49	8.49	8.55	5.89	6.04	8.61	7.65	6.8	7.25	7.73	6.02	5.88
Electrical Conductivity	µS/cm	1610	1350	1110	128	129	3680	101	399	343	454	183	168
Total Dissolved Solids @180 °C	mg/L	1010	869	700	62	89	2310	98	260	224	320	141	125
Dissolved Anions													
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	28	30	33	< 1	< 1	24	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	655	654	538	6	6	212	30	155	120	195	12	12
Total alkalinity as $CaCO_3$	mg/L	683	684	572	6	6	236	30	155	120	195	12	12
Residual alkalinity	meq/L	13.2	11.3	-0.04	-0.04	3.11	0.34	0.83	1.64	2.42	-0.01	0.03	1.62
Chloride	mg/L	129	42	46	27	33	974	11	25	28	38	47	38
Sulphate as SO_4 2-	mg/L	36	< 1	< 1	< 1	< 1	< 1	< 1	9	< 1	3	< 1	1
Fluoride	mg/L	1	1.2	0.8	< 0.1	< 0.1	0.5	< 0.1	0.2	0.1	0.1	< 0.1	< 0.1
Dissolved Cations													
Calcium	mg/L	3	6	2	< 1	< 1	9	2	28	11	14	< 1	1
Magnesium	mg/L	2	2	< 1	2	2	14	2	14	5	6	3	2
Sodium	mg/L	384	322	264	17	14	461	12	34	39	86	26	27
Potassium	mg/L	5	3	1	5	5	382	4	2	18	6	7	4
Total hardness as $CaCO_3$	mg/L	16	23	5	8	8			128	48	60	12	11
Sodium absorption ratio (calc)	-	46.2	29.2	50.3	2.67	2.31	22.5	1.39	1.31	2.45	4.84	3.22	3.58
Ionic balance	%	2.59	1.1	4.66			1.18		1.1	1.13	0.52		
Dissolved Metals													
Aluminium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	0.05	0.01	0.45	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic	mg/L	0.018	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001
Barium	mg/L	0.077	0.085	0.049	0.076	0.103	0.463	0.006	0.043	0.188	0.25	0.124	0.042
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	0.3	0.18	0.13	< 0.05	< 0.05	0.08	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.002
Copper	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001
Iron	mg/L	< 0.05	0.07	< 0.05	< 0.05	< 0.05	0.21	0.87	< 0.05	0.67	< 0.05	< 0.05	< 0.05
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Lithium	mg/L	0.011	0.025	0.018	0.002	0.004	0.032	0.001	0.001	0.02	0.012	0.005	0.005
Manganese	mg/L	0.011	0.014	0.015	0.006	0.019	0.002	0.009	< 0.001	0.318	0.021	0.001	0.02
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	0.001	< 0.001	0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	< 0.001	< 0.001	< 0.001	0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.002
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	mg/L	0.074	0.098	0.084	0.013	0.019	0.169	0.025	0.356	0.114	0.175	0.02	0.018
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	0.008	< 0.005	< 0.005	0.007	0.033	0.006	< 0.005	0.006	< 0.005	< 0.005	0.014	0.009

Table 4 – Private Landholder Bores – Summary of Groundwater Analytical Data

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample Date	29/03/2012	6/02/2013	29/07/2013	29/07/2013	29/07/2013	30/07/2013	30/07/2013	31/07/2013	31/07/2013	31/07/2013	9/09/2013	9/09/2013
Analyte	**Units**												
Physiochemical													
pH	pH Unit	6.02	7.77	7.16	8.09	8.23	8.1	7.41	7.88	8.17	8.17	7.27	8.15
Electrical Conductivity	µS/cm	185	461	386	1280	1270	1300	6240	1680	1300	1300	314	494
Total Dissolved Solids @180 °C	mg/L	114	330	264	759	740	710	3440	1060	804	804	212	263
Dissolved Anions													
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	15	190	129	534	530	562	425	523	580	580	103	213
Total alkalinity as $CaCO_3$	mg/L	15	190	129	534	530	562	425	523	580	580	103	213
Residual alkalinity	meq/L	11.8	3.34	2.48	10.3	10.5	10.6	14.2	9.82	11.3	11.3	1.74	3.74
Chloride	mg/L	39	28	30	60	59	58	1600	205	58	58	30	23
Sulphate as SO_4 2-	mg/L	< 1	2	< 1	< 1	< 1	< 1	86	12	< 1	< 1	< 1	3
Fluoride	mg/L	< 0.1	< 0.1	0.2	0.9	1.1	0.8	0.5	0.9	1.1	1.1	0.1	0.1
Dissolved Cations													
Calcium	mg/L	< 1	32	2	4	2	5	29	6	4	4	3	7
Magnesium	mg/L	3	7	< 1	2	< 1	2	45	4	1	1	2	2
Sodium	mg/L	24	49	69	284	291	312	1260	391	328	328	53	105
Potassium	mg/L	5	9	17	8	4	9	39	12	3	3	14	3
Total hardness as $CaCO_3$	mg/L	12	109	5	18	5	21	258	31	14	14	16	26
Sodium absorption ratio (calc)	-	2.97	2.04	13.4	28.9	56.6	29.8	34.1	30.3	38	38	5.81	9.01
Ionic balance	%		1.03	1.57	2.16	2.35	4.93	4.74	4.19	4.97	4.97		1.83
Dissolved Metals													
Aluminium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.33	0.33	< 0.01	< 0.01
Arsenic	mg/L	< 0.001	< 0.001	0.001	< 0.001	0.003	< 0.001	< 0.001	0.005	< 0.001	< 0.001	< 0.001	< 0.001
Barium	mg/L	0.109	0.319	0.042	0.115	0.048	0.331	0.219	0.201	0.102	0.102	0.091	0.093
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	0.06	< 0.05	0.23	0.27	0.24	0.08	0.18	0.25	0.25	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Copper	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Iron	mg/L	< 0.05	0.16	0.9	0.08	0.08	0.08	0.11	< 0.05	0.15	0.15	8.67	0.16
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Lithium	mg/L	0.005	0.026	0.019	0.022	0.028	0.012	0.002	0.01	0.025	0.025	0.013	0.021
Manganese	mg/L	0.018	0.03	0.044	0.002	0.004	0.004	0.009	0.057	0.002	0.002	0.245	0.007
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	mg/L	0.018	0.313	0.03	0.071	0.043	0.138	0.663	0.145	0.099	0.099	0.058	0.168
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	0.007	0.031	< 0.005	< 0.005	< 0.005	0.005	0.007	< 0.005	< 0.005	< 0.005	0.012	< 0.005

Table 4 – Private Landholder Bores – Summary of Groundwater Analytical Data

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample Date	9/09/2013	10/09/2013	10/09/2013	10/09/2013	10/09/2013	10/09/2013	11/09/2013	11/09/2013	11/09/2013	11/09/2013	11/09/2013	11/09/2013
Analyte	**Units**												
Physiochemical													
pH	pH Unit	8.15	6.75	5.85	6.01	5.5	5.5	7.66	7.66	7.97	7.97	8.49	8.49
Electrical Conductivity	µS/cm	494	50	148	137	147	147	1490	1490	471	471	638	638
Total Dissolved Solids @180 °C	mg/L	263	78	104	100	100	100	780	780	262	262	364	364
Dissolved Anions													
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	15	15
Bicarbonate alkalinity as $CaCO_3$	mg/L	213	7	6	15	6	6	243	243	209	209	270	270
Total alkalinity as $CaCO_3$	mg/L	213	7	6	15	6	6	243	243	209	209	285	285
Residual alkalinity	meq/L	3.66	0.14	-0.04	0.14	-0.04	-0.04	4.46	4.46	3.2	3.2	5.41	5.25
Chloride	mg/L	23	4	37	28	38	38	281	281	24	24	30	30
Sulphate as SO_4 2-	mg/L	3	6	< 1	1	< 1	< 1	53	53	2	2	5	5
Fluoride	mg/L	0.1	< 0.1	0.1	< 0.1	0.1	0.1	0.8	0.8	0.1	0.1	0.2	0.2
Dissolved Cations													
Calcium	mg/L	7	< 1	< 1	< 1	< 1	< 1	3	3	13	13	4	4
Magnesium	mg/L	2	< 1	2	2	2	2	3	3	4	4	1	1
Sodium	mg/L	105	5	20	18	22	22	278	278	90	90	151	151
Potassium	mg/L	3	4	6	3	3	3	8	8	6	6	3	3
Total hardness as $CaCO_3$	mg/L	26	< 1	8	8	8	8	20	20	49	49	14	14
Sodium absorption ratio (calc)	-	9.01		3.03	2.73	3.34	3.34	27.1	27.1	5.6	5.6	17.5	17.5
Ionic balance	%	1.83					0.26	4.52	4.52	1.48	1.48	2.02	1.96
Dissolved Metals													
Aluminium	mg/L	< 0.01	0.04	< 0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Barium	mg/L	0.092	0.031	0.369	0.036	0.049	0.049	0.049	0.049	0.117	0.121	0.1	0.101
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.1	0.1	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	< 0.001	< 0.001	0.002	0.002	0.003	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Copper	mg/L	< 0.001	0.023	< 0.001	0.004	0.002	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Iron	mg/L	0.15	< 0.05	< 0.05	5	< 0.05	< 0.05	0.1	0.1	0.09	0.08	< 0.05	< 0.05
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Lithium	mg/L	0.021	0.001	0.005	0.002	0.002	0.002	0.003	0.003	0.021	0.021	0.008	0.008
Manganese	mg/L	0.007	0.023	0.002	0.06	0.002	0.002	0.044	0.044	0.015	0.016	0.012	0.012
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.002	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	< 0.001	< 0.001	0.003	0.001	0.002	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	mg/L	0.164	0.002	0.03	0.008	0.008	0.008	0.093	0.093	0.123	0.126	0.061	0.061
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	< 0.005	0.104	0.016	0.038	0.014	0.014	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

Table 4 – Private Landholder Bores – Summary of Groundwater Analytical Data

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample Date	11/09/2013	11/09/2013	12/09/2013	12/09/2013	19/11/2013
Analyte	**Units**					
Physiochemical						
pH	pH Unit	8.06	8.06	7.91	8.17	6.08
Electrical Conductivity	µS/cm	832	832	449	743	146
Total Dissolved Solids @180 ºC	mg/L	474	474	271	444	106
Dissolved Anions						
Hydroxide alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	298	298	179	316	12
Total alkalinity as $CaCO_3$	mg/L	298	298	179	316	12
Residual alkalinity	meq/L	5.64	5.48	3.09	5.42	0.24
Chloride	mg/L	70	70	24	47	37
Sulphate as SO_4 2-	mg/L	23	23	2	< 1	1
Fluoride	mg/L	0.8	0.8	0.1	0.1	< 0.1
Dissolved Cations						
Calcium	mg/L	3	3	6	13	< 1
Magnesium	mg/L	2	2	2	3	< 1
Sodium	mg/L	192	192	88	160	22
Potassium	mg/L	5	5	7	4	8
Total hardness as $CaCO_3$	mg/L	16	16	23	45	< 1
Sodium absorption ratio (calc)	-	21.1	21.1	7.94	10.4	
Ionic balance	%	1.99	1.99	1.96	1.99	
Dissolved Metals						
Aluminium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Barium	mg/L	0.104	0.104	0.155	0.19	0.137
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	0.07	0.07	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.001
Copper	mg/L	< 0.001	< 0.001	0.008	< 0.001	0.002
Iron	mg/L	< 0.05	< 0.05	0.07	0.2	0.44
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Lithium	mg/L	0.006	0.006	0.019	0.024	0.003
Manganese	mg/L	0.006	0.006	0.013	0.042	0.01
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	0.004	0.004	< 0.001	< 0.001	< 0.001
Nickel	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.002
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Strontium	mg/L	0.075	0.075	0.093	0.172	0.016
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	< 0.005	< 0.005	0.012	0.691	0.013

Table 5 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

Analyte	Units	Minimum	Mean	Maximum	Number of Samples
Physiochemical					
pH	pH Unit	6.01	7.83	9.41	265
Turbidity	NTU	2.4	146.48	7970	265
Electrical conductivity	µS/cm	19	369.44	3030	265
Total dissolved solids	mg/L	36	350.51	7020	265
BOD	mg/L	2	3.46	59	265
Dissolved Anions					
Hydroxide alkalinity as $CaCO_3$	mg/L	1	1.00	1	265
Carbonate alkalinity as $CaCO_3$	mg/L	1	4.72	357	265
Bicarbonate alkalinity as $CaCO_3$	mg/L	3	118.26	928	265
Total alkalinity as $CaCO_3$	mg/L	3	122.06	1280	265
Residual alkalinity	meq/L	-1.57	0.57	22.2	265
Chloride	mg/L	2	31.79	298	267
Sulphate as SO_4 2-	mg/L	1	16.17	127	266
Fluoride	mg/L	0.1	0.19	2.7	263
Dissolved Cations					
Calcium	mg/L	1	18.44	59	267
Magnesium	mg/L	1	11.45	40	267
Sodium	mg/L	1	38.89	714	267
Potassium	mg/L	1	5.21	48	267
Sodium absorption ratio (calc)	-	0.01	2.13	24.2	263
Dissolved Metals					
Aluminium	mg/L	0.02	0.49	20.1	267
Arsenic	mg/L	0.001	0.00	0.016	267
Barium	mg/L	0.001	0.04	0.472	267
Beryllium	mg/L	ND	ND	ND	267
Boron	mg/L	0.05	0.05	0.4	267
Cadmium	mg/L	0.0001	0.00	0.0006	267
Chromium	mg/L	0.001	0.00	0.014	267
Cobalt	mg/L	0.001	0.00	0.02	267
Copper	mg/L	0.001	0.00	0.011	267
Iron	mg/L	0.05	0.67	17.4	267
Lead	mg/L	0.001	0.00	0.305	267
Lithium	mg/L	0.001	0.00	0.032	267
Manganese	mg/L	0.001	0.08	2.63	267
Mercury	mg/L	ND	ND	ND	267
Molybdenum	mg/L	0.001	0.00	0.019	267
Nickel	mg/L	0.001	0.00	0.016	267
Selenium	mg/L	0.01	0.01	0.01	267
Silver	mg/L	0.001	0.00	0.001	267
Strontium	mg/L	0.001	0.20	0.58	267
Tin	mg/L	ND	ND	ND	267
Uranium	mg/L	ND	ND	ND	267
Vanadium	mg/L	0.01	0.01	0.04	267
Zinc	mg/L	0.005	0.01	0.104	267

Table 5 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

Analyte	Units	Minimum	Mean	Maximum	Number of Samples
Total Metals					
Aluminium	mg/L	0.01	6.66	275	266
Arsenic	mg/L	0.001	0.00	0.034	266
Barium	mg/L	0.009	0.17	23.3	266
Beryllium	mg/L	0.001	0.00	0.014	266
Boron	mg/L	0.05	0.09	0.4	40
Cadmium	mg/L	0.0001	0.00	0.0002	266
Chromium	mg/L	0.001	0.01	0.244	266
Cobalt	mg/L	0.001	0.01	0.116	266
Copper	mg/L	0.001	0.01	0.084	266
Iron	mg/L	0.05	7.82	289	266
Lead	mg/L	0.001	0.01	0.138	266
Lithium	mg/L	0.001	0.00	0.148	266
Manganese	mg/L	0.003	0.23	3.09	266
Mercury	mg/L	0.0001	0.00	0.0001	266
Molybdenum	mg/L	0.001	0.00	0.022	266
Nickel	mg/L	0.001	0.01	0.127	266
Selenium	mg/L	0.01	0.01	0.01	266
Silver	mg/L	0.001	0.00	0.001	266
Strontium	mg/L	0.002	0.23	1.16	266
Tin	mg/L	0.001	0.00	0.006	266
Uranium	mg/L	0.001	0.00	0.004	266
Vanadium	mg/L	0.01	0.03	0.33	266
Zinc	mg/L	0.005	0.03	0.312	266

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7500_SURF_W	NAR_7501_SURF_W	NAR_7502_SURF_W	NAR_7502_SURF_W	NAR_7502_SURF_W	NAR_7502_SURF_W	NAR_7502_SURF_W	NAR_7502_SURF_W	NAR_7502_SURF_W	NAR_7502_SURF_W	NAR_7502_SURF_W	NAR_7502_SURF_W	NAR_7502_SURF_W
Surface Water Body Location		Tributary upstream of Bibblewindi WTF	Tributary downstream of Bibblewindi WTF	Yarrie Lake Road Industrial Area	Yarrie Lake Road Industrial Area	Yarrie Lake Road Industrial Area	Yarrie Lake Road Industrial Area	Yarrie Lake Road Industrial Area	Yarrie Lake Road Industrial Area	Yarrie Lake Road Industrial Area	Yarrie Lake Road Industrial Area	Yarrie Lake Road Industrial Area	Yarrie Lake Road Industrial Area	Yarrie Lake Road Industrial Area
Stream Type				Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral
Land Use				Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing
Lab Sample ID		EB1205164003	EB1205164005	EB1205164006	EB1207610002	ES1209204003	ES1212312002	ES1214897003	ES1217889004	ES1220549001	ES1222707001	ES1225490001	ES1227820001	ES1229332009
Sample Date		24/02/2012	24/02/2012	21/02/2012	20/03/2012	18/04/2012	16/05/2012	14/06/2012	19/07/2012	22/08/2012	19/09/2012	24/10/2012	22/11/2012	11/12/2012
Sample Time		9:13	9:13	8:00	15:58	16:37	11:32	12:43	12:23	16:30	16:20	16:30	8:30	16:13
Analyte	**Units**													
Physiochemical														
pH	pH Unit	7.02	7.55	7.47	8.39	7.48	7.99	8.09	6.94	7.89	8.39	8.11	8.36	8.92
Turbidity	NTU	203	709	71	74	196	77.3	121	208	254	263	215	70.8	118
Electrical conductivity	µS/cm	124	272	248	772	510	819	833	67	414	990	1300	1890	2880
Total dissolved solids	mg/L	480	1980	201	545	314	512	616	332	578	806	964	1180	1840
BOD	mg/L	2	2	12	4	15	7	7	2	4	11	9	5	13
Dissolved Anions														
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	11	< 1	< 1	< 1	< 1	< 1	10	< 1	18	198
Bicarbonate alkalinity as $CaCO_3$	mg/L	12	99	92	315	141	298	367	14	125	261	385	592	778
Total alkalinity as $CaCO_3$	mg/L	12	99	92	325	141	298	367	14	125	272	385	610	976
Residual alkalinity	meq/L	0.08	1.85	0.88	5.19	1.63	4.81	5.64	0.2	1.87	4.52	6.02	9.97	16.6
Chloride	mg/L	24	31	14	39	36	62	69	12	34	101	127	188	298
Sulphate as SO_4 2-	mg/L	9	14	11	1	50	23	19	4	31	56	92	101	127
Fluoride	mg/L	0.1	0.1	0.1	0.6	0.3	0.5	0.4	0.1	0.2	0.5	0.8	0.9	1.6
Dissolved Cations														
Calcium	mg/L	< 1	1	11	15	14	13	14	< 1	6	8	17	23	31
Magnesium	mg/L	2	1	5	7	6	6	6	1	4	6	10	13	17
Sodium	mg/L	22	65	30	146	74	156	186	9	75	196	279	425	659
Potassium	mg/L	3	4	10	14	14	21	21	3	10	16	23	29	39
Sodium absorption ratio (calc)	-	3.34	11	1.88	7.8	4.17	8.98	10.5	1.72	5.82	12.8	13.3	17.7	23.6
Dissolved Metals														
Aluminium	mg/L	0.79	5.87	0.71	0.33	1.76	0.13	0.26	0.5	0.48	0.18	0.03	<0.01	0.03
Arsenic	mg/L	0.001	0.001	0.004	0.004	0.004	0.004	< 0.001	< 0.001	< 0.001	0.003	0.004	0.008	0.015
Barium	mg/L	0.025	0.472	0.089	0.11	0.164	0.052	0.057	0.038	0.071	0.078	0.082	0.128	0.17
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.09	0.05	0.05	0.06	0.05	0.05	0.07	0.25	0.17	0.24
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0005	< 0.0001
Chromium (III)	mg/L	0.012	0.007	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.002	0.002	0.003	0.001	0.006	0.002	0.001	0.001	0.001	0.001	0.002	0.001	0.002
Copper	mg/L	0.003	0.007	0.003	0.001	0.009	0.003	0.001	0.001	0.002	0.002	0.002	0.001	0.002
Iron (total)	mg/L	7.52	3.76	0.83	0.73	2.81	0.36	0.25	0.91	1.2	0.2	0.1	0.05	0.05
Lead	mg/L	0.002	0.001	0.001	0.001	0.004	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Lithium	mg/L	0.004	0.003	0.002	0.008	0.004	0.001	0.01	0.002	0.004	0.006	0.012	0.009	0.009
Manganese	mg/L	0.011	0.013	0.415	0.142	0.548	0.08	0.114	0.009	0.022	0.046	0.139	0.144	0.024
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	0.002	0.004	0.002	0.003	0.002	< 0.001	0.001	0.003	0.008	0.009	0.018
Nickel	mg/L	0.005	0.006	0.006	0.004	0.011	0.007	0.003	0.002	0.003	0.003	0.006	0.006	0.009
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.015	0.023	0.116	0.158	0.185	0.136	0.152	0.014	0.064	0.119	0.17	0.246	0.376
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.04
Zinc	mg/L	0.006	< 0.005	0.012	0.018	0.052	0.037	< 0.005	0.008	0.012	0.007	0.005	0.005	< 0.005
Total Metals														
Aluminium	mg/L	17.1	44.4	3.14	1.64	7.87	1.82	7.72	3.93	14	13.8	10.8	2.72	4.95
Arsenic	mg/L	< 0.001	0.004	0.004	0.005	0.004	0.005	0.002	0.001	0.002	0.006	0.006	0.009	0.014
Barium	mg/L	23.3	0.583	0.147	0.191	0.177	0.114	0.125	0.142	0.192	0.278	0.267	0.174	0.278
Beryllium	mg/L	< 0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	0.1	0.05	< 0.05	0.07	< 0.05	< 0.05	0.08	0.12	0.2	0.24
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.012	0.052	0.004	0.002	0.009	0.002	0.008	0.004	0.013	0.017	0.012	0.003	0.005
Cobalt	mg/L	0.003	0.032	0.005	0.002	0.008	0.003	0.004	0.002	0.004	0.007	0.005	0.002	0.004
Copper	mg/L	0.003	0.021	0.008	0.003	0.011	0.006	0.005	0.005	0.011	0.011	0.008	0.004	0.006
Iron	mg/L	9.9	46.2	4.78	3.21	8.46	2.79	8.06	3	14.6	18.2	12	2.73	4.54
Lead	mg/L	0.004	0.022	0.002	0.003	0.005	0.003	0.003	0.003	0.007	0.011	0.007	0.006	0.005
Lithium	mg/L	0.004	0.026	0.003	0.008	0.006	0.011	0.013	0.004	0.008	0.013	0.014	0.01	0.01
Manganese	mg/L	0.045	0.454	0.516	0.236	0.564	0.154	0.191	0.048	0.161	0.369	0.31	0.242	0.399
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	0.003	0.005	0.003	0.004	0.003	< 0.001	0.001	0.003	0.007	0.011	0.02
Nickel	mg/L	0.004	0.027	0.01	0.006	0.014	0.008	0.008	0.002	0.01	0.013	0.013	0.008	0.013
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.019	0.098	0.134	0.175	0.198	0.156	0.168	0.036	0.09	0.162	0.191	0.316	0.408
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.003
Vanadium	mg/L	0.02	0.08	0.02	0.01	0.02	0.01	0.02	0.01	0.03	0.04	0.02	0.02	0.05
Zinc	mg/L	0.007	0.044	0.041	0.019	0.053	0.085	0.032	0.015	0.045	0.065	0.052	0.014	0.024

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics
Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7502_SURF_W	NAR_7502_SURF_W	NAR_7503_SURF_W	NAR_7503_SURF_W	NAR_7503_SURF_W	NAR_7503_SURF_W	NAR_7503_SURF_W	NAR_7503_SURF_W	NAR_7503_SURF_W	NAR_7503_SURF_W	NAR_7503_SURF_W	NAR_7503_SURF_W	NAR_7503_SURF_W	NAR_7503_SURF_W
Surface Water Body Location		Yarrie Lake Road Industrial Area	Yarrie Lake Road Industrial Area	Narrabri Lake	Narrabri Lake	Narrabri Lake	Narrabri Lake	Narrabri Lake	Narrabri Lake	Narrabri Lake	Narrabri Lake	Narrabri Lake	Narrabri Lake	Narrabri Lake	Narrabri Lake
	Stream Type	Ephemeral	Ephemeral	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial
	Land Use	Grazing	Grazing	Urban	Urban	Urban	Urban	Urban	Urban	Urban	Urban	Urban	Urban	Urban	Urban
	Lab Sample ID	ES1300648001	ES1303496005	EB1205164007	EB1207610001	ES1209055005	ES1212312001	ES1214897008	ES1217889005	ES1220549002	ES1222707002	ES1225490004	ES1227820002	ES1229424004	ES1300408002
	Sample Date	9/01/2013	14/02/2013	21/02/2012	20/03/2012	16/04/2012	16/05/2012	14/06/2012	19/07/2012	22/08/2012	19/09/2012	25/10/2012	22/11/2012	12/12/2012	8/01/2013
	Sample Time	16:15	14:37	8:25	15:58	16:23	11:32	12:43	12:23	17:15	17:20	12:26	9:05	11:03	13:01
Analyte	**Units**														
Physiochemical															
pH	pH Unit	9.15	8.15	7.42	7.42	7.51	7.34	7.61	7.35	7.47	7.67	7.63	7.58	7.78	7.75
Turbidity	NTU	22.9	46.5	58	89	99.8	141	178	127	177	233	333	863	1420	2850
Electrical conductivity	µS/cm	3030	1080	77	88	96	118	132	105	121	153	169	203	231	357
Total dissolved solids	mg/L	2170	690	90	123	132	150	257	258	303	336	474	736	1280	2640
BOD	mg/L	17	3	2	2	4	3	4	2	2	2	4	4	2	6
Dissolved Anions															
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	357	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	928	435	34	38	42	47	53	37	42	46	55	68	74	101
Total alkalinity as $CaCO_3$	mg/L	1280	435	34	38	42	47	53	37	42	46	55	68	74	101
Residual alkalinity	meq/L	22.2	6.08	0.37	0.45	0.52	0.62	0.74	0.47	0.52	0.6	0.73	0.89	1.06	1.47
Chloride	mg/L	209	82	4	5	7	8	9	10	10	13	13	19	26	42
Sulphate as SO_4 2-	mg/L	93	38	1	1	1	1	1	1	1	1	18	12	26	29
Fluoride	mg/L	2.7	0.7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.3
Dissolved Cations															
Calcium	mg/L	36	19	3	3	3	3	3	2	3	3	4	4	3	6
Magnesium	mg/L	20	9	2	2	2	2	2	2	2	2	2	2	2	3
Sodium	mg/L	714	249	7	9	12	16	18	13	15	18	30	40	56	67
Potassium	mg/L	48	20	4	5	6	6	6	6	6	7	6	6	7	10
Sodium absorption ratio (calc)	-	23.7	11.8	0.77	0.99	1.32	1.76	1.97	1.59	1.64	1.97	3.05	3.92	6.14	5.57
Dissolved Metals															
Aluminium	mg/L	0.21	0.15	0.27	0.62	0.62	2.5	0.42	0.25	0.39	0.18	0.58	0.28	0.49	0.65
Arsenic	mg/L	0.016	0.002	0.004	0.002	0.002	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	0.001	0.002
Barium	mg/L	0.128	0.094	0.016	0.016	0.015	0.018	0.014	0.016	0.013	0.014	0.013	0.013	0.014	0.019
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.4	0.12	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.09
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.008	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.007	0.001	0.002	0.002	0.002	0.002	0.001	0.001	0.003	0.003	0.003	0.005	0.007	0.011
Iron (total)	mg/L	0.93	0.68	0.63	0.64	0.66	1.69	0.51	0.66	0.46	0.31	0.45	0.24	0.44	0.54
Lead	mg/L	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.056	0.008	0.001	0.001	0.001	0.001
Lithium	mg/L	0.031	0.014	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.961	0.994	0.055	0.017	0.012	0.011	0.006	0.018	0.018	0.012	0.024	0.02	0.009	0.011
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.019	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	0.003
Nickel	mg/L	0.016	0.004	0.003	0.003	0.003	0.004	0.003	0.002	0.002	0.003	0.004	0.004	0.005	0.007
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.334	0.186	0.043	0.044	0.04	0.038	0.038	0.031	0.034	0.034	0.037	0.032	0.032	0.049
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Zinc	mg/L	0.025	0.01	0.011	0.012	0.007	0.008	< 0.005	< 0.005	0.007	0.008	0.008	0.037	0.01	0.007
Total Metals															
Aluminium	mg/L	0.62	1.99	2.97	2.93	3.38	7.54	12.7	3.36	12	15.9	3.6	27.8	49.3	102
Arsenic	mg/L	0.014	0.002	0.004	0.002	0.003	< 0.001	0.002	0.002	0.003	0.003	0.002	0.005	0.009	0.014
Barium	mg/L	0.177	0.15	0.039	0.04	0.042	0.044	0.064	0.049	0.063	0.079	0.09	0.21	0.332	0.622
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.002	0.004
Boron	mg/L	0.4	0.13	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.07	0.07	0.12
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.003	0.003	0.003	0.004	0.003	0.008	0.014	0.003	0.014	0.02	0.003	0.032	0.052	0.105
Cobalt	mg/L	0.009	0.004	0.002	0.002	0.002	0.003	0.004	0.002	0.004	0.006	0.003	0.014	0.022	0.038
Copper	mg/L	0.008	0.002	0.004	0.005	0.004	0.005	0.007	0.004	0.01	0.011	0.007	0.027	0.04	0.065
Iron	mg/L	1.58	3.02	4.44	4.07	4.4	8.2	14.5	3.18	15.3	20.2	5.61	35.1	59	106
Lead	mg/L	0.004	< 0.001	0.002	0.002	0.002	0.002	0.003	< 0.001	0.006	0.004	0.003	0.01	0.018	0.032
Lithium	mg/L	0.033	0.014	0.002	0.002	0.002	0.003	0.005	0.003	0.006	0.007	0.002	0.009	0.018	0.037
Manganese	mg/L	1.3	1.15	0.201	0.188	0.182	0.154	0.152	0.084	0.128	0.189	0.172	0.614	0.913	1.41
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	0.022	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001
Nickel	mg/L	0.017	0.005	0.006	0.006	0.006	0.008	0.013	0.003	0.012	0.016	0.007	0.03	0.047	0.09
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.381	0.199	0.054	0.052	0.056	0.056	0.06	0.049	0.06	0.069	0.076	0.127	0.17	0.334
Tin	mg/L	< 0.001	< 0.001	0.006	< 0.001	0.004	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.002
Vanadium	mg/L	0.05	0.01	0.01	0.01	0.01	0.02	0.03	0.01	0.02	0.03	0.02	0.07	0.12	0.23
Zinc	mg/L	0.034	0.03	0.012	0.006	0.023	0.017	0.021	0.012	0.029	0.037	0.01	0.063	0.12	0.204

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7503_SURF_W	NAR_7504_SURF_W	NAR_7504_SURF_W	NAR_7504_SURF_W	NAR_7504_SURF_W	NAR_7504_SURF_W	NAR_7504_SURF_W	NAR_7504_SURF_W	NAR_7504_SURF_W	NAR_7504_SURF_W	NAR_7504_SURF_W	NAR_7504_SURF_W	NAR_7504_SURF_W	NAR_7504_SURF_W
Surface Water Body Location		Narrabri Lake	Namoi River, through Narrabri Township	Namoi River, through Narrabri Township	Namoi River, through Narrabri Township	Namoi River, through Narrabri Township	Namoi River, through Narrabri Township	Namoi River, through Narrabri Township	Namoi River, through Narrabri Township	Namoi River, through Narrabri Township	Namoi River, through Narrabri Township	Namoi River, through Narrabri Township	Namoi River, through Narrabri Township	Namoi River, through Narrabri Township	Namoi River, through Narrabri Township
	Stream Type	Perennial													
	Land Use	Urban													
	Lab Sample ID	ES1303392009	EB1205164008	EB1207610003	ES1209204002	ES1212312003	ES1214897005	ES1217889006	ES1220549007	ES1222571005	ES1225305011	ES1227820003	ES1229424005	ES1300408003	ES1303496001
	Sample Date	13/02/2013	24/02/2012	20/03/2012	18/04/2012	16/05/2012	14/06/2012	19/07/2012	23/08/2012	19/09/2012	24/10/2012	22/11/2012	12/12/2012	8/01/2013	14/02/2013
	Sample Time	14:10	9:13	15:58	16:37	11:32	12:43	12:23	13:53	15:16	14:15	10:40	12:45	13:01	14:37
Analyte	**Units**														
Physiochemical															
pH	pH Unit	7.52	7.93	8.1	7.85	7.85	7.82	7.85	7.98	7.92	7.86	8	8.07	8.01	7.03
Turbidity	NTU	129	11	12	15.5	12	4.7	180	14	11.5	13.3	16	11.3	8.8	8
Electrical conductivity	µS/cm	120	287	325	349	403	412	299	316	354	398	470	509	596	134
Total dissolved solids	mg/L	240	155	228	166	231	206	251	134	222	194	268	278	328	92
BOD	mg/L	9	3	2	5	3	3	2	5	2	3	3	2	5	8
Dissolved Anions															
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	37	116	130	144	166	187	98	130	120	151	193	204	255	43
Total alkalinity as $CaCO_3$	mg/L	37	116	130	144	166	187	98	130	120	151	193	204	255	43
Residual alkalinity	meq/L	0.34	0.27	0.21	0.61	0.82	0.92	0.16	0.38	0.41	0.62	0.57	0.87	0.5	0.05
Chloride	mg/L	9	17	17	20	20	26	21	21	25	30	24	39	38	10
Sulphate as SO_4 2-	mg/L	1	8	1	2	3	4	14	14	10	4	3	1	1	1
Fluoride	mg/L	0.1	0.1	0.2	0.4	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.3	0.1
Dissolved Cations															
Calcium	mg/L	3	23	28	24	27	30	18	23	20	25	30	33	42	8
Magnesium	mg/L	3	11	12	13	14	16	11	13	12	14	17	19	23	5
Sodium	mg/L	13	19	24	21	27	32	22	25	24	29	38	44	44	14
Potassium	mg/L	8	7	6	7	7	7	5	6	6	6	8	9	11	10
Sodium absorption ratio (calc)	-	1.27	0.82	0.96	0.86	1.05	1.17	1.01	1.03	1.05	1.14	1.41	1.51	1.38	0.96
Dissolved Metals															
Aluminium	mg/L	0.93	0.05	0.02	0.02	0.02	<0.01	0.06	0.12	0.06	0.04	0.04	0.05	<0.01	0.31
Arsenic	mg/L	0.002	0.003	0.003	0.002	0.003	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.002	0.004	0.005	0.002
Barium	mg/L	0.02	0.027	0.025	0.022	0.032	0.035	0.021	0.019	0.023	0.033	0.033	0.028	0.026	0.012
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
Copper	mg/L	0.01	0.002	0.001	0.001	0.008	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
Iron (total)	mg/L	0.82	0.1	0.05	0.05	0.06	0.05	0.07	0.18	0.09	0.08	0.1	0.07	0.06	0.9
Lead	mg/L	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.065	0.006	0.001	0.001
Lithium	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.055	0.028	0.131	0.163	0.082	0.225	0.005	0.005	0.082	0.361	0.155	0.128	0.427	0.68
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.004	0.004	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.048	0.238	0.272	0.306	0.304	0.319	0.23	0.212	0.216	0.294	0.3	0.403	0.428	0.083
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	0.009	0.009	< 0.005	0.006	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.005	0.016	< 0.005	< 0.005	< 0.005
Total Metals															
Aluminium	mg/L	12.8	0.93	0.29	0.51	0.23	0.29	5.73	2.94	0.75	0.64	0.92	0.34	0.18	0.45
Arsenic	mg/L	0.004	0.003	0.003	0.003	< 0.001	< 0.001	0.001	< 0.001	0.001	0.003	0.004	0.004	0.005	0.002
Barium	mg/L	0.068	0.039	0.034	0.058	0.047	0.039	0.068	0.042	0.03	0.035	0.04	0.037	0.039	0.022
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05	0.05	0.06	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.015	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.006	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	mg/L	0.005	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.004	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003
Copper	mg/L	0.008	0.004	< 0.001	< 0.001	< 0.001	< 0.001	0.01	0.004	0.001	0.001	0.001	< 0.001	< 0.001	< 0.001
Iron	mg/L	13.3	1.34	0.61	1.07	0.53	0.57	3.24	2.89	0.95	1.06	1.28	0.8	0.84	1.7
Lead	mg/L	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.005	0.006	< 0.001	< 0.001
Lithium	mg/L	0.006	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Manganese	mg/L	0.227	0.156	0.492	0.404	0.36	0.278	0.172	0.07	0.165	0.398	0.307	0.353	0.509	0.821
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.013	0.005	0.004	0.003	0.003	0.003	0.011	0.005	0.004	0.003	0.004	0.003	0.003	0.005
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.068	0.25	0.275	0.318	0.352	0.315	0.288	0.227	0.245	0.291	0.359	0.409	0.454	0.083
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	0.025	0.009	< 0.005	< 0.005	0.008	< 0.005	0.011	< 0.005	< 0.005	< 0.005	0.008	< 0.005	< 0.005	< 0.005

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7505_SURF_W	NAR_7505_SURF_W	NAR_7506(1)_SURF_W	NAR_7506(2)_SURF_W	NAR_7506_SURF_W	NAR_7506_SURF_W	NAR_7506_SURF_W	NAR_7506_SURF_W	NAR_7506_SURF_W	NAR_7506_SURF_W	NAR_7506_SURF_W	NAR_7506_SURF_W	NAR_7507_SURF_W	NAR_7507_SURF_W
Surface Water Body Location		Bohena Creek, Upstream of Bibblewindi Site	Bohena Creek, Upstream of Bibblewindi Site	Bohena Creek of Newell Highway	Bohena Creek of Newell Highway	Bohena Creek of Newell Highway	Bohena Creek of Newell Highway	Bohena Creek of Newell Highway	Bohena Creek of Newell Highway	Bohena Creek of Newell Highway	Bohena Creek of Newell Highway	Bohena Creek of Newell Highway	Bohena Creek of Newell Highway	Garlands Dam	Garlands Dam
Stream Type		Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Permanent	Permanent
Land Use		Nature Reserve	Nature Reserve	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Nature Reserve	Nature Reserve
Lab Sample ID		EB1205302001	ES1217499001	ES1305997005	ES1305997006	ES1209055004	ES1212386004	ES1214531004	ES1217499004	ES1220319002	ES1222339003	ES1225252002	ES1303086003	EB1207610004	ES1209055001
Sample Date		27/02/2012	16/07/2012	12/03/2013	12/03/2013	16/04/2012	17/05/2012	12/06/2012	16/07/2012	21/08/2012	17/09/2012	23/10/2012	11/02/2013	20/03/2012	16/04/2012
Sample Time		9:46	16:49	14:26	14:26	15:50	13:24	17:27	16:49	10:43	13:30	14:18	14:00	15:58	11:00
Analyte	**Units**														
Physiochemical															
pH	pH Unit	7.12	8.03	6.81	7.02	7.37	6.71	7.08	7.35	7.59	7.43	7.36	7.33	7.38	7.45
Turbidity	NTU	165	109	19.1	101	29.5	18.6	7.2	11.5	50.1	59.2	30	18.1	28.2	52.9
Electrical conductivity	µS/cm	147	512	118	197	158	172	167	151	199	189	195	147	86	90
Total dissolved solids	mg/L	86	586	220	192	116	114	110	87	139	90	126	172	109	112
BOD	mg/L	2	2	4	6	2	2	2	2	4	2	2	4	2	4
Dissolved Anions															
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	29	81	26	50	42	36	53	34	54	48	44	41	26	22
Total alkalinity as $CaCO_3$	mg/L	29	81	26	50	42	36	53	34	54	48	44	41	26	22
Residual alkalinity	meq/L	0.23	-1.16	0.04	0.04	0.01	-0.07	0.18	0.07	0.2	0.03	0.14	0.03	0.26	0.18
Chloride	mg/L	25	102	17	28	22	28	27	29	25	32	30	24	9	12
Sulphate as SO_4 2-	mg/L	1	10	1	1	1	1	1	1	1	1	1	1	1	1
Fluoride	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4
Dissolved Cations															
Calcium	mg/L	2	21	3	6	7	6	6	6	4	6	7	5	2	2
Magnesium	mg/L	3	23	4	8	6	6	7	5	7	7	6	6	2	2
Sodium	mg/L	21	37	14	18	14	17	17	15	16	17	17	16	10	10
Potassium	mg/L	2	5	1	2	2	2	2	2	2	2	2	4	5	5
Sodium absorption ratio (calc)	-	2.19	1.34	1.24	1.13	0.94	1.17	1.12	1.14	1.05	1.09	1.27	1.1	1.2	1.2
Dissolved Metals															
Aluminium	mg/L	0.25	0.13	0.23	0.12	0.02	0.02	0.04	0.07	0.08	0.12	<0.01	1.07	0.72	0.44
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.002
Barium	mg/L	0.024	0.066	0.022	0.034	0.042	0.049	0.039	0.023	0.033	0.027	0.041	0.039	0.023	0.03
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	0.0003	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.001	0.001	0.002	0.004	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Copper	mg/L	0.001	0.002	0.001	0.004	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Iron (total)	mg/L	1.68	0.15	0.3	1.01	0.81	1.8	0.66	0.27	0.46	1.34	1.27	0.69	0.97	0.89
Lead	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Lithium	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.072	0.007	0.053	0.056	0.338	0.396	0.139	0.047	0.024	0.056	0.222	0.106	0.005	0.006
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.003	0.002	0.003	0.002	0.003	0.003	0.003	0.003	0.002	0.002	0.003	0.002	0.002	0.002
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.034	0.295	0.043	0.1	0.101	0.086	0.078	0.065	0.093	0.087	0.092	0.07	0.034	0.034
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	0.011	< 0.005	< 0.005	0.037	< 0.005	< 0.005	0.01	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.007	< 0.005
Total Metals															
Aluminium	mg/L	7.46	5.48	2.31	0.11	0.12	0.25	0.25	0.5	0.3	0.24	0.28	2.88	0.96	1.08
Arsenic	mg/L	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.003
Barium	mg/L	0.052	0.108	0.04	0.037	0.056	0.095	0.048	0.026	0.038	0.032	0.056	0.052	0.029	0.043
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.011	0.009	0.004	< 0.001	< 0.001	0.004	< 0.001	< 0.001	0.001	< 0.001	< 0.001	0.006	0.001	0.003
Cobalt	mg/L	0.004	0.004	0.002	< 0.001	0.003	0.003	0.02	0.003	< 0.001	< 0.001	0.001	0.004	0.002	0.004
Copper	mg/L	0.004	0.005	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	0.002	< 0.001
Iron	mg/L	16.3	7.77	5.76	1.99	3.79	11.2	5.14	2.85	1.28	2.77	9.8	3.78	2.15	3.54
Lead	mg/L	0.005	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001
Lithium	mg/L	0.003	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Manganese	mg/L	0.122	0.212	0.172	0.147	0.483	2.04	0.257	0.064	0.066	0.108	0.321	0.16	0.054	0.064
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001
Nickel	mg/L	0.006	0.012	0.005	0.003	0.003	0.005	0.003	0.003	0.002	0.003	0.004	0.004	0.002	0.002
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.048	0.32	0.049	0.104	0.109	0.096	0.08	0.068	0.105	0.096	0.102	0.076	0.037	0.041
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	0.02	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	0.008	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7507_SURF_W	NAR_7507_SURF_W	NAR_7507_SURF_W	NAR_7507_SURF_W	NAR_7507_SURF_W	NAR_7507_SURF_W	NAR_7507_SURF_W	NAR_7507_SURF_W	NAR_7507_SURF_W	NAR_7508_SURF_W	NAR_7508_SURF_W	NAR_7508_SURF_W	NAR_7508_SURF_W	NAR_7508_SURF_W
Surface Water Body Location		Garlands Dam	Garlands Dam	Garlands Dam	Garlands Dam	Garlands Dam	Garlands Dam	Garlands Dam	Garlands Dam	Garlands Dam	Lagoons near road, Newell Highway	Lagoons near road, Newell Highway	Lagoons near road, Newell Highway	Lagoons near road, Newell Highway	Lagoons near road, Newell Highway
	Stream Type	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral
	Land Use	Nature Reserve	Nature Reserve	Nature Reserve	Nature Reserve	Nature Reserve	Nature Reserve	Nature Reserve	Nature Reserve	Nature Reserve	Forest	Forest	Forest	Forest	Forest
	Lab Sample ID	ES1212386001	ES1214531001	ES1220209001	ES1222339001	ES1225135001	ES1227459001	ES1229115001	ES1300507001	ES1303086001	EB1207610006	ES1209055012	ES1212386003	ES1214531003	ES1217499003
	Sample Date	16/05/2012	12/06/2012	20/08/2012	17/09/2012	22/10/2012	19/11/2012	10/12/2012	9/01/2013	11/02/2013	20/03/2012	16/04/2012	16/05/2012	12/06/2012	16/07/2012
	Sample Time	15:30	17:27	16:19	16:39	14:15	18:01	12:30	12:47	12:10	15:58	13:25	16:40	17:27	16:49
Analyte	**Units**														
Physiochemical															
pH	pH Unit	7.5	7.46	7.94	7.51	7.6	7.66	8.05	7.53	8.25		6.95	6.01	7.04	6.42
Turbidity	NTU	53.3	60.6	57.6	41	27.9	83.6	44.1	19	15.3		43.1	26.9	57.3	11
Electrical conductivity	µS/cm	98	80	202	88	108	118	124	128	135		62	64	28	19
Total dissolved solids	mg/L	156	144	220	152	102	154	149	83	94		44	48	51	38
BOD	mg/L	2	2	3	4	2	8	3	2	4		6	2	3	2
Dissolved Anions															
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	29	24	41	25	49	44	36	33	40		13	4	8	3
Total alkalinity as $CaCO_3$	mg/L	29	24	41	25	49	44	36	33	40		13	4	8	3
Residual alkalinity	meq/L	0.32	0.22	0.6	0.24	0.71	0.85	0.37	0.44	0.37		0.05	0.01	0.16	0.06
Chloride	mg/L	12	11	10	13	13	13	15	14	21	6	10	12	3	2
Sulphate as SO_4 2-	mg/L	1	1	1	1	1	1	1	1	1	1	1	1	1	7
Fluoride	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2		0.1	0.1	0.1	0.1
Dissolved Cations															
Calcium	mg/L	2	2	2	1	2	2	< 1	2	1	1	< 1	< 1	< 1	< 1
Magnesium	mg/L	2	2	2	2	2	2	3	2	4	2	2	1	1	1
Sodium	mg/L	12	9	10	11	16	17	17	16	19	4	6	7	2	2
Potassium	mg/L	6	5	4	5	6	6	7	6	8	5	6	6	2	2
Sodium absorption ratio (calc)	-	1.44	1.08	1.38	1.32	1.93	2.34	1.78	1.78	1.78	0.48	0.8	1.5	0.01	NS
Dissolved Metals															
Aluminium	mg/L	0.2	0.43	0.78	0.61	0.82	1.81	0.5	0.11	0.52	0.1	0.42	0.97	0.91	1.5
Arsenic	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.002	0.003	0.002	0.001	< 0.001	< 0.001	< 0.001
Barium	mg/L	0.053	0.042	0.032	0.031	0.019	0.017	0.024	0.024	0.02	0.033	0.023	0.018	0.006	0.005
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.002	0.001	0.001
Iron (total)	mg/L	0.94	0.58	0.69	0.62	0.7	1.23	0.84	0.55	0.87	1.63	2.3	1.41	0.58	0.76
Lead	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001
Lithium	mg/L	0.001	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.005	0.002	0.003	0.002	0.002	0.004	0.004	0.02	0.004	0.079	0.02	0.026	0.004	0.006
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.002	0.001	0.001	0.002	0.002	0.001	0.002	0.002	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.033	0.025	0.018	0.022	0.026	0.019	0.027	0.022	0.03	0.017	0.01	0.006	0.002	0.002
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	0.008	0.007	0.01	0.005	< 0.005	< 0.005	0.006	0.006	0.005	0.006	0.008	0.006	< 0.005	< 0.005
Total Metals															
Aluminium	mg/L	1.67	2.74	2.04	3.5	3.55	2.48	2.67	1.75	2.04	0.4	0.6	1.55	1.2	1.96
Arsenic	mg/L	0.002	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.002	0.001	< 0.001	< 0.001	0.001
Barium	mg/L	0.076	0.066	0.05	0.053	0.046	0.047	0.048	0.04	0.044	0.038	0.028	0.025	0.009	0.014
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.002	0.003	0.004	0.004	0.006	0.005	0.004	0.004	0.002	0.002	0.002	0.002	0.003	< 0.001
Cobalt	mg/L	0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.004	0.004	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Copper	mg/L	0.001	0.001	0.001	0.001	< 0.001	0.002	0.002	0.001	0.001	0.002	0.002	< 0.001	< 0.001	0.001
Iron	mg/L	3.8	5.3	3.62	6.01	6.71	5.5	5.28	3.58	4.7	5.94	4.5	3.93	1.32	2.36
Lead	mg/L	< 0.001	0.002	0.002	0.002	0.01	0.002	0.004	< 0.001	0.001	0.002	0.003	< 0.001	0.001	0.001
Lithium	mg/L	< 0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Manganese	mg/L	0.045	0.041	0.02	0.051	0.125	0.15	0.152	0.103	0.117	0.12	0.033	0.038	0.007	0.014
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.002	0.003	0.002	0.004	0.004	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.042	0.034	0.026	0.03	0.035	0.025	0.028	0.027	0.035	0.019	0.013	0.008	0.003	0.003
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	0.011	< 0.005	< 0.005	< 0.005	< 0.005	0.006	0.007	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7509_SURF_W	NAR_7509_SURF_W	NAR_7509_SURF_W	NAR_7509_SURF_W	NAR_7509_SURF_W	NAR_7509_SURF_W	NAR_7509_SURF_W	NAR_7509_SURF_W	NAR_7509_SURF_W	NAR_7509_SURF_W	NAR_7509_SURF_W	NAR_7509_SURF_W	NAR_7510_SURF_W	NAR_7510_SURF_W	NAR_7510_SURF_W
Surface Water Body Location		Large Lagood East of Newell Highway	Large Lagood East of Newell Highway	Large Lagood East of Newell Highway	Large Lagood East of Newell Highway	Large Lagood East of Newell Highway	Large Lagood East of Newell Highway	Large Lagood East of Newell Highway	Large Lagood East of Newell Highway	Large Lagood East of Newell Highway	Large Lagood East of Newell Highway	Large Lagood East of Newell Highway	Large Lagood East of Newell Highway	Bohena Creek Crossing, Newell Highway	Bohena Creek Crossing, Newell Highway	Bohena Creek Crossing, Newell Highway
	Stream Type	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral
	Land Use	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest	Forest
	Lab Sample ID	EB1207610005	ES1209055002	ES1212386002	ES1214531002	ES1217499002	ES1220209002	ES1222339002	ES1225252001	ES1227459002	ES1229115002	ES1300507002	ES1303086002	ES1209055003	ES1212386005	ES1214731001
	Sample Date	20/03/2012	16/04/2012	16/05/2012	12/06/2012	16/07/2012	20/08/2012	17/09/2012	23/10/2012	19/11/2012	10/12/2012	9/01/2013	11/02/2013	16/04/2012	17/05/2012	12/06/2012
	Sample Time	15:58	12:25	16:15	17:27	16:49	16:19	16:39	14:18	18:01	13:15	12:47	13:15	14:10	13:24	16:05
Analyte	**Units**															
Physiochemical																
pH	pH Unit		7.14	6.58	6.91	7.04	7.09	7.09	7	7.17	7.2	6.91	6.95	7.44	7.37	7.4
Turbidity	NTU		16.4	10.7	10.4	9	9	15.8	30.1	26.8	38.5	83.9	51.8	13.1	35.6	41.4
Electrical conductivity	µS/cm		43	46	36	35	41	42	60	70	82	147	23	226	301	275
Total dissolved solids	mg/L		36	48	44	74	77	102	248	74	132	178	158	142	210	146
BOD	mg/L		6	2	2	2	2	2	2	3	2	19	4	4	5	7
Dissolved Anions																
Hydroxide alkalinity as $CaCO_3$	mg/L		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L		< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L		14	8	6	7	6	10	12	8	8	9	3	63	75	85
Total alkalinity as $CaCO_3$	mg/L		14	8	6	7	6	10	12	8	8	9	3	63	75	85
Residual alkalinity	meq/L		0.2	0.08	0.04	0.14	0.12	0.12	0.24	0.08	0.01	-0.08	0.06	-0.01	-0.16	-0.08
Chloride	mg/L	6	7	8	6	6	6	7	8	12	15	29	3	28	34	38
Sulphate as SO_4 2-	mg/L	1	1	1	1	1	1	1	1	1	1	6	1	1	45	1
Fluoride	mg/L		0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1
Dissolved Cations																
Calcium	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2	9	4	14	11	5
Magnesium	mg/L	2	1	1	1	1	1	1	1	1	2	2	1	10	16	15
Sodium	mg/L	4	4	5	4	3	4	5	7	10	10	20	3	20	28	24
Potassium	mg/L	2	2	2	2	2	2	2	2	2	4	3	2	3	3	3
Sodium absorption ratio (calc)	-	0.61	0.86	1.07	0.86	NS	0.01	1.07		1.86	1.52	2.19		1.09	1.16	1.1
Dissolved Metals																
Aluminium	mg/L	0.91	0.22	0.11	0.38	0.3	0.87	0.87	1.08	2.02	0.45	1.08	1.1	0.05	0.02	0.02
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Barium	mg/L	0.021	0.016	0.015	0.012	0.012	0.011	0.015	0.016	0.011	0.012	0.035	0.004	0.054	0.047	0.04
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001
Copper	mg/L	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Iron (total)	mg/L	1.23	0.67	0.55	0.55	0.63	0.76	0.77	0.83	1.78	0.35	1.63	0.52	1.14	1.16	2.54
Lead	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.071	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Lithium	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.014	0.014	0.003	0.002	0.003	0.002	0.004	0.004	0.008	0.003	0.023	0.002	0.223	0.024	0.088
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.004	0.006	0.005	0.005	0.004
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.006	0.004	0.004	0.003	0.003	0.003	0.003	0.004	0.007	0.003	0.01	0.001	0.129	0.183	0.158
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	< 0.005	0.007	0.005	< 0.005	< 0.005	< 0.005	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.008	< 0.005	0.007
Total Metals																
Aluminium	mg/L	0.49	0.7	0.56	0.48	0.48	0.48	0.63	0.93	1.37	2.02	3.44	1.8	0.29	0.1	0.05
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	0.001
Barium	mg/L	0.023	0.034	0.02	0.014	0.014	0.012	0.017	0.024	0.02	0.022	0.074	0.014	0.066	0.058	0.046
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	0.002	0.004	< 0.001	0.003	< 0.001	< 0.001	0.005
Cobalt	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.003	0.008	0.002	0.002	0.007
Copper	mg/L	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	0.002
Iron	mg/L	1.5	1.7	1.32	1.09	0.82	0.74	1.22	1.7	1.65	3.42	8.27	1.94	2.68	2.78	4.77
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.072	< 0.001	0.008	< 0.001	0.004	< 0.001	< 0.001	< 0.001	< 0.001	0.002
Lithium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002
Manganese	mg/L	0.02	0.04	0.009	0.006	0.005	0.003	0.007	0.012	0.015	0.032	0.098	0.015	0.321	0.214	0.168
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.004	0.004	0.005
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.006	0.007	0.005	0.004	0.004	0.003	0.003	0.005	0.004	0.004	0.013	0.002	0.14	0.197	0.164
Tin	mg/L	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Zinc	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.008	< 0.005	< 0.005	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7510_SURF_W	NAR_7510_SURF_W	NAR_7510_SURF_W	NAR_7510_SURF_W	NAR_7511_SURF_W	NAR_7511_SURF_W	NAR_7511_SURF_W	NAR_7511_SURF_W	NAR_7511_SURF_W	NAR_7511_SURF_W	NAR_7511_SURF_W	NAR_7511_SURF_W	NAR_7511_SURF_W
Surface Water Body Location		Bohena Creek Crossing, Newell Highway	Bohena Creek Crossing, Newell Highway	Bohena Creek Crossing, Newell Highway	Bohena Creek Crossing, Newell Highway	Bohena Creek, Yarrie Lake Road Culvert	Bohena Creek, Yarrie Lake Road Culvert	Bohena Creek, Yarrie Lake Road Culvert	Bohena Creek, Yarrie Lake Road Culvert	Bohena Creek, Yarrie Lake Road Culvert	Bohena Creek, Yarrie Lake Road Culvert	Bohena Creek, Yarrie Lake Road Culvert	Bohena Creek, Yarrie Lake Road Culvert	Bohena Creek, Yarrie Lake Road Culvert
Stream Type		Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral
Land Use		Forest	Forest	Forest	Forest	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing
Lab Sample ID		ES1217499005	ES1220319001	ES1222339004	ES1303086004	EB1207610010	ES1209055006	ES1212311001	ES1214731002	ES1217527010	ES1220319004	ES1222453001	ES1225252003	ES1303253003
Sample Date		16/07/2012	21/08/2012	17/09/2012	11/02/2013	20/03/2012	17/04/2012	15/05/2012	12/06/2012	16/07/2012	21/08/2012	17/09/2012	23/10/2012	12/02/2013
Sample Time		16:49	10:43	14:00	14:30	15:58	8:10	10:58	17:00	17:00	10:43	16:00	14:18	13:46
Analyte	**Units**													
Physiochemical														
pH	pH Unit	7.23	7.46	7.57	6.9	7.7	7.44	7.55	7.25	7.12	7.35	7.42	7.57	6.62
Turbidity	NTU	167	75.2	16.9	47.9	87	72.4	56.9	39.4	51.6	19.5	15.2	40.4	128
Electrical conductivity	µS/cm	133	185	237	117	292	338	336	342	260	278	319	361	313
Total dissolved solids	mg/L	134	216	212	214	182	189	212	178	252	230	219	170	292
BOD	mg/L	4	4	2	5	2	5	2	2	2	2	2	2	2
Dissolved Anions														
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	35	61	66	28	78	80	80	91	37	67	84	85	76
Total alkalinity as $CaCO_3$	mg/L	35	61	66	28	78	80	80	91	37	67	84	85	76
Residual alkalinity	meq/L	-0.02	0.55	0.01	0.03	0.24	0.19	0.51	0.41	0.21	0.33	0.54	0.83	0.15
Chloride	mg/L	20	24	33	22	33	56	49	57	39	42	50	51	55
Sulphate as SO_4 2-	mg/L	1	1	1	1	1	1	1	1	1	1	1	1	1
Fluoride	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Dissolved Cations														
Calcium	mg/L	6	8	10	10	7	10	4	7	9	8	11	11	4
Magnesium	mg/L	5	8	11	4	10	11	9	11	4	8	10	9	10
Sodium	mg/L	16	17	19	12	32	41	42	45	29	33	40	44	37
Potassium	mg/L	2	2	3	5	3	4	4	4	4	3	4	4	6
Sodium absorption ratio (calc)	-	1.26	1.07	1.02	1.01	1.71	2.23	2.47	2.34	2.43	2.02	2.18	2.48	1.94
Dissolved Metals														
Aluminium	mg/L	0.65	0.29	0.35	1.08	0.02	0.12	0.21	0.04	0.46	0.1	0.08	0.12	0.03
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001
Barium	mg/L	0.034	0.033	0.037	0.049	0.07	0.044	0.031	0.043	0.025	0.041	0.048	0.047	0.109
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.002	0.001	0.001	0.006	0.006	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.015
Copper	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Iron (total)	mg/L	0.81	1.81	1.8	0.87	4.59	1.91	0.88	1.63	1.12	0.8	0.59	0.54	17.4
Lead	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Lithium	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.175	0.034	0.117	0.987	0.772	0.038	0.006	0.006	0.01	0.005	0.012	0.323	1.47
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.003	0.005	0.003	0.005	0.002	0.003	0.003	0.003	0.005	0.006	0.012	0.005	0.003
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.061	0.091	0.122	0.051	0.154	0.154	0.123	0.142	0.054	0.096	0.122	0.152	0.148
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	0.007	< 0.005	0.006	0.01	0.007	0.008	0.006	0.007	0.006	< 0.005	0.01	0.006	0.006
Total Metals														
Aluminium	mg/L	3.76	1.83	0.47	2.76	0.12	0.62	1.1	0.25	0.85	0.42	0.4	0.7	0.49
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.002	< 0.001
Barium	mg/L	0.059	0.047	0.044	0.064	0.08	0.057	0.04	0.05	0.038	0.048	0.06	0.06	0.145
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.003	< 0.001	< 0.001	< 0.001	0.002	< 0.001	0.001	< 0.001	< 0.001	0.001	0.003	< 0.001	0.002
Cobalt	mg/L	0.003	0.002	< 0.001	0.006	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.016	0.004	< 0.001
Copper	mg/L	0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	0.005	< 0.001	0.001
Iron	mg/L	10.4	9.83	2.88	4.2	10.9	7.88	7.7	5.52	4.14	3.96	2.99	5.6	30.5
Lead	mg/L	0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001
Lithium	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001
Manganese	mg/L	0.485	0.166	0.172	1.2	0.821	0.053	0.014	0.01	0.022	0.01	0.022	0.419	1.65
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.006	0.004	0.004	0.007	0.005	0.004	0.003	0.003	0.004	0.003	0.005	0.008	0.013
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.075	0.088	0.133	0.055	0.159	0.166	0.126	0.131	0.065	0.102	0.15	0.161	0.164
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	0.007	< 0.005	< 0.005	< 0.005	0.007	< 0.005	0.007	< 0.005	0.01

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7512_SURF_W	NAR_7512_SURF_W	NAR_7512_SURF_W	NAR_7512_SURF_W	NAR_7513_SURF_W	NAR_7513_SURF_W	NAR_7513_SURF_W	NAR_7513_SURF_W	NAR_7513_SURF_W	NAR_7513_SURF_W	NAR_7513_SURF_W	NAR_7513_SURF_W	NAR_7513_SURF_W	NAR_7513_SURF_W
Surface Water Body Location		Bohena Creek, adjacent to Walgett Railway	Bohena Creek, adjacent to Walgett Railway	Bohena Creek, adjacent to Walgett Railway	Bohena Creek, adjacent to Walgett Railway	Namoi River, irrigation areas	Namoi River, irrigation areas	Namoi River, irrigation areas	Namoi River, irrigation areas	Namoi River, irrigation areas	Namoi River, irrigation areas	Namoi River, irrigation areas	Namoi River, irrigation areas	Namoi River, irrigation areas	Namoi River, irrigation areas
Stream Type		Ephemeral	Ephemeral	Ephemeral	Ephemeral	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial
Land Use		Cropping	Cropping	Cropping	Cropping	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing
Lab Sample ID		EB1207610012	ES1217527009	ES1220319003	ES1303392008	EB1207610014	ES1209055009	ES1212311004	ES1214731010	ES1217757002	ES1220443006	ES1222453009	ES1225305008	ES1227704001	ES1229332006
Sample Date		20/03/2012	16/07/2012	21/08/2012	13/02/2013	15/03/2012	17/04/2012	15/05/2012	13/06/2012	18/07/2012	22/08/2012	18/09/2012	24/10/2012	21/11/2012	11/12/2012
Sample Time		15:58	16:15	10:43	13:35	16:42	10:55	14:20	13:35	16:21	15:39	15:58	12:43	8:25	16:13
Analyte	**Units**														
Physiochemical															
pH	pH Unit	7.87	7.28	7.29	7.21	8.24	7.95	8.29	8.28	7.83	8.29	8.26	8.15	8	8.13
Turbidity	NTU	31	38.9	16.6	23.2	282	111	9	7	593	27.3	7.2	21.4	21.8	39
Electrical conductivity	µS/cm	303	222	362	307	513	636	693	557	308	478	470	343	396	243
Total dissolved solids	mg/L	238	373	336	326	314	352	294	208	180	248	120	192	310	284
BOD	mg/L	2	2	2	5	3	2	3	2	3	2	2	2	2	2
Dissolved Anions															
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	83	34	72	69	178	207	215	209	96	152	171	110	127	87
Total alkalinity as $CaCO_3$	mg/L	83	34	72	69	178	207	215	209	96	152	171	110	127	87
Residual alkalinity	meq/L	0.2	0.15	0.29	0.24	0.23	-0.3	-0.12	-0.3	0.12	0.3	0.41	0.16	-0.03	0.02
Chloride	mg/L	37	36	56	52	37	51	53	50	23	32	38	23	30	12
Sulphate as SO_4 2-	mg/L	1	1	1	1	1	42	31	38	15	30	30	24	27	16
Fluoride	mg/L	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.2
Dissolved Cations															
Calcium	mg/L	9	8	32	46	44	42	18	28	33	22	25	18	22	32
Magnesium	mg/L	11	4	10	9	21	26	27	29	11	19	21	13	16	10
Sodium	mg/L	34	28	37	35	42	47	46	43	21	32	35	23	27	16
Potassium	mg/L	3	4	3	6	4	4	3	3	4	3	4	3	4	4
Sodium absorption ratio (calc)	-	1.73	2.3	2.02	2.02	1.42	1.37	1.34	1.25	0.95	1.14	1.17	0.96	1.06	0.75
Dissolved Metals															
Aluminium	mg/L	<0.01	0.52	0.03	0.17	0.02	<0.01	<0.01	<0.01	0.05	0.02	0.02	0.04	0.03	0.06
Arsenic	mg/L	< 0.001	0.001	0.002	0.002	0.001	< 0.001	< 0.001	0.001	< 0.001	0.001	0.001	0.002	< 0.001	0.001
Barium	mg/L	0.05	0.024	0.056	0.129	0.035	0.045	0.041	0.036	0.019	0.027	0.03	0.024	0.028	0.019
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.003	0.001	0.001	0.02	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.001	0.001	0.001	0.002	0.004	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001
Iron (total)	mg/L	1.92	1.32	2.91	2.74	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05
Lead	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.004	0.001	0.001	0.001
Lithium	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.784	0.017	0.004	2.63	0.003	0.001	0.002	0.003	0.001	0.003	0.002	0.003	0.002	0.002
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.005	0.012	0.004	0.001	0.001	< 0.001	0.002	0.001	0.001	0.002	< 0.001	0.001	0.001	0.002
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.172	0.055	0.146	0.135	0.383	0.476	0.474	0.418	0.214	0.321	0.331	0.234	0.272	0.166
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	0.006	< 0.005	0.006	< 0.005	< 0.005	0.005	< 0.005	< 0.005	< 0.005	0.006	< 0.005	< 0.005	0.008	0.011
Total Metals															
Aluminium	mg/L	0.03	0.54	0.35	0.86	15	1	0.73	1.12	27.8	1.34	0.2	0.78	2.46	1.43
Arsenic	mg/L	0.001	0.002	0.004	0.002	0.001	0.002	0.003	0.001	< 0.001	0.001	0.002	< 0.001	0.002	0.003
Barium	mg/L	0.061	0.033	0.061	0.148	0.174	0.054	0.043	0.042	0.117	0.037	0.033	0.03	0.049	0.027
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.002	0.003	0.017	0.001	< 0.001	0.001	0.036	0.002	< 0.001	< 0.001	0.002	0.001	0.004	0.009
Cobalt	mg/L	< 0.001	0.023	0.013	< 0.001	< 0.001	< 0.001	0.012	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.005
Copper	mg/L	0.002	0.003	0.022	0.003	0.001	0.002	0.026	0.003	0.002	0.002	0.005	0.003	0.006	0.012
Iron	mg/L	4.84	4.06	8.43	7.72	16.7	1	0.69	1.18	27.5	1.54	0.18	0.74	2.61	1.47
Lead	mg/L	< 0.001	< 0.001	0.006	< 0.001	< 0.001	< 0.001	0.004	< 0.001	0.001	< 0.001	< 0.001	< 0.001	0.001	0.003
Lithium	mg/L	< 0.001	0.001	0.005	0.001	0.001	0.001	0.009	0.002	0.001	0.001	0.002	0.001	0.003	0.003
Manganese	mg/L	0.953	0.028	0.014	2.66	0.846	0.063	0.063	0.062	0.438	0.068	0.026	0.06	0.136	0.069
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001
Nickel	mg/L	0.006	0.004	0.006	0.012	0.026	0.002	0.002	0.002	0.043	0.003	0.001	0.003	0.003	0.002
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.178	0.064	0.148	0.142	0.481	0.51	0.532	0.453	0.278	0.343	0.334	0.239	0.292	0.169
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002
Uranium	mg/L	< 0.001	< 0.001	0.002	0.002	0.003	0.002	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002
Vanadium	mg/L	< 0.01	< 0.01	0.06	0.01	< 0.01	< 0.01	0.06	< 0.01	< 0.01	< 0.01	0.01	< 0.01	0.01	0.04
Zinc	mg/L	0.006	< 0.005	0.034	0.007	0.009	< 0.005	0.042	0.01	< 0.005	< 0.005	0.006	< 0.005	0.01	0.023

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7513_SURF_W	NAR_7513_SURF_W	NAR_7514_SURF_W	NAR_7515_SURF_W	NAR_7515_SURF_W	NAR_7515_SURF_W	NAR_7515_SURF_W	NAR_7515_SURF_W	NAR_7515_SURF_W	NAR_7515_SURF_W	NAR_7515_SURF_W	NAR_7515_SURF_W	NAR_7515_SURF_W	NAR_7515_SURF_W
Surface Water Body Location		Namoi River, irrigation areas	Namoi River, irrigation areas	Australian Cotton Research Institute irrigation channel	Spring Creek, tributary of Namoi River	Spring Creek, tributary of Namoi River	Spring Creek, tributary of Namoi River	Spring Creek, tributary of Namoi River	Spring Creek, tributary of Namoi River	Spring Creek, tributary of Namoi River	Spring Creek, tributary of Namoi River	Spring Creek, tributary of Namoi River	Spring Creek, tributary of Namoi River	Spring Creek, tributary of Namoi River	Spring Creek, tributary of Namoi River
Stream Type		Perennial	Perennial		Semi-Perennial	Semi-Perennial	Semi-Perennial	Semi-Perennial	Semi-Perennial	Semi-Perennial	Semi-Perennial	Semi-Perennial	Semi-Perennial	Semi-Perennial	Semi-Perennial
Land Use		Grazing	Grazing		Cropping	Cropping	Cropping	Cropping	Cropping	Cropping	Cropping	Cropping	Cropping	Cropping	Cropping
Lab Sample ID		ES1300507005	ES1303253001	ES1303253002	ES1209055011	ES1212311006	ES1215389001	ES1217757005	ES1220549003	ES1222571003	ES1225252006	ES1227704004	ES1229424003	ES1300507004	ES1303392004
Sample Date		9/01/2013	12/02/2013	12/02/2013	17/04/2012	15/05/2012	19/06/2012	18/07/2012	23/08/2012	19/09/2012	23/10/2012	21/11/2012	12/12/2012	9/01/2013	13/02/2013
Sample Time		12:47	13:46	14:00	13:15	16:15	16:30	16:21	13:53	15:16	14:18	12:10	11:03	12:47	11:32
Analyte	**Units**														
Physiochemical															
pH	pH Unit	8.16	8.28	8.97	8.13	8.44	7.96	7.76	8.14	8.14	8.17	8.74	8.66	8.42	8.76
Turbidity	NTU	46.4	97.6	58.7	48	38.2	51.3	247	29.2	70	110	454	142	72.4	137
Electrical conductivity	µS/cm	262	482	352	509	612	370	189	394	478	420	681	409	615	354
Total dissolved solids	mg/L	308	324	250	339	220	302	296	360	210	422	244	257	212	166
BOD	mg/L	2	2	5	2	3	3	3	2	2	2	8	16	9	7
Dissolved Anions															
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	31	< 1	16	< 1	< 1	< 1	< 1	< 1	41	17	14	20
Bicarbonate alkalinity as $CaCO_3$	mg/L	98	157	100	168	184	130	70	142	144	120	185	114	201	100
Total alkalinity as $CaCO_3$	mg/L	98	157	131	168	200	130	70	142	144	120	226	131	215	120
Residual alkalinity	meq/L	-0.04	-0.1	0.01	0.02	0.16	-0.09	0.49	0.26	0.08	0.3	0.26	0.14	0.57	0.88
Chloride	mg/L	12	38	25	36	46	29	11	22	39	29	46	31	42	28
Sulphate as SO_4 2-	mg/L	17	31	25	31	27	22	1	26	26	28	46	32	40	16
Fluoride	mg/L	0.2	0.2	0.3	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.4	0.3	0.4	0.3
Dissolved Cations															
Calcium	mg/L	29	34	39	24	10	27	28	23	44	25	40	18	41	42
Magnesium	mg/L	11	20	13	20	23	13	5	15	17	14	25	15	21	10
Sodium	mg/L	16	36	30	40	44	37	15	30	35	30	56	38	58	36
Potassium	mg/L	4	4	6	5	4	5	6	5	4	5	6	6	7	5
Sodium absorption ratio (calc)	-	0.7	1.23	1.16	1.34	1.38	1.51	0.95	1.15	1.29	1.23	1.66	1.48	1.85	1.69
Dissolved Metals															
Aluminium	mg/L	0.06	0.04	0.09	0.02	<0.01	0.08	0.73	0.03	<0.01	0.04	<0.01	0.04	<0.01	0.04
Arsenic	mg/L	0.004	0.002	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.002	0.004	0.002	< 0.001	< 0.001
Barium	mg/L	0.019	0.03	0.029	0.064	0.056	0.043	0.032	0.045	0.051	0.051	0.087	0.054	0.079	0.042
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.05	0.06	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.001	0.002	0.003	0.001	0.008	0.003	0.001	0.002	0.002	0.003	0.003	0.002	0.002	0.006
Iron (total)	mg/L	0.05	0.05	0.07	0.05	0.05	0.07	0.5	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Lead	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Lithium	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.002	0.002	0.002	0.009	0.001	0.001	0.001	0.001	0.001	0.002	0.016	0.006	0.008	0.003
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	0.001	0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	0.002	0.001	0.004	0.002	< 0.001	0.003
Nickel	mg/L	0.003	0.002	0.003	0.003	0.004	0.002	0.002	0.003	0.003	0.002	0.004	0.005	< 0.001	0.002
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.174	0.342	0.318	0.417	0.464	0.272	0.148	0.298	0.311	0.325	0.569	0.326	0.438	0.276
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.02	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03
Zinc	mg/L	< 0.005	< 0.005	0.007	< 0.005	< 0.005	< 0.005	< 0.005	0.006	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Total Metals															
Aluminium	mg/L	4.45	7.39	4.73	2.38	1.04	1.01	15.6	1.59	3.37	5.64	5.55	5.2	3.94	9.75
Arsenic	mg/L	0.004	0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	0.002	0.004	0.002	0.004	0.004	0.001	< 0.001
Barium	mg/L	0.046	0.104	0.054	0.084	0.079	0.06	0.096	0.059	0.078	0.083	0.118	0.096	0.116	0.088
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.07	< 0.05	0.06	0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.004	0.003	0.001	< 0.001	0.018	< 0.001	0.004	0.006	0.006	0.005	0.004	0.012	< 0.001	< 0.001
Cobalt	mg/L	0.002	0.001	0.001	< 0.001	0.003	< 0.001	0.002	0.002	0.003	0.003	0.002	0.004	< 0.001	< 0.001
Copper	mg/L	0.007	0.004	0.002	0.004	0.01	0.004	0.004	0.006	0.007	0.007	0.005	0.012	< 0.001	< 0.001
Iron	mg/L	4.7	10.2	5.19	2.58	0.97	0.99	15	1.57	3.31	5.33	5.62	5.22	3.86	9
Lead	mg/L	< 0.001	< 0.001	0.004	< 0.001	0.002	< 0.001	< 0.001	< 0.001	0.001	0.003	0.003	0.002	< 0.001	< 0.001
Lithium	mg/L	0.002	0.002	0.001	< 0.001	0.005	0.001	0.002	0.003	0.002	0.002	0.002	0.003	< 0.001	< 0.001
Manganese	mg/L	0.119	0.303	0.086	0.11	0.136	0.094	0.113	0.079	0.092	0.118	0.273	0.357	0.226	0.166
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	0.001	0.001	0.001	0.001	0.001	< 0.001	0.001	< 0.001	0.003	0.001	0.004	0.003	0.002	0.002
Nickel	mg/L	0.005	0.012	0.007	0.005	0.003	0.004	0.018	0.004	0.006	0.008	0.009	0.008	0.008	0.014
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.204	0.436	0.337	0.451	0.562	0.282	0.178	0.32	0.352	0.355	0.61	0.329	0.491	0.315
Tin	mg/L	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	0.002	0.003	0.001	< 0.001	0.001	0.001	0.001	0.004	0.002	0.003	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	0.03	0.02	0.01	0.01	0.03	0.01	0.01	0.02	0.03	0.03	0.02	0.04	< 0.01	< 0.01
Zinc	mg/L	0.01	0.005	0.012	< 0.005	0.026	< 0.005	< 0.005	0.012	0.014	0.014	0.008	0.019	< 0.005	< 0.005

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7516_SURF_W	NAR_7516_SURF_W	NAR_7516_SURF_W	NAR_7516_SURF_W	NAR_7516_SURF_W	NAR_7516_SURF_W	NAR_7516_SURF_W	NAR_7516_SURF_W	NAR_7516_SURF_W	NAR_7517_SURF_W	NAR_7517_SURF_W	NAR_7517_SURF_W	NAR_7517_SURF_W	NAR_7517_SURF_W
	Surface Water Body Location	Bullawa Creek, tributaryof Namoi River	Bullawa Creek, tributaryof Namoi River	Bullawa Creek, tributaryof Namoi River	Bullawa Creek, tributaryof Namoi River	Bullawa Creek, tributaryof Namoi River	Bullawa Creek, tributaryof Namoi River	Bullawa Creek, tributaryof Namoi River	Bullawa Creek, tributaryof Namoi River	Bullawa Creek, tributaryof Namoi River	Namoi River at Tarriaro Cultural Reserve	Namoi River at Tarriaro Cultural Reserve	Namoi River at Tarriaro Cultural Reserve	Namoi River at Tarriaro Cultural Reserve	Namoi River at Tarriaro Cultural Reserve
	Stream Type	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Perennial	Perennial	Perennial	Perennial	Perennial
	Land Use	Cropping (dry)	Cropping (dry)	Cropping (dry)	Cropping (dry)	Cropping (dry)	Cropping (dry)	Cropping (dry)	Cropping (dry)	Cropping (dry)	Grazing	Grazing	Grazing	Grazing	Grazing
	Lab Sample ID	EB1207610009	ES1209204005	ES1212312005	EB1216301001	ES1217527002	ES1220443002	ES1222571008	ES1225305002	ES1303392007	EB1207610007	ES1209204004	ES1212312004	EB1216301002	ES1217527001
	Sample Date	20/03/2012	18/04/2012	16/05/2012	20/06/2012	17/07/2012	22/08/2012	19/09/2012	23/10/2012	13/02/2013	15/03/2012	18/04/2012	16/05/2012	20/06/2012	17/07/2012
	Sample Time	15:58	16:37	13:10	15:58	15:33	15:39	15:16	17:30	12:10	14:00	16:37	12:15	15:58	15:33
Analyte	**Units**														
Physiochemical															
pH	pH Unit	8.34	7.96	7.95	8.12	8.03	8	8.12	8.05	8	8.43	8.18	8.01	8.26	7.75
Turbidity	NTU	4.5	6	2.5	2.8	17.6	4.6	3	5.3	2.4	73	29.5	12.6	21	514
Electrical conductivity	µS/cm	419	478	496	436	205	417	483	536	439	483	733	451	476	304
Total dissolved solids	mg/L	283	132	264	272	286	226	281	334	220	296	212	326	294	166
BOD	mg/L	2	2	2	2	2	2	2	2	2	2	3	2	2	3
Dissolved Anions															
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	28	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	161	190	186	169	71	160	160	198	177	170	224	143	157	91
Total alkalinity as $CaCO_3$	mg/L	166	190	186	169	71	160	160	198	177	198	224	143	157	91
Residual alkalinity	meq/L	-0.05	0.3	0.04	0.06	0.23	0.3	-0.11	0.18	0.36	0.81	-0.44	0.01	0.01	0.02
Chloride	mg/L	21	29	32	32	14	24	40	50	28	24	63	29	42	21
Sulphate as SO_4 2-	mg/L	1	4	7	9	7	9	8	4	7	1	47	23	34	15
Fluoride	mg/L	0.3	0.2	0.2	0.3	0.2	0.1	0.2	0.1	0.3	0.1	0.2	0.2	0.2	0.1
Dissolved Cations															
Calcium	mg/L	44	40	14	35	40	46	39	30	49	29	30	18	33	31
Magnesium	mg/L	16	17	18	16	6	14	16	18	15	20	30	17	20	11
Sodium	mg/L	27	22	24	27	14	23	24	30	24	32	52	30	46	22
Potassium	mg/L	5	6	5	4	2	4	4	6	6	3	4	3	3	4
Sodium absorption ratio (calc)	-	0.9	0.72	0.77	0.92	0.79	0.81	0.81	0.96	0.83	1.11	1.44	1.09	1.58	1.01
Dissolved Metals															
Aluminium	mg/L	<0.01	<0.01	<0.01	<0.01	0.37	<0.01	<0.01	<0.01	<0.01	0.02	0.14	0.02	0.02	0.08
Arsenic	mg/L	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.002	0.002	0.002	0.001	< 0.001	< 0.001
Barium	mg/L	0.046	0.067	0.053	0.04	0.017	0.046	0.049	0.055	0.056	0.031	0.046	0.023	0.023	0.02
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.001	0.001	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.006	0.002	0.003
Iron (total)	mg/L	0.05	0.05	0.07	0.05	0.2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.1
Lead	mg/L	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Lithium	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.001	0.224	0.709	0.306	0.01	0.181	0.306	0.372	0.059	0.008	0.005	0.007	0.007	0.009
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.002	0.001	< 0.001	< 0.001	0.002	0.002	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.003	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.002	0.002	0.001	0.002	0.001	0.003	0.001	0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.371	0.472	0.467	0.303	0.134	0.347	0.363	0.463	0.386	0.353	0.57	0.307	0.264	0.217
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	0.005	0.006	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.005	0.008	0.005	0.009	< 0.005	0.005	< 0.005
Total Metals															
Aluminium	mg/L	0.01	0.14	0.02	0.02	0.58	0.11	0.06	0.07	0.03	2.2	1.74	0.57	0.72	10.6
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.002	< 0.001	0.002	0.002	0.002	< 0.001
Barium	mg/L	0.048	0.072	0.059	0.053	0.022	0.05	0.058	0.06	0.057	0.046	0.058	0.026	0.036	0.136
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.002	< 0.001	0.001	0.012	0.002	< 0.001
Cobalt	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	0.011	< 0.001	< 0.001
Copper	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.005	0.003	< 0.001	0.003	0.02	0.003	0.002
Iron	mg/L	0.05	0.35	0.37	0.16	0.49	0.22	0.3	0.2	0.19	2.23	1.69	0.5	0.87	5.91
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.001	< 0.001
Lithium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.002	0.001	< 0.001	0.005	0.002	0.001
Manganese	mg/L	0.13	0.348	0.752	0.309	0.021	0.183	0.381	0.509	0.207	0.124	0.156	0.047	0.054	0.585
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	0.002	0.002	< 0.001	0.001	0.001	0.002	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.002	0.001	0.005	0.003	0.001	0.003	0.028
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.382	0.498	0.481	0.334	0.145	0.355	0.388	0.47	0.388	0.359	0.594	0.314	0.319	0.335
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.003	0.001	0.002	< 0.001	0.002	0.001
Vanadium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	0.01	< 0.01	< 0.01	0.04	< 0.01	< 0.01
Zinc	mg/L	< 0.005	0.006	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.006	< 0.005	< 0.005	< 0.005	0.024	< 0.005	< 0.005

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7517_SURF_W	NAR_7517_SURF_W	NAR_7517_SURF_W	NAR_7517_SURF_W	NAR_7517_SURF_W	NAR_7517_SURF_W	NAR_7517_SURF_W	NAR_7518_SURF_W	NAR_7518_SURF_W	NAR_7518_SURF_W	NAR_7518_SURF_W	NAR_7518_SURF_W	NAR_7518_SURF_W	NAR_7518_SURF_W
Surface Water Body Location		Namoi River at Tarriaro Cultural Reserve	Namoi River at Tarriaro Cultural Reserve	Namoi River at Tarriaro Cultural Reserve	Namoi River at Tarriaro Cultural Reserve	Namoi River at Tarriaro Cultural Reserve	Namoi River at Tarriaro Cultural Reserve	Namoi River at Tarriaro Cultural Reserve	Nuable Creek West of Narrabri along Yarrie Lake Road	Nuable Creek West of Narrabri along Yarrie Lake Road	Nuable Creek West of Narrabri along Yarrie Lake Road	Nuable Creek West of Narrabri along Yarrie Lake Road	Nuable Creek West of Narrabri along Yarrie Lake Road	Nuable Creek West of Narrabri along Yarrie Lake Road	Nuable Creek West of Narrabri along Yarrie Lake Road
Stream Type		Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral
Land Use		Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing
Lab Sample ID		ES1220443001	ES1222571007	ES1225305001	ES1227704005	ES1229424001	ES1300408001	ES1303392006	EB1207610011	ES1209055007	ES1212311002	ES1214731003	ES1217527004	ES1220319005	ES1222453002
Sample Date		22/08/2012	19/09/2012	23/10/2012	21/11/2012	12/12/2012	8/01/2013	13/02/2013	14/03/2012	17/04/2012	15/05/2012	13/06/2012	17/07/2012	21/08/2012	17/09/2012
Sample Time		15:39	15:16	16:45	13:25	11:03	13:01	11:32	13:30	8:50	12:30	12:43	15:33	10:45	16:30
Analyte	**Units**														
Physiochemical															
pH	pH Unit	8.18	8.24	8.27	8.17	7.86	8.26	8.06	7.79	7.51	7.3	7.49	7.47	7.35	7.59
Turbidity	NTU	20.5	7.1	22.1	73.3	26	16.4	62.4	33	79.7	85.3	52.3	147	162	172
Electrical conductivity	µS/cm	529	524	353	348	261	273	300	174	117	131	251	104	109	115
Total dissolved solids	mg/L	232	165	131	150	186	148	236	183	293	374	370	492	572	566
BOD	mg/L	2	2	2	3	2	4	3	3	3	2	4	2	2	2
Dissolved Anions															
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	176	154	113	104	95	98	100	69	52	51	108	37	43	46
Total alkalinity as $CaCO_3$	mg/L	176	154	113	104	95	98	100	69	52	51	108	37	43	46
Residual alkalinity	meq/L	0.06	-0.11	0.09	-0.27	-0.19	-0.13	0.16	0.49	0.46	0.44	0.58	0.38	0.41	0.47
Chloride	mg/L	37	45	26	29	12	12	21	10	7	8	13	8	8	9
Sulphate as SO_4 2-	mg/L	33	30	24	27	20	17	23	1	1	1	7	1	1	2
Fluoride	mg/L	0.1	0.2	0.1	0.2	0.2	0.2	0.3	0.1	0.1	0.1	0.2	0.1	0.1	0.1
Dissolved Cations															
Calcium	mg/L	22	25	21	21	19	8	5	6	5	20	4	4	4	3
Magnesium	mg/L	22	20	14	15	11	11	12	6	4	4	7	2	3	3
Sodium	mg/L	38	35	25	23	18	16	22	17	13	15	25	12	12	13
Potassium	mg/L	3	3	3	3	4	4	3	5	6	6	8	5	4	6
Sodium absorption ratio (calc)	-	1.27	1.2	1.02	0.9	0.79	0.7	0.97	1.11	1.05	1.21	1.22	1.18	1.1	1.2
Dissolved Metals															
Aluminium	mg/L	0.02	<0.01	0.05	0.05	<0.01	0.08	0.03	0.6	0.69	1.1	0.66	0.53	0.44	0.78
Arsenic	mg/L	< 0.001	0.002	0.002	0.001	0.001	0.003	0.001	0.002	0.001	0.001	< 0.001	< 0.001	< 0.001	0.001
Barium	mg/L	0.03	0.027	0.023	0.023	0.001	0.017	0.022	0.045	0.036	0.043	0.067	0.024	0.022	0.025
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.008	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.001
Copper	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.006	0.001	0.001	0.002	0.003
Iron (total)	mg/L	0.05	0.05	0.05	0.05	0.05	0.07	0.05	1.41	1.1	5.71	0.61	0.58	0.51	0.72
Lead	mg/L	0.001	0.001	0.001	0.001	0.001	0.005	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001
Lithium	mg/L	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.004	0.001	0.001	0.001	0.001
Manganese	mg/L	0.003	0.003	0.002	0.042	0.001	0.003	0.002	0.178	0.013	0.027	0.092	0.004	0.003	0.005
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.002	0.001	< 0.001	< 0.001	0.001	0.004	0.003	0.006	0.007	0.003	0.002	0.002	0.002	0.003
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.363	0.311	0.231	0.246	0.001	0.165	0.216	0.113	0.065	0.07	0.158	0.04	0.042	0.04
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	< 0.005	0.005	< 0.005	< 0.005	< 0.005	0.01	0.011	0.021	0.023	0.011	0.011	0.013	0.014	0.014
Total Metals															
Aluminium	mg/L	1.24	0.95	1.12	3.2	1.6	0.45	5.59	0.84	5.67	7.08	2.37	2.53	10.2	4.81
Arsenic	mg/L	0.001	0.002	< 0.001	0.001	0.002	0.004	0.002	0.004	0.001	0.002	0.001	0.001	0.002	0.002
Barium	mg/L	0.036	0.034	0.029	0.044	0.029	0.023	0.046	0.054	0.057	0.048	0.083	0.053	0.056	0.057
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.001	0.003	0.002	< 0.001	0.007	0.001	0.006	0.019	0.004	0.002	0.003	0.012	0.006	0.016
Cobalt	mg/L	< 0.001	0.001	< 0.001	< 0.001	0.002	0.003	0.003	0.008	0.002	0.002	0.002	0.005	0.002	0.007
Copper	mg/L	0.002	0.005	0.003	0.002	0.006	0.002	0.004	0.011	0.012	0.002	0.004	0.011	0.006	0.008
Iron	mg/L	1.28	1	1.1	3.44	1.71	0.41	4.96	2.92	6.42	7.03	2.96	3.33	11.6	5.3
Lead	mg/L	< 0.001	< 0.001	0.003	< 0.001	< 0.001	0.001	0.003	0.008	0.003	0.002	0.003	0.006	0.003	0.062
Lithium	mg/L	0.002	0.002	0.002	0.001	0.002	0.001	0.003	0.006	0.004	0.001	0.003	0.004	0.002	0.006
Manganese	mg/L	0.073	0.068	0.066	0.156	0.066	0.03	0.128	0.322	0.106	0.055	0.148	0.053	0.057	0.047
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.003	0.002	0.003	0.004	0.003	0.001	0.008	0.004	0.006	0.005	0.007	0.004	0.008	0.005
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.371	0.332	0.244	0.253	0.194	0.183	0.243	0.12	0.08	0.064	0.159	0.061	0.061	0.067
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	0.01	< 0.01	< 0.01	0.02	< 0.01	0.01	0.03	0.02	< 0.01	0.01	0.02	0.01	0.03
Zinc	mg/L	< 0.005	0.008	< 0.005	< 0.005	0.013	< 0.005	0.014	0.032	0.022	0.005	0.016	0.028	0.02	0.034

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7518_SURF_W	NAR_7518_SURF_W	NAR_7518_SURF_W	NAR_7518_SURF_W	NAR_7519_SURF_W	NAR_7519_SURF_W	NAR_7519_SURF_W	NAR_7519_SURF_W	NAR_7519_SURF_W	NAR_7519_SURF_W	NAR_7519_SURF_W	NAR_7519_SURF_W	NAR_7519_SURF_W
	Surface Water Body Location	Nuable Creek West of Narrabri along Yarrie Lake Road	Nuable Creek West of Narrabri along Yarrie Lake Road	Nuable Creek West of Narrabri along Yarrie Lake Road	Nuable Creek West of Narrabri along Yarrie Lake Road	Unnamed tributary of Bundock Creek at Yarrie Lake Road bridge crossing	Unnamed tributary of Bundock Creek at Yarrie Lake Road bridge crossing	Unnamed tributary of Bundock Creek at Yarrie Lake Road bridge crossing	Unnamed tributary of Bundock Creek at Yarrie Lake Road bridge crossing	Unnamed tributary of Bundock Creek at Yarrie Lake Road bridge crossing	Unnamed tributary of Bundock Creek at Yarrie Lake Road bridge crossing	Unnamed tributary of Bundock Creek at Yarrie Lake Road bridge crossing	Unnamed tributary of Bundock Creek at Yarrie Lake Road bridge crossing	Unnamed tributary of Bundock Creek at Yarrie Lake Road bridge crossing
	Stream Type	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral
	Land Use	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing
	Lab Sample ID	ES1225252004	ES1227538001	ES1229332001	ES1303253004	EB1207610013	ES1209055008	ES1212311003	ES1214731004	ES1217527006	ES1220319006	ES1222453003	ES1225252005	ES1303253005
	Sample Date	23/10/2012	20/11/2012	11/12/2012	12/02/2013	20/03/2012	17/04/2012	15/05/2012	13/06/2012	17/07/2012	21/08/2012	18/09/2012	23/10/2012	12/02/2013
	Sample Time	14:18	8:15	16:13	13:46	15:58	9:40	13:15	12:43	15:33	11:30	15:58	14:18	13:46
Analyte	**Units**													
Physiochemical														
pH	pH Unit	7.54	7.52	7.8	6.69	8.06	7.98	7.82	7.59	7.29	7.54	7.61	7.77	6.67
Turbidity	NTU	226	235	218	50.5	72	73.9	63.9	281	251	445	654	993	121
Electrical conductivity	µS/cm	142	181	206	64	328	347	375	268	133	168	202	310	313
Total dissolved solids	mg/L	114	245	208	220	468	280	717	984	1360	256	699	229	369
BOD	mg/L	3	5	2	3	2	4	3	3	5	3	2	9	3
Dissolved Anions														
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	52	74	81	21	136	138	145	103	62	60	74	97	15
Total alkalinity as $CaCO_3$	mg/L	52	74	81	21	136	138	145	103	62	60	74	97	15
Residual alkalinity	meq/L	0.72	0.85	0.91	0.11	1.49	1.45	1.67	1.02	0.92	0.65	0.8	1.37	-0.61
Chloride	mg/L	9	13	13	5	18	23	23	20	11	12	17	21	20
Sulphate as SO_4 2-	mg/L	2	9	9	1	1	1	1	8	4	8	8	22	24
Fluoride	mg/L	0.1	0.2	0.2	0.1	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.2	0.1
Dissolved Cations														
Calcium	mg/L	6	3	13	13	13	11	3	6	7	8	10	2	1
Magnesium	mg/L	2	4	5	2	7	8	7	6	2	3	4	4	5
Sodium	mg/L	19	30	28	7	42	46	49	35	18	20	24	45	36
Potassium	mg/L	5	7	7	5	9	9	9	9	7	7	9	7	12
Sodium absorption ratio (calc)	-	1.99	2.33	2.04	0.77	2.33	2.59	2.72	2.11	1.83	1.66	1.79	3.14	2.32
Dissolved Metals														
Aluminium	mg/L	0.91	7.12	1.58	0.56	0.38	0.22	0.4	1.13	1.47	0.52	5.88	0.8	0.68
Arsenic	mg/L	0.002	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001
Barium	mg/L	0.028	0.024	0.033	0.02	0.036	0.051	0.048	0.041	0.018	0.029	0.025	0.057	0.046
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.06	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.06	0.07	0.07
Cadmium	mg/L	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.004	0.001	0.001
Cobalt	mg/L	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.002	0.004	0.002	0.001	0.002	0.001	0.002	0.002	0.002	0.003	0.004	0.005	0.004
Iron (total)	mg/L	0.74	3.76	0.97	0.78	0.31	0.13	0.18	0.47	0.76	0.45	2.85	0.38	0.37
Lead	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.006
Lithium	mg/L	0.001	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.002	0.002
Manganese	mg/L	0.046	0.078	0.071	0.067	0.088	0.042	0.009	0.011	0.011	0.011	0.011	0.066	0.055
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	0.002	0.001	0.002	0.001	< 0.001	< 0.001	0.001	0.003	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.004	0.002	0.002	0.002	0.003	0.002	0.003	0.003	0.006	0.004	0.002	0.004	< 0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.053	0.068	0.086	0.027	0.169	0.174	0.161	0.115	0.038	0.064	0.075	0.11	0.1
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	0.011	0.032	0.006	0.009	0.01	0.012	0.011	0.013	< 0.005	0.023	0.009	0.011	< 0.005
Total Metals														
Aluminium	mg/L	14.5	17.8	17.6	3.22	2.56	2.43	3.02	19.8	4.64	29.9	25.3	41.5	7.89
Arsenic	mg/L	0.006	0.001	0.002	0.002	< 0.001	0.002	0.001	0.002	0.003	0.006	< 0.001	0.002	< 0.001
Barium	mg/L	0.078	0.076	0.099	0.034	0.047	0.073	0.056	0.097	0.062	0.105	0.138	0.236	0.073
Beryllium	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	0.001	0.002	< 0.001	< 0.001	< 0.001
Boron	mg/L	0.06	< 0.05	0.07	< 0.05	0.07	< 0.05	< 0.05	0.06	0.05	0.07	0.1	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.02	0.003	0.002	0.002	< 0.001	0.018	0.004	0.028	0.028	0.043	0.008	0.012	0.004
Cobalt	mg/L	0.009	0.002	0.002	0.002	0.002	0.006	0.003	0.009	0.009	0.019	0.003	0.003	0.002
Copper	mg/L	0.008	0.002	0.003	0.003	< 0.001	0.008	0.007	0.014	0.016	0.02	0.007	0.005	0.002
Iron	mg/L	13.9	17.6	18	4.63	3	2.68	2.92	15.6	3.14	25.7	24.4	37.5	7.13
Lead	mg/L	0.007	0.001	0.002	0.002	0.001	0.006	0.004	0.01	0.012	0.021	0.003	0.007	0.004
Lithium	mg/L	0.007	0.002	0.001	0.001	0.002	0.006	0.005	0.013	0.011	0.016	0.006	0.003	0.003
Manganese	mg/L	0.205	0.253	0.245	0.106	0.206	0.23	0.122	0.194	0.097	0.229	0.262	0.775	0.109
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	0.002	0.001	0.002	0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.01	0.012	0.014	0.003	0.004	0.004	0.004	0.012	0.007	0.017	0.018	0.028	0.007
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.082	0.103	0.121	0.036	0.18	0.187	0.143	0.15	0.072	0.122	0.15	0.253	0.129
Tin	mg/L	< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	0.03	< 0.01	< 0.01	< 0.01	< 0.01	0.03	0.01	0.05	0.05	0.08	0.01	0.02	< 0.01
Zinc	mg/L	0.03	0.047	< 0.005	0.02	< 0.005	0.029	0.012	0.049	0.049	0.069	0.022	0.011	0.007

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7520_SURF_W	NAR_7520_SURF_W	NAR_7521_SURF_W	NAR_7522_SURF_W	NAR_7522_SURF_W	NAR_7523_SURF_W	NAR_7524_SURF_W	NAR_7526_SURF_W	NAR_7528_SUFR_W	NAR_7528_SURF_W	NAR_7528_SUFR_W	NAR_7528_SURF_W	NAR_7528_SUFR_W	NAR_7528_SURF_W	NAR_7528_SUFR_W
Surface Water Body Location		Bullock Creek	Bullock Creek		Bohena Creek (ESG/Santos discharge location)	Bohena Creek (ESG/Santos discharge location)			Overflow of Dam on Westport Road	Irrigation Channel, Kamilaroi Highway	Irrigation Channel, Kamilaroi Highway	Irrigation Channel, Kamilaroi Highway	Irrigation Channel, Kamilaroi Highway	Irrigation Channel, Kamilaroi Highway	Irrigation Channel, Kamilaroi Highway	Irrigation Channel, Kamilaroi Highway
Stream Type										Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral
Land Use										Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing
Lab Sample ID		EB1208016001	ES1217889003	EB1208016002	EB1208016003	ES1217889002	EB1208016004	EB1208010003	EB1208236005	ES1300507007	ES1209055010	ES1212311005	ES1215389002	ES1217757004	ES1220443008	ES1222571002
Sample Date		22/03/2012	18/07/2012	22/03/2012	22/03/2012	18/07/2012	22/03/2012	22/03/2012	27/03/2012	9/01/2013	17/04/2012	15/05/2012	20/06/2012	18/07/2012	22/08/2012	19/09/2012
Sample Time		16:16	17:20	16:16	16:16	16:30	16:16	11:49	11:16	12:47	12:20	15:30	12:20	16:21	15:39	15:16
Analyte	**Units**															
Physiochemical																
pH	pH Unit	7.87	6.54	7.22	8.14	7.9	7.6	7.96	8.03	8.24	8.85	8.52	8.3	7.85	8.71	8.2
Turbidity	NTU	181	217	74	59	37.2	68	7970	625	102	210	55.2	60.3	526	491	198
Electrical conductivity	µS/cm	277	101	299	253	448	256	1040	610	341	591	601	559	313	514	571
Total dissolved solids	mg/L	248	290	278	7020	2880	206	322	314	330	323	480	402	284	358	218
BOD	mg/L	4	2	5	2	2	4	59	2	4	4	5	3	2	5	5
Dissolved Anions																
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	47	< 1	21	< 1	< 1	21
Bicarbonate alkalinity as $CaCO_3$	mg/L	56	12	77	82	74	88	328	222	109	167	154	201	99	142	179
Total alkalinity as $CaCO_3$	mg/L	56	12	77	82	74	88	328	222	109	214	175	201	99	163	179
Residual alkalinity	meq/L	0.69	0.03	0.5	1.37	-0.85	0.16	5.83	4.01	-0.04	0.11	-0.09	-0.28	0.13	0.49	-0.08
Chloride	mg/L	45	19	38	23	96	19	132	42	15	44	50	44	22	33	47
Sulphate as SO_4 2-	mg/L	1	7	1	1	3	1	1	1	23	33	29	36	15	30	28
Fluoride	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	0.3	0.2	0.3	0.1	0.2	0.2
Dissolved Cations																
Calcium	mg/L	6	2	18	14	< 1	2	28	44	28	34	38	19	31	37	33
Magnesium	mg/L	4	2	9	2	19	11	1	4	10	24	23	23	11	18	22
Sodium	mg/L	47	14	38	48	37	16	1	130	19	47	46	47	22	37	40
Potassium	mg/L	4	3	4	2	4	7	1	5	5	5	5	4	4	4	4
Sodium absorption ratio (calc)	-	5.07	1.92	2.38	6.34	1.39	0.86	13.9	12.2	0.8	1.42	1.49	1.48	0.98	1.29	1.29
Dissolved Metals																
Aluminium	mg/L	0.65	0.42	0.07	0.13	0.25	0.04	<0.01	2.89	0.02	0.03	0.02	<0.01	0.07	<0.01	<0.01
Arsenic	mg/L	0.002	< 0.001	< 0.001	< 0.001	0.012	0.008	0.002	0.003	0.002	0.002	0.001	< 0.001	0.002	0.002	0.002
Barium	mg/L	0.03	0.024	0.044	0.009	0.053	0.092	0.074	0.057	0.024	0.039	0.043	0.049	0.02	0.034	0.031
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.1	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.006	0.001	0.001	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.003	0.001	0.001	0.001	0.001	0.001	0.008	0.004	0.002	0.002	0.002	0.001	0.002	0.003	0.002
Iron (total)	mg/L	1.64	0.79	7.22	0.7	0.19	5.28	0.09	1.76	0.05	0.05	0.05	0.05	0.07	0.05	0.05
Lead	mg/L	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.007	0.001
Lithium	mg/L	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.014	0.026	0.385	0.025	0.033	0.412	0.035	0.003	0.018	0.038	0.014	0.41	0.001	0.057	0.297
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.005	0.003	< 0.001	0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	0.002	0.001
Nickel	mg/L	0.005	0.001	0.002	0.01	0.007	0.003	0.001	0.003	0.001	0.003	0.003	0.003	0.003	0.003	0.003
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.026	0.018	0.104	0.032	0.26	0.187	0.136	0.023	0.294	0.5	0.482	0.511	0.221	0.426	0.436
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.01	0.02	0.01
Zinc	mg/L	0.013	0.005	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.006	< 0.005	< 0.005	< 0.005	< 0.005	0.005
Total Metals																
Aluminium	mg/L	8.2	3.44	0.76	0.86	0.9	0.08	275	55.4	6.52	6.42	2.87	4.6	26.3	10.4	10
Arsenic	mg/L	0.004	< 0.001	< 0.001	0.001	0.034	0.013	0.002	0.003	0.002	0.002	0.002	0.002	0.003	0.003	0.002
Barium	mg/L	0.056	0.055	0.052	0.02	0.068	0.1	2.26	0.621	0.056	0.062	0.056	0.079	0.109	0.109	0.079
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.014	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	0.12	< 0.05	< 0.05	0.14	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.002	0.001	0.002	< 0.001	0.244	0.063	0.006	0.002	0.006	0.003	0.005	0.034	0.01	0.01	0.002
Cobalt	mg/L	0.007	0.002	0.001	0.005	0.116	0.026	0.002	0.002	0.002	0.002	0.004	0.011	0.006	0.005	0.002
Copper	mg/L	0.001	0.001	0.001	< 0.001	0.084	0.013	0.008	0.006	0.008	0.005	0.006	0.025	0.015	0.011	0.005
Iron	mg/L	11.7	3.02	22.4	3.78	1.33	8.46	289	70.2	5.93	6.29	2.6	4.67	26.2	10.1	9.85
Lead	mg/L	0.001	< 0.001	< 0.001	< 0.001	0.138	0.028	0.002	< 0.001	0.002	< 0.001	0.001	0.004	0.004	0.003	< 0.001
Lithium	mg/L	0.001	0.004	< 0.001	< 0.001	0.085	0.014	0.003	0.001	0.003	0.002	0.002	0.007	0.003	0.004	0.002
Manganese	mg/L	0.044	0.047	0.44	0.11	0.083	0.464	3.09	0.168	0.127	0.199	0.211	0.553	0.4	0.383	0.521
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.001	< 0.001	0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	0.001	< 0.001
Nickel	mg/L	0.006	0.001	0.005	0.002	0.001	0.011	0.127	0.02	0.006	0.006	0.005	0.008	0.038	0.013	0.012
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.034	0.029	0.113	0.036	0.282	0.194	1.16	0.075	0.327	0.555	0.552	0.543	0.282	0.487	0.525
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.004	0.002	< 0.001	0.002	< 0.001	0.003	0.002	< 0.001	0.002	0.002	0.002
Vanadium	mg/L	0.01	< 0.01	< 0.01	< 0.01	0.33	0.14	0.02	0.03	0.02	0.02	0.02	0.06	0.04	0.03	0.02
Zinc	mg/L	0.009	0.008	< 0.005	0.01	0.312	0.059	0.012	< 0.005	0.012	0.006	0.008	0.04	0.02	0.014	< 0.005

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7528_SURF_W	NAR_7528_SUFR_W	NAR_7528_SURF_W	NAR_7528_SUFR_W	NAR_7528_SURF_W	NAR_7529_SURF_W	NAR_7529_SURF_W	NAR_7529_SURF_W	NAR_7529_SURF_W	NAR_7529_SURF_W	NAR_7529_SURF_W	NAR_7529_SURF_W	NAR_7529_SURF_W	NAR_7529_SURF_W	NAR_7529_SURF_W
Surface Water Body Location		Irrigation Channel, Kamilaroi Highway	Irrigation Channel, Kamilaroi Highway	Irrigation Channel, Kamilaroi Highway	Irrigation Channel, Kamilaroi Highway	Irrigation Channel, Kamilaroi Highway	Namoi River upstream of Bohena Creek junction	Namoi River upstream of Bohena Creek junction	Namoi River upstream of Bohena Creek junction	Namoi River upstream of Bohena Creek junction	Namoi River upstream of Bohena Creek junction	Namoi River upstream of Bohena Creek junction	Namoi River upstream of Bohena Creek junction	Namoi River upstream of Bohena Creek junction	Namoi River upstream of Bohena Creek junction	Namoi River upstream of Bohena Creek junction
	Stream Type	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial
	Land Use	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing
	Lab Sample ID	ES1225305010	ES1227704003	ES1229332008	ES1300507007	ES1303392003	ES1209204001	ES1212311007	ES1214897002	ES1217757006	ES1220549004	ES1222571004	ES1225252007	ES1229424002	ES1300507003	ES1303392005
	Sample Date	24/10/2012	21/11/2012	11/12/2012	9/01/2013	13/02/2013	17/04/2012	15/05/2012	13/06/2012	18/07/2012	23/08/2012	19/09/2012	23/10/2012	12/12/2012	9/01/2013	13/02/2013
	Sample Time	12:43	10:05	16:13	1:30	11:32	17:25	17:00	17:00	16:21	13:53	15:16	14:18	11:03	12:47	11:32
Analyte	**Units**															
Physiochemical																
pH	pH Unit	8.58	8.53	9.41	8.24	8.12	8.15	7.93	8.37	7.8	8.23	8.27	8.17	8.05	8	8.24
Turbidity	NTU	111	53.9	90	102	111	15.1	14.9	13.2	415	16.1	8	24.3	17.9	34.9	69.7
Electrical conductivity	µS/cm	519	563	422	341	376	688	456	616	300	445	508	352	262	255	320
Total dissolved solids	mg/L	206	212	338	230	336	276	274	266	198	148	169	176	4410	190	290
BOD	mg/L	2	3	2	4	3	3	2	3	2	2	2	2	2	3	3
Dissolved Anions																
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	19	16	54	< 1	< 1	< 1	11	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	151	131	61	109	122	213	154	177	98	175	150	102	95	87	105
Total alkalinity as $CaCO_3$	mg/L	170	146	115	109	122	213	154	188	98	175	150	102	95	87	105
Residual alkalinity	meq/L	0.11	-0.79	0.18	-0.04	0.17	-0.52	0.1	-0.06	0.16	0.04	-0.24	0.18	-0.08	-0.08	0.18
Chloride	mg/L	46	29	45	15	30	60	30	66	22	42	44	22	12	11	23
Sulphate as SO_4 2-	mg/L	30	37	34	23	23	44	23	33	13	33	28	24	20	17	22
Fluoride	mg/L	0.2	0.3	0.3	0.4	0.2	0.5	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2
Dissolved Cations																
Calcium	mg/L	40	16	24	48	30	36	18	33	32	21	20	20	21	< 1	32
Magnesium	mg/L	21	21	16	10	15	29	18	28	11	22	20	12	11	10	13
Sodium	mg/L	39	34	46	19	27	50	32	47	21	38	36	23	18	15	23
Potassium	mg/L	5	5	4	5	4	4	3	4	4	3	4	3	4	3	3
Sodium absorption ratio (calc)	-	1.3	1.09	1.94	0.8	1.06	1.41	1.14	1.43	0.95	1.26	1.23	0.98	0.8	0.68	0.97
Dissolved Metals																
Aluminium	mg/L	0.02	<0.01	0.03	0.02	0.02	0.02	<0.01	<0.01	0.06	<0.01	<0.01	0.03	0.07	0.06	0.03
Arsenic	mg/L	0.001	0.002	0.002	0.002	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	0.002	0.001	0.003	< 0.001
Barium	mg/L	0.048	0.047	0.007	0.024	0.031	0.048	0.026	0.037	0.018	0.029	0.027	0.029	0.022	0.019	0.023
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.003	0.002	0.003	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.002	0.002	0.002	0.001
Iron (total)	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.05	0.05	0.05	0.06	0.06	0.05
Lead	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Lithium	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.164	0.003	0.001	0.018	0.031	0.001	0.002	0.009	0.001	0.002	0.001	0.002	0.005	0.006	0.011
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.001	0.002	0.002	0.001	0.001	0.002	0.003	< 0.001	< 0.001	0.001	0.001	0.002	0.002	0.009	0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.441	0.464	0.331	0.294	0.292	0.538	0.304	0.474	0.221	0.341	0.293	0.248	0.19	0.16	0.244
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	< 0.005	< 0.005	< 0.005	0.006	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.005	< 0.005	< 0.005	< 0.005	0.028	< 0.005
Total Metals																
Aluminium	mg/L	2.46	11.6	3.15	6.52	8.25	1.12	0.47	1.05	20.4	0.84	0.76	1.12	1.48	1.66	4.99
Arsenic	mg/L	0.003	0.003	0.003	0.002	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	0.002	0.001	0.002	0.008	0.001
Barium	mg/L	0.072	0.121	0.019	0.056	0.062	0.054	0.029	0.04	0.091	0.036	0.035	0.028	0.028	0.028	0.045
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.006	< 0.001
Boron	mg/L	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.1	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001
Chromium	mg/L	0.011	0.003	0.01	0.001	< 0.001	0.001	0.026	< 0.001	< 0.001	< 0.001	0.001	0.002	0.006	0.126	< 0.001
Cobalt	mg/L	0.005	0.002	0.003	< 0.001	< 0.001	< 0.001	0.008	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.058	< 0.001
Copper	mg/L	0.016	0.005	0.008	0.003	< 0.001	< 0.001	0.019	0.002	0.002	0.002	0.004	0.002	0.005	0.049	0.002
Iron	mg/L	2.76	11.1	2.91	5.93	7.38	1.1	0.44	1.02	19.2	0.9	0.82	1.13	1.42	1.85	4.44
Lead	mg/L	0.024	< 0.001	0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.052	< 0.001
Lithium	mg/L	0.004	0.002	0.003	0.001	0.001	< 0.001	0.005	0.001	0.002	0.001	0.001	0.002	0.002	0.148	0.001
Manganese	mg/L	0.315	0.284	0.214	0.127	0.189	0.092	0.064	0.042	0.325	0.08	0.068	0.062	0.06	0.08	0.136
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.006	0.013	0.005	0.006	0.009	0.002	0.001	0.003	0.029	0.002	0.002	0.002	0.003	0.003	0.007
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.454	0.502	0.36	0.327	0.32	0.552	0.336	0.466	0.278	0.361	0.334	0.214	0.196	0.194	0.259
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	0.002	0.002	< 0.001	0.002	0.001	0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.001
Vanadium	mg/L	0.03	0.03	0.02	< 0.01	< 0.01	0.01	0.05	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	0.22	< 0.01
Zinc	mg/L	0.019	0.007	0.017	< 0.005	< 0.005	< 0.005	0.026	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.009	0.096	< 0.005

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7530_SURF_W	NAR_7531_SURF_W	NAR_7531_SURF_W	NAR_7531_SURF_W	NAR_7531_SURF_W	NAR_7531_SURF_W	NAR_7531_SURF_W	NAR_7531_SURF_W	NAR_7531_SURF_W	NAR_7531_SURF_W	NAR_7531_SURF_W	NAR_7532_SURF_W	NAR_7532_SURF_W	NAR_7532_SURF_W	NAR_7532_SURF_W
Surface Water Body Location			Stormwater outlet intio Narrabri Creen near Leitch Oval	Stormwater outlet intio Narrabri Creen near Leitch Oval	Stormwater outlet intio Narrabri Creen near Leitch Oval	Stormwater outlet intio Narrabri Creen near Leitch Oval	Stormwater outlet intio Narrabri Creen near Leitch Oval	Stormwater outlet intio Narrabri Creen near Leitch Oval	Stormwater outlet intio Narrabri Creen near Leitch Oval	Stormwater outlet intio Narrabri Creen near Leitch Oval	Stormwater outlet intio Narrabri Creen near Leitch Oval	Stormwater outlet intio Narrabri Creen near Leitch Oval	Narrabri Creek near Leitch Oval	Narrabri Creek near Leitch Oval	Narrabri Creek near Leitch Oval	Narrabri Creek near Leitch Oval
	Stream Type		Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial
	Land Use		Urban	Urban	Urban	Urban	Urban	Urban	Urban	Urban	Urban	Urban	Urban	Urban	Urban	Urban
	Lab Sample ID	EB1210480003	ES1212386006	ES1214897006	ES1217889007	ES1220549006	ES1222707003	ES1225490002	ES1227820004	ES1229424006	ES1300408004	ES1303496002	ES1212386007	ES1214897007	ES1220549005	ES1222707004
	Sample Date	20/04/2012	17/05/2012	14/06/2012	19/07/2012	23/08/2012	20/09/2012	25/10/2012	22/11/2012	12/12/2012	8/01/2013	14/02/2013	17/05/2012	14/06/2012	23/08/2012	20/09/2012
	Sample Time	10:30	13:24	12:43	12:23	13:53	14:03	12:26	11:25	13:00	13:01	14:37	13:24	12:45	13:53	14:03
Analyte	**Units**															
Physiochemical																
pH	pH Unit	7.73	7.9	7.93	7.86	8.25	8.32	8.06	8.11	8.06	8.11	7.92	7.96	8.13	8.2	8.25
Turbidity	NTU	2140	10.8	13.1	202	9.3	7	14.1	43	30.4	16.7	64.1	12.2	12.9	12.3	14.6
Electrical conductivity	µS/cm	785	459	496	305	535	714	378	359	260	268	306	462	494	525	537
Total dissolved solids	mg/L	260	246	372	220	208	149	139	186	254	260	248	276	254	246	125
BOD	mg/L	12	2	3	2	2	3	2	2	2	2	2	2	3	2	2
Dissolved Anions																
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	4	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	217	155	172	100	188	240	117	118	97	102	130	157	170	176	157
Total alkalinity as $CaCO_3$	mg/L	217	155	172	100	188	245	117	118	97	102	130	157	170	176	157
Residual alkalinity	meq/L	4.17	-0.16	-0.23	0.06	1.31	2.49	0.2	-0.43	-0.05	-0.12	-0.14	-0.22	-0.09	0.06	-0.14
Chloride	mg/L	118	34	45	18	39	53	27	26	12	12	14	36	44	45	51
Sulphate as SO_4 2-	mg/L	1	22	31	14	32	27	24	27	19	18	20	22	31	33	29
Fluoride	mg/L	0.1	0.2	0.2	0.1	0.2	0.4	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.2
Dissolved Cations																
Calcium	mg/L	34	18	26	28	23	27	19	22	23	32	32	33	31	24	28
Magnesium	mg/L	2	18	24	11	14	12	12	14	11	11	14	19	23	22	21
Sodium	mg/L	160	32	36	21	66	102	29	23	18	18	25	32	35	40	38
Potassium	mg/L	13	3	4	5	8	11	3	4	4	4	4	3	4	3	3
Sodium absorption ratio (calc)	-	24.2	1.12	1.16	0.97	2.59	4.06	1.23	0.94	0.81	0.78	1.01	1.11	1.15	1.32	1.29
Dissolved Metals																
Aluminium	mg/L	20.1	0.03	<0.01	0.08	0.06	0.06	0.02	0.04	0.07	0.07	0.03	<0.01	<0.01	0.02	<0.01
Arsenic	mg/L	< 0.001	0.001	< 0.001	0.002	< 0.001	< 0.001	0.002	0.001	0.001	0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001
Barium	mg/L	0.092	0.027	0.03	0.022	0.037	0.054	0.022	0.024	0.021	0.02	0.021	0.028	0.03	0.029	0.028
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.06	0.05	0.05	0.05	0.05	0.06	0.07	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0006	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0002
Chromium (III)	mg/L	0.014	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.007	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.01	0.002	0.001	0.003	0.009	0.006	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
Iron (total)	mg/L	9.98	0.05	0.05	0.06	0.05	0.13	0.05	0.05	0.06	0.06	0.05	0.05	0.05	0.05	0.05
Lead	mg/L	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Lithium	mg/L	0.032	0.001	0.001	0.001	0.003	0.004	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.125	0.016	0.005	0.003	0.01	0.012	0.008	0.005	0.008	0.005	0.002	0.02	0.007	0.006	0.004
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	0.002	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.002	0.004	0.006	0.013	0.002	0.001	0.001	< 0.001	0.002	0.001	0.002	< 0.001	0.001	0.002	< 0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.02	0.304	0.38	0.243	0.28	0.277	0.225	0.222	0.188	0.179	0.223	0.315	0.382	0.36	0.325
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.03	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	< 0.005	< 0.005	0.086	0.104	< 0.005	0.013	< 0.005	0.006	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.014
Total Metals																
Aluminium	mg/L	170	0.6	1.54	7.51	0.51	0.56	0.55	1.46	2.13	0.79	4.5	0.66	1.72	0.29	0.98
Arsenic	mg/L	< 0.001	0.002	< 0.001	0.001	0.001	0.001	< 0.001	0.002	0.002	0.001	< 0.001	< 0.001	0.001	0.001	0.001
Barium	mg/L	0.86	0.031	0.036	0.073	0.042	0.064	0.03	0.032	0.033	0.039	0.041	0.032	0.037	0.034	0.035
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	0.0002	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.002	0.008	< 0.001	< 0.001	< 0.001	0.001	0.002	< 0.001	0.006	< 0.001	0.002	0.002	0.002	< 0.001	0.002
Cobalt	mg/L	< 0.001	0.006	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Copper	mg/L	< 0.001	0.012	0.01	0.007	0.002	0.003	0.003	0.005	0.006	0.002	< 0.001	0.002	0.001	0.002	0.004
Iron	mg/L	151	0.64	1.59	4.32	0.56	0.93	0.58	1.57	2.15	0.85	4.14	0.75	1.74	0.44	1.14
Lead	mg/L	< 0.001	< 0.001	< 0.001	0.08	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001
Lithium	mg/L	< 0.001	0.003	0.003	0.004	0.001	0.001	0.002	0.002	< 0.001	0.001	< 0.001	< 0.001	0.001	0.001	0.001
Manganese	mg/L	1.42	0.059	0.058	0.23	0.05	0.05	0.065	0.11	0.087	0.09	0.121	0.066	0.064	0.072	0.074
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	0.002	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.046	0.002	0.003	0.013	0.008	0.014	0.002	0.003	0.004	0.002	0.006	0.001	0.003	0.002	0.002
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.104	0.332	0.376	0.307	0.272	0.303	0.24	0.246	0.202	0.259	0.239	0.324	0.377	0.364	0.321
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	0.002	0.001	< 0.001	< 0.001
Vanadium	mg/L	0.01	0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	mg/L	< 0.005	0.015	0.106	0.112	0.005	< 0.005	0.006	0.015	0.006	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7532_SURF_W	NAR_7532_SURF_W	NAR_7532_SURF_W	NAR_7532_SURF_W	NAR_7532_SURF_W	NAR_7533_SURF_W	NAR_7533_SURF_W	NAR_7533_SURF_W	NAR_7533_SURF_W	NAR_7533_SURF_W	NAR_7533_SURF_W	NAR_7533_SURF_W	NAR_7533_SURF_W	NAR_7533_SURF_W
Surface Water Body Location		Narrabri Creek near Leitch Oval	Narrabri Creek near Leitch Oval	Narrabri Creek near Leitch Oval	Narrabri Creek near Leitch Oval	Narrabri Creek near Leitch Oval	Namoi River downstreamof confluence with Bohena Creek	Namoi River downstreamof confluence with Bohena Creek	Namoi River downstreamof confluence with Bohena Creek	Namoi River downstreamof confluence with Bohena Creek	Namoi River downstreamof confluence with Bohena Creek	Namoi River downstreamof confluence with Bohena Creek	Namoi River downstreamof confluence with Bohena Creek	Namoi River downstreamof confluence with Bohena Creek	Namoi River downstreamof confluence with Bohena Creek
Stream Type		Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial
Land Use		Urban	Urban	Urban	Urban	Urban	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing
Lab Sample ID		ES1225490003	ES1227820005	ES1229424007	ES1300408005	ES1303496003	ES1300507008	ES1212386008	ES1214897001	ES1217757003	ES1220443007	ES1222571001	ES1225305009	ES1227704002	ES1229332007
Sample Date		25/10/2012	22/11/2012	12/12/2012	8/01/2013	14/02/2013	9/01/2013	17/05/2012	13/06/2012	18/07/2012	22/08/2012	19/09/2012	24/10/2012	21/11/2012	11/12/2012
Sample Time		12:26	11:50	13:30	13:01	14:37	13:00	13:24	16:05	16:21	15:39	15:16	12:43	9:25	16:13
Analyte	**Units**														
Physiochemical															
pH	pH Unit	8.07	8.13	7.88	8.14	8.01	7.89	8.26	8.36	7.84	8.28	8.1	7.93	8.17	7.9
Turbidity	NTU	16.2	39	26.1	17.3	63.2	33.2	6.8	7.6	537	9.2	8.9	19.7	24	19
Electrical conductivity	µS/cm	364	367	257	260	302	257	690	554	304	472	487	342	394	238
Total dissolved solids	mg/L	138	176	140	335	328	340	290	264	180	232	134	140	318	420
BOD	mg/L	2	2	2	3	2	2	2	4	2	2	2	2	2	2
Dissolved Anions															
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	11	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	114	119	90	99	135	92	229	184	98	151	147	115	124	88
Total alkalinity as $CaCO_3$	mg/L	114	119	90	99	135	92	229	195	98	151	147	115	124	88
Residual alkalinity	meq/L	0.06	-0.41	0.03	-0.16	-0.16	0.02	-0.52	-0.19	0.16	0.28	-0.07	0.13	0.01	0.04
Chloride	mg/L	24	29	11	11	14	12	62	50	22	32	36	23	31	12
Sulphate as SO_4 2-	mg/L	26	30	19	18	19	17	30	36	14	30	29	24	27	15
Fluoride	mg/L	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.2
Dissolved Cations															
Calcium	mg/L	19	22	23	20	20	48	39	18	28	29	22	26	18	29
Magnesium	mg/L	14	15	10	11	14	10	29	26	11	19	19	14	16	10
Sodium	mg/L	25	25	17	16	24	17	51	41	21	33	33	23	28	16
Potassium	mg/L	3	4	4	4	4	3	3	3	4	3	3	3	3	4
Sodium absorption ratio (calc)	-	1	0.96	0.78	0.7	0.97	0.77	1.43	1.25	0.97	1.17	1.17	0.94	1.06	0.75
Dissolved Metals															
Aluminium	mg/L	<0.01	0.03	0.07	0.06	0.04	0.04	<0.01	<0.01	0.06	0.02	<0.01	0.03	0.03	0.07
Arsenic	mg/L	< 0.001	0.001	0.001	0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	0.001	< 0.001
Barium	mg/L	0.021	0.024	0.021	0.019	0.021	0.021	0.04	0.034	0.019	0.028	0.028	0.025	0.028	0.017
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.002	0.001	0.001
Iron (total)	mg/L	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05
Lead	mg/L	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Lithium	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.003	0.003	0.006	0.009	0.003	0.001	0.005	0.003	0.001	0.003	0.002	0.004	0.001	0.001
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.001	0.001	0.001	0.001	0.001	< 0.001	0.001	0.003	0.001	< 0.001	0.002	< 0.001	< 0.001	0.002
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.233	0.238	0.183	0.178	0.224	0.176	0.434	0.422	0.216	0.327	0.292	0.242	0.267	0.158
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.005	< 0.005	< 0.005
Total Metals															
Aluminium	mg/L	0.43	1.83	1.69	0.62	4.04	2.04	0.28	1.1	28.9	0.74	0.63	0.62	2.29	1.82
Arsenic	mg/L	0.002	0.002	0.002	0.001	0.001	0.001	< 0.001	0.002	0.001	< 0.001	0.001	0.002	0.001	0.002
Barium	mg/L	0.026	0.033	0.03	0.026	0.04	0.031	0.044	0.039	0.123	0.032	0.035	0.029	0.041	0.028
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001
Chromium	mg/L	0.001	< 0.001	0.005	0.002	0.002	< 0.001	0.001	0.037	< 0.001	< 0.001	< 0.001	0.003	0.002	0.004
Cobalt	mg/L	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	0.012	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002
Copper	mg/L	0.003	0.002	0.002	0.003	0.003	< 0.001	< 0.001	0.028	0.002	0.002	0.002	0.003	0.003	0.005
Iron	mg/L	0.38	2.09	1.77	0.62	3.99	2.24	0.28	1.14	28.8	0.76	0.68	0.59	2.41	1.94
Lead	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.004	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001
Lithium	mg/L	0.002	0.001	< 0.001	0.002	0.002	0.001	0.001	0.008	0.001	0.002	0.001	0.002	0.001	0.002
Manganese	mg/L	0.053	0.114	0.075	0.058	0.118	0.08	0.044	0.053	0.475	0.05	0.054	0.055	0.136	0.069
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.002	0.003	0.004	0.002	0.006	0.003	0.001	0.002	0.044	0.002	0.002	0.002	0.003	0.003
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.217	0.242	0.199	0.184	0.244	0.19	0.477	0.413	0.28	0.336	0.328	0.241	0.28	0.172
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.002	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium	mg/L	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.06	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Zinc	mg/L	< 0.005	< 0.005	0.006	< 0.005	< 0.005	< 0.005	0.006	0.043	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.006

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7533_SURF_W	NAR_7534_SURF_W	NAR_7534_SURF_W	NAR_7534_SURF_W	NAR_7534_SURF_W	NAR_7534_SURF_W	NAR_7534_SURF_W	NAR_7534_SURF_W	NAR_7534_SURF_W	NAR_7534_SURF_W	NAR_7535_SURF_W	NAR_7535_SURF_W	NAR_7535_SURF_W	NAR_7535_SURF_W
Surface Water Body Location		Namoi River downstreamof confluence with Bohena Creek	Pian Creek	Pian Creek	Pian Creek	Pian Creek	Pian Creek	Pian Creek	Pian Creek	Pian Creek	Pian Creek	The canal, west of Wee Waa	The canal, west of Wee Waa	The canal, west of Wee Waa	The canal, west of Wee Waa
Stream Type		Perennial	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral
Land Use		Grazing	Cropping	Cropping	Cropping	Cropping	Cropping	Cropping	Cropping	Cropping	Cropping	Grazing	Grazing	Grazing	Grazing
Lab Sample ID		ES1300507008	ES1212386009	ES1214731006	ES1217527007	ES1220319008	ES1222453005	ES1225305004	ES1227538002	ES1229332002	ES1303253007	ES1212386010	ES1214731007	ES1217527008	ES1220443003
Sample Date		9/01/2013	17/05/2012	13/06/2012	17/07/2012	21/08/2012	18/09/2012	24/10/2012	20/11/2012	11/12/2012	12/02/2013	17/05/2012	13/06/2012	17/07/2012	22/08/2012
Sample Time		1:30	13:24	12:43	15:33	14:15	15:58	12:43	11:30	16:13	13:46	13:30	12:43	15:33	15:39
Analyte	**Units**														
Physiochemical															
pH	pH Unit	7.89	8.18	8.2	7.84	8.15	8.17	8.09	8.17	8.02	7.93	8.18	8.34	7.88	8.31
Turbidity	NTU	33.2	33.6	21.1	188	31.2	23.2	61.6	77	48	128	41.2	7.3	365	40.9
Electrical conductivity	µS/cm	257	568	756	310	507	501	351	424	259	442	561	775	285	488
Total dissolved solids	mg/L	146	340	270	180	260	120	302	312	438	140	298	306	216	254
BOD	mg/L	2	2	2	2	2	2	2	3	2	2	2	3	2	2
Dissolved Anions															
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	7	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	92	177	248	94	155	171	114	148	97	158	175	251	88	154
Total alkalinity as $CaCO_3$	mg/L	92	177	248	94	155	171	114	148	97	158	175	258	88	156
Residual alkalinity	meq/L	0.02	-0.3	-0.88	-0.02	0.29	0.22	0.06	0.11	0.57	0.02	-0.34	-1.08	0.04	0.33
Chloride	mg/L	12	52	93	24	32	41	26	25	12	33	52	97	22	31
Sulphate as SO_4 2-	mg/L	17	25	50	18	32	32	24	31	17	22	24	50	16	32
Fluoride	mg/L	0.2	0.2	0.2	0.1	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1
Dissolved Cations															
Calcium	mg/L	39	56	20	29	33	23	17	30	28	39	59	18	29	34
Magnesium	mg/L	10	23	37	11	19	22	14	17	10	18	23	40	10	19
Sodium	mg/L	17	41	64	23	33	36	25	35	16	37	40	66	22	33
Potassium	mg/L	3	4	4	4	3	4	4	4	4	5	4	4	4	3
Sodium absorption ratio (calc)	-	0.77	1.29	1.63	1.03	1.17	1.19	1.02	1.28	0.76	1.32	1.26	1.62	1.02	1.18
Dissolved Metals															
Aluminium	mg/L	0.04	<0.01	<0.01	0.07	0.02	<0.01	0.02	0.02	0.84	0.02	<0.01	<0.01	0.07	0.02
Arsenic	mg/L	0.001	0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	0.002	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001
Barium	mg/L	0.021	0.038	0.052	0.023	0.03	0.032	0.026	0.034	0.031	0.031	0.036	0.052	0.021	0.031
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.001	0.002	0.001	0.002	0.001	0.001	0.002	0.002	0.003	0.003	0.002	0.001	0.002	0.001
Iron (total)	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.66	0.05	0.05	0.05	0.05	0.05
Lead	mg/L	0.001	0.001	0.001	0.001	0.305	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.118
Lithium	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.001	0.002	0.002	0.001	0.005	0.004	0.002	0.004	0.08	0.005	0.002	0.003	0.001	0.002
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.001	< 0.001	0.002	0.001	0.002	0.001	0.003	0.004	0.002	0.001	< 0.001	0.003	0.001	0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.176	0.386	0.544	0.203	0.347	0.32	0.242	0.295	0.184	0.3	0.38	0.58	0.185	0.341
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01
Zinc	mg/L	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Total Metals															
Aluminium	mg/L	2.04	2.16	1.65	4.22	2.33	0.93	2.74	4.57	2.99	9.98	2.33	1.42	7.59	2.23
Arsenic	mg/L	0.001	0.002	0.001	< 0.001	< 0.001	0.002	0.002	0.003	0.002	0.001	0.002	0.002	0.001	0.001
Barium	mg/L	0.031	0.05	0.065	0.073	0.047	0.043	0.041	0.052	0.037	0.079	0.05	0.061	0.099	0.042
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.002	0.001	0.004	0.002	< 0.001	0.003	0.003	0.011	0.004	0.002	0.001	0.008	0.003	< 0.001
Cobalt	mg/L	< 0.001	< 0.001	0.004	< 0.001	< 0.001	0.001	0.001	0.004	0.002	< 0.001	< 0.001	0.007	0.001	< 0.001
Copper	mg/L	0.003	0.002	0.009	0.003	0.004	0.004	0.004	0.012	0.005	0.003	0.002	0.013	0.004	0.002
Iron	mg/L	2.24	2.15	1.69	3.24	2.63	0.96	3.4	4.58	2.97	11.9	2.31	1.44	5.5	2.38
Lead	mg/L	< 0.001	< 0.001	0.002	< 0.001	0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001
Lithium	mg/L	0.002	0.002	0.003	0.002	0.001	0.002	0.002	0.003	0.002	0.002	0.001	0.005	0.002	0.001
Manganese	mg/L	0.08	0.108	0.064	0.243	0.084	0.056	0.088	0.125	0.093	0.215	0.114	0.064	0.393	0.078
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	mg/L	0.003	0.003	0.002	0.01	0.003	0.002	0.004	0.006	0.004	0.015	0.003	0.002	0.017	0.004
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.19	0.416	0.6	0.257	0.354	0.348	0.256	0.308	0.194	0.39	0.402	0.588	0.263	0.349
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	0.002	0.003	< 0.001	0.001	0.002	< 0.001	< 0.001	0.001	< 0.001	0.002	0.003	< 0.001	0.002	0.002
Vanadium	mg/L	0.01	< 0.01	0.02	0.01	< 0.01	0.01	0.01	0.04	0.02	0.01	< 0.01	0.02	< 0.01	< 0.01
Zinc	mg/L	< 0.005	< 0.005	0.013	0.006	< 0.005	0.006	0.006	0.019	0.008	< 0.005	< 0.005	0.022	< 0.005	< 0.005

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7535_SURF_W	NAR_7535_SURF_W	NAR_7535_SURF_W	NAR_7535_SURF_W	NAR_7535_SURF_W	NAR_7535_SURF_W	NAR_7536_SURF_W	NAR_7536_SURF_W	NAR_7536_SURF_W	NAR_7536_SURF_W	NAR_7536_SURF_W	NAR_7536_SURF_W	NAR_7536_SURF_W	NAR_7536_SURF_W	NAR_7536_SURF_W
Surface Water Body Location		The canal, west of Wee Waa	The canal, west of Wee Waa	The canal, west of Wee Waa	The canal, west of Wee Waa	The canal, west of Wee Waa	The canal, west of Wee Waa	Gunidgera Creek	Gunidgera Creek	Gunidgera Creek	Gunidgera Creek	Gunidgera Creek	Gunidgera Creek	Gunidgera Creek	Gunidgera Creek	Gunidgera Creek
	Stream Type	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral
	Land Use	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Cropping	Cropping	Cropping	Cropping	Cropping	Cropping	Cropping	Cropping	Cropping
	Lab Sample ID	ES1222453006	ES1225305005	ES1227538003	ES1229332003	ES1303253008	ES1303392001	ES1212386011	ES1214731008	ES1217757001	ES1220443004	ES1222453007	ES1225305006	ES1227538004	ES1229332004	ES1303253009
	Sample Date	18/09/2012	24/10/2012	20/11/2012	11/12/2012	12/02/2013	13/02/2013	17/05/2012	13/06/2012	18/07/2012	22/08/2012	18/09/2012	24/10/2012	20/11/2012	11/12/2012	12/02/2013
	Sample Time	15:58	12:43	12:10	16:13	13:46	11:32	14:00	12:43	16:21	15:39	15:58	12:43	12:55	16:13	13:46
Analyte	**Units**															
Physiochemical																
pH	pH Unit	8.25	8.13	8.21	8.05	7.9	8.23	8.18	8.31	7.87	8.28	8.24	8.06	8.16	8.09	8.08
Turbidity	NTU	23.3	52.4	73.5	43	135	81	28.9	20.6	637	28.2	35.4	34.9	60.9	54	121
Electrical conductivity	µS/cm	494	368	423	258	414	369	556	700	354	490	494	338	413	250	498
Total dissolved solids	mg/L	122	266	210	398	335	297	254	162	252	130	312	155	145	225	276
BOD	mg/L	2	2	2	2	2	4	2	3	3	2	2	2	2	2	2
Dissolved Anions																
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	2	< 1	< 1	< 1	< 1	< 1	< 1	< 1	4	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	170	112	147	93	155	114	176	224	105	167	171	111	144	90	168
Total alkalinity as $CaCO_3$	mg/L	170	112	147	93	155	114	176	228	105	167	171	111	144	90	168
Residual alkalinity	meq/L	0.07	0.17	0.14	0.19	0.1	0.25	-0.19	-0.54	-0.07	0.01	0.18	0.13	0.08	0.13	-0.09
Chloride	mg/L	42	27	24	13	29	26	51	88	31	32	42	22	31	12	44
Sulphate as SO_4 2-	mg/L	31	26	30	17	19	22	24	37	20	32	32	22	30	17	25
Fluoride	mg/L	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.2	0.2
Dissolved Cations																
Calcium	mg/L	23	17	28	20	28	38	46	22	32	34	22	17	32	2	1
Magnesium	mg/L	22	14	17	10	17	14	22	34	13	21	22	13	17	10	21
Sodium	mg/L	36	25	33	16	36	26	39	61	24	33	35	22	35	16	42
Potassium	mg/L	4	3	4	4	5	4	4	5	5	3	4	3	4	4	5
Sodium absorption ratio (calc)	-	1.18	1.01	1.21	0.76	1.32	1.09	1.24	1.66	1.02	1.13	1.15	0.92	1.28	0.76	1.42
Dissolved Metals																
Aluminium	mg/L	<0.01	0.02	0.02	0.05	0.02	0.03	<0.01	<0.01	0.03	0.02	0.02	0.03	<0.01	0.06	0.02
Arsenic	mg/L	< 0.001	0.002	0.002	0.002	0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001
Barium	mg/L	0.033	0.028	0.033	0.022	0.032	0.025	0.038	0.046	0.025	0.029	0.033	0.026	0.031	0.021	0.036
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.001	0.002	0.001	0.001	0.003	0.002	0.002	0.002	0.001	0.001	0.002	0.001	0.001	0.001	0.003
Iron (total)	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Lead	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.006	0.001	0.001	0.001	0.001	0.001
Lithium	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.002	0.001	0.002	0.001	0.002	0.001	0.003	0.007	0.001	0.004	0.007	0.003	0.01	0.006	0.008
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001
Nickel	mg/L	0.002	0.001	0.003	0.002	0.002	0.001	0.002	0.002	0.001	0.001	0.002	0.001	0.004	0.002	< 0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.308	0.255	0.288	0.177	0.316	0.253	0.386	0.547	0.246	0.321	0.326	0.232	0.273	0.171	0.365
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Zinc	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.021	0.009
Total Metals																
Aluminium	mg/L	0.62	2.67	4.48	3.07	9.8	6.05	1.91	1.66	31.5	1.56	0.55	1.35	2.68	2.4	5.7
Arsenic	mg/L	0.001	< 0.001	0.002	0.003	< 0.001	< 0.001	0.002	0.003	0.001	0.001	0.001	0.002	0.003	0.002	0.001
Barium	mg/L	0.043	0.041	0.053	0.037	0.075	0.046	0.048	0.054	0.142	0.037	0.041	0.034	0.048	0.034	0.071
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron	mg/L	< 0.05	< 0.05	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	< 0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chromium	mg/L	0.003	0.003	0.011	0.007	0.002	0.002	0.001	0.04	0.002	< 0.001	0.001	0.002	0.006	0.013	0.005
Cobalt	mg/L	0.001	0.001	0.004	0.002	< 0.001	< 0.001	< 0.001	0.014	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.005	< 0.001
Copper	mg/L	0.005	0.005	0.012	0.007	0.004	0.003	0.003	0.031	0.003	0.002	0.003	0.004	0.008	0.006	0.002
Iron	mg/L	0.55	3.29	4.69	3.22	11.9	5.41	1.97	1.61	32.3	1.65	0.45	1.35	2.57	2.56	6.92
Lead	mg/L	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	0.006	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.009	0.001
Lithium	mg/L	0.002	0.002	0.003	0.002	0.002	0.002	0.001	0.01	0.001	0.001	0.001	0.002	0.002	0.006	0.002
Manganese	mg/L	0.046	0.083	0.127	0.1	0.203	0.136	0.096	0.059	0.548	0.069	0.043	0.066	0.123	0.095	0.181
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001
Nickel	mg/L	0.002	0.004	0.006	0.004	0.015	0.008	0.002	0.004	0.048	0.003	0.002	0.003	0.004	0.004	0.011
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Strontium	mg/L	0.332	0.268	0.317	0.198	0.361	0.279	0.393	0.54	0.319	0.348	0.37	0.242	0.304	0.187	0.428
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.002	0.001	0.002	0.002	< 0.001	< 0.001	0.001	< 0.001	< 0.001
Vanadium	mg/L	0.01	0.01	0.04	0.02	0.01	0.01	0.01	0.06	< 0.01	< 0.01	< 0.01	< 0.01	0.03	0.03	< 0.01
Zinc	mg/L	0.006	0.007	0.019	0.015	< 0.005	< 0.005	0.006	0.052	< 0.005	< 0.005	< 0.005	0.006	0.014	0.022	0.007

Table 6 - Santos Surface Water Monitoring Infrastructure – Surface Water Analytical Data Summary Statistics

Baseline Environmental Monitoring Data - Bibblewindi Gas Exploration Pilot Expansion

	Sample ID	NAR_7537_SURF_W	NAR_7537_SURF_W	NAR_7537_SURF_W	NAR_7537_SURF_W	NAR_7537_SURF_W	NAR_7537_SURF_W	NAR_7538_SURF_W	NAR_7538_SURF_W	NAR_7538_SURF_W	NAR_7538_SURF_W	NAR_7538_SURF_W	NAR_7538_SURF_W	NAR_7538_SURF_W
Surface Water Body Location		Werah Creek	Werah Creek	Werah Creek	Werah Creek	Werah Creek	Werah Creek	Namoi River at Kamilaroi Highway Crossing	Namoi River at Kamilaroi Highway Crossing	Namoi River at Kamilaroi Highway Crossing	Namoi River at Kamilaroi Highway Crossing	Namoi River at Kamilaroi Highway Crossing	Namoi River at Kamilaroi Highway Crossing	Namoi River at Kamilaroi Highway Crossing
	Stream Type	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral
	Land Use	Grazing	Grazing	Grazing	Grazing	Grazing	Grazing	Forest	Forest	Forest	Forest	Forest	Forest	Forest
	Lab Sample ID	EB1213733001	ES1214731005	ES1217527005	ES1220319007	ES1222453004	ES1303253006	EB1213733002	ES1214731009	ES1220443005	ES1222453008	ES1225305007	ES1227538005	ES1229332005
	Sample Date	24/05/2012	13/06/2012	17/07/2012	21/08/2012	18/09/2012	12/02/2013	24/05/2012	13/06/2012	22/08/2012	18/09/2012	24/10/2012	20/11/2012	11/12/2012
	Sample Time	15:42	12:43	15:33	12:35	15:58	13:46	15:42	12:45	15:39	15:58	12:43	13:35	16:13
Analyte	**Units**													
Physiochemical														
pH	pH Unit	8.16	6.66	6.96	7.06	7.27	6.92	8.59	8	7.97	8.06	8.1	8.25	8.11
Turbidity	NTU	122	40.4	37	50.4	73.7	150	34	12.3	18.7	6.8	18.3	19.9	17
Electrical conductivity	µS/cm	145	74	71	96	109	138	651	638	510	502	342	394	249
Total dissolved solids	mg/L	514	404	372	288	248	162	248	120	150	622	1140	136	244
BOD	mg/L	4	3	3	2	2	6	2	3	2	2	2	2	2
Dissolved Anions														
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	29	< 1	< 1	< 1	< 1	< 1
Bicarbonate alkalinity as $CaCO_3$	mg/L	76	17	13	24	28	40	130	221	156	174	111	136	88
Total alkalinity as $CaCO_3$	mg/L	76	17	13	24	28	40	159	221	156	174	111	136	88
Residual alkalinity	meq/L	1.34	0.21	0.26	0.43	0.38	0.58	-1.57	-0.63	0.33	0.15	0.18	0.19	0.22
Chloride	mg/L	16	10	11	14	16	12	55	69	31	43	23	21	12
Sulphate as SO_4 2-	mg/L	3	14	1	1	2	3		40	30	32	22	28	17
Fluoride	mg/L		0.1	0.1	0.1	0.1	0.1		0.2	0.1	0.2	0.1	0.2	0.2
Dissolved Cations														
Calcium	mg/L	< 1	1	2	1	26	49	45	29	34	22	16	26	16
Magnesium	mg/L	1	1	1	1	1	2	28	34	19	22	13	15	9
Sodium	mg/L	29	13	13	16	19	32	48	52	32	36	22	32	16
Potassium	mg/L	2	2	1	1	2	3	2	5	3	4	3	4	4
Sodium absorption ratio (calc)	-	4.18	2.2	1.99	4.4	2.74	4.25	1.35	1.42	1.15	1.18	0.92	1.25	0.79
Dissolved Metals														
Aluminium	mg/L	0.55	0.83	0.63	0.43	0.55	0.33	<0.01	<0.01	0.02	<0.01	0.03	0.02	0.06
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	0.002	0.002	0.001	< 0.001	< 0.001	0.001	0.001	< 0.001	0.002	0.001
Barium	mg/L	0.027	0.013	0.01	0.018	0.016	0.028	0.041	0.045	0.028	0.032	0.026	0.031	0.02
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	0.0001
Chromium (III)	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	mg/L	0.003	0.001	0.001	0.002	0.002	0.003	0.001	0.002	0.001	0.001	0.002	0.001	0.001
Iron (total)	mg/L	1.76	0.67	0.47	0.64	0.67	0.64	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Lead	mg/L	0.002	0.001	0.001	0.001	0.001	0.006	0.001	0.001	0.001	0.001	0.001	0.062	0.001
Lithium	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Manganese	mg/L	0.018	0.011	0.005	0.02	0.014	0.07	0.004	0.002	0.002	0.005	0.003	0.005	0.002
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001
Nickel	mg/L	0.001	0.001	0.001	0.004	0.001	< 0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001
Strontium	mg/L	0.019	0.008	0.006	0.012	0.01	0.014	0.455	0.499	0.329	0.338	0.235	0.27	0.172
Tin	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zinc	mg/L	0.007	0.009	0.009	0.014	< 0.005	0.007	0.006	< 0.005	< 0.005	0.005	< 0.005	0.005	0.005
Total Metals														
Aluminium	mg/L	11.9	5.32	2.2	6.93	5.19	26.4	1.01	0.98	0.9	0.3	1	1.73	
Arsenic	mg/L	< 0.001	< 0.001	< 0.001	0.004	0.002	0.002	0.001	< 0.001	0.001	0.002	0.001	0.002	
Barium	mg/L	0.082	0.026	0.02	0.044	0.054	0.126	0.05	0.052	0.033	0.037	0.032	0.03	
Beryllium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	
Boron	mg/L	< 0.05	< 0.05	< 0.05	0.07	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05	0.05	
Cadmium	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	0.0001	
Chromium	mg/L	0.002	0.007	0.005	0.027	0.001	< 0.001	0.001	< 0.001	0.001	0.002	0.001	0.002	
Cobalt	mg/L	< 0.001	0.002	0.002	0.01	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	
Copper	mg/L	< 0.001	0.003	0.004	0.009	0.002	0.002	0.002	0.002	0.002	0.003	0.002	0.003	
Iron	mg/L	14	4.32	1.89	7.17	5.14	25.5	1.08	0.94	0.92	0.31	0.98	1.86	
Lead	mg/L	< 0.001	0.003	0.004	0.01	< 0.001	< 0.001	< 0.001	0.016	< 0.001	< 0.001	0.001	0.001	
Lithium	mg/L	0.002	0.004	0.004	0.009	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Manganese	mg/L	0.179	0.029	0.017	0.058	0.087	0.325	0.07	0.039	0.056	0.044	0.056	0.072	
Mercury	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001	
Molybdenum	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	
Nickel	mg/L	0.007	0.002	0.002	0.004	0.003	0.016	0.002	0.002	0.002	0.002	0.002	0.003	
Selenium	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01	
Silver	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	
Strontium	mg/L	0.044	0.012	0.011	0.021	0.025	0.047	0.484	0.54	0.34	0.362	0.243	0.281	
Tin	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	0.001	
Uranium	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.002	0.001	0.001	< 0.001	< 0.001	0.001	
Vanadium	mg/L	< 0.01	0.01	0.01	0.05	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01	
Zinc	mg/L	0.005	0.012	0.014	0.058	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	

Appendix 3

Energy NSW CSG Exploration and Appraisal Program – Impact Assessment under the EPBC Act

ENERGY NSW COAL SEAM GAS (CSG) EXPLORATION AND APPRAISAL PROGRAM

IMPACT ASSESSMENT UNDER THE EPBC ACT

Prepared for:
Santos Limited

June 2013

DOCUMENT TRACKING

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Abbreviations

ABBREVIATION	DESCRIPTION
BWTP	Bibblewindi Water Treatment Plant
CAMBA	China-Australia Migratory Bird Agreement
CEEC	Critically Endangered Ecological Community
CSG	Coal Seam Gas
CUCCLG	Coonabarabran and Upper Castlereagh Catchment and Landcare Group
DTIRIS	NSW Department of Trade & Investment, Regional Infrastructure and Services
ELA	Eco Logical Australia Pty Ltd
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
ESG	Eastern Star Gas (now Santos Limited)
Ha	Hectares
JAMBA	Japan-Australia Migratory Bird Agreement
MNES	Matters of National Environmental Significance
NGDP	Narrabri Gas Development Project
NICE	Northern Inland Council for the Environment
NPWS	NSW National Parks and Wildlife Service
NW Act	NSW *Noxious Weeds Act 1993*
OEH	NSW Office of Environment and Heritage
PAL	Petroleum Assessment Lease
PEL	Petroleum Exploration Lease
REF	Review of Environmental Factors (Under Part 5 of the NSW EP&A Act)
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RVC	Regional Vegetation Community
SSD	State Significant Development
TSC Act	NSW *Threatened Species Conservation Act 1995*

1 Introduction

1.1 ENERGY NSW COAL SEAM GAS (CSG) EXPLORATION AND APPRAISAL PROGRAM

Santos NSW (Eastern) Pty Ltd (Santos) is proposing to undertake the Energy NSW Coal Seam Gas (CSG) Exploration and Appraisal Program in the Narrabri area within Petroleum Exploration Licence (PEL) 238 and Petroleum Assessment Lease (PAL) 2 (hereafter referred to as the program). The program is scheduled to commence in 2013 and will take two to three years. The program includes recommencing operation of a number of existing pilot wells, drilling and operating new pilot wells and constructing and operating water and gas management facilities to support the program.

Eastern Star Gas (ESG) was the operator of the PEL 238 from 2002 to 2011 on the back of early stage exploration undertaken by various US based companies in the period 1998-2002. During that period, ESG carried out exploration and appraisal activities across much of PEL 238 and PAL 2, which in the period 2006-2011 focused more closely on the CSG resources underlying Pilliga East and Bibblewindi State Forests and surrounding freehold lands. The impacts associated with these early stage reconnaissance and exploration and appraisal activities were assessed under Part 5 of the *Environmental Planning and Assessment Act 1979 (NSW).*

In 2011, ESG lodged a major project application for up to 550 well sets within PEL 238 and PAL 2, known previously as the Narrabri Gas Development Project (NGDP), to the NSW State Government. Following a series of field based ecological surveys in late 2010 and early 2011, the production project was referred to the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 12 April 2011 (EPBC 2011/5914).

Santos acquired ESG in November 2011 and commenced a full review of ESG's operations. Following the acquisition of ESG, Santos withdrew both the major project application and referral for the NGDP and commenced the decommissioning and progressive rehabilitation at thirty two well sites, the Bibblewindi Water Treatment Plant (BWTP) and a number of ponds within the PEL 238 and PAL 2 area (inclusive of PAL 2, hereafter referred to as the PEL 238 area). The objective of the rehabilitation activities is to rehabilitate these sites to natural pre-disturbance vegetation condition and improve the ecological values of the PEL 238 area.

Santos is now proposing to undertake an exploration and appraisal program to determine the viability of a gas production project in PEL 238 and PAL 2. This is dependent on geology, resource availability, environmental and land access constraints which will be investigated through early stage exploration and appraisal activities.

1.2 PURPOSE OF THIS REPORT

This report assesses the impact of the proposed program on MNES. The report includes an assessment of clearing undertaken for CSG activities within the Pilliga Forest to date and provides a cumulative assessment as to whether the proposed program, when added to the CSG clearing undertaken to date, would be likely to have a significant impact on MNES.

2 Description of activities

2.1 GENERAL LOCALITY

For the purpose of this report, the 'study area' is defined as an area covering approximately 48,000 ha and includes (in part) Pilliga East State Forest, Bibblewindi State Forest, Jacks Creek State Forest and Pilliga East State Conservation Area as well as Crown Land and privately owned land. The study area is being utilised for this report as it is the boundary of ESG's former NGDP, within which detailed studies into the biodiversity values of the north-east Pilliga Forest were conducted. The study area contains all existing and proposed exploration and appraisal activities for the program within the Pilliga Forest.

At least seven distinct vegetation types (in accordance with the NSW Vegetation Types Database, OEH 2012) are present within the study area including large contiguous remnants and patches of endangered ecological communities (State listed only).

Table 1: Vegetation types within the study area

VEGETATION TYPES	TOTAL AREA (HA)
Broombush shrubland of the sand plains of the Pilliga region, subtropical sub-humid climate zone (Benson 141)	1,217
Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	33,556
Fuzzy Box on loams in the Nandewar Bioregion and northern Brigalow Belt South Bioregion (Benson 202)	289
Pilliga Box - Poplar Box- White Cypress Pine grassy open woodland on alluvial loams mainly of the temperate (hot summer) climate zone (Benson 88)	547
Red Ironbark - Brown Bloodwood shrubby woodland of the Brigalow Belt South Bioregion	13,668
Rough-barked Apple riparian forb/grass open forest of the Nandewar Bioregion	6,609
White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	22,878
Total	48,764

The vegetation across the study area has been variously affected by a long history of forestry, fires and small-scale agriculture Forestry tracks (both formal and informal) form a fragmented network across the site; however, there are large patches (>1,000 ha) of contiguous vegetation which have not been dissected by forestry. Areas which have been spared from high intensity crown fires generally support large hollow-bearing trees.

A severe fire in 2006 consumed approximately 30% of the study area from the south-west through to the central portion. This fire has temporarily reduced the overall condition of heavily burnt areas through the alteration of vegetation structure and reduction in availability of hollow bearing canopy trees; however, it is expected that these areas will return to benchmark condition over time.

Within the study area, a number of small unmapped areas of derived grassland occur as a result of the removal of canopy, mid and shrub layers. These areas of derived grassland are all located on private or crown land outside of state forest and are generally associated with current or past agricultural activities.

The remainder of the vegetation within the study area is generally considered to be in good condition. Few weeds are present within the study area, with weeds currently present primarily within riparian zones and along the Newell Highway.

2.2 EXPLORATION ACTIVITIES

In order to determine the viability of a gas production project within PEL 238 and PAL 2, exploration and appraisal of aspects such as geology, resource availability, environmental and land access constraints are necessary.

Existing exploration activities undertaken within the study area have included seismic surveys, stratigraphic corehole drilling, pilot well drilling and production appraisal activities including management of water and gas products. Existing disturbance associated with these works includes vegetation clearing for coreholes, well leases, water and gas flow lines and water management (ponds).

Figure 1 details the location of all previous exploration activities and the proposed program that Santos plans to undertake as follows:

- Pre 2002 Footprint – these areas were cleared prior to ESG's involvement in the Pilliga and are not included in this report
- 2002 – 2012 Footprint – exploratory activities that were undertaken by ESG. The impacts of these works have been considered as part of this report
- Proposed Program Footprint (2013 onwards) – exploratory activities and appraisal activities which are proposed to be undertaken in the program. Impacts of the proposed program are the primary subject of this report.

The following reconnaissance and exploration and appraisal activities have been undertaken to date within the current study area. Environmental assessments in the form of Review of Environmental Factors (REFs) were submitted to the NSW State Government regulators for all of the activities listed below and undertaken in accordance with the consent of that agency and the landholder, the Forestry Corporation of NSW.

2004 - 2006		
Dampier Seismic Survey	May-04	seismic survey
Bohena South-1C	Jul-04	corehole
Bohena-4L	Jul-04	production pilot well
Bohena-9	Aug-04	production pilot well
Bohena South-1	Sep-04	production pilot well
Bibblewindi CSG Pilot	Mar-06	production pilot wells and flow lines

2007 - 2008		
Bibblewindi North-1C	Mar-07	corehole
Bohena-12C	May-07	corehole
Bohena South-2C	Jul-07	corehole
Bibblewindi West-1C	Aug-07	corehole
Bohena-13C	Aug-07	corehole
Bibblewindi-11	Oct-07	corehole
Dewhurst-2	Mar-08	corehole
Dewhurst-3	Apr-08	corehole
Dewhurst-4	May-08	corehole
Dewhurst-7	Jul-08	corehole
Dewhurst Seismic Survey	Aug-08	seismic survey
Dewhurst-5	Sep-08	corehole
Bibblewindi Multilateral pilot	Dec-08	production pilot wells and flow lines

2009 - 2010		
Bibblewindi Multilateral Pilot (cont'd)	Jan-09	production pilot wells and flow lines
Dewhurst-6	Apr-09	appraisal well
Bibblewindi-19H	Apr-09	production pilot well
Dewhurst-8	May-09	exploration well
Bibblewindi West Pilot	May-09	production pilot wells and flow lines
Dewhurst-9	Jul-09	appraisal well
Dewhurst-10	Jul-09	appraisal well
Bibblewindi-20	Jul-09	appraisal well
Bibblewindi Multilateral Pilot (cont'd)	Aug-09	production pilot well and flow lines
Bibblewindi-21H	Sep-09	production pilot well
Dewhurst 8 Pilot	Oct-09	production pilot well and flow lines
Bibblewindi Water Treatment Plant	2009	Water Treatment Plant

2010 - 2013		
Bohena-14	Feb-10	corehole
Dewhurst/Coghill Seismic Survey	Apr-10	seismic survey

Dewhurst-19	Apr-11	corehole
Leewood Produced Water Facility	2013	Produced Water Facility

2.2.1 Proposed program

The activities included as part of the proposed program are:

- operation of the existing Bibblewindi Multi-Lateral Pilot (Bibblewindi 12, 13, 14, 15, 16, 17, 18H, 19H, 21H, 27, 28H and 29), construction, drilling and operation of two additional pilot wells (Bibblewindi 31 and 32), and the operation of existing water flow lines from Bibblewindi Multi-Lateral Pilot to the Bibblewindi Water Transfer Facility
- operation of the existing Bibblewindi West Pilot (Bibblewindi 22, 23, 24, 25 and 26) and operation of existing water flow lines from the Bibblewindi West Pilot to the Bibblewindi Water Transfer Facility
- operation of the existing Dewhurst 13-18H Pilot (Dewhurst 13, 14, 15, 16H, 17H and 18H) and the construction, drilling and operation of additional lateral wells from well casing within Dewhurst 16H, 17H and 18H
- construction, drilling and operation of the Dewhurst 22-25 Pilot (Dewhurst 6, 22, 23, 24 and 25)
- construction, drilling and operation of the Dewhurst 26-31 Pilot (Dewhurst 26, 27, 28, 29, 30 and 31)
- construction of the Dewhurst Northern Water and Gas Flow Lines and operation the Dewhurst Northern Water Flow Line
- construction of the Dewhurst Southern Water and Gas Flow Lines and operation of the Dewhurst Southern Water Flow Line
- operation of a produced water tank at the Bibblewindi Water Transfer Facility (Bibblewindi Water Transfer Tank) to facilitate the transfer of produced water from the pilot wells to the Leewood Produced Water Facility
- operation of the Leewood Water Pipeline to transfer water produced by the operation of the above pilot wells from the Bibblewindi Water Transfer Facility to the Leewood Produced Water Facility
- operation of the Leewood Produced Water Facility to store water produced by the operation of the above pilot wells
- transport of produced water from Leewood Produced Water Facility to an appropriately licensed facility
- construction and operation of ancillary and supporting infrastructure to facilitate the above activities and ongoing maintenance.

The proposed program is essential to determine whether commercial gas production in the Pilliga is economically viable. Further information is required on the effectiveness of drilling and operating the tri-stacked lateral well design, coal fines and gas composition before any decision to progress to gas production can be made.

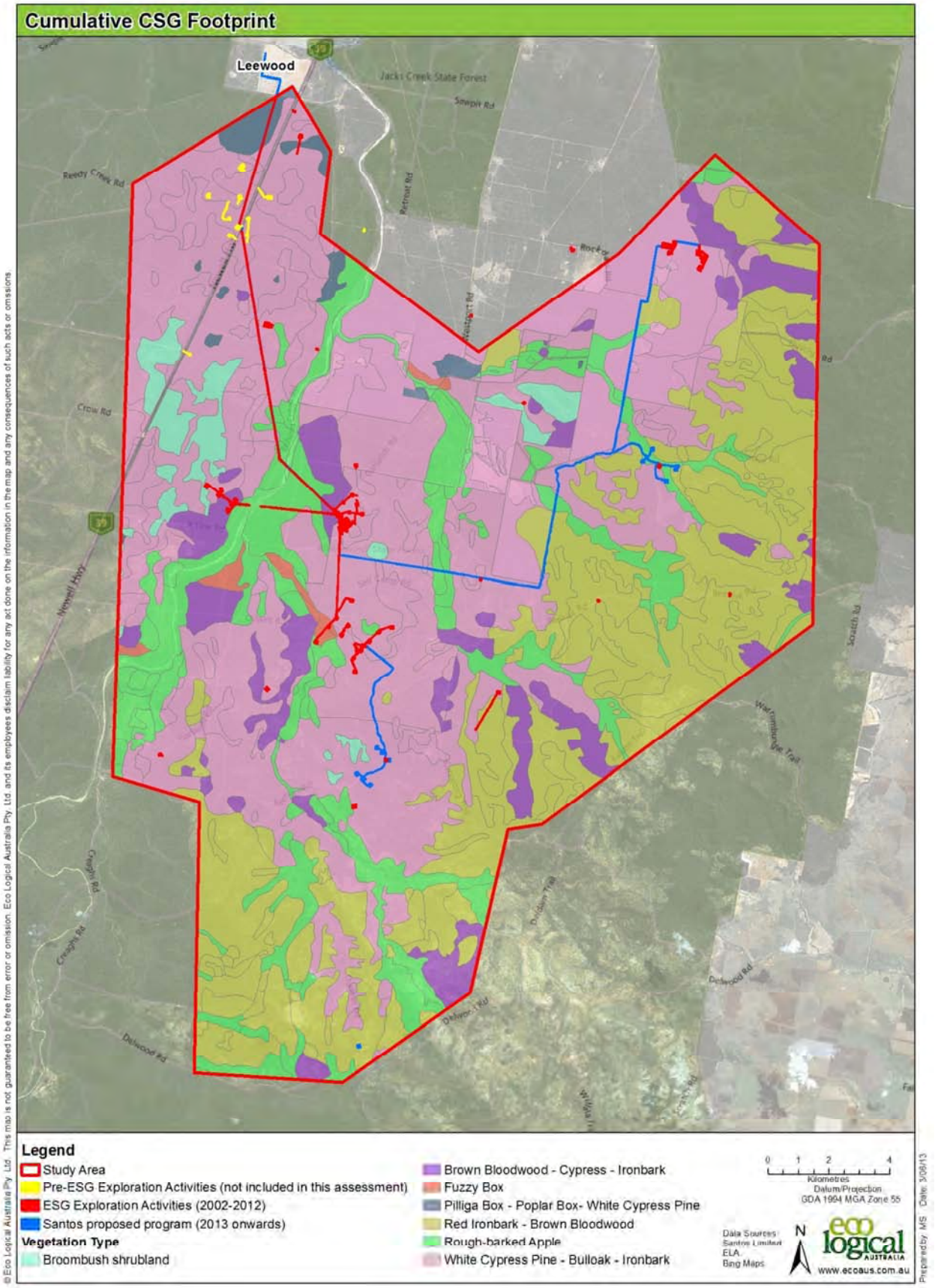

Figure 1: Cumulative CSG footprint within the Pilliga

3 Legislative framework

3.1 NSW PLANNING AND APPROVALS

Exploration and production appraisal activities require environmental assessment under the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Part 5 of the EP&A Act applies to most exploration and appraisal activities, with assessments undertaken by the NSW Department of Trade & Investment, Regional Infrastructure and Services (DTIRIS, formerly I&I NSW, Department of Primary Industries and other iterations). DTIRIS is responsible for assessing the environmental impacts of activities within titles issued under the *Petroleum (Onshore) Act 1991* that fall under Part 5 of the EP&A Act.

To assess the impacts, DTIRIS requires the titleholder to undertake an activity specific environmental assessment such as an REF. A REF details the environmental impact assessment of activities taking place within petroleum title and the measures taken to avoid, minimise and mitigate impacts. The consent of the agency is required prior to any activity being undertaken.

Some exploration activities require assessment and approval by the Minister for Planning and Infrastructure as State Significant Development (SSD) under Part 4 of the EP&A Act. These exploration activities include the drilling or operating petroleum exploration wells not including:

(a) stratigraphic boreholes;

(b) monitoring wells; or

(c) a set of 5 or fewer wells that is more than 3 kilometres from any other petroleum well (other than an abandoned petroleum well) in the same petroleum title.

Santos is proposing to seek development consent under Part 4 of the EP&A Act for the drilling and operation of sets of more than 5 wells proposed to be undertaken as part of the program.

REFs have been, or are in the process of being, prepared for each other activity within the program as required under Part 5 of the EP&A Act.

3.2 COMMONWEALTH EPBC ACT

The EPBC Act establishes a need for Australian Government environmental assessment and approval of (amongst other things), actions that are likely to have a significant impact on MNES. There are eight MNES listed under the EPBC Act which are:

- world heritage sites
- national heritage places
- wetlands of international importance (often called 'Ramsar' wetlands after the international treaty under which such wetlands are listed)
- nationally threatened species and ecological communities
- migratory species

- Commonwealth marine areas
- the Great Barrier Reef Marine Park
- nuclear actions.

Of these, the matters relevant to the exploration and appraisal activities within PEL 238 and PAL 2 are 'nationally threatened species and ecological communities' and 'listed migratory species'.

Actions that may have a significant impact on one or more MNES need to be referred under the EPBC Act. SEWPaC have issued significant impact guidelines to help clarify what may constitute a significant impact on MNES (DEWHA 2009). These guidelines outline a set of criteria for each MNES and outline the types of actions and impacts that may be considered significant.

The significant impact guidelines also provide industry specific guidance for a number of sectoral activities, including mineral exploration activity. While it is clear that the guidance offered is not conclusive, it does specifically address seismic surveys and exploratory drilling and suggests that these activities would not be expected to have a significant impact on MNES. The guidelines state that a seismic survey or exploratory drilling may have a significant impact if, for example, it is likely to damage habitat critical to the survival of a species or disrupt the breeding cycle of a population of the species.

The program has been assessed against these guidelines and the assessment forms the basis of the EPBC Act Referral.

4 Ecological assessment

4.1 ECOLOGICAL SURVEYS UNDERTAKEN

A number of flora and fauna surveys have been carried out within the study area since 2002, totalling more than 3,000 person-hours in the field. The majority of the 48,000 ha study area has been covered by one or more of these surveys over this time.

The most recent flora and fauna surveys undertaken (RPS 2012a-c, 2013a-c), address the potential impacts of the proposed program on MNES. An outlined of survey undertaken for each activity and relevant survey dates is included in **Table 2**.

Table 2: Ecological assessments, survey dates and effort for the proposed program

ACTIVITY	SURVEY DATES	SURVEY EFFORT
Bibblewindi Multi-Lateral Pilot	27 November 2012	Bibblewindi 31 and 32: • Flora survey • Fauna habitat assessment • Targeted survey for threatened flora species Supplementary survey was not required for existing infrastructure as no additional habitat disturbance is proposed.
Bibblewindi West Pilot	N/A	• N/A – survey was not required for existing infrastructure as no additional habitat disturbance is proposed.
Dewhurst 13-18H Pilot	24 January 2013	Water and gas gathering system: • Flora survey • Fauna habitat assessment • Targeted survey for threatened flora species Supplementary survey was not required for existing infrastructure as no additional habitat disturbance is proposed.
Dewhurst 22-25 Pilot	17 and 19 September 2012 8 – 12 October 2012 24 January 2013	• Flora survey • Fauna habitat assessment • Detailed fauna trapping program o Diurnal bird surveys o Spotlighting o Active searches

ACTIVITY	SURVEY DATES	SURVEY EFFORT
		o Anabat detection o Terrestrial trapping (Elliot, Cage, Camera and Hair Tube) • Targeted survey for threatened flora species
Dewhurst 26-31 Pilot	12 - 16 November 2012	• Flora survey • Fauna habitat assessment • Detailed fauna trapping program o Diurnal bird surveys o Spotlighting o Active searches o Anabat detection o Terrestrial trapping (Elliot, Cage, Camera and Hair Tube) • Targeted survey for threatened flora species
Dewhurst Northern Water and Gas Flow Lines	8 - 12 October 2012 4 – 9 November 2012	• Flora survey • Fauna habitat assessment • Detailed fauna trapping program o Diurnal bird surveys o Spotlighting o Active searches o Anabat detection o Terrestrial trapping (Elliot, Snake Funnel, Camera, Hair Tube and Pitfall) • Targeted survey for threatened flora species
Dewhurst Southern Water and Gas Flow Lines	11 – 16 November 2012	• Flora survey • Fauna habitat assessment • Detailed fauna trapping program o Diurnal bird surveys o Spotlighting o Active searches o Anabat detection o Terrestrial trapping (Elliot, Snake Funnel, Camera, Hair

ACTIVITY	SURVEY DATES	SURVEY EFFORT
		Tube and Pitfall) • Targeted survey for threatened flora species

4.2 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

Based on searches of SEWPaC's Protected Matters Search Tool (SEWPaC 2013a), the Atlas of NSW Wildlife (OEH 2013), review of relevant literature, vegetation mapping, constraints analysis, flora and fauna survey results, and professional judgement, a number of EPBC listed species have been identified as having the potential to be impacted by the proposed program.

The likelihood of presence or absence of species and ecological communities has been assessed. The assessment took into account results of field surveys, suitable habitat presence, geographic features of the study area, searches of the Atlas of NSW Wildlife and professional judgement by qualified and experienced ecologists.

Three terms for the likelihood of occurrence of species and communities are used and are defined as follows:

LIKELIHOOD OF OCCURRENCE	DEFINITION
Known	the species was or has been observed within the site
Likely	a medium to high probability that a species uses the site
Potential	suitable habitat for a species occurs on the site, but there is insufficient information to categorise the species as likely to occur, or unlikely to occur

Seven bird species, five mammals and two plants which are listed as MNES are determined to have a likelihood of occurrence of 'known', 'likely', or 'potential' within the area impacted by the proposed action (**Table 3**). Impacts to these (and other) species have been considered in the ecological assessments for the proposed program. A number of other species have been considered in relation to their likelihood of presence within the study area and determined to be unlikely to occur, as the study area is outside of their distribution, and/or there is not suitable habitat present. These species are not addressed in this report, but have been considered in supporting ecological reports and include species such as the Murray Cod, Malleefowl and Satin Flycatcher.

Table 3: MNES identified as having a likelihood of occurrence of 'known', 'likely' or 'potential' within the area impacted by the proposed action

SCIENTIFIC NAME	COMMON NAME	EPBC LISTING STATUS	LIKELIHOOD OF OCCURRENCE	SIGNIFICANT IMPACT LIKELY?
Birds				
Anthochaera phrygia	Regent Honeyeater	Endangered, Migratory	Potential	No
Apus pacificus	Fork-tailed Swift	Migratory	Potential	No
Ardea alba	Great Egret	Migratory	Unlikely	No
Ardea ibis	Cattle Egret	Migratory	Unlikely	No
Botaurus poiciloptilus	Australasian Bittern	Endangered	Unlikely	No
Calyptorhynchus banksii	Red-tailed Black-Cockatoo	Endangered, Migratory	Unlikely	No
Erythrotriorchis radiatus	Red Goshawk	Vulnerable	Unlikely	No
Geophaps scripta scripta	Squatter Pigeon	Vulnerable	Unlikely	No
Haliaeetus leucogaster	White-bellied Sea Eagle	Migratory	Potential	No
Hirundapus caudacutus	White-throated Needletail	Migratory	Known	No
Lathamus discolour	Swift Parrot	Endangered, Migratory	Potential	No
Leipoa ocellata	Malleefowl	Vulnerable, Migratory	Unlikely	No
Merops omatus	Rainbow Bee-eater	Migratory	Known	No
Polytelis swainsonii	Superb Parrot	Vulnerable	Potential	No
Rostratula australis	Australian Painted Snipe	Vulnerable	Unlikely	No
Mammals				
Chalinolobus dwyeri	Large-eared Pied Bat	Vulnerable	Potential	No
Dasyurus maculatus	Spotted-tailed Quoll	Endangered	Potential	No

SCIENTIFIC NAME	COMMON NAME	EPBC LISTING STATUS	LIKELIHOOD OF OCCURRENCE	SIGNIFICANT IMPACT LIKELY?
Nyctophilus corbeni (formerly *N. timoriensis*)	South-eastern/South-eastern Long-eared Bat	Vulnerable	Known	No
Petrogale penicillata	Brush-tailed Rock-wallaby	Vulnerable	Unlikely	No
Phascolarctos cinereus	Koala	Vulnerable	Known	No
Pseudomys pilligaensis	Pilliga Mouse	Vulnerable	Known	No
Pteropus poliocephalus	Grey-headed Flying-fox	Vulnerable	Unlikely	No
Reptiles				
Underwoodisaurus sphyrurus	Border Thick-tailed Gecko	Vulnerable	Unlikely	No
Delma torquata	Collared Delma	Vulnerable	Unlikely	No
Anomalopus mackayi	Five-clawed Worm-skink	Vulnerable	Unlikely	No
Aprasia parapulchella	Pink-tailed Legless Lizard	Vulnerable	Unlikely	No
Amphibians				
Litoria booroolongensis	Booroolong Frog	Endangered	No	No
Fish				
Maccullochella peelii	Murray Cod	Vulnerable	No	No
Invertebrates				
Jalmenus eubulus	Pale Imperial Hairstreak	Endangered	Unlikely	No
Plants				
Bertya opponens	Coolabah Bertya	Vulnerable	No	No
Boronia granitica	Granite Boronia	Endangered	No	No
Cadellia pentastylis	Ooline	Vulnerable	No	No

SCIENTIFIC NAME	COMMON NAME	EPBC LISTING STATUS	LIKELIHOOD OF OCCURRENCE	SIGNIFICANT IMPACT LIKELY?
Dichanthium setosum	Bluegrass	Vulnerable	No	No
Digitaria porrecta	Finger Panic Grass	Endangered	No	No
Haloragis exalata	-	Vulnerable	No	No
Homopholis belsonii	Belson's Panic	Vulnerable	No	No
Lepidium aschersonii	Spiny Peppercress	Vulnerable	No	No
Lepidium monoplocoides	Winged Peppercress	Endangered	Unlikely	No
Philotheca ericifolia		Vulnerable	Unlikely	No
Pterostylis cobarensis	Cobar Greenhood Orchid	Vulnerable	Known	No
Rulingia procumbens		Vulnerable	No	No
Swainsona murrayana	Slender Darling Pea	Vulnerable	No	No
Thesium australe	Austral Toadflax	Vulnerable	No	No
Tylophora linearis		Endangered	Known	No
Endangered Ecological Communities				
Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions		Endangered	No	No
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions		Endangered	No	No
Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of south-eastern Australia		Endangered	No	No
Myall Woodlands in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW south western slopes bioregions		Endangered	No	No
Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and		Critically Endangered	No	No

SCIENTIFIC NAME	COMMON NAME	EPBC LISTING STATUS	LIKELIHOOD OF OCCURRENCE	SIGNIFICANT IMPACT LIKELY?
southern Queensland				
Semi-evergreen Vine Thicket in the Brigalow Belt South and Nandewar Bioregions		Endangered	No	No
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland		Critically Endangered	No	No

5 Impact Assessment

This section of the report outlines the potential impacts from the proposed program on MNES. It also provides information on cumulative impacts of exploration and appraisal activities within the study area and a detailed fragmentation analysis. Measures to avoid, minimise and mitigate the impacts of the proposed program were considered prior to the assessment of impacts. Measures include:

- Consideration of alternative options
- Locating infrastructure adjacent to existing roads wherever possible to minimise disturbance to vegetation and reduce fragmentation
- Avoidance of habitat trees where possible
- Minimising clearing to the maximum extent possible and demarcation of works areas
- Vehicle speed limitations to minimise fauna collisions and dust
- Presence of a fauna ecologist/spotter during clearing works
- Adequate storage and appropriate disposal of all liquids and implementation of erosion and sediment control measures
- Rehabilitation including replacing topsoil, re-installing habitat features such as fallen timber and bush rock, natural re-establishment of slashed and cleared native vegetation and direct seeding where required.

5.1 IMPACTS TO VEGETATION

The proposed program has a total disturbance footprint of 58.5 ha which includes 36.42 ha in remnant vegetation and 22.08 ha to be located within previously disturbed flow line corridors (**Table 4**). The proposed program (excluding the previously disturbed flow line corridors) represents a loss of approximately 0.08% of vegetation within the study area.

The impact associated with exploration and appraisal activities in the Pilliga Forest from 2002 to present is 150.5 ha, which includes 48.2 ha for the Leewood Produced Water Facility for which construction has commenced, but vegetation has not yet been cleared (**Table 5**). The Leewood Produced Water Facility will result in the removal of 48.2 ha of vegetation, 41.4 ha of which is derived native grassland (low condition vegetation resulting from the removal of canopy and shrub layers of Pilliga Box - Poplar Box-White Cypress Pine grassy open woodland). The pre-2002 footprint (12.2 ha) was cleared prior to ESG's involvement in the Pilliga and has not been included in the total. The impact of 150.5 ha represents a loss of approximately 0.31% of vegetation within the study area.

The cumulative impact associated with the proposed program and existing exploration and appraisal activities (from 2002 to present) is 186.92 ha which represents a loss of approximately 0.39% of consolidated vegetation within the study area (**Table 6**).

Wherever possible, the exploration and appraisal activities have utilised existing tracks for access, for conducting seismic surveys and for the installation of flow line infrastructure. Some of the exploration

has taken place in areas that have previously been cleared and are used for activities such as farming and grazing. Impacts are largely linear in nature, and within a context of a well vegetated landscape predominately managed for forestry. Given the relatively small amount of clearing as a proportion of available habitat, the current land uses and extent of rehabilitation, exploration impacts are not expected to significantly fragment or reduce the availability of habitat in a way which will adversely affect species within the study area.

Table 4: Areas of clearing of proposed program

VEGETATION TYPE	AREA OF CLEARING (HA)
Areas of clearing within remnant vegetation	
Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	3.36
Rough-barked Apple riparian forb/grass open forest of the Nandewar Bioregion	1.37
White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	31.69
Total	**36.42**
Areas of clearing within previously disturbed flow line corridors (regenerating)#	
Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	1.20
Pilliga Box - Poplar Box- White Cypress Pine grassy open woodland on alluvial loams mainly of the temperate (hot summer) climate zone (Benson 88)	2.14
Rough-barked Apple riparian forb/grass open forest of the Nandewar Bioregion	3.90
White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	14.84
Total	**22.08**

These areas were cleared approximately 5 years ago and have since been allowed to naturally regenerate. The current condition of these areas approximates 50% of values in adjoining areas. Due to previous clearing, these areas support little to no potential breeding habitat for MNES.

Table 5: Areas of clearing for exploration and appraisal activities undertaken from 2002 to present

VEGETATION TYPE	AREA OF CLEARING (HA)
Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	9.08
Fuzzy Box on loams in the Nandewar Bioregion and northern Brigalow Belt South Bioregion (Benson 202)	1.78
Pilliga Box - Poplar Box- White Cypress Pine grassy open woodland on alluvial loams mainly of the temperate (hot summer) climate zone (Benson 88)#	8.82
Derived Native Grassland (from Pilliga Box - Poplar Box- White Cypress Pine grassy open	41.4

VEGETATION TYPE	AREA OF CLEARING (HA)
woodland on alluvial loams mainly of the temperate (hot summer) climate zone (Benson 88)#	
Red Ironbark - Brown Bloodwood shrubby woodland of the Brigalow Belt South Bioregion	1.66
Rough-barked Apple riparian forb/grass open forest of the Nandewar Bioregion	9.66
White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	78.1
Total	**150.5**

The Leewood Produced Water Facility will result in the removal of 48.2 ha of vegetation, 41.4 ha of which is derived native grassland, the remaining 6.8 ha consists of scattered paddock trees conforming with Pilliga Box - Poplar Box- White Cypress Pine grassy open woodland.

Table 6: Cumulative areas of clearing

VEGETATION TYPE	AREA OF CLEARING (HA)
Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	12.4
Fuzzy Box on loams in the Nandewar Bioregion and northern Brigalow Belt South Bioregion (Benson 202)	1.8
Pilliga Box - Poplar Box- White Cypress Pine grassy open woodland on alluvial loams mainly of the temperate (hot summer) climate zone (Benson 88)#	8.8
Derived Native Grassland (from Pilliga Box - Poplar Box- White Cypress Pine grassy open woodland on alluvial loams mainly of the temperate (hot summer) climate zone (Benson 88)#	41.4
Red Ironbark - Brown Bloodwood shrubby woodland of the Brigalow Belt South Bioregion	1.7
Rough-barked Apple riparian forb/grass open forest of the Nandewar Bioregion	11.0
White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	109.8
Total	**186.9**

5.2 IMPACTS TO THREATENED FAUNA HABITAT

The total amount of potential foraging, breeding and roosting/sheltering/dispersing habitat has been calculated for the proposed program, to inform the formal significant impact assessment under the EPBC Act (**Section 6**). The amount of loss of potential habitat in relation to the vegetation present in the study area and the Namoi CMA region has also been calculated.

Determination of the different types of habitat (foraging, breeding, roosting/sheltering/dispersing) for individual threatened fauna species was made by first allocating vegetation types that would be used for foraging, breeding, and roosting/sheltering/dispersing to individual species. The areas impacted were then summed for all vegetation types representing the type of habitat used by individual species.

Table 7 provides details on the potential impacts of the proposed program on threatened fauna habitat, while the impacts associated with exploration and appraisal activities in the Pilliga from 2002 to present is provided in **Table 8**. The cumulative impact associated with the proposed program and existing exploration and appraisal activities (from 2002 to present) on threatened fauna habitat is outlined in **Table 9**.

Table 7: Impacts of the proposed program to threatened fauna habitat

SPECIES	FORAGING (HA) / LOSS IN STUDY AREA (%)	BREEDING (HA) / LOSS IN STUDY AREA (%)	ROOSTING / SHELTERING / DISPERSING HABITAT (HA) / LOSS IN STUDY AREA (%)
Swift Parrot	36.4 / 0.08	N/A	36.4 / 0.08
Superb Parrot	1.4 / <0.01	N/A	1.4 / <0.01
Regent Honeyeater	36.4 / 0.08	N/A	36.4 / 0.08
South-eastern Long-eared Bat	36.4 / 0.08	36.4 / 0.08	36.4 / 0.08
Large-eared Pied Bat	36.4 / 0.08	N/A	N/A
Koala	1.4 / 0.02	1.4 / 0.02	5.4 / 0.05
Pilliga Mouse	4.7 / 0.04	4.7 / 0.04	36.4 / 0.08
Spotted-tailed Quoll	36.4 / 0.08	36.4 / 0.08	36.4 / 0.08

Table 8: Impacts of existing CSG infrastructure to threatened fauna habitat (undertaken from 2002 to present)

SPECIES	FORAGING (HA) / LOSS IN STUDY AREA (%)#	BREEDING (HA) / LOSS IN STUDY AREA (%)#	ROOSTING / SHELTERING / DISPERSING HABITAT (HA) / LOSS IN STUDY AREA (%)#
Swift Parrot	109.1 / 0.23	N/A	109.1 / 0.23
Superb Parrot	9.7 / 0.02	N/A	9.7 / 0.02
Regent Honeyeater	109.1 / 0.23	N/A	109.1 / 0.23
South-eastern Long-eared Bat	109.1 / 0.23	109.1 / 0.23	109.1 / 0.23
Large-eared Pied Bat	109.1 / 0.23	N/A	N/A
Koala	20.3 / 0.27	20.3 / 0.27	30.1 / 0.3
Pilliga Mouse	18.7 / 0.16	18.7 / 0.16	109.1 / 0.23
Spotted-tailed Quoll#	150.5 / 0.31	109.1 / 0.23	109.1 / 0.23

Table 9: Cumulative impacts to threatened fauna habitat

SPECIES	FORAGING (HA) / LOSS IN STUDY AREA (%)	BREEDING (HA) / LOSS IN STUDY AREA (%)	ROOSTING / SHELTERING / DISPERSING HABITAT (HA) / LOSS IN STUDY AREA (%)
Superb Parrot	11 / 0.02	N/A	11 / 0.02
Swift Parrot	145.5 / 0.31	N/A	145.5 / 0.31
Regent Honeyeater	145.5 / 0.31	N/A	145.5 / 0.31
Greater Long-eared Bat	145.5 / 0.3	145.5 / 0.31	145.5 / 0.31
Large-eared Pied Bat	145.5 / 0.3	N/A	N/A
Koala	21.6 / 0.29	21.6 / 0.29	35.5 / 0.35
Pilliga Mouse	23.5 / 0.21	23.5 / 0.21	77.1 / 0.16
Spotted-tailed Quoll	186.9 / 0.39	145.5 / 0.31	145.5 / 0.3

5.3 IMPACTS TO THREATENED FLORA HABITAT

The total number of threatened flora individuals potentially impacted and their habitat has been calculated for the proposed program, to inform the formal significant impact assessment under the EPBC Act (**Section 6**). The amount of loss of potential habitat in relation to the vegetation present in the study area and the total modelled species' population has also been calculated.

Table 10 provides details on the potential impacts of the proposed program on threatened flora individuals and habitat, while the impacts associated with exploration and appraisal activities in the Pilliga from 2002 to present is provided in **Table 11**. The cumulative impact associated with the proposed program and existing exploration and appraisal activities (from 2002 to present) on threatened flora individuals and their habitat is outlined in **Table 12**.

The potential impacts of the proposed program and existing exploration activities on threatened flora individuals relies on modelled data, except for *Tylophora linearis* for the proposed program which consists of a combination of both known records and modelled data (ELA 2012).

Table 10: Impacts of the proposed program to threatened flora habitat

SPECIES	NUMBER OF INDIVIDUALS POTENTIALLY IMPACTED / LOSS IN STUDY AREA (%)	HABITAT (HA) / LOSS IN STUDY AREA (%)
Pterostylis cobarensis	185 / 0.05	35.05 / 0.09
Tylophora linearis[#]	30 / 0.17	35.05 / 0.09

Table 11: Impacts of existing CSG infrastructure to threatened flora habitat (undertaken from 2002 to present)

SPECIES	NUMBER OF INDIVIDUALS POTENTIALLY IMPACTED	HABITAT (HA) / LOSS IN STUDY AREA (%)
Pterostylis cobarensis	468 / 0.14	96.00 / 0.24
Tylophora linearis	28 / 0.16	96.00 / 0.24

Table 12: Cumulative impacts to threatened flora habitat

SPECIES	NUMBER OF INDIVIDUALS POTENTIALLY IMPACTED	HABITAT (HA) / LOSS IN STUDY AREA (%)
Pterostylis cobarensis	653 / 0.19	131.05 / 0.32
Tylophora linearis	58 / 0.33	131.05 / 0.32

5.4 FRAGMENTATION ANALYSIS

Habitat fragmentation is the division of a single area of habitat into two or more smaller areas, with a new habitat type occurring in the area between the fragments. The proposed program requires the clearing of vegetation within a largely intact landscape, resulting in a degree of habitat fragmentation which needs to be considered in both the local and regional context. The potential fragmentation impacts of the proposed program also need to be considered against the existing exploration and appraisal activities to assess the cumulative impacts.

The process of fragmentation could potentially impact on MNES within the newly created fragments by creating barriers to fauna movement or impediments to processes such as pollination, which could result in genetic isolation of flora and fauna populations. Fragmentation could also impact on MNES by creating edge effects. Edge effects can be particularly detrimental to flora and fauna species that are “core sensitive” rather than “edge” species if habitats are heavily fragmented by a series of new habitat types e.g. a network of roads compared to a single road.

The following section identifies the MNES potentially impacted by habitat fragmentation from exploration and appraisal activities and assesses the degree of habitat fragmentation for impacted species from existing disturbances and impacts from the proposed program within the study area.

5.4.1 Methods

An assessment of whether any of the identified MNES (**Table 3**) have been potentially impacted by the exploration and appraisal activities was made based on knowledge of the species’ ecology. Considerations included the movement potential and habitat requirements of species (e.g. do species rely on particular habitat elements that may have been potentially impacted, or are species dependant on large, intact patches), and whether species used the study area for life stages such as breeding.

Identification of habitat for MNES impacted and habitat mapping

Habitats present in the study area, such as breeding, foraging, and dispersing habitats in the case of fauna species, were determined for those species identified as potentially impacted by the exploration and appraisal activities. Determination of habitat was made through reviews of threatened and migratory species profiles (OEH 2013b, SEWPaC 2013b), as well as reviews of available literature on the species impacted, such as research papers on the species and results of previous flora and fauna surveys for the species within, or in the vicinity of, the study area.

Habitat types for MNES impacted were then mapped in the study area. Habitat mapping was based on Biometric vegetation types mapped and validated for the study area. Biometric vegetation types were considered appropriate for use as the basis of habitat mapping given that, along with specific structural habitat elements and microhabitats, flora and fauna species are associated with broad vegetation types, which have specific associations with attributes such as soil types, geology, water, aspect and slope. It is important to note however, that due to specific micro-habitat requirements within each vegetation type for MNES, the calculations provided are likely to be conservative.

Fragmentation analysis

Analyses of habitat fragmentation in the locality and region utilised a two-step process:

1. Identify movement pathways
2. Assess levels of fragmentation.

The first step identified potential movement pathways for potentially impacted fauna or potential pollination/dispersal routes for potentially impacted flora across the study area. Potential fauna movement pathways focussed on paths between areas representing potential breeding and foraging habitat, and were less focussed on paths within dispersing habitat, since there are likely to be an innumerable number of potential paths that fauna species could take across the landscape. Potential paths were drawn as visual representations over habitat maps for MNES impacted.

The second step quantified the number of breaks / barriers currently present in the study area, as represented by natural breaks in the landscape, such as creek lines, and by artificial structures or clearings, such as roads, tracks and trails, by tallying the number of natural and artificial breaks within potential paths identified. The number of existing breaks and breaks due to the proposed program and existing exploration and appraisal activities was identified for each potential path.

Breaks due to the proposed program and existing exploration and appraisal activities were considered as either short-term (<5 years) or long-term impacts due to the nature of the disturbances involved in exploration and appraisal activities.

Short-term impacts are associated with water and gas flow lines that require temporary removal of vegetation within a construction corridor via slashing. Vegetation is allowed to naturally regenerate following the installation of pipelines over 60% of the width of the flow line corridor. Other than directly where the flowlines are installed (approximately 4 m width within the corridor), short-term impacts do not disturb the soil layer/seed bank.

Long-term impacts are associated with pilot wells, water storage and gas compression facilities and access roads which compact surfaces and require the complete removal of vegetation.

5.4.2 Results

Potential MNES impacted

Given the nature of habitat fragmentation from exploration and appraisal activities, where vegetation clearing occurs within a contiguous, mostly open woodland landscape which does not split contiguous habitat into two or more distinct patches, habitat fragmentation from the proposed program and existing exploration and appraisal activities is not considered to be a significant issue for the majority of MNES.

The proposed program and existing exploration and appraisal activities fragment previously contiguous habitat at pilot well locations (by a distance of up to 100 m) and along roads/gas pipelines (by a maximum distance of up to 20 m). Pilot well locations (the source of the largest breaks) are surrounded

by areas of contiguous habitat and therefore fragmentation at these locations is unlikely to disrupt processes such as pollination and dispersal for threatened flora species.

Of the threatened and migratory fauna that are considered likely to be affected by habitat fragmentation, only Pilliga Mouse was considered further due to the species' dependence on a moderate to high level of low shrub cover and preference for a moist groundcover of plants, leaf litter and fungi (OEH 2013b) and its previously recorded movement distances (average movement distances recorded as 40 m within a range of 0-181 m; Tokushima and Jarman 2008). The remaining threatened and migratory fauna are highly mobile and can traverse large distances across modified and cleared landscapes. The South-eastern Long-eared Bat may make less extensive movements across modified and cleared landscapes given its preference for large intact patches of habitat (SEWPaC 2013), however the proposed program and existing exploration and appraisal activities are not considered likely to completely fragment South-eastern Long-eared Bat habitat, with this species recorded moving up to 5 km between roosts (Schulz and Lumsden 2010).

Habitat fragmentation is unlikely to significantly affect any threatened flora species as the proposed program and existing exploration and appraisal activities are unlikely to split contiguous habitat into two or more distinct patches with pollination and dispersal mechanisms able to continue largely unimpeded.

The following sections provide an overview of Pilliga Mouse ecology which is followed by an analysis of potential habitat fragmentation on this species.

Pilliga Mouse habitat and ecology

It is important to note that the Pilliga Mouse is now considered a southern population of the widespread *Pseudomys delicatulus* (Delicate Mouse) based on genetic analyses, morphological studies and recent surveys which revealed a continuous distribution of the Delicate Mouse to the Pilliga region (Breed and Ford 2007; Ford 2008, as cited in SEWPaC 2011). It is important to note that this taxonomic change has not yet been formally recognised under the EPBC Act (SEWPaC 2011), hence this report considers the Pilliga Mouse as currently listed.

Review of available information revealed that knowledge of Pilliga Mouse habitat is limited. The most recent study on Pilliga Mouse habitat selection published in scientific literature was conducted by Paull (2009), with other studies conducted by NPA (2002), NPWS 2000a, and Tokushuma *et al.* (2008). Vegetation associations in which the Pilliga Mouse was previously recorded by NPA (2002), NPWS 2000, and Paull (2009) are provided in **Table 13**. Of these studies, Paull (2009) identified vegetation associations likely to be used as breeding versus other habitat. Important vegetation associations for the Pilliga Mouse, which are likely to be used as breeding habitat are:

- Moist gullies in areas recently burnt by wild fire
- Broombush complex (predominantly *Melaleuca uncinata* but also *M. erubescens*)
- Kurricabah / Brown Bloodwood (*Acacia burrowii* / *Corymbia trachyphloia*) complex.

The understorey and shrub species found to be present in these vegetation associations were *Acacia triptera*, *Cassytha pubescens*, *Philotheca ericifolia*, *Eucalyptus dwyeri*, *Hibbertia sericea*, *H. riparia*, *H. circumdans*, *H. covenyana*, *Melaleuca erubescens*, *M. uncinata*, *Micromyrtus sessilis*, *Phebalium glandulosum*, *Bursaria spinosa*, *Cryptandra longistaminea*, *Dodonaea falcata*, and *Prostanthera leichhardtii*. Vegetation associations, likely to be used as foraging and / or dispersing habitat by the Pilliga Mouse, were also identified, with some vegetation associations identified as not used by Pilliga Mouse (**Table 13**).

Table 13: Vegetation associations in which the Pilliga Mouse has been previously recorded

VEGETATION ASSOCIATION	NPA (2002)	NPWS (2000)	PAULL (2009)	NICE and CUCCLG (2012)	RPS (2012b)
Bloodwood-Broad leaf Ironbark shrubby woodland (dominant canopy species: *Eucalyptus fibrosa* and *Corymbia trachyphloia*)	Y	-	-	Y	Y
She-oak scrub (dominant canopy species: *Eucalyptus fibrosa* and *Corymbia trachyphloia*)	Y	-	-	-	-
Eucalyptus albens shrubby woodland	N	-	-	-	-
Bloodwood woodland (dominant canopy species: *Corymbia trachyphloia*, *Eucalyptus fibrosa*, *E. dwyeri*)	N	-	-	Y	Y
Angophora leiocarpa woodland (dominant canopy species: *Callitris endlicheri*, *Angophora leiocarpa*, *Eucalyptus chloroclada*, *E. crebra*)	N	-	-	Y	-
Eucalyptus rossii woodland with heathy understorey (dominant canopy species: *E. rossii* and *Angophora floribunda*)	N	-	-	Y	-
Narrow-leafed Ironbark woodland (dominant canopy species: *Eucalyptus crebra*, *E. fibrosa*, *Callitris endlicheri*)	N	-	-	-	-
Gully Narrow-leaf Ironbark (*Eucalyptus crebra*) with Red Gum (*E. blakelyi*) woodland	-	Y	-	-	-
Broad-leaf Ironbark (*Eucalyptus fibrosa*/*Corymbia trachyphloia*/*Callitris endlicheri*) forests	-	Y	-	Y	-
Red Gum/Rough-barked Apple (*Eucalyptus blakelyi* /*Angophora floribunda*) woodlands	-	Y	-	Y	Y
Heath/Scrubland/Mallee (*Melaleuca uncinata*/*Acacia triptera*/*Eucalyptus dumosa*/*E. dwyeri*/*E. chloroclada*)	-	Y	-	Y	-
Narrow-leaf Ironbark (*Eucalyptus crebra*/*Allocasuarina luehmannii*/*Callitris glaucophylla*/*C. endlicheri*) forests	-	N	-	-	-
Blue-leaf Ironbark (*Eucalyptus nubila*/*Callitris endlicheri*) forests	-	N	-	-	-
Pilliga Box *(Eucalyptus pilligaensis*/*Callitris glaucophylla*) woodlands	-	N	-	-	-
Bimble Box (*Eucalyptus populnea*) woodlands	-	N	-	-	-
Red Gum (*Eucalyptus blakelyi*) woodlands	-	N	-	-	-
Belah (*Casuarina cristata*) woodlands	-	N	-	-	-
Moist burnt gully	-	-	Y	-	-
Broombush scrub/heath (*Melaleuca uncinata*)	-	-	Y	-	-

VEGETATION ASSOCIATION	NPA (2002)	NPWS (2000)	PAULL (2009)	NICE and CUCCLG (2012)	RPS (2012b)
Kurricabah/Bloodwood (*Acacia burrowii*/*Corymbia trachyphloia*) scrub	-	-	Y	-	-
Shrubby mixed woodlands (*Eucalyptus blakelyi*, *E. crebra*, *E. fibrosa*, *E. pilligaensis*, *Corymbia trachyphloia*)	-	-	Y	Y	-
Mallee (*Eucalyptus viridis*) Scrub	-	-	Y	-	-
Acacia tindaleae with *Eucalyptus crebra* overstorey (may contain *Callitris glaucophylla* and *Allocasuarina luehmannii*)	-	-	Y	-	-
Burnt flat scrub	-	-	N	-	-
Eucalyptus crebra / *Callitris* forest (grassy understorey with *Allocasuarina luehmannii*)	-	-	N	-	-
Eucalyptus fibrosa / *Callitris* woodland (heathy understorey, lower and more open canopy than previous)	-	-	N	Y	-
Crown Wattle scrub (*Acacia tindaleae*)	-	-	N	-	-
Red Gum (*Eucalyptus camaldulensis*, *E. chloroclada*) woodlands	-	-	N	-	-
Rocky area (*Eucalyptus fibrosa*, *Callitris endlicheri* canopy)	-	-	N	-	-

NB: Y = recorded, N = not recorded, - = not applicable

In terms of Pilliga Mouse habitat in general, Paull (2009) concluded that vegetation associations with over-storeys of *Eucalyptus fibrosa* / *Corymbia trachyphloia*; *Eucalyptus crebra* / *Corymbia trachyphloia*; *Eucalyptus dwyeri* / *Melaleuca uncinata*/*erubescens*; and *Acacia burrowii* / *Corymbia trachyphloia* represented habitat for the Pilliga Mouse, particularly if topsoil depth was > 20 cm; the time since fire was either 18 months to 5 years or > 25 years; the low understorey cover (at 50 cm height) was high (> 50 %); the high understorey cover (at 2 m height) was low (< 25 %); ground layer cover (litter and ground-storey) was moderate to high (45-80%); and key understorey shrub species (listed above) were present.

In addition to Paull (2009), NPWS (2000) reported that an important vegetation association for Pilliga Mouse was that which comprised a *Eucalyptus blakelyi*/*Angophora floribunda* over-storey with a well-developed under-storey cover of low shrubs with an extensive leaf litter cover.

Recent studies undertaken by NICE and CUCCLG (2012) and RPS (2012b) identified the Pilliga Mouse in a broader range of vegetation associations than previously known. Vegetation associations within the study area where Pilliga Mouse has been recorded are generally characterised by a high diversity, moderate density, and a low (<1 m) sclerophyllous shrubby layer. The structure of vegetation where Pilliga Mouse has been recorded ranges from heathland to open forest (**Table 13**).

Given the findings of previous studies, Pilliga Mouse breeding, breeding/foraging and dispersing habitat were mapped in the study area. **Table 13** shows the vegetation types in the study area that represent potential Pilliga Mouse habitats. **Figure 2** shows the locations of Pilliga Mouse habitat in the study area.

Pilliga Mouse habitat has been divided into 'Breeding', 'Breeding/Foraging' and 'Dispersing' habitats. There is potential for the Pilliga Mouse to breed in discrete areas within mapped 'Breeding/Foraging Habitat', however due to the scale of the mapping currently available these areas cannot be adequately delineated at this time, therefore a precautionary approach has been undertaken.

Table 14: Pilliga Mouse breeding, foraging and dispersing habitats by Biometric vegetation types

BIOMETRIC VEGETATION TYPES	BREEDING HABITAT	FORAGING HABITAT	DISPERSING HABITAT
Broombush Shrubland of the Sand Plains of the Pilliga Region, Subtropical Sub-humid Climate Zone (Benson 141)	Yes (Paull 2009, NPWS 2000)	Yes (Paull 2009, NPWS 2000)	Yes
Brown Bloodwood - Cypress - Ironbark Heathy Woodland in the Pilliga Region of the Brigalow Belt South Bioregion	Yes (NICE and CUCCLG (2012), RPS 2012b)	Yes (NPWS 2000)	Yes
Red Ironbark - Brown Bloodwood Shrubby Woodland of the Brigalow Belt South Bioregion	Yes#	Yes (although not recorded by Paull 2009, the species was recorded in this vegetation association (NPA 2002, Tokushuma *et al.* 2008). Patches within the vegetation type contain indicator species listed by Paull 2009 - *Acacia triptera* and *Dodonaea falcata*)	Yes
Rough-barked Apple Riparian Forb/Grass Open Forest of the Nandewar Bioregion	Yes#	Yes (NPWS 2000)	Yes
White Cypress Pine - Bulloak - Ironbark Woodland of the Pilliga Area of the Brigalow Belt South Bioregion	No	No	Yes
Fuzzy Box on Loams in the Nandewar Bioregion and Northern Brigalow Belt South Bioregion (Benson 202)	No (box habitats not preferred; NPWS 2000)	No (box habitats not preferred; NPWS 2000)	Yes
Pilliga Box - Poplar Box- White Cypress Pine Grassy Open Woodland on Alluvial Loams Mainly of the Temperate (Hot Summer) Climate Zone (Benson 88)	No (box habitats not preferred; NPWS 2000)	No (box habitats not preferred; NPWS 2000)	Yes

Only areas within these vegetation types characterised by a high diversity, moderate density, low (<1 m) sclerophyllous shrubby layer.

The proposed program requires the removal of 36.4 ha of potential breeding, foraging and dispersing habitat for this species while the existing exploration and appraisal activities have involved the removal of 109.1 ha of potential breeding, foraging and dispersing habitat. Of the 145.5 ha of breeding, foraging and dispersing habitat for this species, a maximum of 23.5 ha constitutes potential breeding/foraging habitat and 122 ha constitutes dispersing habitat. It is important to note that only 4.7 ha of the 23.5 ha of

potential breeding habitat for the Pilliga Mouse has been identified through on-ground assessment, the remainder has been identified through broad scale vegetation type mapping and does not necessarily equate to optimal breeding habitat as identified through micro-habitat characteristics on the ground due to the scale of the study area. This equates to a reduction of approximately 0.07% of potential breeding habitat within the study area.

Analysis

The fragmentation analysis has determined that seven out of twenty-five potential movement pathways for Pilliga Mouse are likely to be potentially impacted by the proposed program, however all of these are short-term impacts (flow lines) rather than long-term (pilot wells).

Six of the twenty-five potential movement pathways for Pilliga Mouse have been potentially impacted by the existing exploration and appraisal activities, however five of these are short-term impacts (flow lines) rather than long-term (pilot wells).

The analysis has determined that twelve out of twenty-five potential movement pathways for Pilliga Mouse are likely to be potentially impacted by the cumulative impacts of the combined proposed program and existing exploration and appraisal activities, although eleven of these twelve are short-term impacts (flow lines) rather than long-term (pilot wells) (**Figure 3**). It is important to note that the cumulative impact will not result in the direct long-term fragmentation of one area of breeding habitat into two smaller areas; rather only one movement pathway (dispersal and foraging) between different patches of habitat has been fragmented in the long-term.

Table 15 details presents the results of the fragmentation analysis including the number of existing roads, trails, creeklines, as well as the number of breaks that have occurred as a result of exploration and appraisal activities. The dark colouration in **Table 15** represents long term fragmentation impacts as a result of exploration and appraisal activities while the lighter colouration represents short term impacts. **Table 15** also details those existing exploration and appraisal activities, and those proposed (yet to be undertaken).

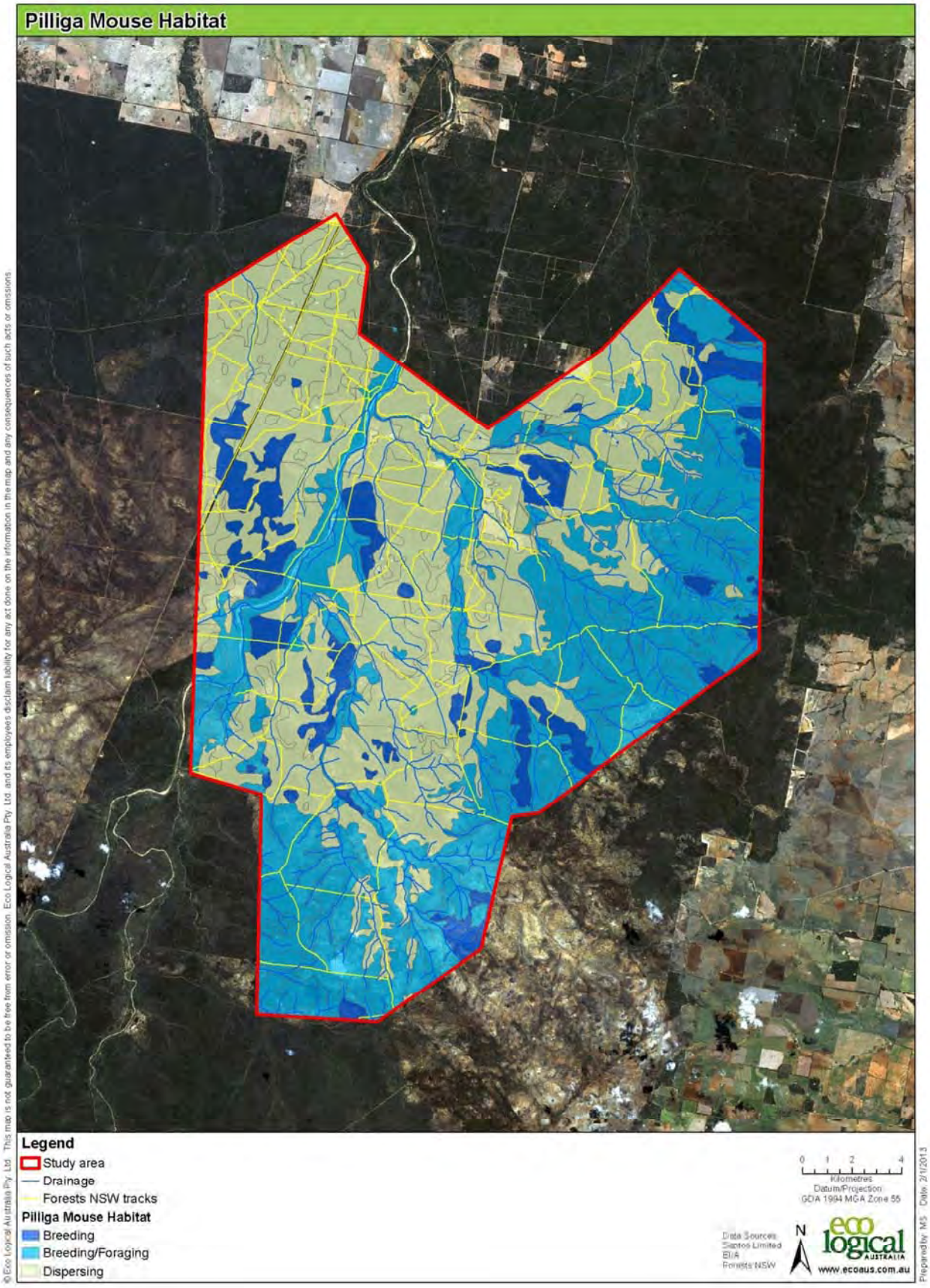

Figure 2: Pilliga Mouse breeding, foraging and dispersing habitat in the study area

Table 15: Number of existing roads, trails and drainage, and breaks caused by exploration and appraisal activities, crossing potential Pilliga Mouse movement paths

POTENTIAL MOVEMENT PATHWAY	EXISTING EXPLORATORY WORKS	PROPOSED PROGRAM	EXISTING ROADS	EXISTING TRAILS	EXISTING DRAINAGE	PROPOSED PROGRAM		EXISTING EXPLORATION AND APPRAISAL ACTIVITIES	
						SHORT-TERM IMPACTS	LONG-TERM IMPACTS	SHORT-TERM IMPACTS	LONG-TERM IMPACTS
1	No	No	3	6	1	0	0	0	0
2	No	No	1	3	0	0	0	0	0
3	No	No	3	2	0	0	0	0	0
4	Yes	No	1	1	0	0	0	0	1
5	Yes	Yes	3	0	2	1	0	1	0
6	No	No	4	13	1	0	0	0	0
7	No	No	16	4	2	0	0	0	0
8	No	Yes	3	0	2	1	0	0	0
9	No	No	3	0	0	0	0	0	0
10	No	Yes	4	2	6	1	0	0	0
11	Yes	Yes	7	2	6	0	0	2	0
12	Yes	Yes	1	2	0	0	0	1	0
13	No	Yes	1	0	2	0	0	1	0
14	No	No	1	0	0	0	0	0	0
15	No	No	0	0	0	0	0	0	0
16	No	No	1	0	1	0	0	0	0
17	No	Yes	1	4	0	1	0	0	0
18	No	No	2	0	3	0	0	0	0
19	No	Yes	2	5	0	1	0	0	0
20	No	Yes	4	4	2	1	0	0	0
21	Yes	Yes	0	3	0	0	0	1	0
22	No	Yes	1	0	0	1	0	0	0
23	No	No	1	2	3	0	0	0	0
24	No	No	3	0	2	0	0	0	0
25	No	No	1	0	0	0	0	0	0

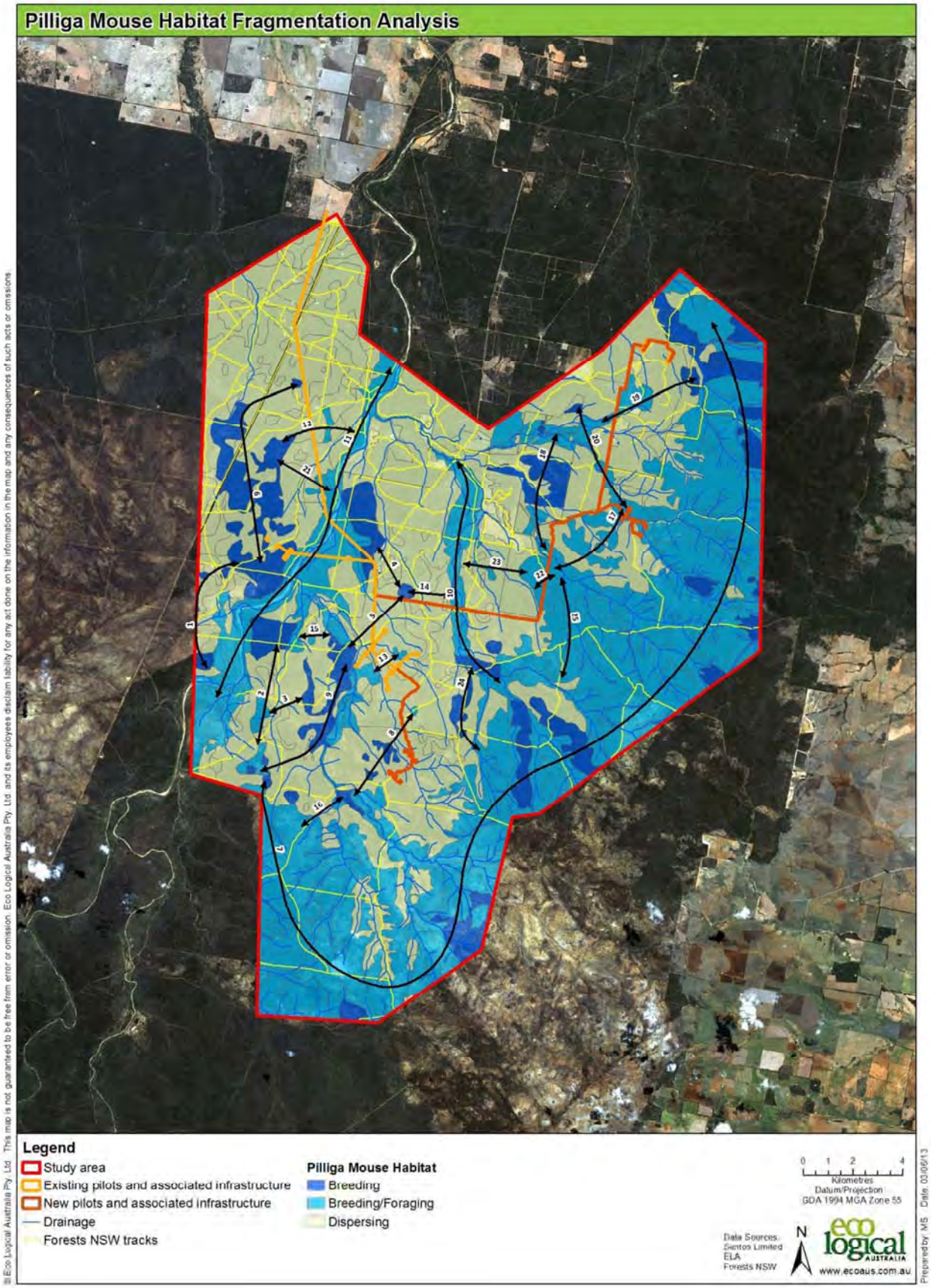

Figure 3: Pilliga Mouse fragmentation analysis

5.4.3 Discussion

The habitat fragmentation analysis identified one MNES, the Pilliga Mouse, which could potentially be affected by habitat fragmentation with other MNES identified as unlikely to be impacted. Potential movement paths for the Pilliga Mouse through the study area were identified.

The potentially impacted movement pathways were considered to be of potential significance to the Pilliga Mouse, because these potential movement paths were located between breeding and foraging habitat (**Figure 3**). Tokushuma *et al.* (2008) has indicated that the Pilliga Mouse is distributed in disjunct patches of refuge habitat (considered in this report to be breeding habitat) within its range except when environmental conditions are favourable, when it then is able to irrupt and become briefly ubiquitous before suddenly declining to a lower density and sparse distribution.

For the proposed program, of the twenty-five potential movement pathways identified for the Pilliga Mouse, only seven are likely to be impacted by the proposed program, however all of these are short-term impacts (flow lines) rather than long-term (pilot wells).

Cumulatively (considering the proposed program and existing exploration and appraisal activities), eleven of the twelve paths were identified as being impacted by short-term impacts only (**Table 15**) while only 1 of the paths was identified as impacted by long-term impacts (Path 4; **Figure 2**). It should be noted than an alternative route for path 4 potentially exists heading due east to the nearest patch of potential foraging and dispersing habitat, however this pathway crosses one short-term break and the receiving patch is also fragmented in an east-west direction by the flowlines (i.e. has the same amount of impact).

The movement pathways identified are generally the shortest and most direct route between habitat types (breeding and foraging). In most cases a longer and more indirect pathway could be taken by the Pilliga Mouse, hence avoiding any potential fragmentation/disturbance. It is important to note that the fragmentation analysis has shown that the proposed program and existing exploration and appraisal activities are not likely to result in the long-term direct fragmentation of one area of breeding habitat into two smaller areas.

The extent to which habitat fragmentation may impact on Pilliga Mouse habitat is not fully understood. The specific conditions or factors that would prevent the Pilliga Mouse from crossing roads or barriers are not documented as little is known of its movement patterns and behaviour. Access roads and pipelines could represent a real or perceived barrier to movement, preventing the Pilliga Mouse from moving through the study area. Other studies of small mammals have found that many small mammal species avoid edge habitats and crossing roads (Mader 1984, Garland and Bradley 1984; Goosem 2001; Rondinini and Doncaster 2002) due to unfavourable microclimates, the amount of open space, and disturbances from traffic (the cars themselves and noise). Thus, it is possible that access roads could be a barrier to movement to Pilliga Mouse leading to an existing population being fragmented into two or more populations in the study area. It should be noted, however, that the majority of roads in the study area are existing forestry roads.

Conversely, the Pilliga Mouse inhabits open woodland and shrub areas, sometimes in areas with sparse ground cover. A much higher number of existing roads, trails and drainage lines currently fragment Pilliga Mouse habitat in the study area than those created by the proposed program and existing exploration and appraisal activities. Existing roads and trails were recorded crossing potential Pilliga Mouse movement paths 120 times (**Figure 3**) and these were intersected by drainage lines on 33 occasions Only twelve of twenty five potential movement pathways have been intersected by existing and proposed exploratory works (**Table 15**). In addition, flow lines for the proposed program have been

largely located along existing roads to minimise the impacts of fragmentation and have been allowed to naturally regenerate following installation.

When considered in relation to the amount of habitat available for the Pilliga Mouse in the study area and the region, the small number of additional short-term breaks across potential movement pathways, the proposed program is considered unlikely to significantly increase the effects of habitat fragmentation on the Pilliga Mouse. Similarly when combined with the existing exploration and appraisal activities, the small number of additional short-term breaks across potential movement pathways are considered unlikely to significantly increase the effects of habitat fragmentation on the Pilliga Mouse.

Due to the natural rehabilitation of the flowlines, eleven of the twelve movement pathways are considered to be impacted only in the short-term.

6 Significant impact assessment under the EPBC Act

6.1 SIGNIFICANT IMPACT CRITERIA

The EPBC Act Administrative Guidelines on Significance set out 'Significant Impact Criteria' that are to be used to assist in determining whether a proposed action is likely to have a significant impact on matters of national environmental significance. Matters listed under the EPBC relevant to the exploration and appraisal activities within the Pilliga Forest are 'nationally threatened species and ecological communities' and 'listed migratory species'.

Specific 'Significant Impact Criteria' are provided for each matter of national environmental significance, except for threatened species and ecological communities, in which case separate criteria are provided for species listed as endangered and vulnerable under the EPBC Act (**Table 16**)

Table 16: Significant Impact Criteria

STATUS	SIGNIFICANT IMPACT CRITERIA
Critically endangered and endangered species	An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will: • lead to a long-term decrease in the size of a population • reduce the area of occupancy of the species • fragment an existing population into two or more populations • adversely affect habitat critical to the survival of a species • disrupt the breeding cycle of a population • modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat • introduce disease that may cause the species to decline, or • interfere with the recovery of the species.
Vulnerable species	An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • lead to a long-term decrease in the size of an important population of a species • reduce the area of occupancy of an important population • fragment an existing important population into two or more populations • adversely affect habitat critical to the survival of a species • disrupt the breeding cycle of an important population • modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

STATUS	SIGNIFICANT IMPACT CRITERIA
	• result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat • introduce disease that may cause the species to decline, or • interfere substantially with the recovery of the species.
Migratory species	An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species • result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or • seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

6.2 IMPACT ASSESSMENT

This section provides an assessment of the potential significance of impacts from the proposed program on MNES. Additional context on the cumulative impact associated with the proposed program and existing exploration and appraisal activities (from 2002 to present) is provided in **Section 6.3**. MNES considered relevant to this assessment are identified in **Section 4** of this report and include:

Birds

Swift Parrot, Regent Honeyeater, Superb Parrot, Fork-tailed Swift, White-bellied Sea Eagle, White-throated Needletail and Rainbow Bee-eater

Mammals

Koala, Large-eared Pied Bat, Pilliga Mouse, South-eastern Long-eared Bat and Spotted-tailed Quoll

Plants

Pterostylis cobarensis and *Tylophora linearis*

The relevant Significant Impact Criteria have been applied to these threatened and migratory species to determine the significance of impact of the proposed program.

6.2.1 Birds

***Anthochaera phrygia* (Regent Honeyeater) – Endangered**

The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia, particularly Box-Ironbark woodland, and riparian forests of River Sheoak. Birds are also found in drier coastal woodlands and forests in some years. There are three known key breeding regions: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands, although other potential breeding sites, close to the Study area,

include the Warrumbungles National Park and Pilliga Nature Reserve (NPWS 1999a). The species is known to make large scale nomadic movements across the landscape, which is thought to coincide with flowering times of different eucalypt species on which they feed (SEWPAC 2013).

There are no existing records for the species within the study area and they were not identified during surveys. The species has been recorded nearby with two records in the Pilliga Nature Reserve, and one in Pilliga East State Forest. Breeding behaviour has been recorded in the Pilliga Nature Reserve; however the important Bundarra-Barraba breeding area is located 150 km to the east. It is considered likely that the species would utilise habitats present in the study area for foraging.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of a population

The proposed action could lead to a long-term decrease in the size of a population of Regent Honeyeaters if it significantly reduced or degraded foraging, roosting and breeding habitat available to the species, or contributed to the direct mortality of the species.

The proposed action will lead to the loss of approximately 36 ha of potential foraging/roosting habitat for this species, which equates to less than 0.1% of the available habitat within the study area and much less in Namoi CMA region. The loss of potential foraging/roosting habitat will occur in small areas across the landscape for the well leases and linear corridors for the flow lines which generally follow existing tracks and infrastructure. Up to 40% of clearing associated with the well pads and 60% of clearing associated with the flowlines and water and gas gathering systems will be rehabilitated.

As such, it is considered unlikely that the proposed action would lead to a long-term decrease in the size of a population of the Regent Honeyeater.

Reduce the area of occupancy of the species

The area of occupancy for Regent Honeyeaters could be reduced if significant amounts of foraging and roosting habitat were lost in the study area, or if habitats were degraded to the point that the species avoided degraded areas and could not move through the study area to undisturbed areas.

The loss of habitat through clearing is small relative to the amount of habitat retained in the study area and the wider Namoi CMA region, hence the proposed action is considered unlikely to reduce the area of occupancy of the species

Fragment an existing population into two or more populations

The proposed action could potentially fragment foraging/roosting habitat, however linear infrastructure (flow lines) has been aligned with existing roads to minimise fragmentation impacts. Regent Honeyeaters are nomadic and can make large regional movements across their range. Regent Honeyeaters would be able to traverse the length and width of the study area to access potential foraging resources despite the potential fragmentation caused by the proposed action. Habitat connectivity would be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the study area, allowing an existing population to move across the wider landscape. Thus, it is unlikely that the proposed action would fragment an existing population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat critical to the survival of the species includes breeding habitat, and foraging/roosting habitat. Breeding habitat is critical to the survival of the species as Regent Honeyeaters only use a small number of specific areas to breed. Any impacts to breeding habitat could threaten the survival of the species. Unlike breeding habitat, Regent Honeyeaters would likely be able to withstand minor impacts to foraging/roosting habitat, i.e. not all habitat representing foraging/roosting habitat is critical to the survival of the species. The levels tolerated would depend on the amount and quality of foraging/roosting habitat impacted, the location of the habitat in the landscape, and the amount of habitat remaining in the study area and Namoi CMA region.

There are three known key breeding regions remaining for the species: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. The species has also been recorded breeding in the Pilliga Nature Reserve and Warrumbungles National Park (NPWS 1999a), located to the south of the study area. The study area is not a known key breeding area for the species, and thus the proposed action would not directly impact on breeding habitat.

The foraging/roosting habitat proposed to be removed by the action constitutes less than 0.1% of the available habitat within the Namoi CMA region and is unlikely to be critical to the survival of the species.

Disrupt the breeding cycle of a population

The proposed action could impact on or disrupt the breeding cycle of the Regent Honeyeater if it impacted on breeding habitat directly, or reduced/degraded foraging resources used during the breeding season. The study area is not a known key breeding area for the species, and thus the proposed action would not directly impact on breeding habitat.

The vegetation types impacted by the proposed action are not considered to contain profusely flowering winter-flowering species and as such the study area is considered to only represent transient foraging/roosting habitat which is unlikely to be considered a significant foraging resource for the Regent Honeyeater during breeding.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed action will lead to the loss of approximately 36 ha of potential foraging/roosting habitat for this species, which equates to less than 0.1% of the available habitat within the study area and much less in Namoi CMA region.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing foraging/roosting habitat for the species would be retained in the study area.

Therefore it is unlikely that the proposed action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

It is unlikely that the proposed action would result in the introduction of invasive species that would impact on Regent Honeyeater in the study area. The species suffers from competition from larger

aggressive honeyeaters, particularly Noisy Miners, Noisy Friarbirds and Red Wattlebirds. However, the proposed action is unlikely to lead to an increase in the incidence of these species in the study area.

Introduce disease that may cause the species to decline, or

Disease is not listed as a threat to this species. The proposed action would be unlikely to introduce a disease that may cause this species to decline.

Interfere with the recovery of the species.

In consideration of the above factors, the proposed action is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed action is not considered likely to have a significant impact on the Regent Honeyeater for the following reasons:

- The proposed action will disturb a very small proportion (<0.1%) of available foraging/roosting habitat within the study area - the species is highly mobile and thus able to utilise areas across the landscape
- Fragmentation impacts have been minimised by aligning linear infrastructure (flow lines) with existing roads
- The proposed action will not disrupt the breeding cycle of the species as important breeding habitat will not be impacted
- The regional extent of suitable foraging habitat types is sufficient that the proposed action will not result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline.

***Lathamus discolour* (Swift Parrot) – Endangered**

The Swift Parrot is a wide-ranging, highly mobile species which is endemic to south-eastern Australia (SEWPAC 2013). It is known to use habitat within the Namoi CMA region (OEH 2013b). Swift Parrots breeds in Tasmania during spring and summer, migrating in the autumn and winter months to south-eastern Australia from Victoria and the eastern parts of South Australia to south-east Queensland. In NSW this species mostly occurs on the coast and south west slopes.

On the mainland birds occur in areas where eucalypts are flowering profusely or where there is abundant lerp (from sap-sucking bugs) infestations (OEH 2013b). Favoured feed trees include winter flowering species such as *Eucalyptus robusta* (Swamp Mahogany), *Corymbia maculata* (Spotted Gum), *C. gummifera* (Red Bloodwood), *E. sideroxylon* (Mugga Ironbark), and *E. albens* (White Box). Commonly used lerp infested trees include *E. microcarpa* (Inland Grey Box), *E. moluccana* (Grey Box) and *E. pilularis* (Blackbutt). Following winter they return to Tasmania where they breed from September to January.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of a population

There are no existing records for the species within the study area. The closest records according to the Atlas of NSW Wildlife are approximately 24 km to the east in Boggabri and 55 km to the south east near

Gunnedah. The vegetation types impacted by the proposed action are not considered to contain profusely flowering winter-flowering species and as such the study area is considered to only represent transient foraging habitat.

The proposed action will lead to the loss of approximately 36 ha of potential foraging habitat for this species, which equates to less than 0.1% of the available habitat within the study area and much less in Namoi CMA region. The loss of habitat will occur in small areas across the landscape for the well pads and linear corridors for the flow lines which generally follow existing tracks and infrastructure. Up to 40% of clearing associated with the well pads and 60% of clearing associated with the flowlines and water and gas gathering systems will be rehabilitated.

As such, it is considered unlikely that the proposed action would lead to a long-term decrease in the size of a population of the Swift Parrot

Reduce the area of occupancy of the species

The area of occupancy for Swift Parrots could be reduced if significant amounts of foraging/roosting habitat were lost in the study area, or if habitats were degraded to the point that the species avoided degraded areas and could not move through the study area to undisturbed areas.

The loss of habitat through clearing is small relative to the amount of habitat retained in the study area and the wider Namoi CMA region, hence the proposed action is considered unlikely to reduce the area of occupancy of the species

Fragment an existing population into two or more populations

The proposed action could potentially fragment foraging/roosting habitat, however linear infrastructure (flow lines) has been aligned with existing roads to minimise fragmentation impacts. Swift Parrots are migratory and can make large movements across their range. Swift Parrots would be able to traverse the length and width of the study area to access potential foraging resources despite the potential fragmentation caused by the proposed action. Habitat connectivity would be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the study area, allowing an existing population to move across the wider landscape. Thus, it is unlikely that the proposed action would fragment an existing population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat that is necessary to the survival of the species includes breeding habitat, and foraging and roosting habitat. Breeding habitat is critical to the survival of the species as Swift Parrots only breed in Tasmania. Any impacts to breeding habitat could threaten the survival of the species. Unlike breeding habitat, Swift Parrots would likely be able to withstand some level of impact to foraging/roosting habitat, i.e. not all habitat representing foraging/roosting habitat is critical to the survival of the species.

The levels tolerated would depend on the amount and quality of foraging/roosting habitat impacted, the location of the habitat in the landscape, and the amount of habitat remaining in the study area and Namoi CMA region.

The foraging/roosting habitat proposed to be removed by the action constitutes less than 0.1% of the available habitat within the Namoi CMA region and is unlikely to be critical to the survival of the species.

Disrupt the breeding cycle of a population

The study area is not used as a breeding area for the species, and thus the proposed action would not directly impact on breeding habitat. The species would not use the study area as foraging habitat during

the breeding season as it remains in Tasmania during its breeding season (spring and summer months), only migrating to mainland Australia during its non-breeding season (autumn and winter months). Thus, the proposed action is unlikely to disrupt the breeding cycle of the species.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed action will lead to the loss of approximately 36 ha of potential foraging/roosting habitat for this species, which equates to less than 0.1% of the available habitat within the study area and much less in Namoi CMA region.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing foraging/roosting habitat for the species would be retained in the study area.

Therefore it is unlikely that the proposed action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

It is unlikely that the proposed action would result in the introduction of invasive species that would impact on Swift Parrots in the study area.

Introduce disease that may cause the species to decline, or

A disease that could potentially infect Swift Parrots is beak and feather disease. However, the proposed action would be unlikely to introduce a disease that may cause this species to decline, given the disease is transmitted by other birds of the same species.

Interfere with the recovery of the species.

In consideration of the above factors, the proposed action is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed action is not considered likely to have a significant impact on the species for the following reasons:

- The species is not known to occur in the study area
- The proposed action will disturb a very small proportion (<0.1%) of available foraging/roosting habitat within the study area - the species is highly mobile and thus able to utilise areas across the landscape
- Fragmentation impacts have been minimised by aligning linear infrastructure (flow lines) with existing roads
- The vegetation within the development footprint is not considered to represent core foraging habitat
- The species' migratory route will not be affected by the proposed action
- The proposed action will not disrupt the breeding cycle of the species as it breeds exclusively in Tasmania.

***Polytelis swainsonii* (Superb Parrot) – Vulnerable**

The Superb Parrot is found throughout eastern inland NSW and northern Victoria, with occasional vagrants recorded in southern Queensland (SEWPAC 2013). On the South-western Slopes of NSW their core breeding area is roughly bounded by Cowra and Yass in the east, and Grenfell, Cootamundra and Coolac in the west. Birds breeding in this region are mainly absent during winter, when they migrate north to the region of the upper Namoi and Gwydir Rivers. The other main breeding sites in NSW and Victoria are in the Riverina along the corridors of the Murray, Edward and Murrumbidgee Rivers where birds are present all year round.

The species inhabits Box-Gum, Box-Cypress-pine and Boree Woodlands and River Red Gum Forest. In the Riverina the birds nest in the hollows of large trees (dead or alive) mainly in tall riparian River Red Gum Forest or Woodland. On the South West Slopes nest trees can be in open Box-Gum Woodland or isolated paddock trees. Species known to be used are Blakely's Red Gum, Yellow Box, Apple Box and Red Box. During the breeding season, individuals may forage up to 10 km from nesting sites, primarily in grassy box woodland. The species feed in trees and understorey shrubs and on the ground and their diet consists mainly of grass seeds and herbaceous plants. Also eaten are fruits, berries, nectar, buds, flowers, insects and grain (OEH 2013b).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of an important population of a species

An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- key source populations either for breeding or dispersal
- populations that are necessary for maintaining genetic diversity, and/or
- populations that are near the limit of the species range.

This species was not observed during field surveys and there are no existing records for the species within the study area. The closest records according to the Atlas of NSW Wildlife are approximately 20 km to the north of the study area and east of Narrabri.

The proposed action will lead to the loss of approximately 1.4 ha of potential foraging habitat for this species, which equates to less than 0.01% of the available habitat within the study area and much less in Namoi CMA region. The loss of potential habitat will occur in small areas across the landscape for the well pads and linear corridors for the flow lines which generally follow existing tracks and infrastructure. Up to 40% of clearing associated with the well pads and 60% of clearing associated with the flowlines and water and gas gathering systems will be rehabilitated.

As the species has not been recorded in the study area and the study area is not within the known breeding distribution of the species, it is considered unlikely that an 'important population' of Superb Parrots occurs within the study area. Therefore the proposed action is unlikely to lead to a long-term decrease in the size of an important population.

Reduce the area of occupancy of an important population

As an 'important population' of Superb Parrots is considered unlikely to occur within the study area, the proposed action is unlikely to reduce the area of occupancy of an important population.

Fragment an existing important population into two or more populations

As an 'important population' of Superb Parrots is considered unlikely to occur within the study area, the proposed action is unlikely to fragment an existing important population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat that is necessary to the survival of the species includes breeding habitat, and foraging/roosting habitat. Breeding habitat is critical to the survival of the Superb Parrot as they only breed in the south west slopes, bounded by Cowra and Yass in the east, and Grenfell, Cootamundra and Coolac in the west, and in the Murray-Riverina area (OEH 2013b). Any impacts to breeding habitat could threaten the survival of the species. Unlike breeding habitat, Superb Parrots would likely be able to withstand some level of impact to foraging and roosting habitat i.e. not all habitat representing foraging/roosting habitat is critical to the survival of the species. The levels tolerated would depend on the amount and quality of foraging and roosting habitat impacted, the location of the habitat in the landscape, and the amount of habitat remaining in the area/Namoi CMA region.

The foraging/roosting habitat proposed to be removed by the action constitutes less than 0.1% of the available habitat within the Namoi CMA region and is unlikely to be critical to the survival of the species

Disrupt the breeding cycle of an important population

As an 'important population' of Superb Parrots is considered unlikely to occur within the study area, the proposed action is unlikely to disrupt the breeding cycle of an important population.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed action will lead to the loss of approximately 1.4 ha of potential foraging habitat for this species, which equates to less than 0.01% of the available habitat within the study area and much less in Namoi CMA region.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing foraging/roosting habitat for the species would be retained in the study area.

Therefore it is unlikely that the proposed action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

The proposed action could potentially lead to the spread of weeds into the study area through the transportation of weed propagules on vehicles and equipment. This could potentially impact on Superb Parrots, which mainly feed on native grass seeds and herbaceous plants, if weeds out-competed native grasses and forbs. However, weeds are actively managed and will be controlled in the study area.

Introduce disease that may cause the species to decline, or

Disease is not listed as a threat to this species. A disease that could infect Superb Parrots is beak and feather disease. However, the proposed action would be unlikely to introduce a disease that may cause this species to decline, given the disease is transmitted by other birds of the same species.

Interfere substantially with the recovery of the species.

In consideration of the above factors, the proposed action is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed action is not considered likely to have a significant impact on the species for the following reasons:

- An 'important population' of Superb Parrots is considered unlikely to occur within the study area
- The species is not currently known to occur in the study area
- The proposed action will disturb an extremely small proportion (<0.1%) of available habitat within the Namoi CMA region
- Fragmentation impacts have been minimised by aligning linear infrastructure (flow lines) with existing roads
- The species does not breed in the study area and as such the proposed action will not disrupt the breeding cycle of the species.

6.2.2 Mammals

***Dasyurus maculatus* (Spotted-tailed Quoll) - Endangered**

The Spotted-tailed or Tiger Quoll occupies a range of environments within a disjunct distribution along the east coast of Australia, extending from south-eastern Queensland through NSW and Victoria to Tasmania. The species is found in a variety of habitats, including sclerophyll forest and woodlands, coastal heathlands and rainforests. Occasional sightings are made in open country, grazing lands, rocky outcrops and other treeless areas (SEWPAC 2013). This species feeds on a wide variety of birds, reptiles, mammals and invertebrates and uses several 'latrines' within its territory for defecation (OEH 2013b). It is essentially terrestrial, but is also an agile climber (OEH 2013b). Nesting occurs in rock shelters, hollow logs, caves or tree hollows and they use numerous dens within the home range. Estimates of home ranges vary from 800 ha to 20 km^2 and individuals may move several kilometres in a night (NPWS 1999b). One individual was tracked travelling 8 km in one night (Belcher *et al.* 2008).

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of a population

The proposed action could lead to a long-term decrease in the size of a population of Spotted-tailed Quolls if it significantly reduced or degraded foraging, sheltering and breeding habitat available to the species, contributed to the direct mortality of the species, or led to an increase in introduced predators such as cats and foxes which would compete with the species for foraging resources.

The species was not observed during field surveys and there are no existing records for the species within the study area. However, this species was recorded in the Pilliga Forest in the 1990s (Paull and Date 1999). While the species occurs more frequently in coastal areas, there are scattered records for Spotted-tailed Quolls west of the study area along the Barwon River. The closest records from the Atlas of NSW Wildlife are approximately 25 km to the south east and 45 km to north east of the study area. Therefore it is considered that the species has the potential to occur in the study area.

The proposed action will lead to the loss of approximately 36 ha of potential habitat for this species, which equates to less than 0.1% of the available habitat within the study area and much less in Namoi CMA region. The loss of habitat will occur in small areas across the landscape for the well pads and linear corridors for the flow lines which generally follow existing tracks and infrastructure. Up to 40% of

clearing associated with the well pads and 60% of clearing associated with the flowlines and water and gas gathering systems will be rehabilitated.

As such, it is considered unlikely that the proposed action would lead to a long-term decrease in the size of a population of Spotted-tailed Quolls.

Reduce the area of occupancy of the species

The area of occupancy for Spotted-tailed Quolls would be reduced if significant amounts of foraging, sheltering and breeding habitat were lost in the study area, or if habitats were degraded to the point that the species avoided degraded areas and could not move through the study area to undisturbed areas.

The loss of habitat through clearing is small relative to the amount of habitat retained in the study area and the wider Namoi CMA region, hence the proposed action is considered unlikely to reduce the area of occupancy of the species.

Fragment an existing population into two or more populations

The proposed action could potentially fragment habitat for the Spotted-tailed Quoll, however linear infrastructure (flow lines) has been aligned with existing roads to minimise fragmentation impacts.

Spotted-tailed Quolls are capable of large movements, and numerous records have been made for overnight movements of several kilometres for the species (NPWS 1999b; Belcher et al. 2008). The proposed action is unlikely to create barriers to movement of this species. Habitat connectivity will be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the study area, allowing any potential populations to move across the wider landscape. Thus, it is unlikely that the proposed action would fragment an existing population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat that is critical to the survival of the species includes foraging, sheltering and breeding habitat. While all habitat types would be important to the species, Spotted-tailed Quolls would likely be able to withstand some level of impact to its habitat. The levels tolerated would depend on the amount and quality of foraging, sheltering and breeding habitat impacted, the time they were impacted, the location of the habitat in the landscape, and the amount of habitat remaining in the area/Namoi CMA region.

The potential habitat proposed to be removed by the action constitutes less than 0.1% of the available habitat within the Namoi CMA region and is unlikely to be critical to the survival of the species.

Disrupt the breeding cycle of a population

The proposed action could impact on or disrupt the breeding cycle of Spotted-tailed Quolls if it impacted on breeding habitat directly, disturbed the species during the breeding season, or reduced/degraded foraging resources used during the breeding season.

There is potential for the study area to be used for breeding by this species. The study area contains habitat elements necessary for breeding, including hollows and fallen logs; however this species has not been detected during field surveys.

As the species has not been detected within the study area and due to the relatively small scale of the impacts of the proposed action, it is considered unlikely that the proposed action will disrupt the breeding cycle of a population.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed action will lead to the loss of approximately 36 ha of potential habitat for this species, which equates to less than 0.1% of the available habitat within the study area and much less in Namoi CMA region.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing potential habitat for the species would be retained in the study area.

Therefore it is unlikely that the proposed action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

Invasive species that are harmful to the Spotted-tailed Quolls such as cats and foxes are already established in the study area. The proposed action is unlikely to exacerbate the impacts of invasive species or lead to increased competition for Spotted-tailed Quolls for resources.

Introduce disease that may cause the species to decline, or

Spotted-tailed Quolls are susceptible to the spread of epidemics, such as a parasitic protozoan, by cats (NPWS 1999b). However, cat populations are already well established in the study area.

Interfere with the recovery of the species.

In consideration of the above factors, the proposed action is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed action is not considered likely to have a significant impact on the species for the following reasons:

- The species has some potential to occur within the study area, however, it is most common in coastal areas
- The proposed action will disturb a very small proportion (<0.1%) of available habitat within the study area
- Fragmentation impacts have been minimised by aligning linear infrastructure (flow lines) with existing roads
- The species is very mobile, able to utilise a variety of habitats within the landscape and is known to travel several kilometres a night
- The regional extent of suitable foraging habitat types is sufficient that the development will not result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline.

***Nyctophilus corbeni* (South-eastern Long-eared Bat) - Vulnerable**

Overall, the distribution of the South-eastern Long-eared Bat coincides approximately with the Murray Darling Basin (SEWPAC 2013). It is common in the Pilliga region (OEH 2013b). The species inhabits a

variety of vegetation types, including mallee, *Allocasuarina luehmannii* (Bull-oak) and box-eucalypt dominated communities, but it is distinctly more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland (OEH 2013b). The species roosts in tree hollows, crevices, and under loose bark. It is a slow flying agile bat, using the understorey to hunt non-flying prey, especially caterpillars and beetles, and will even hunt on the ground. Movement patterns are not well known, although roost sites have been recorded as an average of 1.89 ± 1.61 km (range 0.34–7.06 km) from the capture point of bats (Schulz and Lumsden 2010). It appears the species requires large, intact areas of habitat to persist (Turbill *et al.* 2008).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of an important population of a species

Nyctophilus species were recorded using anabat recorders along the Dewhurst Northern Water and Gas Flow Lines and Dewhurst Southern Water and Gas Flow Lines, although identification between species on the basis of anabat recordings is not conclusive. A number of previous surveys have also detected the species near the study area, with a large number of individuals recorded (NPWS 2000a, NPA 2002, Ecotone 2009). The Atlas of NSW Wildlife records show the species' presence throughout the study area, and NSW OEH considers the Pilliga region to be a distinct stronghold for this species.

As the South-eastern Long-eared Bat is known to occur in the study area and has its core distribution centred on the Pilliga region, it is likely that South-eastern Long-eared Bat populations within the study area would be defined as an important population under the EPBC Act.

The proposed action will lead to the loss of approximately 36 ha of habitat for this species, which equates to less than 0.1% of the available habitat within the study area and much less in Namoi CMA region. The loss of habitat will occur in small areas across the landscape for the well pads and linear corridors for the flow lines which generally follow existing tracks and infrastructure. Up to 40% of clearing associated with the well pads and 60% of clearing associated with the flowlines and water and gas gathering systems will be rehabilitated.

As the proposed action represents a small proportion of the available habitat in the study area, the proportion of hollow-bearing trees to be removed is also likely to be low. As such it is considered unlikely that the proposed action would lead to a long-term decrease in the size of a population of South-eastern Long-eared Bat.

Reduce the area of occupancy of an important population

The area of occupancy for South-eastern Long-eared Bats would be reduced if significant amounts of foraging, roosting and breeding habitat were lost in the study area, or if habitats were degraded to the point that the species avoided or could not cross degraded areas and could not move through the study area to undisturbed areas.

The loss of habitat through clearing is small relative to the amount of habitat retained in the study area and the wider Namoi CMA region, hence the proposed action is considered unlikely to reduce the area of occupancy of the species.

Fragment an existing important population into two or more populations

The nature of the proposed action being in discrete areas for the well pads and in long linear sites adjacent to existing roads for the water and gas gathering system provides a mosaic of impacted areas surrounded by intact habitat. South-eastern Long-eared Bats can travel 3 kilometres in a foraging excursion (Churchill 2008). As the species is highly mobile over the distances involved with the

proposed impacts, the proposed action will not create barriers in relation to the foraging activities of the species.

This species locates prey via echolocation and "passive listening". The effectiveness of these prey detection mechanisms may be impacted by noise associated with the construction and/or operation of the gas facilities. However, noise impacts will be highly localised and large areas of habitat will remain undisturbed. Should the South-eastern Long-eared Bat avoid areas of habitat degraded by noise, individuals of this species would be able to traverse these areas to undisturbed patches within the study area.

Habitat connectivity will be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the study area, allowing any potential populations to move across the wider landscape. Thus, it is unlikely that the proposed action would fragment an existing population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat that is necessary to the survival of South-eastern Long-eared Bats includes foraging, roosting and breeding habitat. While all habitat types would be important to the species, South-eastern Long-eared Bats would likely be able to withstand some level of impact to its habitat.

The proposed action would retain the majority of foraging, roosting and breeding habitat in the study area for South-eastern Long-eared Bats, with only a small proportion of habitat impacted in the study area and Namoi CMA region. Thus, the foraging, roosting and breeding habitat lost or degraded is unlikely to be critical to the survival of the species.

Disrupt the breeding cycle of an important population

The proposed action could impact on or disrupt the breeding cycle of South-eastern Long-eared Bats if it impacted on breeding habitat directly, or reduced/degraded foraging resources used during the breeding season.

The proposed action would impact on foraging and breeding habitat, and reduce/degrade foraging resources indirectly through habitat fragmentation. However, the area directly impacted represents a small proportion available in the study area with the majority of breeding and foraging habitat retained in the study area. South-eastern Long-eared Bats would be able to use undisturbed habitat to complete their life cycles.

As such, the proposed action is unlikely to disrupt the breeding cycle of the South-eastern Long-eared Bat.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed action will lead to the loss of approximately 36 ha of potential habitat for this species, which equates to less than 0.1% of the available habitat within the study area and much less in Namoi CMA region.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing potential habitat for the species would be retained in the study area.

Therefore it is unlikely that the proposed action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

Invasive species that are harmful to the South-eastern Long-eared Bat such as cats and foxes are already established in the study area. The proposed action is unlikely to exacerbate the impacts of invasive species or lead to increased competition for South-eastern Long-eared Bats for resources.

Introduce disease that may cause the species to decline, or

Disease is not listed as a threat to this species. The proposed action would be unlikely to introduce a disease that may cause this species to decline.

Interfere substantially with the recovery of the species.

In consideration of the above factors, the proposed action is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed action is not considered likely to have a significant impact on the species for the following reasons:

- The species is highly mobile and will be able to move across disturbed areas into nearby undisturbed locations
- The regional extent of suitable habitat is sufficient that the proposed action will not result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline
- Fragmentation impacts have been minimised by aligning linear infrastructure (flow lines) with existing roads
- The regional extent of suitable roosting and breeding habitat is sufficient that the proposed action will not result in the substantial disruption of elements of this species' breeding cycle.

***Chalinolobus dwyeri* (Large-eared Pied Bat) - Vulnerable**

The Large-eared Pied Bat is an insectivorous bat distributed from Shoalwater Bay in Queensland through to Ulladulla in NSW. This species tends to occur in small populations of around 50 individuals, particularly around sandstone escarpments and cliff lines. Important populations for this species occur in the Hunter Valley, Sydney Basin and Southern Tablelands of NSW. There are scattered records from the New England Tablelands and North West Slopes.

The relatively short, broad wing combined with the low weight per unit area of wing suggests that the species is manoeuvrable and forages below the canopy (OEH 2013b; SEWPAC 2013). The preferred breeding habitat for the species are caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the *Hirundo ariel* (Fairy Martin). The species has been known to use hollow-bearing trees as roost sites (SEWPAC 2013). Females have been recorded raising young in maternity roosts (c. 20-40 females) from November through to January in roof domes in sandstone caves. They remain loyal to the same cave over many years (OEH 2013b). Breeding females have recently been recorded in sandstone caves at Coonabarabran, NSW (SEWPAC 2013).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of an important population of a species

The species was not observed during field surveys and there are no existing records for the species within the study area. However, previous surveys have detected the species near the study area in East Pilliga State Forest (NPWS 2000a; NPA 2002). The closest records according to the Atlas of NSW Wildlife are approximately 10 km to the south in Pilliga Nature Reserve and 25 km to the north east near Mt Kaputar National Park. Thus, the species has the potential to occur in the study area. This potential predominantly relates to foraging habitat, as preferred breeding habitat for this species (i.e. caves) is not known from within the study area.

As the species has not been recorded in the study area and preferred breeding habitat is not known to occur, it is considered unlikely that an 'important population' of Large-eared Pied Bat occurs within the study area. Therefore the proposed action is unlikely to lead to a long-term decrease in the size of an important population.

Reduce the area of occupancy of an important population

As an 'important population' of Large-eared Pied Bats is considered unlikely to occur within the study area, the proposed action is unlikely to reduce the area of occupancy of an important population.

Fragment an existing important population into two or more populations

As an 'important population' of Large-eared Pied Bats is considered unlikely to occur within the study area, the proposed action is unlikely to fragment an existing important population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat that is necessary to the survival of Large-eared Pied Bats includes foraging, roosting and breeding habitat. Breeding habitat is critical to the survival of the species as the species roosts in caves and these are limited. Any impacts to breeding habitat could potentially threaten the survival of the species.

Unlike breeding habitat, Large-eared Pied Bats would likely be able to withstand some level of impact to foraging and roosting habitat

The proposed action would retain the majority of foraging and roosting and breeding habitat in the study area for South-eastern Long-eared Bats, with only a small proportion of habitat impacted in the study area and Namoi CMA region. Thus, the foraging and roosting habitat lost or degraded is unlikely to be critical to the survival of the species.

Disrupt the breeding cycle of an important population

As an 'important population' of Large-eared Pied Bats is considered unlikely to occur within the study area, the proposed action is unlikely to disrupt the breeding cycle of an important population.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed action will lead to the loss of approximately 36 ha of potential foraging and roosting habitat for this species, which equates to less than 0.1% of the available habitat within the study area and much less in Namoi CMA region. The loss of habitat will occur in small areas across the landscape for the well pads and linear corridors for the flow lines which generally follow existing tracks and infrastructure. Up

to 40% of clearing associated with the well pads and 60% of clearing associated with the flowlines and water and gas gathering systems will be rehabilitated.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing potential habitat for the species would be retained in the study area.

Therefore it is unlikely that the proposed action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

Invasive species that are harmful to the Large-eared Pied Bat such as cats and foxes are already established in the study area. The proposed action is unlikely to exacerbate the impacts of invasive species or lead to increased competition for South-eastern Long-eared Bats for resources.

Introduce disease that may cause the species to decline, or

Disease is not listed as a threat to this species. The proposed action would be unlikely to introduce a disease that may cause this species to decline.

Interfere substantially with the recovery of the species.

In consideration of the above factors, the proposed action is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed action is not considered likely to have a significant impact on the species for the following reasons:

- The species is highly mobile and will be able to move from disturbed areas into nearby undisturbed locations
- The regional extent of suitable foraging habitat types is sufficient that the proposed action is unlikely result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline
- Fragmentation impacts have been minimised by aligning linear infrastructure (flow lines) with existing roads
- The development will not disrupt the breeding cycle of the species as no breeding areas are known within the study area, and no caves or sandstone outcrops (breeding habitat) will be impacted by the proposed action.

***Phascolarctos cinereus* (Koala) - Vulnerable**

Koalas are associated with a wide range of temperate, tropical and sub-tropical forests as well as semi-arid communities. They feed almost exclusively on leaves of Eucalyptus species, although they have been known to forage on other genera as well (SEWPaC 2013). Koalas have large overlapping home ranges with larger home ranges present in areas of poorer quality habitat (recorded up to 135 ha in central Queensland) (SEWPaC 2013).

The species was not identified in the current surveys of the study area but has been identified in previous surveys in the vicinity. There are records of the species within 10 km of the study area on the Atlas of

NSW Wildlife. There is a well-defined Koala population in the broader Pilliga region, and as such, it is likely that Koala populations within the study area will be defined as an important population under the EPBC Act.

Actions which are likely to have a significant impact on the Koala (SEWPaC 2012a) include:

- loss, fragmentation or permanent degradation of habitat critical to the survival or recovery of the listed species
- permanent fragmentation of an important population (e.g. through proposed actions such as power lines and easements, and main road developments)
- clearing or burning of habitat where an important population (see above) is known or suspected to occur, or
- the removal of primary food trees to the extent where an important population declines.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of an important population of a species

The proposed action will lead to the loss of approximately 5.4 ha of potential habitat for this species, which equates to 0.02% of the available habitat within the study area and much less in Namoi CMA region.

The total area of potential habitat loss comprises the following vegetation types:

- 1.4 ha of riparian woodland (Rough-barked Apple riparian forb/grass open forest) which includes species of secondary feed trees for the Koala
- 4 ha of woodland (White Cypress Pine - Bulloak - ironbark woodland) with dense white cypress pine, of which only areas containing dense White Cypress may be used by the Koala as potential refuge habitat.

The habitat proposed to be removed is not considered to be particularly notable as there are no primary feed trees and secondary feed trees occur at low abundance. The loss of breeding habitat represents approximately 0.02% of the habitat available within the study area and much less in the Namoi CMA region. The loss of habitat will occur in small areas across the landscape for the well pads and linear corridors for the flow lines which generally follow existing tracks and infrastructure. Up to 40% of clearing associated with the well pads and 60% of clearing associated with the flowlines and water and gas gathering systems will be rehabilitated.

As the proposed action represents a small proportion of the available habitat in the study area, it is considered unlikely that the proposed action would lead to a long-term decrease in the size of a population of Koala.

Reduce the area of occupancy of an important population

The area of occupancy for Koalas would be reduced if significant amounts of foraging, refuge and breeding habitat were lost in the study area, or if habitats were degraded to the point that the species avoided or could not cross degraded areas and could not move through the study area to undisturbed areas.

The loss of habitat through clearing is small relative to the amount of habitat retained in the study area and the wider Namoi CMA region, hence the proposed action is considered unlikely to reduce the area of occupancy of the species.

Fragment an existing important population into two or more populations

The construction footprint of the proposed action will involve the temporary loss and/or modification of potential habitat. Works in these areas will increase the sizes of some existing disturbances/edges (e.g. roadsides) but will not bisect existing habitat areas into smaller fragments. Works associated with the pilot wells will occur in interior areas of habitat (i.e. not roadside edges) and may introduce edge effects into these areas, but will not bisected habitat into smaller fragments.

Patches will only be separated from other adjacent patches by road and flow line corridors, which will be approximately 10 m during construction, and up to 5 m following construction (the shrub and groundlayer vegetation will be allowed to naturally regenerate following slashing). Thus, the remaining vegetation remnants will not be completely fragmented from other remnants.

While the Koala is thought to be affected by broad-scale habitat fragmentation, the level of fragmentation as a result of proposed action is relatively minor when compared to fragmentation created by dual carriageway roads, urban or agricultural development. Regenerating flow lines are unlikely to prevent the movement of the Koala within the study area. It is also important to note that canopy species occurring on the edges of the corridors are not removed, allowing overhanging canopy over sections of the corridors, providing indirect shelter. In addition, in areas of poorer habitat quality such as in the project area, the Koala is known to occupy large home ranges and disperse large distances (Dique et al 2003).

Habitat connectivity will be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the study area, allowing any potential populations to move across the wider landscape. Thus, it is unlikely that the proposed action would fragment an existing population into two or more populations.

Adversely affect habitat critical to the survival of a species

The interim Koala referral advice for proponents (SEWPaC 2012) identifies that ‘habitat critical’ to the survival of the Koala is forest or woodland where:

- Primary koala food tree species ≥ 30% of the overstorey trees
- Primary koala food tree species comprise < 30% of the overstorey trees, but together with secondary food tree species comprise ≥ 50% of the overstorey trees
- Primary food tree species are absent but secondary food tree species alone comprise ≥ 50% of the overstorey trees
- The above qualities may be absent in a forest or woodland but other essential habitat features are present and adjacent to areas exhibiting the above qualities (e.g. dense C. glaucophylla)
- A relatively high density of koalas is supported, regardless of the presence of food tree species
- Any form of landscape corridor which is essential to the dispersal of koalas between forest of woodland habitats.

Primary Koala feed trees are largely absent from the study area, with commonly occurring secondary feed trees including *Eucalyptus chloroclada* (Dirty Gum), Blakely’s Red Gum, *E. pilligaensis* (Pilliga Box),

E. dwyeri (Dwyer's Red Gum). These species are largely confined to drainage lines across the study area, with vegetation in the north-west of the study area supporting Pilliga Box with *E. crebra.* Areas which meet the above description of 'Habitat critical to the survival of the Koala' are therefore known to occur within the study area.

The proposed action will lead to the loss of approximately 5.4 ha of 'habitat critical' to the survival of this species, which equates to less than 0.1% of the available habitat within the study area and much less in Namoi CMA region. As the majority of habitat for this species will be retained within the study area and the region, the proposed action is considered unlikely to adversely affect habitat critical to the survival of the Koala.

Disrupt the breeding cycle of an important population

When assessing the potential for impacts to the breeding cycle of the Koala, it is also necessary to consider impacts to areas of breeding habitat and the size of the species' home range.

The home range sizes of the Koala are well documented, with populations that occur in poorer habitat (such as that present in the study area) likely to have much larger home ranges than populations in more optimal habitat. Koalas have been shown to disperse up to 10 km (Dique et al 2003) and occur over large home ranges.

The proposed action would impact on foraging, refuge and breeding habitat, and reduce/degrade foraging resources indirectly through habitat fragmentation. However, the area directly impacted represents a small proportion available in the study area with the majority of breeding, refuge and foraging habitat retained in the study area. As such, the proposed action is unlikely to disrupt the breeding cycle of the Koala.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed action will lead to the loss of approximately 5.4 ha of habitat for this species, which equates to less than 0.1% of the available habitat within the study area and much less in Namoi CMA region.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing potential habitat for the species would be retained in the study area.

Therefore it is unlikely that the proposed action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

Invasive species that are harmful to the Koala such as cats and foxes are already established in the study area. The proposed action is unlikely to exacerbate the impacts of invasive species or lead to increased competition for the Koala for resources.

Introduce disease that may cause the species to decline, or

Koalas are susceptible to a number of common diseases; however the proposed action is unlikely to introduce disease which may cause the species to decline.

Interfere substantially with the recovery of the species.

In consideration of the above factors, the proposed action is unlikely to substantially interfere with the recovery of the species.

Conclusion

It is considered unlikely that the proposed action will adversely affect habitat critical to the survival of the Koala, or result in significant impacts to the species given:

- The proposed action will disturb a very small proportion (<0.1%) of available habitat within the study area and the types of impacts and associated regeneration/rehabilitation are not expected to disrupt movement
- Fragmentation impacts have been minimised by aligning linear infrastructure (flow lines) with existing roads
- The species is mobile through the landscape and considered likely to have large home ranges due to the habitat quality within the study area
- The regional extent of suitable foraging habitat types is sufficient that the proposed action will not result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline.

***Pseudomys pilligaensis* (Pilliga Mouse) - Vulnerable**

It is important to note that the Pilliga Mouse is now considered a southern population of the widespread *Pseudomys delicatulus* (Delicate Mouse) based on genetic analyses, morphological studies and recent surveys which revealed a continuous distribution of the Delicate Mouse to the Pilliga region (Breed and Ford 2007; Ford 2008, as cited in SEWPaC 2012b). It is important to note that this taxonomic change has not yet been formally recognised under the EPBC Act (SEWPaC 2012b), hence this assessment considers the Pilliga Mouse as currently listed.

The Pilliga Mouse is restricted to the Pilliga region of New South Wales, where low-nutrient deep sand supports a distinctive vegetation type (Pilliga Scrub). The Pilliga Mouse is very sparsely distributed and appears to prefer areas with a light ground cover. Recent studies indicate that the Pilliga Mouse is found in greatest abundance in recently burnt moist gullies, areas dominated by broombush and areas containing an understorey of *Acacia burrowii* (Kurricabah) with a *Corymbia trachyphloia* (Brown Bloodwood) overstorey (Paull 2009). Consistent features of the latter two habitats are a relatively high plant species richness, a moderate to high low shrub cover; and a moist groundcover of plants, litter and fungi. Consistent features of gully habitat are an extensive cover by low grasses and sedges, with little shrub cover and large areas of ash-covered ground. Some evidence exists of marked population fluctuations by this species. It is nocturnal and appears to live in burrows (OEH 2013b).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of an important population of a species

The species was observed as part of recent surveys for the Dewhurst 22-25 pilot (RPS 2013d) and is known to occur more broadly in the study area and Pilliga East State Forest (NPWS 2000a; NPA 2002). It is likely that the study area supports part of an important population of Pilliga Mouse given that the population within the area is near the north eastern limit of the species' range, and the species is restricted to the Pilliga region of NSW.

The proposed action will lead to the loss of approximately 36 ha of habitat for this species. This area comprises:

- approximately 4.7 ha of Rough-barked Apple riparian forb/grass open forest and Brown Bloodwood - cypress - ironbark heathy woodland which represents optimal habitat in the sense that it may provide areas of potential breeding/foraging habitat for the species
- approximately 31.7 ha of White Cypress Pine - Bulloak - ironbark woodland, which is considered to be sub-optimal habitat and only likely to be used by dispersing individuals.

The proposed action will lead to the loss of 0.04% of breeding and foraging habitat within the study area and much less within the Namoi CMA region. The loss of habitat will not occur in a single large patch; rather it will occur in small areas across the landscape for the well pads and linear corridors for the flow lines which generally follow existing tracks and infrastructure. Much of the vegetation loss is linear in nature and needs to be considered within the context of the surrounding landscape, which supports a considerable amount of foraging habitat. Up to 40% of clearing associated with well pads and 60% of clearing associated with the flow lines will be rehabilitated.

As the proposed action represents a small proportion of the available habitat in the study area, it is considered unlikely that the proposed action would lead to a long-term decrease in the size of a population of Pilliga Mouse.

Reduce the area of occupancy of an important population

The area of occupancy for Pilliga Mouse would be reduced if significant amounts of dispersing, foraging and breeding habitat were lost in the study area, or if habitats were degraded to the point that the species avoided or could not cross degraded areas and could not move through the study area to undisturbed areas.

The loss of habitat through clearing is small relative to the amount of habitat retained in the study area and the wider Namoi CMA region, hence the proposed action is considered unlikely to reduce the area of occupancy of the species.

Fragment an existing important population into two or more populations

The home range sizes of the Pilliga Mouse are not well documented, although Tokushima and Jarman (2008) measured average movement distances of 40 m (range 0–181 m) for recaptured individuals. They did not discount that larger movement patterns could occur. Indeed, Paull (2002) noted that the species can experience marked population fluctuations in response to environmental changes caused by fire or rain. There are also seasonal fluctuations in Pilliga Mouse numbers, with the cooler autumn and winter months showing a time of population congregation for this species and the warmer spring and summer months a time for dispersal, indicating that the species has the ability to move some distances.

Patches will only be separated from other adjacent patches by road and flow line corridors, which will be approximately 10 m on average during construction, and up to 5 m following construction. The extent to which habitat fragmentation may impact on Pilliga Mouse habitat is not fully understood, however it is recognised that these clearings from could represent a real or perceived barrier to movement.

A fragmentation analysis was undertaken as part of this assessment (**Section 5.4**). Based on the results of this analysis, twelve out of twenty five movement pathways between modelled breeding and foraging habitat will be potentially impacted by the proposed action. However, all of these pathways are currently impacted by forestry roads. The species is known to undergo seasonal congregations and dispersals (NPA 2002) suggesting that the species has the ability to move significant distances and is currently doing so within an environment currently bisected by much higher number of existing roads, trails and drainage lines than proposed as part of this action. In this way, the proposed action is not expected to

introduce new fragmentation effects; however, they may contribute to existing impacts in some areas of habitat in the short term until natural regeneration occurs along the flow lines following installation.

Regenerating flow lines are unlikely to prevent the movement of the Pilliga Mouse within the study area. Habitat connectivity will be maintained at a local and regional level, with contiguous vegetation and habitat connectivity retained around the study area, allowing any potential populations to move across the wider landscape.

Given that the Pilliga Mouse persists in the study area that is already fragmented by roads and tracks due to a long history of forestry activities and that they are known to be able to disperse over some distances, the proposed action is considered unlikely to fragment an important population of the Pilliga Mouse.

Adversely affect habitat critical to the survival of a species

Habitat that is critical to the survival of Pilliga Mouse includes foraging and breeding habitat.

The proposed action would retain the majority of foraging and breeding habitat in the study area for Pilliga Mouse, with only a small proportion of habitat impacted in the study area and Namoi CMA region. Thus, the foraging and breeding habitat lost or degraded is unlikely to be critical to the survival of the species.

Disrupt the breeding cycle of an important population

When assessing the potential for impacts to the breeding cycle of the Pilliga Mouse, it is necessary to consider impacts to areas of breeding habitat and the size of the species' home range. Broombush was previously defined as the preferred breeding habitat for the Pilliga Mouse (Paull 2009). Recent surveys undertaken in the study area (e.g. NICE and CUCCLG 2012) indicate that breeding habitat for the Pilliga Mouse potentially occurs in a broader range of vegetation associations than previously thought. Vegetation associations within the study area where Pilliga Mouse has been recorded in breeding condition are generally characterised by a high diversity, moderate density, low (<1 m) sclerophyllous shrubby layer. These characteristics are widespread within the study area and more broadly across the eastern, southern and central Pilliga Forest.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed action will lead to the loss of approximately 36 ha of habitat for this species which includes 4.7 ha of foraging/breeding habitat, which equates to 0.04% of the potential breeding and foraging habitat within the study area and much less in the Namoi CMA region.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing potential habitat for the species would be retained in the study area.

Therefore it is unlikely that the proposed action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

Invasive species that are harmful to the Pilliga Mouse such as house mice, cats and foxes are already established in the study area. The proposed action is unlikely to exacerbate the impacts of invasive species or lead to increased competition for Pilliga Mouse for resources.

Introduce disease that may cause the species to decline, or

Disease is not listed as a threat to this species. The proposed action would be unlikely to introduce a disease that may cause this species to decline.

Interfere substantially with the recovery of the species.

In consideration of the above factors, the proposed action is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed action is not considered likely to have a significant impact on the species for the following reasons:

- The species persists in the study area which is bisected by numerous forestry access tracks and roads,
- Of the twelve movement pathways potentially impacted, all impacts will be short term and involve only a temporary widening of existing impacts
- The proposed action will lead to the loss of a very small proportion (less than 0.1%) of available optimal habitat (i.e., breeding/foraging habitat) within the study area
- Fragmentation impacts have been minimised by aligning linear infrastructure (flow lines) with existing roads
- The regional extent of suitable foraging habitat types is sufficient that the proposed action will not result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline.

6.2.3 Plants

***Pterostylis cobarensis* (Cobar Greenhood Orchid) - Vulnerable**

Pterostylis cobarensis is a terrestrial orchid. The species is known chiefly from the Nyngan-Cobar-Bourke district in the far western plains of NSW. Its presence has been recorded in districts including Narrabri, Nyngan, Cobar, Nymagee, Mt Gundabooka, Mt Grenfel and Mutawintji National Park. There is one outlier record for *P. cobarensis* from 1989 approximately 8 km to the north of the study area, however the remainder of the records for this species are located at least 200 km to the southwest (OEH 2013). There are also records from the Darling Downs district of Queensland (OEH 2013b).

Within the study area, *P. cobarensis* has been recorded primarily within the White Cypress Pine - Bulloak - Ironbark Woodland vegetation type, but has also been recorded within other vegetation types where suitable microhabitat has been present.

The species flowers from September to November. Vegetative reproduction is not common in this group of Greenhoods, but some species may form more than one dropper annually. Plants are deciduous and die back to the large, underground tubers after seed release. New rosettes are produced following soaking autumn and winter rains. Pollination of the species is by the males of small gnats which are attracted to the flower by some pseudosexual perfume. *Pterostylis cobarensis* occurs as frequent to abundant plants in usually very localised populations (OEH 2013b).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of an important population of a species

As *Pterostylis cobarensis* is known to occur in the study area, has a moderately sized population and is near the edge of its known distribution, it is considered likely that the study area supports an important population of this species.

Detailed targeted surveys for *Pterostylis cobarensis* have been undertaken both within the study area and across the broader Pilliga region to model the population in this area (ELA 2012). From these studies it has been estimated that the total population of *Pterostylis cobarensis* within the Pilliga region is approximately 3,300,000 individuals and 345,000 within the study area.

The proposed action will impact on approximately 36 ha of vegetation that may include some areas that support potential habitat for this species. The loss of habitat will occur in small areas across the landscape for the well pads and linear corridors for the flow lines which generally follow existing tracks and infrastructure. Up to 40% of clearing associated with the well pads and 60% of clearing associated with the flowlines and water and gas gathering systems will be rehabilitated.

Based on the modelled data, it is estimated that proposed action could impact on approximately 185 individuals, which equates to 0.05% of the total modelled population of this species within the study area. The total amount of potential habitat likely to be impacted by the proposed program constitutes less than 0.09% of the total habitat within the study area and less than 0.01% across the Pilliga region. Given the relatively small scale of impacts to this species, it is unlikely that the proposed action would lead to a long-term decrease in the population of *P. cobarensis* in the study area.

Reduce the area of occupancy of an important population

The proposed action is likely to reduce the potential habitat for *P. cobarensis* through the clearing of approximately 36 ha of vegetation which represents potential habitat for this species.

The majority of vegetation representing potential habitat for *P. cobarensis* will be retained as part of the proposed action. The amount of habitat that would be directly impacted comprises only a small portion of potential habitat for *P. cobarensis* in the study area and an even smaller portion of potential habitat within the Namoi CMA region; hence the proposed action is unlikely to reduce the area of occupancy of this species.

Fragment an existing important population into two or more populations

P. cobarensis has the potential to be impacted on by habitat fragmentation where pollination (by small gnats) or seed dispersal (largely wind and seed fall) is interrupted. Fragmentation associated with the proposed action is considered unlikely to alter pollination or seed dispersal pathways associated with the lifecycle of *P. cobarensis* and is therefore considered unlikely to fragment an existing important population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat critical to the survival of *P. cobarensis* could include areas that are necessary for dispersal, for the long-term maintenance of the species or to maintain genetic diversity.

Potential habitat for *P. cobarensis* is extensive both within the study area and broader Pilliga region. The loss of less than 0.08% of the total habitat within the study area and less than 0.01% across the Pilliga region is considered unlikely to be critical to the survival of this species.

Disrupt the breeding cycle of an important population

The breeding cycle of *P. cobarensis* could potentially be disrupted through the loss of habitat or the displacement of pollinators through fragmentation. The loss of less than 0.01% of potential habitat across the Pilliga region and minor fragmentation affects associated with the proposed action are considered unlikely to disrupt the breeding cycle of this species.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed action will lead to the loss of approximately 36 ha of potential habitat for this species which includes approximately 185 individuals, which equates to 0.05% of the total modelled population of this species within the study area.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing potential habitat for the species would be retained in the study area.

Therefore it is unlikely that the proposed action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

Invasive weed species such as *Eragrostis curvula* (African Lovegrass) and *Hyparrhenia hirta* (Coolatai Grass) have the potential to invade into suitable habitat for *P. cobarensis* from disturbance associated with the proposed action. Weed and fungal invasion has the potential to degrade the habitat of this species and weed species may directly compete with the species.

Santos implements pest plant procedures to ensure the rapid and progressive rehabilitation of the study area on completion of construction works for temporary impacts (e.g. flow lines) and over the life of the proposed action for longer term impacts (e.g. wells).

Introduce disease that may cause the species to decline, or

Phytophthora cinnamomi (Cinnamon Fungus) is a microscopic soil-borne plant pathogen that can invade and destroy the root systems of susceptible native and introduced plant species. As rainfall is one of the key factors influencing the distribution of *P. cinnamomi*, the pathogen is generally restricted to coastal NSW. As such, the risk of infection of *P. cinnamomi* in the study area is considered lower than that in coastal sites.

Machinery utilised for construction and operation of the proposed action may carry the spores of *P. cinnamomi* if they have been working in coastal areas which are known to be infected by the pathogen. However, all construction machinery and vehicles would be inspected and thoroughly cleaned prior to entry to site. This would occur in Narrabri and would be undertaken initially and for those vehicles/machinery floated/hauled to the study area from outside the locality.

Interfere substantially with the recovery of the species.

In consideration of the above factors, the proposed action is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed action is not considered likely to have a significant impact on the species for the following reasons:

- The modelled loss of individuals is less than 0.1% of the population from within the study area and much less in the Pilliga region
- The regional extent of suitable habitat is sufficient that the proposed action will not result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline
- The proposed action will not disrupt the breeding cycle of the species as vegetation patches would not be separated by distances that would interfere with the pollination of the species (by males of small gnats)
- Weed management procedures will be implemented within the study area.

***Tylophora linearis* - Endangered**

Tylophora linearis is a slender, almost hairless twiner. The species is known only from NSW and Queensland. In NSW, it is found in the Barraba, Mendooran, Temora and West Wyalong districts in the northern and central western slopes. Records include Crow Mountain near Barraba, Goonoo, Pilliga West, Cumbil, and Eura State Forests, Coolbaggie Nature Reserve, Goobang National Park, and Beni Conservation Area. The species grows in dry scrub and open forest. It has been recorded from low-altitude sedimentary flats in dry woodlands of *Eucalyptus fibrosa*, *E. sideroxylon*, *E. albens*, *Callitris endlicheri*, *C. glaucophylla* and *Allocasuarina luehmannii*. It also grows in association with *Acacia hakeoides*, *A. lineata*, *Melaleuca uncinata*, *Myoporum* species and *Casuarina* species. The species flowers in spring, with flowers recorded in November or May with fruiting probably 2 to 3 months later. Where the species occurs, it has been recorded in very low abundances (OEH 2013b).

Detailed targeted surveys for *T. linearis* have been undertaken both within the study area and across the broader Pilliga region to model the population in this area (ELA 2012). From these studies it has been estimated that the total population of *T. linearis* within the Pilliga region is approximately 180,000 individuals and 17,500 within the study area.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of a population

The proposed action will impact on approximately 36 ha of known and potential habitat for this species. The loss of habitat will occur in small areas across the landscape for the well pads and linear corridors for the flow lines which generally follow existing tracks and infrastructure. Up to 40% of clearing associated with the well pads and 60% of clearing associated with the flowlines and water and gas gathering systems will be rehabilitated.

It is estimated that the proposed action will directly impact on approximately 30 individuals, which equates to 0.17% of the total modelled population of this species within the study area. The total amount of potential habitat impacted by the exploration activities constitutes less than 0.09% of the total habitat within the study area and less than 0.01% across the Pilliga region.

Given the relatively small scale of impacts to this species, it is unlikely that the proposed action would lead to a long-term decrease in the population of *T. linearis* in the study area.

Reduce the area of occupancy of the species

The proposed action is likely to reduce the potential habitat for *T. linearis* through the clearing of approximately 36 ha of vegetation which represents potential habitat for this species.

The majority of vegetation representing potential habitat for *T. linearis* will be retained as part of the proposed action. The amount of habitat that would be directly impacted comprises only a small portion of potential habitat for *T. linearis* in the study area and an even smaller portion of potential habitat within the Namoi CMA region; hence the proposed action is unlikely to reduce the area of occupancy of this species.

Fragment an existing population into two or more populations

T. linearis has the potential to be impacted on by habitat fragmentation where pollination (assumed to be insect pollinated, Forster et al. 2004) or seed dispersal (seed fall and wind) is interrupted. Fragmentation associated with the exploration activities is considered unlikely to alter pollination or seed dispersal pathways associated with the lifecycle of *T. linearis* and is therefore considered unlikely to fragment an existing population into two or more populations

Adversely affect habitat critical to the survival of a species

Habitat critical to the survival of *T. linearis* could include areas that are necessary for dispersal, for the long-term maintenance of the species or to maintain genetic diversity.

Potential habitat for *T. linearis* is extensive both within the study area and broader Pilliga region. The loss of less than 0.09% of the total habitat within the study area and less than 0.01% across the Pilliga region is considered unlikely to be critical to the survival of this species.

Disrupt the breeding cycle of a population

The breeding cycle of *T. linearis* could potentially be disrupted through the loss of habitat or the displacement of pollinators through fragmentation. The loss of less than 0.01% of potential habitat across the Pilliga region and minor fragmentation affects associated with the proposed action are considered unlikely to disrupt the breeding cycle of this species.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed action will lead to the loss of approximately 36 ha of potential habitat for this species which includes approximately 30 individuals, which equates to less than 0.17% of the total modelled population of this species within the study area.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing potential habitat for the species would be retained in the study area.

Therefore it is unlikely that the proposed action will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

Invasive weed species such as *Eragrostis curvula* (African Lovegrass) and *Hyparrhenia hirta* (Coolatai Grass) have the potential to invade into suitable habitat for *T. linearis* from disturbance associated with the proposed action. Weed and fungal invasion has the potential to degrade the habitat of this species and weed species may directly compete with the species.

Santos implements pest plant procedures to ensure the rapid and progressive rehabilitation of the study area on completion of construction works for temporary impacts (e.g. flow lines) and over the life of the proposed action for longer term impacts (e.g. wells).

Introduce disease that may cause the species to decline, or

Phytophthora cinnamomi (Cinnamon Fungus) is a microscopic soil-borne plant pathogen that can invade and destroy the root systems of susceptible native and introduced plant species. As rainfall is one of the key factors influencing the distribution of *P. cinnamomi*, the pathogen is generally restricted to coastal NSW. As such, the risk of infection of *P. cinnamomi* in the study area is considered lower than that in coastal sites.

Machinery utilised for construction and operation of the proposed action may carry the spores of *P. cinnamomi* if they have been working in coastal areas which are known to be infected by the pathogen. However, all construction machinery and vehicles would be inspected and thoroughly cleaned prior to entry to site. This would occur in Narrabri and would be undertaken initially and for those vehicles/machinery floated/hauled to the study area from outside the locality.

Interfere substantially with the recovery of the species.

In consideration of the above factors, the proposed action is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed action is not considered likely to have a significant impact on the species for the following reasons:

- The small extent of impacts from the proposed action relative to available habitat in the landscape
- The regional extent of suitable habitat types is sufficient that the proposed action will not result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline
- The proposed action will not disrupt the breeding cycle of the species as vegetation patches would not be separated by distances that would interfere with the pollination of the species
- Weed management procedures will be implemented within the study area.

6.2.4 Migratory species

***Anthochaera phrygia* (Regent Honeyeater) – Migratory**

Regent Honeyeater is listed as an endangered and migratory species under the EPBC Act. A description of the species and distribution in NSW is provided in the Regent Honeyeater Impact Assessment in **Section 6.2.1** of this report.

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will meet any of the following criteria:

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

The proposed action would remove potential foraging and roosting habitat within the study area. No breeding habitat representing important habitat would be impacted.

The majority of vegetation representing foraging and roosting habitat for the species would be retained in the study area. The amount of habitat that would be directly impacted comprises only a small portion of

potential habitat for Regent Honeyeaters throughout the study area and an even smaller portion of potential habitat within the Namoi CMA region. This species could also access vegetation outside of the study area as it is capable of making large regional movements in the order of hundreds of kilometres.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or

It is unlikely that the proposed action would result in the introduction of invasive species that would impact on Regent Honeyeater in the study area. The species suffers from competition from larger aggressive honeyeaters, particularly Noisy Miners, Noisy Friarbirds and Red Wattlebirds. However, the proposed action is unlikely to lead to an increase in the incidence of these species in the study area.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

The species is not known to breed in the study area, although it has been recorded displaying breeding behaviour adjacent to the study area in Pilliga Nature Reserve. The study area could be used as a foraging resource during the species' breeding period and thus the proposed action could potentially disrupt the lifecycle of Regent Honeyeater. However, only a small proportion of the foraging habitat in the study area and in the Namoi CMA region will be removed. Regent Honeyeaters would be able to continue using these resources within and outside of the study area. Thus, the proposed action is unlikely to seriously disrupt the lifecycle of a Regent Honeyeater population.

***Apus pacificus* (Fork-tailed Swift) - Migratory**

The Fork-tailed Swift is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher. In Australia, they mostly occur over inland plains but sometimes above foothills or in coastal areas. They often occur over cliffs and beaches and also over islands and sometimes well out to sea. They also occur over settled areas, including towns, urban areas and cities. They mostly occur over dry or open habitats, including riparian woodland and tea-tree swamps, low scrub, heathland or saltmarsh. They are also found at treeless grassland and sandplains covered with spinifex, open farmland and inland and coastal sand-dunes (SEWPaC 2013b).

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will meet any of the following criteria:

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

The proposed action would remove vegetation above which Fork-tailed Swifts could potentially forage. However, the majority of vegetation in the study area would be retained. The amount of vegetation that would be directly impacted comprises only a small portion of vegetation throughout the study area and an even smaller portion of vegetation within the Namoi CMA region. The proposed action is considered unlikely to constitute important habitat for the Fork-tailed Swift and is unlikely to substantially modify, destroy or isolate areas of important habitat.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or

The proposed action would not result in the establishment of an invasive species that is harmful to Fork-tailed Swifts.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Fork-tailed Swifts do not breed in Australia. The removal of vegetation in the study area would be unlikely to affect the species, which forages aerially over a range of habitats including cleared areas. Therefore the proposed action is unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of Fork-tailed Swift.

***Haliaeetus leucogaster* (White-bellied Sea Eagle) - Migratory**

The White-bellied Sea-Eagle is found in coastal habitats (especially those close to the sea-shore) and around terrestrial wetlands in tropical and temperate regions of mainland Australia and its offshore islands. The habitats occupied by the sea-eagle are characterised by the presence of large areas of open water (larger rivers, swamps, lakes, the sea).

While the species is mostly coastal in its distribution, White-bellied Sea-Eagles may travel inland along major rivers. Birds also occasionally visit inland lakes, rivers or reservoirs that occur outside of the usual distribution of the species (SEWPaC 2013b).

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will meet any of the following criteria:

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

The study area could provide occasional foraging habitat for the species following heavy rainfall periods (within the riparian areas), but would be unlikely to provide permanent foraging or breeding habitat for the species as the breeding territories of White-bellied Sea Eagles are typically located close to bodies of water which are absent from the study area.

As the proposed action would avoid the main riparian area in the study area, would not construct any new major creek crossings, or install in stream devices which would impact on the natural hydrology of creek lines and the integrity of riparian vegetation, the proposed action would not substantially modify potential foraging habitat for White-bellied Sea Eagles.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or

The proposed action would not result in the establishment of an invasive species that is harmful to White-bellied Sea Eagles.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

The study area does not provide breeding habitat for the species. The species could potentially be present in the study area opportunistically following rain periods, however there is more optimal habitat located to the north and east of the study area along the Namoi River. The proposed action would not construct any new major creek crossings or install in stream devices which would impact on the natural hydrology of creek lines and the integrity of riparian vegetation. The proposed action is therefore unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of White-bellied Sea Eagles.

***Hirundapus caudacutus* (White-throated Needletail) - Migratory**

The White-throated Needletail is listed as a migratory species under the EPBC Act, and is included in the Japan-Australia Migratory Bird Agreement (JAMBA), the China-Australia Migratory Bird Agreement (CAMBA), and the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA) (SEWPaC 2013b).

In Australia, the White-throated Needletail is almost exclusively aerial, from heights of less than 1 m up to more than 1000 m above the ground. Because they are aerial, it has been stated that conventional habitat descriptions are inapplicable, but there are, nevertheless, certain preferences exhibited by the species. Although they occur over most types of habitat, they are probably recorded most often above wooded areas, including open forest and rainforest, and may also fly between trees or in clearings, below the canopy, but they are less commonly recorded flying above woodland. They also commonly occur over heathland, but less often over treeless areas, such as grassland or swamps. When flying above farmland, they are more often recorded above partly cleared pasture, plantations or remnant vegetation at the edge of paddocks. In coastal areas, they are sometimes seen flying over sandy beaches or mudflats, and often around coastal cliffs and other areas with prominent updraughts, such as ridges and sand-dunes (SEWPaC 2013b).

During the non-breeding season in Australia, the White-throated Needletail has been recorded eating a wide variety of insects, including beetles, cicadas, flying ants, bees, wasps, flies, termites, moths, locusts and grasshoppers. The White-throated Needletail almost always forage aerially, at heights up to 'cloud level' though usually much lower (SEWPaC 2013b).

The species has been recorded roosting in trees in forests and woodlands, both among dense foliage in the canopy or in hollows. It has been suggested that they also sometimes roost aerially (SEWPaC 2013b).

The species breeds in wooded lowlands and sparsely vegetated hills, as well as mountains covered with coniferous forests in Asia, from central and south-eastern Siberia and Mongolia, east to the Maritime Territories of Russia, Sakhalin and the Kuril Islands and south to northern Japan and north-eastern China (SEWPaC 2013b).

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will meet any of the following criteria:

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

The proposed action would remove vegetation above which White-throated Needletail could potentially forage. However, the majority of vegetation in the study area would be retained. The amount of vegetation that would be directly impacted comprises only a small portion of vegetation throughout the study area and an even smaller portion of vegetation within the Namoi CMA region. The proposed action is considered unlikely to constitute important habitat for the White-throated Needletail and is unlikely to substantially modify, destroy or isolate areas of important habitat.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or

The proposed action would not result in the establishment of an invasive species that is harmful to White-throated Needletails.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

White-throated Needletails do not breed in Australia. The removal of vegetation in the study area would be unlikely to affect the species, which forages aerially over a range of habitats. Therefore the proposed action is unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of White-throated Needletail.

***Lathamus discolour* (Swift Parrot) - Migratory**

The Swift Parrot is listed as an endangered and migratory species under the EPBC Act. A description of the species and distribution in NSW is provided in the Regent Honeyeater Impact Assessment in **Section 6.2.1** of this report.

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will meet any of the following criteria:

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

The proposed action would remove potential foraging and roosting habitat within the study area. No breeding habitat representing important habitat would be impacted.

The majority of vegetation representing foraging and roosting habitat for the species would be retained in the study area. The amount of habitat that would be directly impacted comprises only a small portion of potential habitat for Swift Parrots throughout the study area and an even smaller portion of potential habitat within the Namoi CMA region. This species could also access vegetation outside of the study area as it is capable of making large regional movements in the order of hundreds of kilometres.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or

It is unlikely that the proposed action would result in the introduction of invasive species that would impact on Swift Parrots in the study area.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

The Swift Parrot breeds in Tasmania during spring and summer, migrating in the autumn and winter months to south-eastern Australia from Victoria and the eastern parts of South Australia to south-east Queensland. In NSW this species mostly occurs on the coast and south west slopes.

Only a small proportion of the potential foraging habitat in the study area and in the Namoi CMA region will be removed. Swift Parrots would be able to continue using these resources within and outside of the study area. Thus, the proposed action is unlikely to seriously disrupt the lifecycle of a Swift Parrot population.

***Merops omatus* (Rainbow Bee-eater) – Migratory**

The Rainbow Bee-eater is listed as a migratory species under the EPBC Act, and is included in the Japan-Australia Migratory Bird Agreement (JAMBA) (SEWPaC 2013b).

In Australia, the Rainbow Bee-eater mainly occurs in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation. It usually occurs in open, cleared or lightly-timbered areas that are often, but not always, located in proximity to permanent water. It also occurs in inland and coastal sand dune systems, and in mangroves in northern Australia, and has been recorded in various other habitat types including heathland, sedgeland, vine forest and vine thicket, and on beaches (SEWPaC 2013b).

The Rainbow Bee-eater mainly feeds on insects, and will occasionally take other animal items including earthworms, spiders and tadpoles. The insect component of the diet mainly consists of bees and wasps, but also includes various other insects such as beetles, moths, butterflies, damselflies, dragonflies, flies, ants and bugs. The Rainbow Bee-eater captures most of its prey in flight, although it also takes food items from the ground and from foliage, and has occasionally been seen to snatch items from below the surface of rivers and dams (SEWPaC 2013b).

The Rainbow Bee-eater breeds in socially monogamous pairs that are sometimes assisted by a varying number of auxiliary birds or 'helpers' that are usually male. The nests are typically concentrated together in loose colonies, although in some instances pairs will nest solitarily. The nest is located in an enlarged chamber at the end of long burrow or tunnel that is excavated, by both sexes, in flat or sloping ground, in the banks of rivers, creeks or dams, in roadside cuttings, in the walls of gravel pits or quarries, in mounds of gravel, or in cliff-faces. Nesting areas are often re-used, and banding studies indicate that at least some migrant birds return to the same nesting area each year. However, pairs usually excavate a new nesting burrow for each breeding season (SEWPaC 2013b).

The movement patterns of the Rainbow Bee-eater are complex, and are not fully understood. Populations that breed in southern Australia are migratory. However, populations that breed in northern Australia are considered to be resident, and in many northern localities the Rainbow Bee-eater is present throughout the year. Regarding populations that breed in southern Australia, these move north to northern Australia, Papua New Guinea and eastern Indonesia after breeding and remain there for the duration of the Australian winter. Populations of the Rainbow Bee-eater gather together and assemble into flocks before migration. The migrating flocks, which can consist of tens to hundreds or thousands of birds, often fly high above the ground when on passage (SEWPaC 2013b).

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will meet any of the following criteria:

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

The proposed action would remove foraging, roosting and potential breeding habitat for the Rainbow Bee-eater. However, the majority of vegetation in the study area representing foraging, roosting and potential breeding habitat for Rainbow Bee-eater would be retained. The amount of habitat that would be directly impacted comprises only a small portion of potential habitat for Rainbow Bee-eater throughout the study area and an even smaller portion of potential habitat within the Namoi CMA region.

The proposed action is considered unlikely to substantially modify, destroy or isolate areas of important habitat.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or

The proposed action would not result in the establishment of an invasive species that is harmful to Rainbow Bee-eater.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

The proposed action would remove foraging, roosting and potential breeding habitat for the Rainbow Bee-eater. However, the majority of vegetation representing foraging, roosting and breeding habitat in the study area that could be used by Rainbow Bee-eater would be retained.

The amount of habitat that would be directly impacted comprises only a small portion of potential habitat for Rainbow Bee-eater throughout the study area and an even smaller portion of potential habitat within the Namoi CMA region. The species could also access vegetation outside of the study area. Thus, the proposed action is considered unlikely to seriously disrupt the lifecycle of a Rainbow Bee-eater population.

6.3 CUMULATIVE IMPACT ASSESSMENT

This report considered MNES as they relate to the proposed program, with existing exploration and appraisal activities not being referred as part the proposed program. To provide additional context on the significance of impacts, an assessment of the cumulative impact associated with the proposed program and existing exploration and appraisal activities (from 2002 to present) within the Pilliga Forest has been undertaken.

Cumulative impacts are provided in this report for vegetation (**Table 6**), threatened fauna habitat (**Table 9**) and threatened flora habitat (**Table 12**). An assessment of fragmentation impacts as a result of the proposed program and existing exploration and appraisal activities is also provided in **Section 5.4**.

The cumulative impact as a result of the proposed program and existing exploration and appraisal activities to vegetation within the Pilliga Forest equates to the loss of:

- 186.92 ha which represents a loss of approximately 0.39% of consolidated vegetation within the study area (**Table 6**)
- Between 21.6 and 145.5 ha of potential breeding habitat (depending on species) for threatened fauna species which represents a loss of between 0.21% and 0.31% of the available breeding habitat available within the study area (**Table 9**)
- Between 21.6 and 186.9 ha of potential foraging habitat (depending on species) for threatened fauna species which represents a loss of between 0.21% and 0.39% of the available foraging habitat available within the study area (**Table 9**)
- Between 0.19% and 0.33% of the total threatened flora populations modelled within the study area and 0.32% of the potential habitat available for threatened flora populations within the study area (**Table 12**).

Fragmentation of habitat as a result of the proposed program and existing exploration and appraisal activities is considered unlikely to adversely affect any MNES, with only one of the twenty-five potential movement pathways for the Pilliga Mouse affected by long-term impacts. The remaining threatened and migratory fauna are highly mobile and can traverse large distances across modified and cleared landscapes. Fragmentation is unlikely to significantly affect any threatened flora species as the proposed program and existing exploration and appraisal activities are unlikely to split contiguous habitat into two or more distinct patches with pollination and dispersal mechanisms able to continue largely unimpeded.

Given the relatively small extent of clearing as a proportion of available habitat (both within the study area and the Namoi CMA region), minimisation of fragmentation impacts by locating linear infrastructure (flow lines) along existing tracks wherever possible, and measures proposed to avoid, minimise and mitigate impacts, the proposed program and existing exploration and appraisal activities are not expected to significantly fragment or reduce the availability of habitat in a way which will adversely affect MNES within the study area.

Based on the above, the cumulative impact of the proposed program and existing exploration and appraisal activities is considered unlikely to have a significant impact on any MNES as there is unlikely to be a long term decrease in population sizes, significant fragmentation or adverse disturbance to breeding cycles or critical habitat.

7 Rehabilitation activities

Rehabilitation of existing exploration and appraisal activities is currently being undertaken. These activities provide a benchmark for understanding the potential reduction in impact as a result of rehabilitation works identified for the proposed program.

Santos has commenced a program of rehabilitation works throughout PEL 238 and PAL 2. Rehabilitation works include:

- reducing the size of existing well leases back to the minimum area required for operations
- plugging and abandoning, according to legislative requirements, wells that are no longer required for exploration and appraisal and rehabilitating associated well leases
- rehabilitating a number of water storage ponds that are no longer required for exploration and appraisal activities.

Actions undertaken during the clearing of vegetation include stockpiling 'waste' timber from felled trees not suitable for forestry activities, fallen logs and bush rock for later use in habitat restoration; low vegetation is slashed and mulched on site; and topsoil is striped and stockpiled. Rehabilitation actions include; replacing topsoil; re-installing habitat features such as fallen timber and bush rock; natural re-establishment of slashed and cleared native vegetation; and direct seeding where required.

Monitoring of rehabilitation activities has shown an overall site value close to 45% of nearby reference sites after two years. The replacement of topsoil is producing encouraging results, with sites showing a high number of native species when compared to reference sites. Rehabilitation measures undertaken have been considered using adaptive management principles with monitoring informing future modifications to works and methodology.

Rehabilitation works associated with the proposed program will follow the methods developed for the existing exploration and appraisal activities.

7.1 VEGETATION DIEBACK

Santos has identified approximately six hectares of vegetation dieback which has resulted from ESG's previous operations. The affected areas occur within the White Cypress Pine – Bulloak – Ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion vegetation type adjacent to areas cleared for infrastructure. Santos has progressed rehabilitation of these areas in consultation with the NSW Government. The vegetation dieback areas are not included in the cumulative clearing areas presented in **Table 6**.

To date, rehabilitation of approximately 28 hectares of land, including the vegetation dieback areas, has commenced.

8 Conclusion

This report has brought together information from a variety of sources to document the existing, proposed and cumulative impacts associated with exploration and appraisal activities within the Pilliga Forest.

Six ecological surveys and assessments have been completed to assess the potential impacts of the proposed program on MNES (RPS 2012a-c, 2013a-c). The advice provided from these surveys is that the proposed program is not likely to have a significant impact on any MNES, however a referral has been recommended as a precautionary measure.

An assessment of the significance of the impacts of the proposed program under the EPBC Act was completed as part of this report. The outcome of the assessment is that the proposed program is considered unlikely to result in a significant impact on any MNES. Further to this, when the impacts of the proposed program are considered in conjunction with the impacts of existing exploration and appraisal activities within the Pilliga Forest (i.e. a cumulative impact assessment), the combined impacts are also considered unlikely to result in a significant impact on any MNES.

Given the relatively small extent of clearing as a proportion of available habitat within the study area and more broadly in the Namoi CMA region, minimisation of fragmentation impacts by locating linear infrastructure (flow lines) along existing tracks wherever possible, and measures proposed to avoid, minimise and mitigate impacts, the proposed program is considered unlikely to have a significant impact on MNES.

Additional measures to further reduce impacts such as rehabilitation have been included as part of the proposed program.

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Appendix 4

PEL 238 – TSC Act Cumulative Impact Assessment

PEL 238

TSC Act Cumulative Impact Assessment

Prepared for
Santos Limited

July 2013

DOCUMENT TRACKING

Item	Detail
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Abbreviations

ABBREVIATION	DESCRIPTION
BWTP	Bibblewindi Water Treatment Plant
CEEC	Critically Endangered Ecological Community
CSG	Coal Seam Gas
CUCCLG	Coonabarabran and Upper Castlereagh Catchment and Landcare Group
DTIRIS	NSW Department of Trade & Investment, Regional Infrastructure and Services
ELA	Eco Logical Australia Pty Ltd
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
ESG	Eastern Star Gas (now Santos Limited)
Ha	Hectares
HBT	Hollow Bearing Tree
NGDP	Narrabri Gas Development Project
NES	National Environmental Significance
NICE	Northern Inland Council for the Environment
NPWS	NSW National Parks and Wildlife Service
NW Act	NSW *Noxious Weeds Act 1993*
OEH	NSW Office of Environment and Heritage
P&Ad	Plugged and abandoned
PAL	Petroleum Assessment Lease
PEL	Petroleum Exploration Licence
PPL	Petroleum Production Lease
REF	Review of Environmental Factors (Under Part 5 of the NSW EP&A Act)
RVC	Regional Vegetation Community
SCA	State Conservation Area
SSD	State Significant Development
TSC Act	NSW *Threatened Species Conservation Act 1995*

1 Introduction

1.1 Energy NSW Coal Seam Gas (CSG) Exploration and Appraisal Program

Santos NSW (Eastern) Pty Ltd is proposing to undertake the Energy NSW Coal Seam Gas (CSG) Exploration and Appraisal Program in the Narrabri area within Petroleum Exploration Licence (PEL) 238 and Petroleum Assessment Lease (PAL) 2 (hereafter referred to as the program). The program is scheduled to commence in 2013 and will take two to three years. The program includes recommencing operation of a number of existing pilot wells, drilling and operating new pilot wells and constructing and operating water and gas management facilities to support the program.

PEL 238 wholly contains Petroleum Assessment Lease 2 (PAL 2) and Petroleum Production Lease 3 (PPL 3) which are collectively referred to as 'PEL 238 area' for the purposes of this assessment (**Figure 1)**.

Eastern Star Gas (ESG) was the operator of the PEL 238 from 2002 to 2011 on the back of early stage exploration undertaken by various US based companies in the period 1998-2002. During that period, ESG carried out exploration and appraisal activities across much of PEL 238 and PAL 2, which in the period 2006 to 2011 focused more closely on the CSG resources underlying Pilliga East and Bibblewindi State Forests and surrounding freehold lands. The impacts associated with these early stage reconnaissance and exploration and appraisal activities were assessed under Part 5 of the *Environmental Planning and Assessment Act 1979 (NSW).*

In 2011, ESG lodged a major project application for up to 550 well sets within PEL 238 and PAL 2, known previously as the Narrabri Gas Development Project (NGDP), to the NSW State Government. Following a series of field based ecological surveys in late 2010 and early 2011, the production project was referred to the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 12 April 2011 (EPBC 2011/5914).

Santos acquired ESG in November 2011 and commenced a full review of ESG's operations. Following the acquisition of ESG, Santos withdrew both the major project application and referral for the NGDP and commenced the decommissioning and progressive rehabilitation at thirty two well sites, the Bibblewindi Water Treatment Plant (BWTP) and a number of ponds within PEL 238. The objective of the rehabilitation activities is to rehabilitate these sites to natural pre-disturbance vegetation condition and improve the ecological values of the PEL 238 area.

Santos is now proposing to undertake an exploration and appraisal program to determine the viability of a gas production project in PEL 238 and PAL 2. This is dependent on geology, resource availability, environmental and land access constraints which will be investigated through early stage exploration and appraisal activities.

1.2 Purpose of this report

This report brings together and updates information from a variety of sources to document the exploration activities and cumulative impacts associated with all existing and proposed exploration and production appraisal activities associated with the program, based on current knowledge of the area for ecological values listed under the TSC Act. This report places the program within a regional context,

with impact assessment focussed on state listed ecological values. An equivalent report has also been compiled for matters of national environmental significance (MNES) listed under the Commonwealth's EPBC Act (ELA 2013).

2 Description of activities

2.1 General locality

PEL 238 (incorporating PAL 2 and PPL 3) covers approximately 820,578 ha and includes the townships of Narrabri, Wee Waa, Edgeroi, Baan Baa and Baradine (**Figure 1**). The PEL 238 area includes (in part) numerous conservation areas and state forests such as Pilliga East, Euligal, Cumbil, Kerringle, Bibblewindi, Baradine, Cubbo and Jacks Creek State Forests, Pilliga State Conservation Area (SCA), Pilliga East SCA, Pilliga Nature Reserve and Pilliga National Park which, together represent the largest stand of intact vegetation in western NSW, known collectively as the 'Pilliga Forests'. The PEL 238 area also includes significant areas of crown and leasehold land.

Detailed surveys into the biodiversity values of the north-east Pilliga Forest have broadly been undertaken within an approximately 48,000 ha area which equates to the ESG's former NGDP (and contains all proposed infrastructure in the program). For the purposes of this cumulative impact assessment, impacts to threatened species and ecological communities are assessed against those values contained within the PEL 238 area (the study area) as this contains both existing and proposed exploration and production appraisal activities.

2.2 Exploration activities

In order to determine the design and layout of gas wells and associated infrastructure, exploration and appraisal of aspects such as geology, resource availability, environmental and land access constraints are necessary.

Existing exploration activities undertaken within the study area have included seismic surveys, stratigraphic corehole drilling, pilot well drilling and production appraisal activities including management of water and gas products. Existing disturbance associated with these works includes vegetation clearing for coreholes, well leases, water and gas flow lines and water management (ponds).

Figure 1 details the location of all previous works (undertaken by ESG) and proposed exploration activities within the PEL 238 area as follows:

- Existing exploration activities – activities undertaken by ESG between 2002 and 2012
- Proposed exploration activities – activities scheduled to occur during 2013 and 2014
- Indicative area for pilot production wells – activities scheduled to occur during 2013 and 2014 which are still undergoing detailed design.

2.2.1 Reconnaissance and exploration activities undertaken to date

The following reconnaissance and exploration activities have been undertaken to date within PEL 238. REFs were submitted to the NSW State Government regulators for all of the activities listed below (**Section 4.1**) and undertaken in accordance with the consent of that agency and the landholder, the Forestry Corporation of NSW.

2002 - 2006		
Coonarah 1B ST	2002	production pilot well

2002 - 2006		
Coonarah 5	2002	production pilot well
Coonarah 3	2002	production pilot well
Dampier Seismic Survey	May-04	seismic survey
Bohena South-1C	Jul-04	appraisal well
Bohena-4L	Jul-04	appraisal well
Bohena-9	Aug-04	appraisal well
Coonarah 6L	Aug-04	production pilot well
Bohena South-1	Sep-04	appraisal well
Brigalow Park 1	Oct-04	corehole
Coonarah 8	Mar-05	production pilot well
Coonarah 7	Apr-05	production pilot well
Bibblewindi CSG Pilot	Mar-06	production pilot wells

2007 - 2008		
Bibblewindi North-1C	Mar-07	corehole
Bohena-12C	May-07	corehole
Bohena South-2C	Jul-07	corehole
Bibblewindi West-1C	Aug-07	corehole
Bohena-13C	Aug-07	corehole
Bibblewindi-11	Oct-07	corehole
Dewhurst-2	Mar-08	corehole
Dewhurst-3	Apr-08	corehole
Dewhurst-4	May-08	corehole
Dewhurst-7	Jul-08	corehole
Dewhurst Seismic Survey	Aug-08	seismic survey
Dewhurst-5	Sep-08	corehole
Edgeroi 1	Oct-08	corehole
Blue Hills (NSW 1)	Dec-08	corehole
Bibblewindi Multilateral pilot	Dec-08	production pilot wells

2009 - 2010		
Coonarah 9	09	corehole, plugged and abandoned (P&A)

2009 - 2010		
Bibblewindi Multilateral Pilot (cont'd)	Jan-09	production pilot wells
Dewhurst-6	Apr-09	appraisal well
Bibblewindi-19H	Apr-09	production pilot well
Dewhurst-8	May-09	appraisal well
Bibblewindi West Pilot	May-09	production pilot wells
Dewhurst-9	Jul-09	appraisal well
Dewhurst-10	Jul-09	appraisal well
Bibblewindi-20	Jul-09	appraisal well
Bibblewindi Multilateral Pilot (cont'd)	Aug-09	production pilot well
Tintsfield 1	Aug-09	production pilot well
Bibblewindi-21H	Sep-09	corehole
Dewhurst 8 Pilot	Oct-09	production pilot wells
Coogal 2	Oct-09	corehole
Rosevale 1	Nov-09	corehole

2010 - 2011		
Tintsfield 5	Jan-10	production pilot well
Tintsfield 6	Feb-10	production pilot well
Tintsfield 7	Feb-10	production pilot well
Bohena-14	Feb-10	corehole
Tintsfield 3H	Feb-10	production pilot well
Tintsfield 2H	Mar-10	production pilot well
Tintsfield 4H	Mar-10	production pilot well
Edgeroi 2	Mar-10	corehole
Dewhurst/Coghill Seismic Survey	Apr-10	seismic survey
Blue Hills 2	Apr-10	corehole
Culgoora 1	Sep-10	corehole
Culgoora 1a	Sep-10	corehole
Brigalow Park 2	Oct-10	corehole
Culgoora 2	Nov-10	corehole
Rosevale	Nov-10	corehole
Willala 1	Jan-11	corehole

2010 - 2011		
Strathmore 2ST1	Feb-11	corehole
Yallambee 2	Mar-11	corehole
Dewhurst-19	Apr-11	corehole
Strathmore 2	2011	corehole
Leewood Produced Water Facility	2013	Produced Water Facility

PROPOSED*		
Bibblewindi Multi-Lateral Pilot	Existing/ Proposed	operation of the existing Bibblewindi Multi-Lateral Pilot (Bibblewindi 12, 13, 14, 15, 16, 17, 18H, 19H, 21H, 27, 28H and 29), construction, drilling and operation of two additional pilot wells (Bibblewindi 31 and 32), and the operation of existing water flow lines from Bibblewindi Multi-Lateral Pilot to the Bibblewindi Water Transfer Facility
Bibblewindi West Pilot	Existing	operation of the existing Bibblewindi West Pilot (Bibblewindi 22, 23, 24, 25 and 26) and operation of existing water flow lines from the Bibblewindi West Pilot to the Bibblewindi Water Transfer Facility
Dewhurst 13-18H Pilot	Proposed	operation of the existing Dewhurst 13-18H Pilot (Dewhurst 13, 14, 15, 16H, 17H and 18H) including construction, drilling and operation of additional lateral wells from well casing within Dewhurst 16H, 17H and 18H
Dewhurst 22-25 Pilot	Proposed	construction, drilling and operation of the Dewhurst 22-25 Pilot (Dewhurst 6, 22, 23, 24 and 25)
Dewhurst 26-31 Pilot	Proposed	construction, drilling and operation of the Dewhurst 26-31 Pilot (Dewhurst 26, 27, 28, 29, 30 and 31)
Dewhurst Northern Water and Gas Flow Lines	Proposed	construction of the Dewhurst Northern Water and Gas Flow Lines and operation the Dewhurst Northern Water Flow Line
Dewhurst Northern Water and Gas Flow Lines	Proposed	construction of the Dewhurst Southern Water and Gas Flow Lines and operation of the Dewhurst Southern Water Flow Line
Bibblewindi Water Transfer Facility	Existing	operation of the Bibblewindi Water Transfer Facility
Leewood Pipeline	Existing	operation of the Leewood Water Pipeline
Leewood Produced Water Facility	Existing	operation of the Leewood Produced Water Facility
transport of produced water	Proposed	transport of produced water from Leewood Produced Water Facility to an appropriately licensed facility at Homebush Bay, NSW

PROPOSED*		
ancillary and supporting infrastructure	Proposed	construction and operation of ancillary and supporting infrastructure to facilitate the above activities and ongoing maintenance

*all proposed areas include surface facilities that include gathering lines

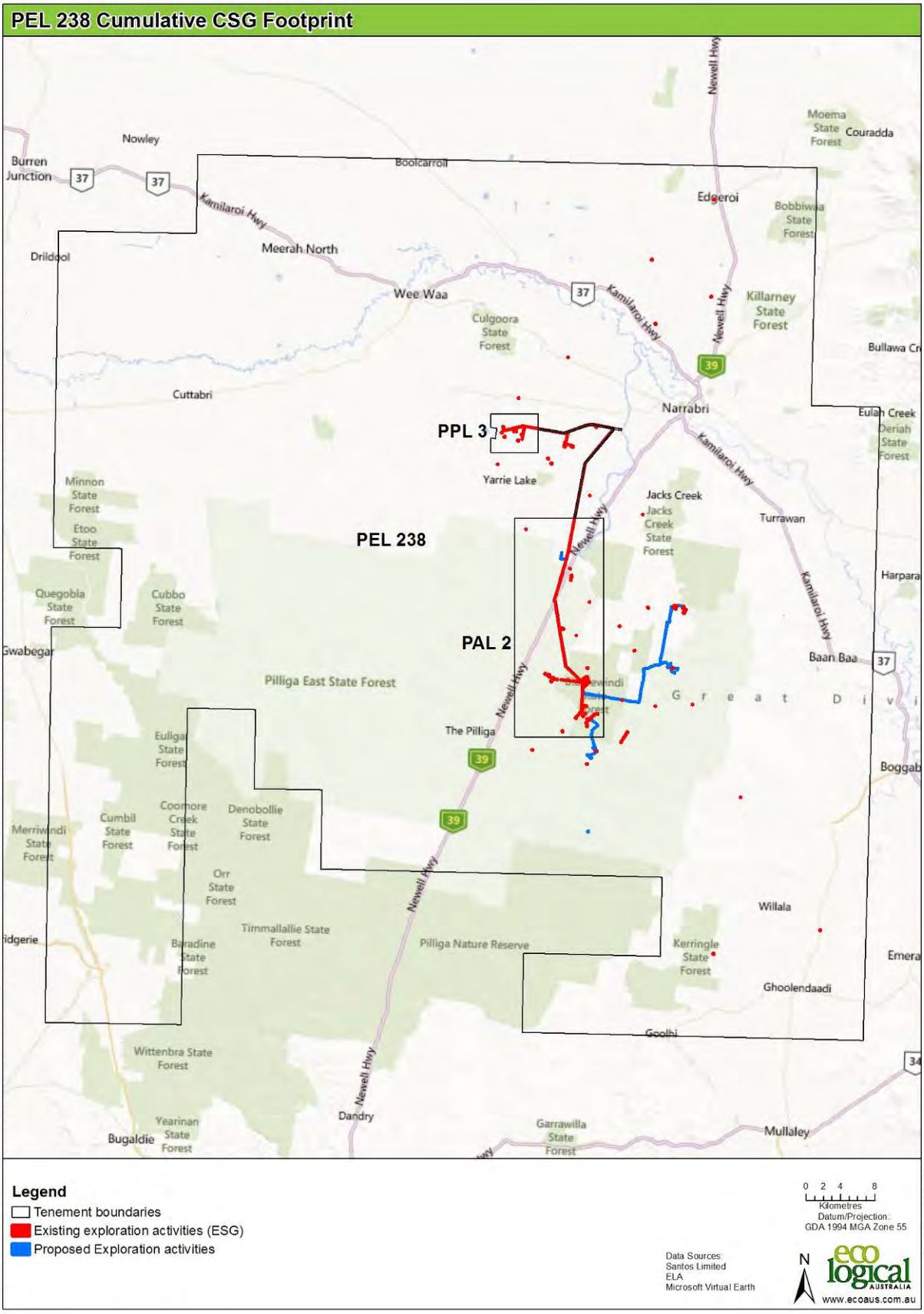

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Figure 1: Cumulative CSG footprint within PEL 238 area

3 Legislative and planning history

3.1 NSW planning and approvals

Exploration and production appraisal activities require environmental assessment under the *Environmental Planning and Assessment Act 1979* (EP&A Act).

Part 5 of the EP&A Act applies to most exploration and appraisal activities, with assessments undertaken by the NSW Department of Trade & Investment, Regional Infrastructure and Services (DTIRIS, formerly I&I NSW, Department of Primary Industries and other iterations). DTIRIS is responsible for assessing the environmental impacts of activities within titles issued under the *Petroleum (Onshore) Act 1991* that fall under Part 5 of the EP&A Act.

To assess the impacts, DTIRIS requires the titleholder to undertake an activity specific environmental assessment such as an REF. A REF details the environmental impact assessment of activities taking place within petroleum title and the measures taken to avoid, minimise and mitigate impacts. The consent of the agency is required prior to any activity being undertaken.

Some exploration activities require assessment and approval by the Minister for Planning and Infrastructure as State Significant Development (SSD) under Part 4 of the EP&A Act. These exploration activities include the drilling or operating petroleum exploration wells not including:

a) stratigraphic boreholes

b) monitoring wells

c) a set of 5 or fewer wells that is more than 3 kilometres from any other petroleum well (other than an abandoned petroleum well) in the same petroleum title.

Santos is proposing to seek development consent under Part 4 of the EP&A Act for the drilling and operation of sets of more than 5 wells proposed to be undertaken as part of the program.

REFs have been, or are in the process of being, prepared for each other activity within the program as required under Part 5 of the EP&A Act.

4 Potential impacts

4.1 Ecological surveys and consultant advice

A number of flora and fauna surveys and assessments have been undertaken in PEL 238 since 2002, totalling more than 3,000 person-hours in the field.

Recent flora and fauna assessments undertaken (RPS 2012a-c; 2013a-c), address potential impacts of proposed exploration activities. An outline of survey undertaken for each activity and relevant survey dates is included in **Table 1**. The advice from these surveys is that the proposed exploration activities are unlikely to have a significant impact on TSC Act listed ecological values.

Table 1: Ecological assessments, survey dates and effort for the proposed program

ACTIVITY	SURVEY DATES	SURVEY EFFORT
Bibblewindi Multi-Lateral Pilot	27 November 2012	Bibblewindi 31 and 32: • Flora survey • Fauna habitat assessment • Targeted survey for threatened flora species Supplementary survey was not required for existing infrastructure as no additional habitat disturbance is proposed.
Bibblewindi West Pilot	N/A	• N/A – survey was not required for existing infrastructure as no additional habitat disturbance is proposed.
Dewhurst 13-18H Pilot	24 January 2013	Water and gas gathering system: • Flora survey • Fauna habitat assessment • Targeted survey for threatened flora species Supplementary survey was not required for existing infrastructure as no additional habitat disturbance is proposed.
Dewhurst 22-25 Pilot	17 and 19 September 2012 8 – 12 October 2012 24 January 2013	• Flora survey • Fauna habitat assessment • Detailed fauna trapping program o Diurnal bird surveys o Spotlighting o Active searches

ACTIVITY	SURVEY DATES	SURVEY EFFORT
		o Anabat detection o Terrestrial trapping (Elliot, Cage, Camera and Hair Tube) • Targeted survey for threatened flora species
Dewhurst 26-31 Pilot	12 - 16 November 2012	• Flora survey • Fauna habitat assessment • Detailed fauna trapping program o Diurnal bird surveys o Spotlighting o Active searches o Anabat detection o Terrestrial trapping (Elliot, Cage, Camera and Hair Tube) • Targeted survey for threatened flora species
Dewhurst Northern Water and Gas Flow Lines	8 - 12 October 2012 4 – 9 November 2012	• Flora survey • Fauna habitat assessment • Detailed fauna trapping program o Diurnal bird surveys o Spotlighting o Active searches o Anabat detection o Terrestrial trapping (Elliot, Snake Funnel, Camera, Hair Tube and Pitfall) • Targeted survey for threatened flora species
Dewhurst Southern Water and Gas Flow Lines	11 – 16 November 2012	• Flora survey • Fauna habitat assessment • Detailed fauna trapping program o Diurnal bird surveys o Spotlighting o Active searches o Anabat detection o Terrestrial trapping (Elliot, Snake Funnel, Camera, Hair

ACTIVITY	SURVEY DATES	SURVEY EFFORT
		Tube and Pitfall) • Targeted survey for threatened flora species

4.2 NSW listed threatened species and ecological communities

Based on searches of the Atlas of NSW Wildlife (OEH 2013a), review of relevant literature, vegetation mapping, constraints analysis, results of flora and fauna surveys, presence of suitable habitat and professional judgement, a number of TSC Act listed species and ecological communities have been identified as having the potential to be impacted within PEL 238 (within all existing and currently planned early-stage exploration and production appraisal sites – known for this report as 'exploration activity areas').

The likelihood of presence or absence of species and ecological communities has been assessed with full details provided in **Appendix A**.

A summary of this likelihood of occurrence has been present below for the ecological values defined as known, likely or potential to occur within the exploration activity areas. These terms are defined as follows:

Likelihood of occurrence	Definition
Known	the species was or has been observed in the area
Likely	a medium to high probability that a species uses the area
Potential	suitable habitat for a species occurs, but there is insufficient information to categorise the species as likely to occur, or unlikely to occur

Twenty-four bird species, fourteen mammals, one reptile, eight plants and three ecological communities which are listed under the NSW TSC Act are determined to have a likelihood of occurrence of 'known', 'likely', or 'potential' within the exploration activity areas (**Table 2**).

Impacts to these (and other) species have been considered in the various ecological reports and REFs for existing and planned exploration activities. A number of other species have been considered in relation to their likelihood of occurrence within the exploration activity areas and determined to be unlikely to occur, as the area is outside of their distribution, and/or suitable habitat is not present. These species are not addressed in detail in this report, but have been considered in supporting ecological reports and are outlined in a full likelihood of occurrence table in **Appendix A**.

Table 2: NSW TSC Act threatened species and ecological communities listed as having a likelihood of occurrence of 'known', 'likely' or 'potential'.

SCIENTIFIC NAME	COMMON NAME	TSC ACT STATUS	LIKELIHOOD OF OCCURRENCE IN PROGRAM AREA
Birds			
Anthochaera phrygia	Regent Honeyeater	Critically Endangered	Potential
Ardeotis australis	Australian Bustard	Endangered	Potential
Burhinus grallarius	Bush Stone-curlew	Endangered	Known
Calyptorhynchus lathami	Glossy Black-Cockatoo	Vulnerable	Known
Chthonicola sagittata	Speckled Warbler	Vulnerable	Known
Circus assimilis	Spotted Harrier	Vulnerable	Potential
Daphoenositta chrysoptera	Varied Sittella	Vulnerable	Known
Falco hypoleucos	Grey Falcon	Endangered	Potential
Glossopsitta pusilla	Little Lorikeet	Vulnerable	Known
Grantiella picta	Painted Honeyeater	Vulnerable	Likely
Hamirostra melanosternon	Black-breasted Buzzard	Vulnerable	Potential
Hieraaetus morphnoides	Little Eagle	Vulnerable	Potential
Lathamus discolor	Swift Parrot	Endangered	Potential
Lophoictinia isura	Square-tailed Kite	Vulnerable	Likely
Melanodryas cucullata	Hooded Robin	Vulnerable	Known
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	Vulnerable	Likely
Neophema pulchella	Turquoise Parrot	Vulnerable	Known
Ninox connivens	Barking Owl	Vulnerable	Known
Pachycephala inornata	Gilbert's Whistler	Vulnerable	Potential
Petroica boodang	Scarlet Robin	Vulnerable	Potential
Polytelis swainsonii	Superb Parrot	Vulnerable	Potential
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	Vulnerable	Known
Stagonopleura guttata	Diamond Firetail	Vulnerable	Known
Tyto novaehollandiae	Masked Owl	Vulnerable	Likely
Reptiles			
Hoplocephalus bitorquatus	Pale-headed Snake	Vulnerable	Likely

SCIENTIFIC NAME	COMMON NAME	TSC ACT STATUS	LIKELIHOOD OF OCCURRENCE IN PROGRAM AREA
Mammals			
Aepyprymnus rufescens	Rufous Bettong	Vulnerable	Potential
Cercartetus nanus	Eastern Pygmy-possum	Vulnerable	Known
Chalinolobus dwyeri	Large-eared Pied Bat	Vulnerable	Potential
Chalinolobus picatus	Little Pied Bat	Vulnerable	Known
Dasyurus maculatus	Spotted-tailed Quoll	Vulnerable	Potential
Macropus dorsalis	Black-striped Wallaby	Endangered	Known
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	Vulnerable	Known
Nyctophilus timoriensis / Nyctophilus corbeni	Greater Long-eared Bat / South-eastern Long eared Bat	Vulnerable	Known
Petaurus norfolcensis	Squirrel Glider	Vulnerable	Likely
Phascolarctos cinereus	Koala	Vulnerable	Known
Pseudomys pilligaensis	Pilliga Mouse	Vulnerable	Known
Pteropus poliocephalus	Grey-headed Flying-fox	Vulnerable	Potential
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	Vulnerable	Known
Vespadelus troughtoni	Eastern Cave Bat	Vulnerable	Known
Flora			
Bertya opponens	Coolabah Bertya	Vulnerable	Potential
Diuris tricolor	Painted Diuris	Vulnerable	Likely
Lepidium monoplocoides	Winged Peppercress	Endangered	Potential
Polygala linariifolia	Native Milkwort	Endangered	Known
Pomaderris queenslandica	Scant Pomaderris	Endangered	Potential
Pterostylis cobarensis	Greenhood Orchid	Vulnerable	Known
Rulingia procumbens	-	Vulnerable	Potential
Tylophora linearis	-	Vulnerable	Known
Endangered Ecological Communities			
Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions		Endangered	Known
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland		Endangered	Potential

SCIENTIFIC NAME	COMMON NAME	TSC ACT STATUS	LIKELIHOOD OF OCCURRENCE IN PROGRAM AREA
Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions		Endangered	Known

4.3 Impacts of exploration activities

4.3.1 Impacts to vegetation

The impact associated with CSG exploration activities in PEL 238 from 2002 to present is 200.94 ha (excluding 12.2 ha within the Pilliga Forest as a result of exploration activities pre-ESG prior to 2002) (**Table 3**). This represents a loss of approximately 0.42% of consolidated vegetation within the ESG's former NGDP area and 0.04% of all vegetation within the PEL 238 area.

The proposed exploration activities will contribute an additional 58.5 ha of vegetation clearing which includes 36.42 ha in remnant woodland and 22.08 ha to be located within previously disturbed flowline corridors (**Table 4**). The previously disturbed woodland has not been included in the calculations for the impact assessments as part of the proposed exploration activities due to its highly disturbed nature and its inclusion in the cleared areas to date. The proposed exploration activities therefore represent approximately 0.08% of consolidated vegetation within the ESG's former NGDP area and less than 0.01% of all vegetation within the PEL 238 area.

This equates to a cumulative impact from the exploration activities (combining existing and proposed activities) of 237.36 ha, representing approximately 0.50% of consolidated vegetation within the ESG's former NGDP area and 0.045% of all vegetation within the PEL 238 area.

Impacts associated with exploration activities have occurred in a staged manner with progressive regeneration and rehabilitation of components of the activities. For temporary exploration works (core holes and seismic lines) and flowlines, works are generally completed within a short period (approximately 6 weeks) following which the vegetation is allowed to naturally regenerate. For more permanent exploration activities (e.g. pilot wells) topsoil has been stockpiled and the well sites will be rehabilitated on completion of the pilot programs.

Wherever possible, the exploration activities have utilised existing tracks for access, for conducting surveys and for the installation of flowline infrastructure. Some of the exploration has taken place in areas that have previously been cleared and are used for activities such as farming and grazing. Impacts are largely linear in nature within the context of a well vegetated landscape predominately managed for forestry. Given the relatively small amount of clearing as a proportion of available habitat, the current land uses and extent of rehabilitation, exploration impacts are generally not expected to significantly fragment or reduce the availability of habitat in a way which will adversely affect species within the PEL 238 area.

Table 3: Areas of clearing for exploration activities within PEL 238, PAL 2 and PPL 3 undertaken from 2002 to present

VEGETATION TYPE	AREA OF CLEARING (HA)
Brigalow - Belah woodland on alluvial often gilgaied clay soil mainly in the Brigalow Belt South Bioregion (Benson 35)	10.22
Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	9.08
Derived Grassland#	74.89
Fuzzy Box on loams in the Nandewar Bioregion and northern Brigalow Belt South Bioregion (Benson 202)	1.77
Native Millet – Cup grassland of the Darling Riverine Plain Bioregion (Benson 214)	1.94
Pilliga Box - Poplar Box- White Cypress Pine grassy open woodland on alluvial loams mainly of the temperate (hot summer) climate zone (Benson 88)#	11.77
Plains Grass grassland on basaltic black earth soils mainly on the Liverpool Plains in the Brigalow Belt South Bioregion	0.38
Red Ironbark - Brown Bloodwood shrubby woodland of the Brigalow Belt South Bioregion	1.66
Rough-barked Apple riparian forb/grass open forest of the Nandewar Bioregion	10.90
Semi-permanent open freshwater wetlands of the inland slopes and plains (Benson 238)	0.25
White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	78.08
Total	**200.94**

The Leewood Produced Water Facility will result in the removal of 48.2 ha of vegetation, 41.4 ha of which is derived native grassland, the remaining 6.8 ha consists of scattered paddock trees conforming with Pilliga Box - Poplar Box- White Cypress Pine grassy open woodland. Construction of the Leewood Produced Water Facility has commenced, but vegetation has not yet been cleared.

Table 4: Areas of clearing of proposed exploration activities (2013 onwards)

VEGETATION TYPE	AREA OF CLEARING (HA)
Areas of clearing within remnant vegetation	
Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	3.36
Rough-barked Apple riparian forb/grass open forest of the Nandewar Bioregion	1.37

VEGETATION TYPE	AREA OF CLEARING (HA)
White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	31.69
Total	**36.42**
Areas of clearing within previously cleared CSG areas (regenerating)#	
Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion	1.20
Pilliga Box - Poplar Box- White Cypress Pine grassy open woodland on alluvial loams mainly of the temperate (hot summer) climate zone (Benson 88)	2.14
Rough-barked Apple riparian forb/grass open forest of the Nandewar Bioregion	3.90
White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	14.84
Total	**22.08**

These areas were cleared approximately 5 years ago and have since been allowed to naturally regenerate. The current condition of these areas approximates 50% of values in adjoining areas. Due to previous clearing, these areas support little to no potential habitat for TSC Act listed ecological values.

4.3.2 Impacts to fauna habitat

The total amount of potential foraging, breeding and roosting/sheltering habitat has been calculated for the disturbance areas of the existing and proposed exploration activities, to inform the significant impact assessments for the cumulative impacts from all CSG activities (**Table 5**). The amount of loss of potential habitat in relation to the vegetation present within the PEL 238 area has also been calculated.

Determination of the different types of habitat (foraging, breeding, roosting/sheltering) for individual threatened fauna species was made by first allocating vegetation types that would be used for foraging, breeding, and roosting/sheltering to individual species. The areas impacted were then summed for all vegetation types representing the type of habitat used by individual species.

The calculations include areas of clearing for exploration activities undertaken from 2002 to present and proposed exploration activities within remnant vegetation only.

Table 5: Cumulative direct impacts areas to potential threatened fauna habitat

SPECIES	FORAGING (HA) / LOSS IN PEL 238 (%)	BREEDING (HA) / LOSS IN PEL 238 (%)	ROOSTING (HA) / LOSS IN PEL 238 (%)
Glossy Black-Cockatoo	237.1 / 0.05	159.9 / 0.05	159.9 / 0.05
Little Lorikeet	237.1 / 0.08	159.9 / 0.05	159.9 / 0.05
Superb Parrot	237.1 / 0.08	n/a	159.9 / 0.05
Swift Parrot	237.1 / 0.08	n/a	159.9 / 0.05

SPECIES	FORAGING (HA) / LOSS IN PEL 238 (%)	BREEDING (HA) / LOSS IN PEL 238 (%)	ROOSTING (HA) / LOSS IN PEL 238 (%)
Turquoise Parrot	237.1 / 0.08	159.9 / 0.05	159.9 / 0.03
Barking Owl	237.1 / 0.05	159.9 / 0.05	159.9 / 0.05
Masked Owl	237.1 / 0.08	n/a	n/a
Black-breasted Buzzard	113.5 / 0.63	n/a	12.3 / 0.09
Grey Falcon	113.5 / 0.63	n/a	12.3 / 0.09
Little Eagle	237.1 / 0.08	159.9 / 0.05	159.9 / 0.05
Spotted Harrier	110.9 / 0.36	36.0 / 0.20	36.0 / 0.20
Square-tailed Kite	237.1 / 0.05	12.3 / 0.09	12.3 / 0.09
Australian Bustard	220.7 / 0.17	n/a	145.8 / 0.11
Bush Stone-curlew	220.7 / 0.17	145.8 / 0.11	145.8 / 0.11
Diamond Firetail	237.1 / 0.05	159.9 / 0.03	159.9 / 0.03
Gilbert's Whistler	223.0 / 0.17	145.8 / 0.11	145.8 / 0.11
Grey-crowned Babbler (eastern subspecies)	237.1 / 0.05	159.9 / 0.03	159.9 / 0.03
Hooded Robin	237.1 / 0.05	159.9 / 0.05	159.9 / 0.05
Scarlet Robin	237.1 / 0.08	n/a	159.9 / 0.05
Speckled Warbler	237.1 / 0.05	159.9 / 0.05	159.9 / 0.05
Varied Sittella	237.1 / 0.08	159.9 / 0.05	159.9 / 0.05
Black-chinned Honeyeater (eastern subspecies)	159.9 / 0.05	159.9 / 0.05	159.9 / 0.05
Painted Honeyeater	159.9 / 0.05	159.9 / 0.05	159.9 / 0.05
Regent Honeyeater	159.9 / 0.05	n/a	159.9 / 0.05
Yellow-bellied Sheathtail-bat	237.1 / 0.05	159.9 / 0.03	159.9 / 0.03
Greater Long-eared Bat	237.1 / 0.05	159.9 / 0.03	159.9 / 0.03
Eastern Bentwing-bat	237.1 / 0.05	n/a	n/a
Eastern Cave Bat	237.1 / 0.05	n/a	n/a
Large-eared Pied Bat	237.1 / 0.05	n/a	n/a
Little Pied Bat	237.1 / 0.05	159.9 / 0.03	159.9 / 0.03
Grey-headed Flying-fox	159.9 / 0.05	n/a	n/a
Koala	159.9 / 0.05	159.9 / 0.05	159.9 / 0.05

SPECIES	FORAGING (HA) / LOSS IN PEL 238 (%)	BREEDING (HA) / LOSS IN PEL 238 (%)	ROOSTING (HA) / LOSS IN PEL 238 (%)
Squirrel Glider	159.9 / 0.05	159.9 / 0.05	159.9 / 0.05
Black-striped Wallaby	224.9 / 0.05	147.6 / 0.03	147.6 / 0.03
Eastern Pygmy-possum	159.9 / 0.05	147.6 / 0.05	147.6 / 0.05
Pilliga Mouse	26.3 / 0.01	n/a	n/a
Spotted-tailed Quoll	159.9 / 0.05	159.9 / 0.05	159.9 / 0.05
Rufous Bettong	212.8 / 0.16	135.6 / 0.10	135.6 / 0.10
Pale-headed Snake	237.1 / 0.05	159.9 / 0.05	159.9 / 0.05

4.3.3 Limitations

The regional vegetation class data utilised in this report is derived from a regional scale map that contains a proportion of modelling. Other datasets utilised are of varying scales and accuracies.

4.4 Key Threatening Processes

The following Key Threatening Processes (KTP) shown with a response following are considered relevant to the exploration activities include:

- Clearing of native vegetation (TSC Act)

Impacts of the exploration activities within PEL 238 on native vegetation in terms of clearing have been outlined in **Section 4.3**. Given that the cumulative impact associated with existing and proposed exploration activities totals 237.36 ha, this KTP is likely to be exacerbated. However, the amount of vegetation to be cleared has been minimised, with clearing of EECs and rare vegetation types avoided as far as practicable. Offsets will be provided to compensate for vegetation loss. Furthermore, vegetation temporarily slashed and mulched will be allowed to regenerate and infrastructure will be progressively rehabilitated as it is decommissioned.

- Competition and grazing by the feral European rabbit (TSC Act)

The European Rabbit currently inhabits PEL 238 area in low numbers. The existing exploration activities have disturbed soils and stockpiled materials (including soil and logs) which have the potential to encourage feral species such as European Rabbit. As such, the exploration activities have the potential to further exacerbate this KTP, although provided rehabilitation and feral animal control programs are implemented correctly, increases in this KTP due to the exploration activities are likely to be low.

- Competition and habitat degradation by Feral Goats, *Capra hircus* Linnaeus 1758 (TSC Act)

Feral Goats currently inhabit PEL 238. The proposed exploration activities would not create additional conditions that would favour the species and as such, it is unlikely that the proposed exploration activities would exacerbate this KTP.

- Degradation of native riparian vegetation along NSW watercourses (FM Act)

The exploration activities have been developed in a manner which minimises the potential impact on Bohena Creek and other drainage lines throughout the PEL 238 area. The number of creek crossings have been minimised and riparian zones have been avoided, where possible.

The proposed exploration activities would avoid riparian areas for the most part, and would seek to minimise impacts on core riparian zones. Sediment controls would be placed around construction work areas where there is a risk of sedimentation of creeks. Therefore it is considered unlikely that the proposed exploration activities would result in the degradation of native riparian vegetation.

- Ecological consequences of high frequency fires (TSC Act)

There is potential for fire during the construction and operation phases of the exploration activities, particularly given the flammability of CSG, which could greater fuel a fire should there be any gas leaks near ignition sources. Provided bushfire prevention and mitigation measures (e.g. adequate asset protection zones) are implemented, it is unlikely that the exploration activities would alter current fire regimes across the site.

- Infection of native plants by *Phytophthora cinnamomi* (TSC Act)

The exploration activities would clear vegetation for gas wells, flowlines and associated infrastructure, and the machinery used could carry the spores of the root-rot fungus, *Phytophthora cinnamomi*, which could result in the infection of native plants. Provided adequate controls (pre-start checks and vehicle cleaning protocols) are implemented to ensure machinery entering the PEL 238 area has been decontaminated, it is unlikely that native plants would be infected by this fungus.

- Invasion of native plant communities by exotic perennial grasses (TSC Act)

There is the potential for the exploration activities to result in the spread of exotic perennial grasses. Provided mitigation measures to prevent the spread of weeds and exotic perennial grasses are implemented (pre-start checks, vehicle cleaning protocols and weed control measures), the spread of weeds within PEL 238 area is likely to be minimal.

- Loss of hollow-bearing trees (TSC Act)

The exploration activities are likely to result in the removal of hollow-bearing trees and therefore this KTP would be exacerbated. Despite the removal of hollow-bearing trees, the majority of hollow-bearing trees within the study area would be retained and felled trees (apart from merchantable trees within State Forests which will be provided to Forests NSW in accordance with Santos' Occupation Permit) will be utilised for fauna habitat reconstruction.

- Predation by feral cats (TSC Act)

Feral cats are likely to be present within the PEL 238 area, and have been recorded during previous surveys of East Pilliga (NPWS 2000). The proposed flowlines and access roads could increase the access of this species to additional areas and hence exacerbate this KTP. A feral animal control strategy will be prepared and implemented throughout the life of the program to minimise potential impacts from feral cats.

- Predation by the European Red Fox (TSC Act)

The European Red Fox is present across the PEL 238 area. The proposed flowlines and access roads are likely to increase the access of this species to additional areas and exacerbate this KTP.

A feral animal control strategy will be prepared and implemented throughout the life of the program to minimise potential impacts from the European Red Fox

- Predation, habitat degradation, competition and disease transmission by Feral Pigs (*Sus scrofa*) (TSC Act)

The Feral Pig is present across PEL 238 and has impacted on flora and fauna habitats throughout this area. However, given that the exploration activities are unlikely to create additional conditions that would favour the species, it is considered unlikely that the exploration activities would further exacerbate this KTP. A feral animal control strategy will be prepared and implemented throughout the life of the program to minimise potential impacts from the Feral Pig.

- Removal of dead wood and dead trees (TSC Act)

Dead wood is present across the study area and provides habitat for a number of reptile and small mammal species. Dead trees are also present across the study area, and many of the dead trees also support hollows, providing habitat for some hollow-dependent species including bird, bat, mammal and reptile species. Where dead wood and trees are removed for the exploration activities they are stockpiled and utilised in the rehabilitation process and hence the exploration activities are unlikely to exacerbate this KTP.

5 Significance assessment under the TSC Act

The following section provides an assessment of the potential significance of the cumulative impacts from exploration activities on ecological values listed under the TSC Act. The ecological values considered relevant to this assessment are identified in **Section 4.2** of this report and consider both the existing and planned exploration activities.

The ecological values have been grouped for the assessment process with other values that contain similar characteristics and those that are likely to be impacted in a similar manner.

The assessment of impact has been conducted where necessary with consideration to the 7-part test criteria (or assessment of significance), as outlined in the text box below:

7-Part Test Assessment of Significance

1. *In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.*
2. *In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.*
3. *In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*
   - *I. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*
   - *II. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,*
4. *In relation to the habitat of a threatened species, population or ecological community:*
   - *I. the extent to which habitat is likely to be removed or modified as a result of the action proposed, an*
   - *II. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*
   - *III. the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality*
5. *Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).*
6. *Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.*
7. *Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.*

The fauna groupings for the assessment of significance for TSC ecological values include:

Birds

- Parrots:
  - Glossy Black-Cockatoo, Little Lorikeet, Superb Parrot, Swift Parrot & Turquoise Parrot
- Owls:
  - Barking Owl & Masked Owl
- Birds of prey:
  - Spotted Harrier, Grey Falcon, Black-breasted Buzzard, Little Eagle & Square-tailed Kite
- Woodland birds – large ground foraging:
  - Australian Bustard & Bush Stone-curlew
- Woodland birds – ground and mid-storey foraging (passerines):
  - Grey-crowned Babbler, Diamond Firetail, Gilbert's Whistler, Scarlet Robin, Speckled Warbler, Varied Sittella and Hooded Robin
- Woodland birds – canopy foraging (excluding parrots):
  - Regent Honeyeater, Painted Honeyeater and Black-chinned Honeyeater

Mammals

- Arboreal mammals and megabats*:*
  - Grey-headed Flying Fox, Koala & Squirrel Glider
- Mid-storey and log dependent mammals*:*
  - Black-striped Wallaby, Eastern Pygmy-possum, Pilliga Mouse & Spotted-tailed Quoll
- Grassy woodland mammals*:*
  - Rufous Bettong
- Predominantly tree-roosting bats*:*
  - Yellow-bellied Sheathtail-bat & Greater Long-eared Bat
- Predominantly cave-roosting bats*:*
  - Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat & Little Pied Bat

Reptiles

- Tree and log dependent reptiles
  - Pale-headed Snake

Plants

- *Bertya opponens, Diuris tricolor, Lepidium monoplocoides, Polygala linariifolia, Pomaderris queenslandica, Pterostylis cobarensis, Rulingia procumbens* and *Tylophora linearis*

Ecological Communities

- *Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions*
- *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland*
- *Fuzzy Box Woodland on alluvial soils*

5.1 Birds

5.1.1 Parrots

The Glossy Black-Cockatoo, Little Lorikeet, Superb Parrot, Swift Parrot and Turquoise Parrot are considered in this impact assessment. Only the Glossy Black Cockatoo, Little Lorikeet and Turquoise Parrot have been recorded in the exploration activity areas.

The exploration activities could potentially impact on the life cycles of these threatened parrots by reducing the amount of foraging, roosting and breeding habitat available to the species, by increasing mortality rates via vehicle collisions and by spreading weeds. Superb Parrots do not breed in the study area, and Swift Parrots breed in Tasmania. Thus, only potential foraging and roosting habitat would be reduced by the exploration works for these species. Glossy Black Cockatoos, Little Lorikeets, and Turquoise Parrots forage, roost and potentially breed across the exploration activity areas.

The exploration activities have resulted in the removal and/or modification of up to 200.6 ha of potential habitat (foraging, breeding or roosting/sheltering) for the threatened parrot species with a further 36.4 ha of potential habitat proposed to be removed. The cumulative impact as a result of the exploration activities is 237.1 ha (**Table 5**). However, this loss is considered relatively minor in the context of similar habitats within PEL 238, constituting up to 0.05% of available habitat for the threatened parrot species.

The disturbance from the exploration activities is considered unlikely to isolate larger areas of potential habitat or impact on important habitat for the threatened parrot species. This is especially true given the highly mobile nature of these parrots. Superb and Swift Parrots are able to migrate large distances from their breeding habitats in southern NSW to northern NSW, and from Tasmania to northern NSW, respectively. Glossy Black Cockatoos, Little Lorikeets, and Turquoise Parrots also move distances to access their foraging resources, although Little Lorikeets have been found to be less nomadic during breeding periods (SEWPaC 2013).

The scale of the fragmentation in relation to the total area of potential habitat and individual fragments of habitat within PEL 238 is considered relatively minor in relation to these highly mobile species. In addition, following the construction of linear infrastructure for the exploration activities, vegetation above the buried flowlines (ground and shrub layers) would be largely rehabilitated, reducing the width of the disturbed habitat between undisturbed habitat fragments and thus, limiting the level of habitat fragmentation.

Although the number of hollow bearing trees (HBTs) to be impacted by the exploration activities has not been calculated within the exploration activity areas, it can be assumed that the scale of loss in the context of the HBTs available in the broader study area is not significant based on the extent of habitat present. In addition, no critical habitat, recovery plans or threat abatement plans exist or are relevant for the Glossy Black-Cockatoo, Little Lorikeet, Superb Parrot, Swift Parrot or Turquoise Parrot in the study area.

The exploration activities are unlikely to constitute a significant impact on the threatened parrot species given that the extent of the activities:

- Have been designed to minimise the total area of habitat to be impacted
- Would only remove a small proportion of the total area of habitat available to these species
- Would not isolate or significantly fragment areas of potential habitat given the highly mobile nature of these species.

On the basis of the above considerations, it is unlikely that the activities will result in a significant impact on the survival of the Glossy Black-Cockatoo, Little Lorikeet, Superb Parrot, Swift Parrot or Turquoise Parrot.

5.1.2 Owls

The Barking Owl and Masked Owl are considered in this impact assessment. These species predominately inhabit woodland and/or dry eucalypt forest where there are suitable hollow-bearing trees for nesting. They both have large home ranges (up to 2,000 ha of Barking Owl and 1,000 ha for Masked Owl) and use a variety of habitats to forage, including closed forest and more open areas.

Despite only the Barking Owl having been recorded in the exploration activities area, the activities could potentially impact on the life cycles of the two owl species by reducing the amount of foraging, roosting and breeding habitat available to the Barking Owl and known foraging habitat for the Masked Owl. The Pilliga Forest, particularly the western Pilliga, is a stronghold of the Barking Owl which supports the largest remaining population of the species in NSW (NPWS 2003; Kavanagh and Stanton 2009).

The exploration activities have resulted in the removal and/or modification of up to 200.7 ha of potential habitat (foraging, breeding or roosting/sheltering) for the threatened owl species with a further 36.4 ha of potential habitat proposed to be removed. The cumulative impacts as a result of the exploration activities is 237.1 ha (**Table 5**). This loss is considered relatively minor in the context of similar habitat within PEL 238, constituting up to 0.08% of available habitat for the threatened owl species.

However, the greatest concern resulting from the exploration activities is the potential removal of breeding habitat (HBTs) for the Barking Owl and whether breeding pairs are present or near vegetation to be removed. The cumulative impact to potential breeding habitat for the Barking Owl is 159.9 ha (as part of the larger 237.1 ha foraging habitat). Barking Owls nest in areas that are less disturbed than surrounding areas, and are highly susceptible to disturbance during the breeding season. If breeding sites are disturbed, this could lead to the abandonment of the breeding site by a nesting pair of birds. Barking Owls predominately use large Red Gum and Narrow-leafed Ironbark HBTs for nesting, but can use large dead ringbarked trees (Kavanagh and Stanton 2009). Masked Owls are unlikely to use the study area to breed as this species roosts and breeds in moist eucalypt forested gullies (SEWPaC 2013).

A number of measures have been implemented to minimise the impact area. The activities have been designed and micro-sited to minimise the number of HBTs which would be removed. As such, it is unlikely that the activities would significantly impact Masked Owls. For this species, only foraging habitat would be lost. This removal of foraging habitat would not represent a significant loss to Masked Owls, as the species is highly mobile with the ability to hunt over areas of between 500 and 1000 ha, and the total impact areas are much less than the species' territory.

Remnant vegetation would be cleared as a result of the proposed exploration activities (**Table 3** & **4**), including an unspecified number of HBTs. However, if known breeding sites for the Barking Owl are avoided, the scale of these impacts in the context of the habitat and HBTs available within PEL 238 is considered relatively minor. In consideration of the above, the exploration activities are unlikely to constitute a significant impact on the Barking Owl, if areas of breeding pairs are avoided. Furthermore, the activities:

- Have been designed to minimise the total area of foraging and roosting habitat to be impacted including the number of HBTs to be removed

- Would only impact upon foraging and roosting habitat, which is widespread within the exploration activities area and the broader PEL 238, and as such constitutes the removal of only a very minor proportion of this habitat
- Would not isolate areas of potential habitat from currently interconnecting areas of potential habitat for these highly mobile species.

5.1.3 Birds of prey

The Spotted Harrier, Grey Falcon, Black-breasted Buzzard, Little Eagle and Square-tailed Kite are considered in this impact assessment. These species are found in a range of woodland, forest and open habitats, however, all have been associated with some form of riparian habitat, such as timbered watercourses or inland wetlands that can be used for breeding or foraging.

None of these species have been recorded within the exploration activity areas. However, the activities could potentially impact on the life cycles of the bird of prey species by reducing the amount of potential foraging, breeding or roosting habitat available to these species. All of the birds of prey are highly mobile species that have extensive home ranges. Black-breasted Buzzard, Grey Falcon, Spotted Harrier, and Square-tailed Kite have been identified as species that are negatively impacted by land clearing, with Black-breasted Buzzard, Grey Falcon, and Square-tailed Kite also negatively impacted by river/stream modification (and therefore habitat loss) in the Brigalow Belt South Bioregion (Biosis 2002).

The exploration activities have resulted in the removal and/or modification of up to 200.7 ha of potential habitat (primarily foraging habitat) for the Little Eagle and Square-tailed Kite with a further 36.4 ha of potential habitat proposed to be removed. The cumulative impact as a result of the exploration activities for these two species is 237.1 ha (**Table 5**). This loss is considered relatively minor in the context of similar habitats within PEL 238, constituting up to 0.08% of available habitat for the birds of prey.

The exploration activities have resulted in the removal and/or modification of up to 112.1 ha of potential habitat (primarily foraging habitat) for the Spotted Harrier, Grey Falcon and Black-breasted Buzzard with a further 1.4 ha of potential habitat proposed to be removed. The cumulative impact as a result of the exploration activities for these three species is up to 113.5 ha (**Table 5**). This is minor when considered in the context of the habitat available within PEL 238, constituting up to 0.63% of available foraging habitat.

In addition, the proposed activities involve relatively small impacts to remnant riparian vegetation (primarily the Pilliga Box – Poplar Box – White Cypress, Rough-barked Apple and Fuzzy Box vegetation types), which are used most commonly by these species for foraging, breeding or roosting, and is the most important habitat type for these species (**Table 5**). The exploration activities will only involve minor impacts upon the larger riparian corridors in the broader PEL 238, thus retaining extensive areas of similar riparian woodland habitats in the locality. As such the small area to be impacted by the activities is not considered to be of high importance for the birds of prey. Furthermore, no critical habitat has been declared for these threatened birds of prey.

As the areas most frequently used by birds of prey would be predominately avoided, the majority of these birds would also be less likely to be impacted by indirect disturbance from noise or traffic, and by habitat degradation through weed invasion. No new major creek crossings traversing potential foraging, breeding and roosting habitat would be constructed, and no in stream devices would be installed which would impact on the hydrology of creek lines and the integrity of riparian vegetation. In addition, indirect impacts have and will been minimised through appropriate controls, best-practice construction techniques, rehabilitation of disturbed areas and weed control programs.

With consideration to the above, the exploration activities are considered unlikely to constitute a significant impact on the Black-breasted Buzzard, Grey Falcon, Little Eagle, Spotted Harrier and Square-tailed Kite as they:

- Would predominantly avoid the most important habitat areas for these species (riparian habitats and timbered watercourses)
- Have been designed to minimise the total area of foraging and roosting habitat to be impacted
- Would only remove a small proportion of the total area of habitat available to these species in PEL 238
- Would not isolate areas of potential habitat from currently interconnecting areas of potential habitat for these highly mobile species.

5.1.4 Woodland birds – large ground foraging

The Australian Bustard and Bush Stone-curlew are considered in this impact assessment. The Australia Bustard mainly inhabits tussock and hummock grasslands while the Bush Stone-curlew inhabits open forests and woodlands with a sparse grassy groundlayer and fallen timber.

Only the Bush Stone-curlew has been recorded within exploration activity areas. However, the activities could potentially impact on the life cycles of both these threatened woodland birds by reducing the amount of foraging, roosting and breeding habitat available to the species. Australian Bustards do are unlikely to breed within the exploration areas, so only potential foraging and roosting habitat would be reduced by the activities for this species. Bush Stone-curlews forage and potentially breed across the exploration activity areas.

The exploration activities have resulted in the removal and/or modification of up to 189.9 ha of potential habitat (foraging, breeding or roosting/sheltering) for the threatened woodland birds with a further 33.1 ha of potential habitat proposed to be removed. The cumulative impacts as a result of the exploration activities is 220.7 ha (**Table 5**). This loss is considered relatively minor in the context of similar habitat within PEL 238, constituting up to 0.17% of available habitat for these threatened woodland birds.

The area of habitat to be impacted by the activities has been minimised through modifications to the design of the impact footprints and micro-siting of any well sites. Furthermore, extensive areas of similar habitat (vegetation representative of foraging and/or breeding habitat) to those which would be impacted from the exploration activities would be retained both in the exploration activities area and PEL 238.

Areas of habitat that would not be removed could be indirectly impacted by disturbance to the point that Australian Bustards and Bush Stone-curlews could avoid these areas of potential habitat. Indirect impacts could include noise, edge effects, increased traffic volumes, and incursion of weeds that effectively reduces the foraging resources of these two species. The implementation of mitigation and management measures for the exploration activities is considered sufficient in reducing these indirect impacts. Such measures include appropriate traffic controls, best-practice construction techniques, rehabilitation of disturbed areas, weed and feral animal control programs.

A recovery plan has been prepared for the Bush Stone-curlew (NPWS 2006) which has the overall objective of managing at least five populations of the species across NSW to ensure they are secure and consistently increasing in both extent of occurrence and area of occupancy. The exploration activities are being conducted in a manner than is not inconsistent with the objectives of the recovery

plan. In addition, the activities are not inconsistent with the objectives of the threat abatement plans relevant to the two species.

It is considered unlikely that the exploration activities will constitute a significant impact on the Australian Bustard or Bush Stone Curlew as:

- The woodland areas which would be impacted by the activities are widespread within PEL 238. Therefore, the impact area is not considered to be of high importance for the two species. In addition, no critical habitat has been declared by the Director General for Australian Bustards or Bush Stone Curlews
- The activities have been designed to minimise the total area of foraging and roosting habitat to be impacted
- The implementation of mitigation measures is considered sufficient to manage the threat of indirect impacts.

5.1.5 Woodland birds – ground and mid-storey foraging (passerines)

The Grey-crowned Babbler, Diamond Firetail, Gilbert's Whistler, Scarlet Robin, Speckled Warbler, Varied Sittella and Hooded Robin are considered in this impact assessment. These species inhabit a range of woodland habitats associated with the exploration activities and within the broader study area. The habitats also range in structural density and complexity.

Only the Grey-crowned Babbler, Speckled Warbler, Diamond Firetail and Hooded Robin have been recorded in the exploration activity areas.

The exploration activities could potentially impact on the life cycles of these woodland birds by reducing the amount of foraging, sheltering and breeding habitat available to the species. Scarlet Robins do not breed in the area. Diamond Firetails, Gilbert's Whistlers, Grey-crowned Babblers, Hooded Robins, Speckled Warblers, and Varied Sittellas forage and potentially breed across the areas impacted by the exploration activities. These species have also been identified as species that are negatively impacted by land clearing, with Diamond Firetails, Gilbert's Whistler, and Speckled Warblers also negatively impacted by inappropriate fire regimes (and therefore habitat loss) (Biosis 2002).

The exploration activities have resulted in the removal and/or modification of up to 200.7 ha of potential habitat (foraging, breeding or roosting/sheltering) for the threatened ground and mid-storey foraging woodland birds with a further 36.4 ha of potential habitat proposed to be removed. The cumulative impacts as a result of the exploration activities is 237.1 ha (**Table 5**). This loss is considered relatively minor in the context of similar habitat within PEL 238, constituting up to 0.05% of available habitat for these threatened birds.

The exploration activities would not involve significant impacts upon the larger riparian corridors in the broader study area, thus retaining the majority of riparian woodland habitats, which are considered to represent the areas most frequently used by these species for foraging and/or breeding and roosting. The woodland areas away from the riparian corridors, which would be impacted by the activities, are widespread within the broader study area. As such the small area to be impacted by the exploration activities is not considered to be of high importance for ground and mid-storey foraging woodland birds.

In addition, no critical habitat has been declared by the Director General for Brown Treecreepers, Diamond Firetails, Gilbert's Whistlers, Grey-crowned Babblers, Hooded Robins, Scarlet Robins, Speckled Warblers, or Varied Sittellas.

Many of the ground and mid-storey foraging woodland birds require remnants of minimum sizes. Diamond Firetails appear unable to persist in areas which lack remnants larger than 200 ha. Hooded Robins appear unable to survive in remnants smaller than 100-200 ha. Scarlet Robins are less common in isolated patches of 30 ha or less where there is no tree cover within 200 m and less than 20% cover within 1 km. Speckled Warblers require remnants larger than 100 ha in size (NSW Scientific Committee 2001). Isolation of populations in small remnants increases vulnerability to local extinction as a result of stochastic events and can decrease their genetic viability in the long term.

Nevertheless, the design of the exploration activities is considered unlikely to isolate large areas of potential habitat from one another. While some species, such as Grey-crowned Babblers which have laborious flight, may be unable to fly across well pads, vegetation surrounding these sites would be retained and allow for these species to move between the exploration activity areas. Vegetation above any linear infrastructure would be rehabilitated, reducing the width of the disturbed habitat type and thus, reducing the level of fragmentation.

Areas of habitat that would not be removed could be indirectly impacted by disturbance to the point that ground and mid-storey foraging woodland birds could avoid these areas of potential habitat. Habitats fragmented by new access roads, or well pad and other exploration activity areas, would experience increased edge effects, including increased traffic volumes, which ground and mid-storey foraging woodland birds could avoid. Weeds could invade remaining areas of habitat reducing the foraging resources of Diamond Firetail, Gilbert's Whistler, and Speckled Warbler, which amongst other food resources, feed on native grasses, vegetative material and seeds. However, the implementation of mitigation and management measures for the exploration activities is considered sufficient in reducing these indirect impacts. Such measures include appropriate traffic controls, best-practice construction techniques, rehabilitation of disturbed areas, weed and feral animal control programs. Furthermore, the exploration activities are not inconsistent with the objectives of any threat abatement plan relevant to ground and mid-storey foraging woodland species.

In conclusion, the exploration activities are unlikely to constitute a significant impact on, Grey-crowned Babbler, Diamond Firetail, Gilbert's Whistler, Scarlet Robin, Speckled Warbler, Varied Sittella and Hooded Robin as the proposed activities:

- Would minimise impacts on the most important habitat areas for these species (large alluvial woodland areas)
- Have been designed to minimise the total area of foraging, roosting and breeding habitat to be impacted
- Would only remove a minor proportion of the total area of habitat available to these species. In addition, the activities will retain significant proportions of grassy woodland habitats in PEL 238
- Are unlikely to isolate or reduce areas of potential habitat from interconnecting areas of similar habitat to the point that thresholds for remnants of minimum sizes for these species are met.

5.1.6 Woodland birds – canopy foraging (excluding parrots)

The Black-chinned Honeyeater, Regent Honeyeater and Painted Honeyeater are considered in this impact assessment. The Black-chinned Honeyeater occupies mostly upper levels of drier open forests or woodlands dominated by box and ironbark eucalypts, especially Mugga Ironbark, White Box, Inland Grey Box, Yellow Box and Forest Red Gum. The Painted Honeyeater inhabits Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests. The Regent Honeyeater inhabits dry open forest and

woodland, particularly Box-Ironbark woodland, and riparian forests of *Casuarina cunninghamiana* (River Oak).

None of these species have been recorded within the exploration activity areas. However, the activities could potentially impact on the life cycles of Black-chinned, Painted, and Regent Honeyeaters by reducing the amount of foraging, roosting and breeding habitat available to the species (**Table 5**). Regent Honeyeaters are not considered likely to breed in PEL 238. Black-chinned and Painted Honeyeaters forage, roost and breed across the PEL 238 area. All three of the species have been identified as species that are negatively impacted by land clearing (and therefore habitat loss) (Biosis 2002).

The exploration activities have resulted in the removal and/or modification of up to 123.5 ha of potential habitat (foraging, breeding or roosting/sheltering) for the threatened canopy feeding woodland birds with a further 36.4 ha of potential habitat proposed to be removed. The cumulative impacts as a result of the exploration activities is 159.9 ha (**Table 5**). This loss is considered relatively minor in the context of similar habitat within PEL 238, constituting up to 0.05% of available habitat for these threatened woodland birds.

The exploration activities would largely avoid riparian vegetation communities (primarily the Pilliga Box – Poplar Box – White Cypress, Rough-barked Apple and Fuzzy Box), thus retaining grassy woodland habitats used by Black-chinned, Painted, and Regent Honeyeaters. No new major creek crossings traversing potential foraging and/or breeding habitat would be constructed, and no in stream devices would be installed which would impact on the natural hydrology of creek lines and the integrity of riparian vegetation. The woodland areas which would be impacted by the exploration activities are widespread within PEL 238 and the locality. As such the small area to be impacted by the exploration activities is not considered to be of high importance for the canopy foraging woodland birds. In addition, no critical habitat has been declared for the Black-chinned, Painted, or Regent Honeyeaters.

The exploration activities could also impact on the life cycles of Black-chinned Honeyeaters through decreases in the sizes of intact habitat. Similar to some ground and mid-storey foraging woodland birds, Black-chinned Honeyeater does not persist in remnants less than 200 ha in area (NSW Scientific Committee 2001b). However, while locally nomadic, they tend to forage in home ranges of around 5 ha (OEH 2013b).

The exploration activities would also retain the majority of vegetation representing foraging, roosting and/or breeding habitat for these species. Thus, the remaining habitat remnants would not be completely fragmented from other remnants. Adjacent patches would together form larger patches of vegetation that Black-chinned, Painted, and Regent Honeyeaters would be able to use, provided these species did not avoid areas degraded by noise and light disturbance.

Areas of habitat that would not be removed could be indirectly impacted by disturbance to the point that Black-chinned, Painted and Regent Honeyeaters could avoid these areas of potential habitat. However, the implementation of mitigation and management measures for the exploration activities is considered sufficient in reducing these indirect impacts. Such measures include appropriate traffic controls, best-practice construction techniques, rehabilitation of disturbed areas, weed and feral animal control programs.

Furthermore, the exploration activities are not inconsistent with the objectives of any threat abatement plan relevant to these species, nor the recovery plan prepared for the Regent Honeyeater (DNRE 1999), which has the overall objective of ensuring the species persists in the wild and is down-listed from endangered to vulnerable.

The exploration activities are unlikely to constitute a significant impact on the Black-chinned, Painted, or Regent Honeyeaters as the proposed exploration activities:

- Have been designed to minimise the total area of foraging, roosting and breeding habitat to be impacted
- Would only remove a minor proportion of the total area of habitat available to these species within PEL 238
- Would not isolate areas of potential habitat from currently interconnecting areas of habitat or reduce intact habitat to the point that Black-chinned, Painted, and Regent Honeyeaters can no longer persist.

5.2 Mammals

5.2.1 Arboreal mammals and megabats:

The Grey-headed Flying Fox, Koala and Squirrel Glider are considered in this impact assessment. Koala's inhabit eucalypt woodlands and forests. The Squirrel Glider inhabits mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest with a shrubby or *Acacia* midstorey. Grey-headed Flying-foxes forage over a range of habitats, and Koalas and Squirrel Gliders occur in a number of open Eucalypt woodland communities supporting preferred feed trees and habitat elements such as tree hollows and a shrub mid-storey layer in the case of Squirrel Gliders (OEH 2013b).

Only the Koala has been recorded within the exploration activity areas. However, the exploration activities could impact on the life cycles of Grey-headed Flying-foxes, Koalas and Squirrel Gliders by reducing the amount of foraging, roosting and breeding habitat available to the species, or degrading their habitat (**Table 5**). Grey-headed Flying-foxes do not roost or breed in the exploration activity areas, but may use it to forage, while Koalas and Squirrel Gliders forage and potentially breed across the exploration activity areas. The potential habitats of these species would be reduced directly through the clearing of vegetation, including, HBTs that could be used by Squirrel Gliders to breed and shelter. No critical habitat has been declared for these species.

The exploration activities have resulted in the removal and/or modification of up to 123.5 ha of potential habitat (foraging, breeding or roosting/sheltering) for these threatened arboreal mammal and megabat species with a further 36.4 ha of potential habitat proposed to be removed. The cumulative impact as a result of the exploration activities is up to 159.9 ha (**Table 5**). This loss is considered relatively minor in the context of similar habitats within PEL 238, constituting up to 0.05% of available habitat for these species.

While the exploration activities would result in the removal of some habitat, the activities have sought to avoid riparian vegetation communities (e.g. Pilliga Box – Poplar Box – White Cypress, Rough-barked Apple and Fuzzy Box) with high densities of HBTs, thus retaining the majority of hollows in this area for Squirrel Gliders, and foraging habitat for Grey-headed Flying-foxes and Koalas. In addition, the locations of the exploration activities have been flexible where possible and conducted in areas with lower densities of hollow-bearing/mature trees further supporting foraging and/or breeding resources. Other habitat elements such as logs would be stockpiled and redistributed during rehabilitation works, or would be relocated to surrounding areas.

Areas of habitat that would not be removed could be indirectly reduced/affected by fragmentation and disturbance (i.e. habitat could be degraded) impacting on Grey-headed Flying-foxes, Koalas and Squirrel Gliders. The exploration activities could also directly impact Koalas by increasing the mortality

rates of the species through increased collisions with vehicles and increased predation by feral or domestic dogs. Furthermore, Squirrel Gliders could be affected by the presence of barbed wire fences around gas well pads, as individuals can get caught on such fences when gliding (OEH 2013b).

Many of the disturbances that could potentially result from the exploration activities are listed as key threats to Grey-headed Flying Foxes, Koalas and Squirrel Gliders, such as the loss and modification of habitat. Furthermore, disturbance to roosting sites, unregulated shooting, and electrocution on powerlines are listed as key threats to Grey-headed Flying Fox. Human-induced climate change, especially drought, fragmentation of habitat, predation by feral and domestic dogs, intense fires that scorch or kill the tree canopy, and collisions with vehicles are key threats to Koalas. Fragmentation of habitat, loss of hollow-bearing trees and flowering understorey and mid-storey shrubs, and barbed wire fences in which individuals can get caught are key threats to Squirrel Glider (OEH 2013b).

The implementation of mitigation and management measures for the exploration activities is considered sufficient in reducing these indirect impacts and disturbances outlined above. Such measures include appropriate traffic controls, best-practice construction techniques, rehabilitation of disturbed areas, minimisation of fragmentation, fauna friendly fencing (in accordance with Santos' Fencing Standard). and weed and feral animal control initiatives. Furthermore, the exploration activities are not inconsistent with the objectives of any recovery plans (Koala and Grey-headed Flying Fox) and threat abatement plans relevant to these species.

In consideration of the above, the exploration activities are not likely to have a significant impact on Grey-headed Flying-foxes, Koalas and Squirrel Gliders in the exploration activity areas.

5.2.2 Ground and log dependent mammals:

The mid-storey and log dependent mammals considered in this impact assessment are the Black-striped Wallaby, Eastern Pygmy-possum, Pilliga Mouse and Spotted-tailed Quoll.

It is important to note that the Pilliga Mouse is now considered a southern population of the widespread *Pseudomys delicatulus* (Delicate Mouse) based on genetic analyses, morphological studies and recent surveys which revealed a continuous distribution of the Delicate Mouse to the Pilliga region (Breed and Ford 2007; Ford 2008, as cited in SEWPaC 2012). It is important to note that this taxonomic change has not yet been formally recognised; hence this assessment considers the Pilliga Mouse as currently listed.

The Black-striped Wallaby prefers habitat characterised by dense woody or shrubby vegetation within three metres of the ground. This dense vegetation must occur near a more open, grassy area to provide suitable feeding habitat. The Eastern Pygmy-possum appears to prefer woodland and heath habitat types, but can also be found in a rainforest and sclerophyll forests. The Pilliga Mouse is restricted to an isolated area of low-nutrient deep sand which has long been recognised as supporting a distinctive vegetation community (Pilliga Scrub), but may forage outside this vegetation type. The Spotted-tailed Quoll is found in a variety of habitats, including sclerophyll forest and woodlands, coastal heathlands and rainforests. No critical habitat has been declared for these species.

Of these species, only the Pilliga Mouse, Black-striped Wallaby and Eastern Pygmy-possum have been recorded within the exploration activity areas.

The cumulative impact from the exploration activities to Pilliga Mouse breeding habitat is up to 26.3 ha (21.6 ha previously cleared and 4.7 ha is proposed to be cleared). This represents 0.1% of all potential habitat within ESG's former NGDP area and less than 0.01% of potential habitat within PEL 238. As

such, the clearing of up to 26.3 ha of Pilliga Mouse breeding habitat is not considered likely to have a significant impact on the Pilliga Mouse.

In addition to the direct impacts to the Pilliga Mouse habitat described above, the exploration activities (all existing and proposed) could impact on the life cycles of the other three mammal species by reducing the amount of foraging, sheltering and breeding habitat available (through clearing of vegetation), or degradation of habitat. Of particular importance is the potential removal of HBTs that could be used by Eastern Pygmy-possums and Spotted-tailed Quolls to breed and shelter.

The exploration activities have resulted in the removal and/or modification of up to 189.8 ha of potential habitat (foraging, breeding or roosting/sheltering) for Black-striped Wallaby, Eastern Pygmy-possum and Spotted-tailed Quoll with a further 36.4 ha of potential habitat proposed to be removed. The cumulative impact as a result of the exploration activities is up to 224.9 ha (**Table 5**). This loss is considered relatively minor in the context of similar habitats within PEL 238, constituting up to 0.05% of available habitat for these species.

The exploration activities largely avoid vegetation communities with high densities of hollows (e.g. primarily the Pilliga Box – Poplar Box – White Cypress, Rough-barked Apple and Fuzzy Box vegetation types), thus retaining hollows for Eastern Pygmy-possums to shelter and breed in, and grassy woodland habitat for Black-striped Wallabies and Spotted-tailed Quolls to forage. No new major creek crossings traversing potential foraging and/or breeding habitat would be constructed, and no in stream devices would be installed which would impact on the natural hydrology of creek lines and the integrity of riparian vegetation. Further, the locations of the exploration activities have been flexible and designed to be located in areas with lower densities of HBTs.

Areas of habitat that would not be removed could be indirectly reduced/affected by fragmentation and disturbance (i.e. habitat could be degraded) impacting on these species and/or creating barrier effects at the local level for Eastern Pygmy-possums and Pilliga Mice. Black-striped Wallabies are mobile with home ranges of 90 ha and Spotted-tailed Quolls are highly mobile with ranges between 2,000 and 5,000 ha.

Eastern Pygmy-possums have small home ranges, with males having non-exclusive home-ranges of about 0.68 ha and females about 0.35 ha (OEH 2013b), but have been recorded moving 450 m in overnight movements (Bladon *et al.* 2002). Following construction, linear infrastructure will be partially rehabilitated, reducing the width of the disturbed habitat and thus any level of fragmentation. Furthermore, habitat connectivity would be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the broader study area, limiting any fragmentation impact on the Eastern Pygmy-possum or Pilliga Mouse.

Many of the disturbances that could potentially result from the exploration activities are listed as key threats to the ground and log dependent mammals. Clearing and fragmentation of habitat and degradation of habitat (through grazing, weeds, collection of firewood, or inappropriate levels of Broombush harvesting) are listed as key threats to these species. Inappropriate fire regimes affecting habitat elements and predation by introduced animals including cats, foxes, and dogs are key threats to Black-striped Wallabies, Eastern Pygmy-possums and Pilliga Mice. Deliberate or accidental killing by poisoning or shooting/trapping are threats to Black-striped Wallabies and Spotted-tailed Quolls. Further, risk of local extinction because populations are small and isolated is a key threat to Black-striped Wallaby. Declining shrub diversity in forests and woodlands due to overgrazing by stock and rabbits is a key threat to Eastern Pygmy-possums. Competition from House Mice is a key threat to Pilliga Mice. Competition with introduced predators such as cats and foxes is a key threat to Spotted-tailed Quoll (OEH 2013b).

The implementation of mitigation and management measures for the exploration activities is considered sufficient in reducing these indirect impacts and disturbances outlined above. Such measures include appropriate traffic controls, best-practice construction techniques, rehabilitation of disturbed areas, minimisation of fragmentation, and weed and feral animal control initiatives. Furthermore, the exploration activities are not inconsistent with the objectives of the threat abatement plans relevant to these mid-storey and log dependent mammals.

In respect to the above, it is considered that the explorative activities will not have a significant impact on the Black-striped Wallaby, Eastern Pygmy-possum, Pilliga Mouse and Spotted-tailed Quoll in the exploration activity areas.

5.2.3 Grassy woodland mammals:

The grassy woodland mammal considered in this impact assessment is the Rufous Bettong. This species inhabits a variety of forests from tall, moist eucalypt forest to open woodland, with a sparse or tussock grass understorey. No critical habitat has been declared for this species.

This species has not been recorded in the exploration activity areas, however the activities could impact on the life cycle of Rufous Bettongs by reducing the amount of foraging, sheltering and breeding habitat (clearing of vegetation) available to the species, or degrading its habitat (**Table 5**). The species is highly mobile, requiring large areas of habitat with foraging movements recorded as 2 to 4.5 km a night.

The exploration activities have resulted in the removal and/or modification of up to 179.7 ha of potential habitat (foraging, breeding or roosting/sheltering) for the Rufous Bettong with a further 33.1 ha of potential habitat proposed to be removed. The cumulative impacts as a result of the exploration activities is 212.8 ha (**Table 5**). This loss is considered relatively minor in the context of similar habitats within PEL 238, constituting up to 0.16 % of available habitat for this species.

The woodland areas which would be impacted by the exploration activities are widespread within PEL 238. As such the small area to be impacted by the exploration activities is not considered to be of high importance for the Rufous Bettong. In addition, habitat elements within impacted areas such as logs would be stockpiled and redistributed during partial rehabilitation works, or would be relocated to surrounding areas.

Habitat connectivity for the Rufous Bettong would be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the exploration activity areas. This greatly mitigates against a number of disturbances (such as fragmentation and degradation of foraging habitat due to weeds or introduced predators) that would otherwise impact species that are restricted in range and not highly mobile. In addition, the implementation of mitigation and management measures for the exploration activities is considered sufficient in reducing these disturbances. Such measures include appropriate traffic controls, best-practice construction techniques, rehabilitation of disturbed areas, minimisation of fragmentation, and weed and feral animal control initiatives.

In consideration of the above, it is unlikely that the explorative activities will not have a significant impact on the Rufous Bettong in the exploration activity areas.

5.2.4 Predominantly tree-roosting bats:

The predominantly tree-roosting bats considered in this impact assessment are the Yellow-bellied Sheathtail-bat and Greater Long-eared Bat. Both the Yellow-bellied Sheathtail-bat and Greater Long-eared Bat have been recorded within the exploration activity areas.

The Yellow-bellied Sheathtail-bat roosts singly or in groups of up to six, in tree hollows and buildings. The Greater Long-eared Bat inhabits a variety of vegetation types, including mallee, Bulloak and box eucalypt dominated communities. The Greater Long-eared Bat roosts in tree hollows, crevices, and under loose bark. No critical habitat has been determined for either species.

Both species of bat are likely to forage, roost and breed in the area, with the Yellow-bellied Sheathtail-bats migrating to the southern parts of Australia during late summer or autumn months. The Pilliga area is considered a strong-hold for the Greater Long-eared Bats (Churchill 1998). The exploration activities largely avoids vegetation communities with high densities of hollows (primarily the Pilliga Box – Poplar Box – White Cypress, Rough-barked Apple and Fuzzy Box vegetation types), retaining areas with higher densities of potential roosting and breeding sites for both species. No new major creek crossings traversing potential foraging and/or breeding habitat would be constructed, and no in stream devices would be installed which would impact on the natural hydrology of creek lines and the integrity of riparian vegetation. Furthermore, the locations of the exploration activities have been flexible and designed to be located in areas with lower densities of HBTs.

The exploration activities have resulted in the removal and/or modification of up to 200.7 ha of potential habitat (foraging, breeding or roosting/sheltering) for the two bat species with a further 36.4 ha of potential habitat proposed to be removed. The cumulative impacts as a result of the exploration activities is 237.1 ha (**Table 5**). This loss is considered relatively minor in the context of similar habitats within PEL 238, constituting up to 0.05% of available habitat for these species.

Indirect impacts on these bat species, including disturbance from noise and or light could add to the impacts associated with habitat loss and or modification. It is possible that Greater Long-eared Bats would avoid areas of noise disturbance while foraging. Yellow-bellied Sheathtail-bats are considered less likely to be affected by noise as the species forages aerially, above the canopy. However, bats of many species have been found roosting in areas disturbed by noise (Schaub *et al.* 2008); thus, it is unlikely that these bat species would be disturbed by noise while roosting. In addition, indirect impacts have largely been minimised through appropriate management controls and best-practice construction techniques. Following construction, linear infrastructure will be partially rehabilitated, reducing the width of the disturbed habitat and thus any level of fragmentation. Weed spread would be controlled to limit the potential for habitat degradation and therefore limit impacts on habitat containing bat prey. More importantly, noise would largely be kept to a minimum and constant, rather than intermittent.

The exploration activities are unlikely to constitute a significant impact on the Yellow-bellied Sheathtail-bat or the Greater Long-eared Bat as they:

- Would minimise impacts on the most important habitat areas for these species (large alluvial woodland areas and riparian habitats containing roosting sites)
- Have been designed to minimise the total area of foraging, roosting and breeding habitat to be impacted including the number of hollow bearing trees to be removed
- Would only remove a small proportion of the total area of habitat available to these species.
- Indirect disturbances have / will be adequately managed to mitigate potential impacts relating to noise, light, and habitat degradation.

5.2.5 Predominantly cave-roosting bats:

The Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat and Little Pied Bat are considered in this impact assessment. Only the Little Pied Bat, Eastern Bentwing-bat and Eastern Cave Bat have been recorded within the exploration activity areas.

The Eastern Bentwing-bat occupies a range of forested environments (including wet and dry sclerophyll forests). The Eastern Cave Bat is usually found in dry open forest and woodland, near cliffs or rocky overhangs. The Large-eared Pied Bat is found in well-timbered areas containing gullies in dry open forest and woodland close to caves or other roost sites. The Little-Pied Bat occurs in dry open forest, open woodland, mulga woodlands, chenopod shrublands, cypress-pine forest, mallee, Bimbil box. No critical habitat has been declared for these species.

The exploration activities could potentially impact on the life cycles of the bat species by reducing the amount of foraging and roosting and breeding habitat available for the Little Pied Bat and the amount of foraging habitat for the Eastern Bentwing-bats, Eastern Cave Bats and Large-eared Pied Bats (**Table 5**). However, these species are predominantly cave-roosting and breeding (Churchill 1998) and since the activities do not impact on caves, it is predominantly foraging habitat that would be reduced by the activities. An exception exists for the Little Pied Bat that can also use tree hollows for roosting.

The exploration activities have resulted in the removal and/or modification of up to 200.7 ha of potential foraging habitat for these four bat species with a further 36.4 ha of potential habitat proposed to be removed. The cumulative impacts as a result of the exploration activities is 237.1 ha (**Table 5**). This loss is considered relatively minor in the context of similar habitats within PEL 238, constituting up to 0.05% of available habitat for these species. The small area to be impacted by the exploration activities compared to the available habitat is not considered to be of high importance for the bat species.

Retention of vegetation outside the impact areas would continue to support these bat species in the study area. No new major creek crossings traversing potential foraging and/or roosting habitat would be constructed, and no in stream devices would be installed which would impact on the natural hydrology of creek lines and the integrity of riparian vegetation. Furthermore, the locations of the exploration activities have been flexible and designed to be located in areas with lower densities of HBTs and away from prime foraging habitat such as near water sources.

The exploration activities could impact the predominantly cave-roosting species through decreases in the sizes of intact habitat. Little Pied Bats, when roosting in trees, have been found to maintain roosts within 200 m of each other. Eastern Cave Bats have been recorded using only 33 ha over 5 consecutive days (Churchill 1998). Eastern Bentwing Bat, Eastern Cave Bat and Little Pied Bat could also be impacted through the potential increases in the numbers of introduced predators as a result of the exploration activities. These species are threatened by predation by cats and foxes.

Further, indirect impacts on these bat species, including disturbance from noise and or light could add to the impacts associated with foraging habitat loss and / or modification. However, overseas studies on bats that listen for their prey in addition to using echolocation have found that these bats avoid areas with noise disturbance while foraging (Schaub *et al.* 2008). It is possible that Large-eared Pied Bats forage in a similar manner to the bat species investigated as they forage under the canopy and close to the ground. As such, it is possible that Large-eared Pied Bats would avoid areas of noise disturbance while foraging. Eastern Bentwing-bats, Eastern Cave Bats and Little Pied Bats are considered less likely to be affected by noise as these species forage aerially, above or within the canopy, or catch their prey from water.

Following construction, linear infrastructure will be partially rehabilitated, reducing the level of habitat

fragmentation and maintaining a suitable size of intact foraging habitat for the bat species. Weed spread would be controlled to limit the potential for habitat degradation and therefore limit impacts on habitat containing bat prey. More importantly, noise would largely be kept to a minimum and constant, rather than intermittent.

The exploration activities are unlikely to constitute a significant impact on the Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat, or the Little Pied Bat as they:

- Largely do not impact breeding / roosting habitat as no caves fall within the exploration activity areas
- Have been designed to minimise the total area of foraging habitat to be impacted
- Would only remove a small proportion of the total area of habitat available to these species in PEL 238
- Have been designed and managed in a way to limit the impact of indirect impacts
- Would not isolate areas of potential foraging habitat from currently interconnecting areas of potential habitat for these species.

5.3 Reptiles

5.3.1 Tree and log dependent reptiles

The Pale-headed Snake is considered in this impact assessment. It has not been recorded within the exploration activity areas.

The species is found mainly in dry eucalypt forests and woodlands, cypress woodland and occasionally in rainforest or moist eucalypt forest. It favours streamside areas, particularly in drier habitats. It shelters during the day between loose bark and tree-trunks, or in hollow trunks and limbs of dead trees. No critical habitat has been declared for this species.

The exploration activities could impact on the life cycle of the Pale-headed Snake by reducing the amount of foraging, sheltering and breeding habitat available to the species (**Table 5**). The exploration activities largely avoids riparian vegetation communities with high densities of hollows that can be used for sheltering and breeding (primarily the Pilliga Box – Poplar Box – White Cypress, Rough-barked Apple and Fuzzy Box vegetation types) and retain grassy woodland habitats.

The exploration activities have resulted in the removal and/or modification of up to 200.7 ha of potential habitat (foraging, breeding or roosting/sheltering) for the Pale-headed Snake with a further 36.4 ha of potential habitat proposed to be removed. The cumulative impacts as a result of the exploration activities is 237.1 ha (**Table 5**). This loss is considered relatively minor in the context of similar habitats within PEL 238, constituting up to 0.05% of available habitat for this species. The small area to be impacted by the activities compared to the available habitat is not considered to be of high importance for the bat species.

Areas of habitat that would not be removed could be indirectly reduced by disturbance to the point that Pale-headed Snake could avoid these areas of potential habitat. Habitats fragmented by linear infrastructure would experience edge effects, including increased traffic volumes, which Pale-headed Snakes could avoid. Weeds could potentially invade remaining areas of habitat reducing the foraging resources of prey species. However, the implementation of mitigation and management measures for the exploration activities is considered sufficient in reducing these indirect impacts and disturbances.

Such measures include appropriate traffic controls, best-practice construction techniques, rehabilitation of disturbed areas, minimisation of fragmentation and weed and feral animal control initiatives.

In addition, the exploration activities would retain the majority of foraging and/or breeding habitat for the Pale-headed Snake in PEL 238. The remaining vegetation remnants would not be completely fragmented from other remnants with adjacent patches forming larger areas that Pale-headed Snakes would be able to use.

The exploration activities are unlikely to constitute a significant impact on the Pale-headed Snake as they:

- Have been designed to minimise the total area of foraging, roosting and breeding habitat to be impacted including the number of hollow bearing trees to be removed
- Would only remove a small proportion of the total area of habitat available to this species in PEL 238
- Have been designed and managed in a way to limit the impact of indirect impacts
- Would not isolate areas of potential habitat from currently interconnecting areas of potential habitat for the Pale-headed Snake.

5.4 Plants

5.4.1 Threatened flora

The following impact assessment includes *Bertya opponens, Diuris tricolor, Lepidium monoplocoides, Polygala linariifolia, Pomaderris queenslandica, Pterostylis cobarensis, Rulingia procumbens, and Tylophora linearis*.

Significant impacts for these threatened species are assessed on the number individuals or populations directly impacted by the exploration activities relative to the broader PEL 238 area. Considerations are also given to important and critical habitat, as well as likely indirect impacts on potential habitat. No critical habitat under the TSC Act has been declared for these species.

Detailed targeted surveys within the exploration activity areas and broader Pilliga region have identified populations of these threatened species. The exploration activity areas and PEL 238 is known to support each of the threatened flora species identified above, however, only *Tylophora linearis, Pterostylis cobarensis*, *Polygala linariifolia* and *Diuris tricolor* have been recorded in or within close proximity to the exploration activity areas.

The magnitude of the impacts resulting from the exploration activities can be inferred from habitat modelling using the details of the targeted surveys (ELA 2012). There are a number of considerations relevant to the habitat modelling and the assessment of significance of impacts to flora species from exploration activities. Taking into account the ecology of the species and the habitat information collected from the targeted surveys, the number of individuals potentially impacted by the proposed exploration activities was only calculated for *Tylophora linearis* and *Pterostylis cobarensis.*

- *Tylophora linearis*: The habitat modelling for *Tylophora linearis* has predicted a cumulative impact to 59 individuals, with 30 individuals from existing exploration activities and 29 from proposed exploration activities. This accounts for 0.34% of the individuals predicted to occur within the study area.

- *Pterostylis cobarensis*: The habitat modelling for *Pterostylis cobarensis* has predicted a cumulative impact to 656 individuals, with 471 individuals from existing exploration activities and 185 from proposed exploration activities. This accounts for 0.19% of the individuals predicted to occur within the study area.

Reliable modelling has yet to be developed for the other two species (*Polygala linariifolia* and *Diuris tricolor*) that are known to occur within the exploration activity areas. Considering no direct impacts are likely to occur for *Pomaderris queenslandica, Bertya opponens, Rulingia procumbens* or *Lepidium monoplocoides* as a result of the exploration activities, habitat modelling for these species has not been developed.

As with the threatened fauna species, only a very small proportion of potential habitat for these species has been impacted relative to available habitat in the PEL 238. Habitat for these species is widespread across the Pilliga region, with significant populations of some species, *Bertya opponens, Lepidium monoplocoides, Pterostylis cobarensis*, *Rulingia procumbens* and *Tylophora linearis* identified outside of the study area including populations within State Forests, National Parks, Nature Reserves and State Conservation Areas. Therefore, significant impacts to the lifecycle and important habitat to these species are unlikely to result from the exploration activities.

The exploration activities have the potential to increase the spread of weed species through the introduction of plant and/or seed material from vehicles and other equipment or through increased penetration of the forest along new access tracks and other disturbed areas. Weed and fungal invasion has the potential to degrade the habitat of these species and weed species may directly compete with them. To address these potential threats, Santos has prepared a weed management strategy and a comprehensive rehabilitation strategy will be prepared which will address issues of restoration, weed invasion and feral animal invasion over the life of the program.

Significant impacts on the threatened flora species are considered unlikely given:

- The small extent of impacts from proposed exploration activities relative to available habitat in PEL 238
- That available potential habitat will not been significantly reduced to an extent likely to cause a significant decline in the species populations
- The demonstrated and anticipated rehabilitation of many areas of impact
- Potential indirect impacts, such as weed invasion are being actively managed.

5.5 Endangered Ecological Communities

5.5.1 Brigalow – Belah Woodland on alluvial often gilgaied clay soil, mainly Brigalow Belt South

Brigalow – Belah Woodland on alluvial often gilgaied clay soil, mainly Brigalow Belt South (Brigalow – Belah Woodland) is part of the TSC Act listed endangered ecological community known as *Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregion*. It is an open forest or woodland up to 25 m high dominated by *Acacia harpophylla* (Brigalow) often with *Casuarina cristata* (Belah) on less gilgaied clays. It usually contains a sparse shrub layer and ground layer with a lot of leaf litter.

This community has been extensively cleared for agriculture, with most of the remaining remnants existing along roadsides and paddock edges (OEH 2013b). The listed threats to this community include clearing and fragmentation, road works and maintenance activities and weed invasion.

Previous exploration activities have required the clearing of approximately 10.22 ha the Brigalow – Belah Woodland (**Table 3**) within PEL 238. However the majority of this EEC (99.9%) has been retained within the broader PEL 238 area.

The exploration activities have the potential to increase existing disturbance regimes, many of which are listed as key threats to Brigalow – Belah Woodland. These include:

- Clearing of remaining remnants and isolated paddock trees
- Senescence and lack of regeneration
- Inappropriate fire regimes
- Invasion of weeds.

However, the implementation of mitigation and management measures for the exploration activities is considered sufficient in reducing these disturbances. Such measures include best-practice construction techniques, rehabilitation of disturbed areas, minimisation of fragmentation and weed control initiatives.

In respect to the information presented above, it is considered unlikely that the exploration activities will have had a significant impact on this EEC.

5.5.2 White Box-Yellow Box-Blakely's Red Gum Grassy Woodland

White Box-Yellow Box-Blakely's Red Gum Grassy Woodland (Box Gum Woodland) is an EEC. The community is characterised by an overstorey dominated, or was once dominated by *Eucalyptus albens* (White Box), *E. melliodora* (Yellow Box) or *E. blakelyi* (Blakely's Red Gum). It contains a species-rich understorey of native tussock grasses, herbs and forbs. The tree-cover is generally discontinuous and consists of widely-spaced trees of medium height in which the canopies are clearly separated. In NSW the community is found from the Queensland border in the north, to the Victorian border in the south along the tablelands and western slopes areas.

Much of the woodlands with a canopy dominated or co-dominated by *Eucalyptus blakelyi* (Blakely's Red Gum) within the study area typically have dense shrub and midstorey layers, have very sparse ground layers and are located on poor sandy or rocky soils and do not qualify as the TSC Act listed EEC.

There is potential for areas of Box Gum Woodland (those dominated or co-dominated by *E. blakleyi* with an open grassy understorey) to occur within the mapped *Rough-barked Apple riparian forb/grass open forest* vegetation type, particularly along the larger floodplain of Bohena Creek and its tributaries, however these areas will require assessment based on the floristic, soil and structural characteristics to determine the presence of this community.

Approximately 0.26 ha (an area of 200 m x 12 m width) of Box Gum Woodland in the vicinity of Bohena Creek in the central portion of the study area may have been impacted by exploration activities to date, however further assessment of this vegetation is required to determine its status as an EEC due to the factors mentioned above.

It is considered unlikely that the cumulative impacts of exploration activities have significantly reduced or adversely affected Box Gum Woodland, given its currently undetermined status.

5.5.3 Fuzzy Box Woodland on alluvial soils

Fuzzy Box Woodland is a tall woodland or open forest with a canopy dominated by *Eucalyptus conica* (Fuzzy Box) and associated species such as *E. microcarpa*, *E. melliodora*, *Brachychiton populneus* (Kurrajong) and *Allocasuarina luehmannii* (OEH 2013b).

Within the study area, Fuzzy Box Woodland has been identified on the floodplain of Bohena Creek and its tributaries. Within this area, Fuzzy Box Woodland generally occurs upslope of Rough-barked Apple Riparian Forb/grass Open Forest.

Existing exploration activities have required the clearing of approximately 1.8 ha of Fuzzy Box Woodland (**Table 3**) in the study area which represents a loss of 0.61% of Fuzzy Box Woodland from within ESG's former NGDP area. Therefore, the amount of vegetation directly impacted comprises only a small portion of the total Fuzzy Box Woodland in ESG's former NGDP area and potentially much less in the study area. The proportion of this impacted EEC within PEL 238 has not been calculated as the regional mapping available does not map this community at a fine enough scale.

The exploration activities have the potential to increase existing disturbance regimes, many of which are listed as key threats to Fuzzy Box Woodland. These include:

- Removal of vegetation and potential habitat
- Fragmentation of habitat
- Infection of native plants by *Phytophthora cinnamomi*
- Invasion of weeds
- Increases in fire.

However, the implementation of mitigation and management measures for the exploration activities is considered sufficient in reducing these disturbances. Such measures include best-practice construction techniques, rehabilitation of disturbed areas, minimisation of fragmentation and weed control initiatives.

Therefore, the removal of only 1.8 ha of Fuzzy Box Woodland is unlikely to place this EEC at risk of extinction in the study area, and thus a significant impact resulting from the exploration activities is considered unlikely.

6 Rehabilitation

Rehabilitation of existing exploration and appraisal activities is currently being undertaken. These activities provide a benchmark for understanding the potential reduction in impact as a result of rehabilitation works identified for the proposed program.

Santos has commenced a program of rehabilitation works throughout PEL 238 and PAL 2. Rehabilitation works include:

- reducing the size of existing well leases back to the minimum area required for operations
- plugging and abandoning, according to legislative requirements, wells that are no longer required for exploration and appraisal and rehabilitating associated well leases
- rehabilitating a number of water storage ponds that are no longer required for exploration and appraisal activities.

Actions undertaken during the clearing of vegetation include stockpiling 'waste' timber from felled trees not suitable for forestry activities, fallen logs and bush rock for later use in habitat restoration; low vegetation is slashed and mulched on site; and topsoil is striped and stockpiled. Rehabilitation actions include; replacing topsoil; re-installing habitat features such as fallen timber and bush rock; natural re-establishment of slashed and cleared native vegetation; and direct seeding where required.

Monitoring of rehabilitation activities has shown an overall site value close to 45% of nearby reference sites after two years. The replacement of topsoil is producing encouraging results, with sites showing a high number of native species when compared to reference sites. Rehabilitation measures undertaken have been considered using adaptive management principles with monitoring informing future modifications to works and methodology.

Rehabilitation works associated with the proposed program will follow the methods developed for the existing exploration and appraisal activities.

6.1 Vegetation dieback

Santos has identified approximately six hectares of vegetation dieback which has resulted from ESG's previous operations. The affected areas occur within the White Cypress Pine – Bulloak – Ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion vegetation type adjacent to areas cleared for infrastructure. Santos has progressed rehabilitation of these areas in consultation with the NSW Government. The vegetation dieback areas are not included in the cumulative clearing areas presented in Table 6.

To date, rehabilitation of approximately 28 hectares of land, including the vegetation dieback areas, has commenced.

7 Conclusion

Early stage exploration and production appraisal activities are not considered likely to have had a significant impact on ecological values listed under the TSC Act or the environment more broadly.

Measures have been taken in planning for and undertaking these works to minimise impacts. Existing tracks, roads and previously cleared areas have been utilised wherever possible and a strategy for managing the spread of exotic species has been developed.

This report has brought together information from a variety of sources to document the exploration activities and cumulative impacts associated with all existing and planned early-stage exploration and production appraisal activities within PEL 238 in relation to ecological values listed under the NSW TSC Act.

An assessment of the significance of cumulative impacts of the exploration activities under the TSC Act has been undertaken. Given the relatively small extent of clearing resulting from the exploration activities as a proportion of available habitat in PEL 238, the implementation of mitigation and management measures and the extent of rehabilitation, the exploration activities are not expected to significantly affect listed ecological values under the TSC Act. As such, a Species Impact Statement (SIS) is not likely to be required.

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Appendix A:

Provided below (**Table 6**) is the likelihood table for ecological values listed under the NSW TSC Act. Species, populations and communities considered to have the potential to occur are highlighted in yellow, those likely to occur are highlighted in brown, and those which are known occur are highlighted in green.

The likelihood of occurrence table includes an analysis of previous reports conducted by Eco Logical Australia (ELA) and RPS.

Key to the table:

- TSC Status = Listing under the *Threatened Species Conservation Act 1995*
- EPBC Status = Listing under the *Environment Protection and Biodiversity Conservation Act 1999*
- CE = Critically Endangered
- E = Endangered (EPBC Act)
- E1 = Endangered (TSC Act)
- E2 = Endangered Population (TSC Act)
- E4 = Extinct (TSC Act)
- V = Vulnerable

Table 6: NSW TSC Act threatened species and ecological communities likelihood of occurrence within the study area.

SCIENTIFIC NAME	COMMON NAME	TSC ACT	EPBC ACT	DISTRIBUTION	HABITAT	AVAILABILITY OF HABITAT IN STUDY AREA	LIKELIHOOD OF OCCURRENCE IN STUDY AREA
FAUNA							
Aepyprymnus rufescens	Rufous Bettong	V	~	The original range from Coen in north Queensland to central Victoria has been reduced to a patchy distribution from Cooktown, Queensland, to north-eastern NSW as far south as Mt Royal National Park. In NSW it has largely vanished from inland areas but there are sporadic, unconfirmed records from the Pilliga and Torrington districts. (OEH 2013b)	Prefer forests with a grassy to sparse understorey including coastal forest, tall wet sclerophyll forest and dry forests west of GDR (OEH 2013b). It is most commonly found on sites derived from sedimentary rock and in north eastern NSW in forests characterised by *Corymbia maculata* (Spotted Gum) and *C. henryi* (OEH 2013b). It has been known to feed on introduced pasture species (OEH 2013b).	Moderate	Potential
Alectura lathami	Australian Brush-turkey	E2	~	The Australian Brush-turkey has a largely coastal distribution from Cape York south as far as the Illawarra in NSW. A population of the Australian Brush-turkey is known from the Nandewar and Brigalow Belt South Bioregions. Recent records for the species show the population to range from north east of Warialda, to Narrabri, approximately 115 km to the south-west, and occur within the local government areas of Yallaroi, Bingara, Narrabri, Barraba and Moree Plains. (OEH 2013b)	It occurs in forested and wooded areas of tropical and warm-temperate districts, particularly above 300 m to at least 1200 m altitude. In NSW the inland vegetation type preferred by the Australian Brush-turkey is a dry rainforest community that is found within the Semi-evergreen Vine Thicket in the Brigalow Belt South and Nandewar Bioregions Endangered Ecological Community.(OEH 2013b)	No habitat	No
Anomalopus mackayi	Five-clawed Worm-skink	E1	V	Patchy distribution on the North West Slopes and Plains of north-east NSW and south-east Queensland, from the Ashford area west to Mungindi and Walgett in NSW and north to Dalby in Queensland.(OEH 2013b)	Close to or on the lower slopes of slight rises in grassy White Box woodland on moist black soils, and River Red Gum-Coolibah-Bimble Box woodland on deep cracking loose clay soils. May also occur in grassland areas and open paddocks with scattered trees. Live in permanent deep tunnel-like burrows and deep soil cracks, coming close to the surface under fallen timber and litter, especially partially buried logs.(OEH 2013b)	Low	Unlikely

SCIENTIFIC NAME	COMMON NAME	TSC ACT	EPBC ACT	DISTRIBUTION	HABITAT	AVAILABILITY OF HABITAT IN STUDY AREA	LIKELIHOOD OF OCCURRENCE IN STUDY AREA
Anseranas semipalmata	Magpie Goose	V	~	The Magpie Goose is still relatively common in the Australian northern tropics, but had disappeared from south-east Australia by 1920 due to drainage and overgrazing of reed swamps used for breeding. Since the 1980s there have been an increasing number of records in central and northern NSW. Vagrants can follow food sources to south-eastern NSW.(OEH 2013b)	Activities centred on terrestrial sedge-dominated wetlands; mainly those on floodplains of rivers (Marchant & Higgins 1993 Simpson & Day 1999).	Low	Unlikely
Anthochaera phrygia	Regent Honeyeater	CE	E,M, JAMBA	The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. Once recorded between Adelaide and the central coast of Queensland, its range has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland (OEH 2013b)	Associated with temperate eucalypt woodland and open forest including forest edges, wooded farmland and urban areas with mature eucalypts, and riparian forests of *Casuarina cunninghamiana* (River Oak) (Garnett 1993). Areas containing *Eucalyptus robusta* (Swamp Mahogany) in coastal areas have been observed to be utilised. The Regent Honeyeater primarily feeds on nectar from box and ironbark eucalypts and occasionally from banksias and mistletoes (NPWS 1995). As such it is reliant on locally abundant nectar sources with different flowering times to provide reliable supply of nectar (Environment Australia 2000).	High	Potential
Aprasia parapulchella	Pink-tailed Legless Lizard	V	V	It is known only to occur in the Central and Southern Tablelands and South Western Slopes of NSW. Populations have been recorded in the Queanbeyan/Canberra district, Cooma, Yass, Bathurst, Albury and West Wyalong areas.(DECC 2007)	It inhabits open woodland that has a predominately native grass understorey that is situated on sloping, well-drained soils with rocky outcrops or scattered partially buried rocks present. Burrows are formed beneath small, partially embedded rocks that are often inhabited by small black ants and termites. The Pink-tailed Worm-lizard feeds on the larvae and eggs of the ants with which it shares its burrows. In the summer months 2 eggs are laid inside the ant nests with the young first appearing in March. (DECC 2007)	Low	Unlikely

SCIENTIFIC NAME	COMMON NAME	TSC ACT	EPBC ACT	DISTRIBUTION	HABITAT	AVAILABILITY OF HABITAT IN STUDY AREA	LIKELIHOOD OF OCCURRENCE IN STUDY AREA
Ardeotis australis	Australian Bustard	E1	~	The Australian Bustard mainly occurs in inland Australia and is now scarce or absent from southern and south-eastern Australia. In NSW, they are mainly found in the north-west corner and less often recorded in the lower western and central west plains regions. Occasional vagrants are still seen as far east as the western slopes and Riverine plain. Breeding now only occurs in the north-west region of NSW.(OEH 2013b)	Mainly inhabits tussock and hummock grasslands, though prefers tussock grasses to hummock grasses; also occurs in low shrublands and low open grassy woodlands; occasionally seen in pastoral and cropping country, golf courses and near dams.(OEH 2013b)	High	Potential
Botaurus poiciloptilus	Australasian Bittern	V	~	Australasian Bitterns are widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west (OEH 2013b)	Terrestrial wetlands with tall dense vegetation, occasionally estuarine habitats (Marchant & Higgins 1993). Reedbeds, swamps, streams, estuaries (Simpson & Day 1999).	Low	Unlikely
Burhinus grallarius	Bush Stone-curlew	E1	~	The Bush Stone-curlew is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is it still common however and in the south-east it is either rare or extinct throughout its former range.	Associated with dry open woodland with grassy areas, dune scrubs, in savanna areas, the fringes of mangroves, golf courses and open forest / farmland (Pittwater Council 2000; Marchant & Higgins 1993). Forages in areas with fallen timber, leaf litter, little undergrowth and where the grass is short and patchy (Environment Australia 2000; Marchant & Higgins 1993). Is thought to require large tracts of habitat to support breeding, in which there is a preference for relatively undisturbed in lightly disturbed	High	Known
Cacatua leadbeateri	Pink Cockatoo	V	~	Found across the arid and semi-arid inland, from south-western Queensland south to north-west Victoria, through most of South Australia, north into the south-west Northern Territory and across to the west coast between Shark Bay and about Jurien. In NSW it is found regularly as far east as about Bourke and Griffith, and sporadically further east than that. (OEH 2013b)	Inhabits a wide range of tree and treeless inland habitats, always within easy reach of water. Feeds mostly on the ground, especially on the seeds of native and exotic melons and on the seeds of species of saltbush, wattles and cypress pines. (OEH 2013b)	Moderate	Unlikely

SCIENTIFIC NAME	COMMON NAME	TSC ACT	EPBC ACT	DISTRIBUTION	HABITAT	AVAILABILITY OF HABITAT IN STUDY AREA	LIKELIHOOD OF OCCURRENCE IN STUDY AREA
Calyptorhynchus banksii	Red-tailed Black-Cockatoo	V	E, M, JAMBA	The Red-tailed Black-Cockatoo is the most widespread of the Black-Cockatoos, ranging broadly across much of northern and western Australia as well as western Victoria. In NSW, one population occurs on the north-western slopes and plains but another small isolated population is found in the coastal north-east. (OEH 2013b).	Occurs in coastal forests and woodlands or inland open shrubland near water (Simpson & Day 1999). This species is noted to feed mainly on seeds, especially of eucalypts, casuarinas, acacia and banksias. May also take berries, nectar, flowers and occasionally insects and their larvae (Marchant & Higgins 1993).	Low	Unlikely
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	~	The species is uncommon although widespread throughout suitable forest and woodland habitats, from the central Queensland coast to East Gippsland in Victoria, and inland to the southern tablelands and central western plains of NSW, with a small population in the Riverina. An isolated population exists on Kangaroo Island, South Australia.(OEH 2013b)	Associated with a variety of forest types containing *Allocasuarina* species, usually reflecting the poor nutrient status of underlying soils (Environment Australia 2000; OEH 2013b). Intact drier forest types with less rugged landscapes are preferred (OEH 2013b). Nests in large trees with large hollows (Environment Australia 2000).	High	Known
Cercartetus nanus	Eastern Pygmy-possum	V	~	The Eastern Pygmy-possum is found in south-eastern Australia, from southern Queensland to eastern South Australia and in Tasmania. In NSW it extends from the coast inland as far as the Pilliga, Dubbo, Parkes and Wagga Wagga on the western slopes . (OEH 2013b). It occupies small home ranges, rarely greater than 1 ha.	Found in wet and dry eucalypt forest, subalpine woodland, coastal banksia woodland and wet heath (Menkhorst & Knight 2004). Pygmy-Possums feed mostly on the pollen and nectar from banksias, eucalypts and understorey plants and will also eat insects, seeds and fruit (Turner & Ward 1995). The presence of *Banksia* sp. and *Leptospermum* sp. are an important habitat feature (OEH 2013b). Small tree hollows are favoured as day nesting sites, but nests have also been found under bark, in old birds nests and in the branch forks of tea-trees (Turner & Ward 1995).	High	Known

SCIENTIFIC NAME	COMMON NAME	TSC ACT	EPBC ACT	DISTRIBUTION	HABITAT	AVAILABILITY OF HABITAT IN STUDY AREA	LIKELIHOOD OF OCCURRENCE IN STUDY AREA
Certhionyx variegatus	Pied Honeyeater	V	~	Widespread throughout acacia, mallee and Spinifex scrubs of arid and semi-arid Australia. Occasionally occurs further east, on the slopes and plains and the Hunter Valley, typically during periods of drought (OEH 2013b).	Inhabits wattle shrub (primarily Mulga, *Acacia aneura*), mallee, Spinifex and eucalypt woodlands, usually when shrubs are flowering; feeds on nectar, predominantly from various species of emu-bushes (*Eremophila* spp.); also from mistletoes and various other shrubs (e.g. *Brachystema* spp. and *Grevillea* spp.); also eats saltbush fruit, berries, seed, flowers and insects. Highly nomadic, following the erratic flowering of shrubs; can be locally common at times.(OEH 2013b)	Low	Unlikely
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Found mainly in areas with extensive cliffs and caves, from Rockhampton in Queensland south to Bungonia in the NSW Southern Highlands. It is generally rare with a very patchy distribution in NSW. There are scattered records from the New England Tablelands and North West Slopes. (OEH 2013b)	The Large-eared Pied Bat has been recorded in a variety of habitats, including dry sclerophyll forests, woodland, sub-alpine woodland, edges of rainforests and wet sclerophyll forests (Churchill 1998; DECC 2007). This species roosts in caves, rock overhangs and disused mine shafts and as such is usually associated with rock outcrops and cliff faces (Churchill 1998).	High	Potential
Chalinolobus picatus	Little Pied Bat	V	~	The Little-Pied Bat is found in inland Queensland and NSW (including Western Plains and slopes) extending slightly into South Australia and Victoria.	The Little-Pied Bat is found in inland Queensland and NSW (including Western Plains and slopes) extending slightly into South Australia and Victoria. Occurs in dry open forest, open woodland, mulga woodlands, chenopod shrublands, cypress-pine forest, mallee, Bimbil box. Roosts in caves, rock outcrops, mine shafts, tunnels, tree hollows and buildings. Feeds on moths and possibly other flying invertebrates.	High	Known

SCIENTIFIC NAME	COMMON NAME	TSC ACT	EPBC ACT	DISTRIBUTION	HABITAT	AVAILABILITY OF HABITAT IN STUDY AREA	LIKELIHOOD OF OCCURRENCE IN STUDY AREA
Chthonicola sagittata	Speckled Warbler	V	~	The Speckled Warbler has a patchy distribution throughout south-eastern Queensland, the eastern half of NSW and into Victoria, as far west as the Grampians. The species is most frequently reported from the hills and tablelands of the Great Dividing Range, and rarely from the coast. There has been a decline in population density throughout its range, with the decline exceeding 40% where no vegetation remnants larger than 100ha survive. (OEH 2013b)	Occupies a wide range of eucalypt dominated communities with a grassy understorey, often on rocky ridges or in gullies (OEH 2013b). Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy (OEH 2013b). Large, relatively undisturbed remnants are required for the species to persist in an area (OEH 2013b). Pairs are sedentary and occupy a breeding territory of about ten hectares, with a slightly larger home-range when not breeding (OEH 2013b)	High	Known
Circus assimilis	Spotted Harrier	V	~	The Spotted Harrier occurs throughout the Australian mainland, except in densely forested or wooded habitats of the coast, escarpment and ranges, and rarely in Tasmania. Individuals disperse widely in NSW and comprise a single population. (OEH 2013b)	Occurs in grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe. It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands. Builds a stick nest in a tree and lays eggs in spring (or sometimes autumn), with young remaining in the nest for several months. Preys on terrestrial mammals (eg bandicoots, bettongs, and rodents), birds and reptile, occasionally insects and rarely carrion.	Moderate	Potential
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	~	The Brown Treecreeper is endemic to eastern Australia and occurs in eucalypt forests and woodlands of inland plains and slopes of the Great Dividing Range. It is less commonly found on coastal plains and ranges. The western boundary of the range of Climacteris picumnus victoriae runs approximately through Corowa, Wagga Wagga, Temora, Forbes, Dubbo and Inverell and along this line the subspecies intergrades with the arid zone subspecies of Brown Treecreeper Climacteris picumnus picumnus which then occupies the remaining parts of the state (OEH 2013b)	Found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range. It mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and *Eucalyptus camaldulensis* (River Red Gum) Forest. Generally not found in woodlands with a dense shrub layer. Fallen timber is an important habitat component for foraging. It is sedentary and nests in tree hollows within permanent territories (OEH 2013b).	High	Unlikely (the study area lies outside of the geographically defined area for the eastern subspecies)

SCIENTIFIC NAME	COMMON NAME	TSC ACT	EPBC ACT	DISTRIBUTION	HABITAT	AVAILABILITY OF HABITAT IN STUDY AREA	LIKELIHOOD OF OCCURRENCE IN STUDY AREA
Crinia sloanei	Sloane's Froglet	V	~	Sloane's Froglet has been recorded from widely scattered sites in the floodplains of the Murray-Darling Basin, with the majority of records in the Darling Riverine Plains, NSW South Western Slopes and Riverina bioregions in New South Wales. It has not been recorded recently in the northern part of its range and has only been recorded infrequently in the southern part of its range in NSW (OEH 2013b)	It is typically associated with periodically inundated areas in grassland, woodland and disturbed habitats.	Low	Unlikely
Daphoenositta chrysoptera	Varied Sittella	V	~	Varied Sittellas are endemic and widespread in mainland Australia. (OEH 2013b)	Varied Sittellas are found in eucalypt woodlands and forests throughout their range. They prefer rough-barked trees like stringybarks and ironbarks or mature trees with hollows or dead branches (OEH 2013b)	High	Known
Dasyurus maculatus	Spotted-tailed Quoll	V	E	The range of the Spotted-tailed Quoll has contracted considerably since European settlement. It is now found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Queensland. Only in Tasmania is it still considered common. (OEH 2013b)	It inhabits a range of environments including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Den sites are found in hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces. Females occupy home ranges of up to 750 ha and males up to 3,500 ha, which are usually traversed along densely vegetated creek lines. (OEH 2013b).	Low	Potential

SCIENTIFIC NAME	COMMON NAME	TSC ACT	EPBC ACT	DISTRIBUTION	HABITAT	AVAILABILITY OF HABITAT IN STUDY AREA	LIKELIHOOD OF OCCURRENCE IN STUDY AREA
Delma torquata	Collared Delma	V	V	The main concentrations of records are from the western suburbs of Brisbane. Urban development in these suburbs has resulted in a contraction of previously recorded populations in this area (Ryan 2006a). The species is also known from the following sites: the Bunya Mountains; Blackdown Tableland National Park (NP); Bullyard Conservation Park (CP); D'Aquilar Range NP, Expedition NP; Naumgna and Lockyer Forest Reserves (inside Bunya Mountains NP; Western Creek, near Millmerran; and the Toowoomba Range (Davidson 1993; Ryan 2006a).	The Collared Delma normally inhabits eucalypt or acacia dominated woodland and open forest where it is associated with suitable microhabitats (exposed rocky outcrops, or a sparse understorey of tussock grass, shrubs or semi-evergreen vine thickets). *Corymbia citriodora* (Lemon-scented Gum) is typically the dominant canopy species. Other dominant canopy species include *Eucalyptus crebra*, E. melanophloia, *E. tessellaris*, *E. moluccana*, *E. microcorys*, *E. tereticornis*, *Angophora* sp. and *Acacia harpophylla* (Brigalow) (Peck 2003, cited in Peck & Hobson 2007; Ryan 2006a). Leaf Litter appears to be an essential part of the microhabitat and is always present. (SEWPaC 2013)	Low	Unlikely
Drymodes brunneopygia	Southern Scrub-robin	V	~	This species is restricted to mallees and shrublands across southern Australia and in NSW is confined to two main areas. The first is in central NSW and is centred on Round Hill and Nombinnie Nature Reserves, though suitable habitat probably exists on adjoining leasehold lands. The other population occurs in the far south west of NSW, mainly within the Scotia mallee centred on Tarawi NR and Scotia Sanctuary	Inhabits mallee and acacia scrub, particularly with dense sub-shrubs in the understorey, including Broombush and other dry shrubs	Moderate	Unlikely
Ephippiorhynchus asiaticus	Black-necked Stork	E1	~	In Australia, Black-necked Storks are widespread in coastal and subcoastal northern and eastern Australia, south to central-eastern NSW and with vagrants recorded at scattered sites well away from the coast (for example, near Moree, north-east of Hay and in Victoria). In NSW, the species becomes more uncommon south of the Northern Rivers region, and rarely occurs south of Sydney (OEH 2013b)	Associated with tropical and warm temperate terrestrial wetlands, estuarine and littoral habitats, and occasionally woodlands and grasslands floodplains (Marchant & Higgins 1993). Forages in fresh or saline waters up to 0.5m deep, mainly in open fresh waters, extensive sheets of shallow water over grasslands or sedgeland, mangroves, mudflats, shallow swamps with short emergent vegetation and permanent billabongs and pools on floodplains (Marchant & Higgins 1993; OEH 2013b).	Low	Unlikely

SCIENTIFIC NAME	COMMON NAME	TSC ACT	EPBC ACT	DISTRIBUTION	HABITAT	AVAILABILITY OF HABITAT IN STUDY AREA	LIKELIHOOD OF OCCURRENCE IN STUDY AREA
Epthianura albifrons	White-fronted Chat	V	~	The White-fronted Chat is found across the southern half of Australia, It is found mostly in temperate to arid climates and very rarely sub-tropical areas, it occupies foothills and lowlands up to 1000 m above sea level. In NSW, it occurs mostly in the southern half of the state, in damp open habitats along the coast, and near waterways in the west. Along the coast, it is found mostly in saltmarsh vegetation but also in open grasslands and sometimes in low shrubs bordering wetland areas. (OEH 2013b)	Gregarious species, usually found foraging on bare or grassy ground in wetland areas, singly or in pairs. They are insectivorous, feeding mainly on flies and beetles caught from or close to the ground. Have been observed breeding from late July through to early March, with 'open-cup' nests built in low vegetation. Nests in the Sydney region have also been seen in low isolated mangroves. Nests are usually built about 23 cm above the ground (but have been found up to 2.5 m above the ground). (OEH 2013b)	Low	No
Erythrotriorchis radiatus	Red Goshawk	E1	V	Red Goshawks are found from across northern Australia, down the east coast of Qld and into the northern coast of NSW. In NSW records are rare. Listed as having occurred south to Port Stephens.	Its habitat consists of wooded and forested areas. Prefers forest and woodland with a mosaic of vegetation types, large populations of birds for prey and permanent water. Riverine vegetation is highly utilised by this species. Its habits are not well known, but it is considered to be a solitary, sedentary bird. They nest in tree forks of *Eucalypt* sp. and *Melaleuca* sp. or those nests of other large birds such as Magpies or Crows. The nests are generally built of sticks, which are lined with soft twigs and leaves	Moderate	Unlikely
Falco hypoleucos	Grey Falcon	E1	~	The Grey Falcon is sparsely distributed in NSW, chiefly throughout the Murray-Darling Basin, with the occasional vagrant east of the Great Dividing Range. The breeding range has contracted since the 1950s with most breeding now confined to arid parts of the range. There are possibly less than 5000 individuals left. Population trends are unclear, though it is believed to be extinct in areas with more than 500 mm rainfall in NSW.(OEH 2013b)	Usually restricted to shrubland, grassland and wooded watercourses of arid and semi-arid regions, although it is occasionally found in open woodlands near the coast. Also occurs near wetlands where surface water attracts prey.(OEH 2013b)	Moderate	Potential

SCIENTIFIC NAME	COMMON NAME	TSC ACT	EPBC ACT	DISTRIBUTION	HABITAT	AVAILABILITY OF HABITAT IN STUDY AREA	LIKELIHOOD OF OCCURRENCE IN STUDY AREA
Geophaps scripta scripta	Squatter Pigeon	E1	V	The Squatter Pigeon (southern) occurs on the inland slopes of the Great Dividing Range. Its distribution extends from the Burdekin-Lynd divide in central Queensland, west to Charleville and Longreach, east to the coastline between Proserpine and Port Curtis (near Gladstone), and south to scattered sites though out south-eastern Queensland. It's distribution historically extended into NSW, however, there have been no confirmed records of the species in NSW since the 1970s.	The Squatter Pigeon (southern) occurs mainly in grassy woodlands and open forests that are dominated by eucalypts . It has also been recorded in sown grasslands with scattered remnant trees, disturbed habitats (i.e. around stockyards, along roads and railways, and around settlements, in scrub and acacia growth, and remains common in heavily-grazed country north of the Tropic of Capricorn (EPA 2006). The species is commonly observed in habitats that are located close to bodies of water.	Low	Unlikely
Glossopsitta pusilla	Little Lorikeet	V	~	The Little Lorikeet is distributed widely across the coastal and Great Divide regions of eastern Australia from Cape York to South Australia. NSW provides a large portion of the species' core habitat, with lorikeets found westward as far as Dubbo and Albury. Nomadic movements are common, influenced by season and food availability, although some areas retain residents for much of the year and 'locally nomadic' movements are suspected of breeding pairs (OEH 2013b).	Little Lorikeets mostly occur in dry, open eucalypt forests and woodlands. They have been recorded from both old-growth and logged forests in the eastern part of their range, and in remnant woodland patches and roadside vegetation on the western slopes. They feed primarily on nectar and pollen in the tree canopy, particularly on profusely-flowering eucalypts, but also on a variety of other species including melaleucas and mistletoes. On the western slopes and tablelands *Eucalyptus albens* and *E. melliodora* are important food sources for pollen and nectar respectively.	High	Known
Grantiella picta	Painted Honeyeater	V	~	The Painted Honeyeater is nomadic and occurs at low densities throughout its range. The greatest concentrations of the bird (and almost all breeding), occurs on the inland slopes of the Great Dividing Range in NSW, Victoria and southern QLD. During the winter it is more likely to be found in the north of its distribution.(OEH 2013b)	The Painted Honeyeater inhabits Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests. It feeds on mistletoes growing on woodland eucalypts and acacias. It nests from spring to autumn in a small, delicate nest hanging within the outer canopy of drooping eucalypts, she-oak, paperbark or mistletoe branches.	High	Likely

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Grus rubicunda	Brolga	V	~	The Brolga was formerly found across Australia, except for the south-east corner, Tasmania and the south-western third of the country. It still abundant in the northern tropics, but very sparse across the southern part of its range (OEH 2013b).	The Brolga was formerly found across Australia, except for the south-east corner, Tasmania and the south-western third of the country. It still abundant in the northern tropics, but very sparse across the southern part of its range (OEH 2013b).	Low	Unlikely
Hamirostra melanosternon	Black-breasted Buzzard	V	~	The Black-breasted Buzzard is found sparsely in areas of less than 500 mm rainfall, from north-western NSW and north-eastern South Australia to the east coast at about Rockhampton, then across northern Australia south almost to Perth, avoiding only the Western Australian deserts (OEH 2013b)	This species lives in a range of inland habitats including open forests, riverine woodlands, scrubs and heathlands. It is often found along timbered watercourses, which is preferred breeding habitat. It can also hunt over grasslands and includes reptiles, small mammals, birds and large eggs in its prey.	Low	Potential
Hieraaetus morphnoides	Little Eagle	V	~	The Little Eagle is found throughout the Australian mainland excepting the most densely forested parts of the Dividing Range escarpment. It occurs as a single population throughout NSW.	The Little Eagle is seen over woodland and forested lands and open country, extending into the arid zone. It tends to avoid rainforest and heavy forest (OEH 2013b)	High	Potential
Hoplocephalus bitorquatus	Pale-headed Snake	V	~	A patchy distribution from north-east Queensland to north-east NSW. In NSW it occurs from the coast to the western side of the Great Divide as far south as Tuggerah (OEH 2013b).	Wide range of habitats from rain or wet sclerophyll forest to drier eucalypt forests (OEH 2013b).	High	Likely
Jalmenus eubulus	Pale Imperial Hairstreak	CE	E	It is found in Queensland and NSW. In Queensland it is restricted to the seasonally sub-humid central and southern areas of the state. In NSW it is found only in Brigalow -dominated open forests and woodlands in northern areas of the state.	Suitable habitat is dominated by *Acacia harpophylla* (Brigalow) and *Casuarina cristata* (Buloke) on clay soils on flat to gently undulating plants, usually with scattered emergent eucalypts. It is only known to breed in old-growth forest or woodland and does not appear to colonise regrowth habitats after clearing	Low	Unlikely
Lagorchestes leporides	Eastern Hare-wallaby	E4	Ex	The Eastern Hare-wallaby was common in open plains country around the Murray River and in the grasslands and woodlands of western Victoria and southeastern South Australia, but it has not been seen alive this century. Last South Australian record: Lucindale, 1892 (South Australia Museum n.d)	This species generally spent the day sheltering and foraged at night, it sheltered under large tussocks which it excavated itself.	Low	No

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Lathamus discolor	Swift Parrot	E1	E	Breeds in Tasmania between September and January. Migrates to mainland in autumn, where it forages on profuse flowering Eucalypts (Blakers et al. 1984; Schodde and Tidemann 1986; Forshaw and Cooper 1981).	On mainland, autumn and winter flowering eucalypts are important for this species. Favoured feed trees include winter flowering species such as *Eucalyptus robusta*, *Corymbia maculata*, *C. gummifera* (Red Bloodwood), *E. sideroxylon* (Mugga Ironbark and *E. albens* (OEH 2013b).	High	Potential
Leipoa ocellata	Malleefowl	E1	V,M	The stronghold for this species in NSW is the mallee in the south west centred on Mallee Cliffs NP and extending east to near Balranald and as far north as Mungo NP. In central NSW it has been significantly reduced through land clearance and fox predation and now occurs chiefly in Yathong, Nombinnie and Round Hill NRs and surrounding areas, though birds continue to survive in Loughnan NR (OEH 2013b).	Dry inland scrub, mallee. Males tend large sand nest-mound (Simpson & Day 1999).	Low	Unlikely
Leporillus apicalis	Lesser Stick-nest Rat	E4	Ex	The last specimen of the Lesser Stick-nest Rat was captured near Mt Crombie. south-west of the present Amata settlement, South Australia in 1933. However, in the nineteenth century it occupied a broad area stretching from the Riverina in New South Wales, through most of inland South Australia and into the Gibson Desert, reaching the Western Australian coast in the Gascoyne region (Burbidge et al. 1988; Cole & Woinarski 2000; Finlayson 1961).	The Lesser Stick-nest Rat occupied arid and semi-arid lands (Burbidge et al. 1988; Cole & Woinarski 2000).	No habitat	No
Limosa limosa	Black-tailed Godwit	V	~	In NSW, it is most frequently recorded at Kooragang Island (Hunter River estuary). Records in western NSW indicate that a regular inland passage is used by the species, as it may occur around any of the large lakes in the western areas during summer, when the muddy shores are exposed. It has been recorded within the Murray-Darling Basin, on the western slopes of the Northern Tablelands and in far north-western NSW.	The Black-tailed Godwit is a migratory wading bird that breeds in Mongolia and Eastern Siberia (Palaearctic) and flies to Australia for the southern summer, arriving in August and leaving in March. Primarily a coastal species, it is usually found in sheltered bays, estuaries and lagoons with large intertidal mudflats and/or sandflats. Further inland, it can also be found on mudflats and in water less than 10 cm deep, around muddy lakes and swamps.	Low	Unlikely

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Litoria booroolongensis	Booroolong Frog	E1	E	It is restricted to the tablelands and slopes from 200 to 1300 m above sea level in NSW and north eastern Victoria. The species is mostly found along the western-flowing streams and their headwaters of the Great Dividing Range. Catchments drain from the Northern Tablelands to the Tumut River in the Southern Highlands, and other tributaries of the Murrumbidgee River. The only records of the species in northern NSW outside the Northern Tablelands are from two streams near Tamworth, NSW.	Typically inhabits rocky western-flowing creeks and their headwaters, although a small number of animals have also been recorded in eastern-flowing streams. along permanent streams with some fringing vegetation cover such as ferns, sedges or grasses (SEWPaC 2013)	No habitat	No
Lophoictinia isura	Square-tailed Kite	V	~	The Square-tailed Kite ranges along coastal and subcoastal areas from south-western to northern Australia, Queensland, NSW and Victoria. In NSW, scattered records of the species throughout the state indicate that it is a regular resident in the north, north-east and along the major west-flowing river systems. It is a summer breeding migrant to the south-east, including the NSW south coast, from September to March	In coastal areas, this species is associated with tropical and temperate forests and woodlands on fertile soils with an abundance of passerine birds (Marchant & Higgins 1993, OEH 2013b). May be recorded inland along timbered watercourses (OEH 2013b). In NSW it is commonly associated with ridge or gully forests dominated by *Eucalyptus longiflora* (Woollybutt), C*. maculata*, or *E. elata* and *E. smithii* (OEH 2013b).	High	Likely
Macropus dorsalis	Black-striped Wallaby	E1	~	From the Townsville area in Queensland to northern NSW where it occurs on both sides of the Great Divide. On the North West Slopes of NSW it occurs in Brigalow remnants to south of Narrabri. On the north coast it is confined to the upper catchments of the Clarence and Richmond Rivers	Preferred habitat is characterised by dense woody or shrubby vegetation within three metres of the ground. This dense vegetation must occur near a more open, grassy area to provide suitable feeding habitat. On the North West Slopes, it is associated with dense vegetation, including brigalow, ooline and semi-evergreen vine thicket. On the north coast, it is closely associated with dry rainforest but also occur in moist eucalypt forest with a rainforest understorey or a dense shrub layer.	High	Known

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Melanodryas cucullata	Hooded Robin	V	~	The Hooded Robin is, found across Australia, except for the driest deserts and the wetter coastal areas - northern and eastern coastal Queensland and Tasmania. However, it is common in few places, and rarely found on the coast. The south-eastern form (subspecies *cucullata* is found from Brisbane to Adelaide and throughout much of inland NSW, with the exception of the extreme north-west, where it is replaced by subsp. *picata*	Associated with a wide range of Eucalypt woodlands, Acacia shrubland and open forests. In temperate woodlands, the species favours open areas adjoining large woodland blocks, with areas of dead timber and sparse shrub cover. Hooded Robin home ranges are relatively large, averaging 18ha for birds from the New England Tableland. It is considered a sedentary species, but local seasonal movements are possible.	High	Known
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	~	This subspecies extends south from central Queensland, through NSW, Victoria into south eastern SA. In NSW it is widespread, with records from the tablelands and western slopes of the Great Dividing Range to the north-west and central-west plains and the Riverina. It is rarely recorded east of the Great Dividing Range, although regularly observed from the Richmond and Clarence River areas. It has also been recorded at a few scattered sites in the Hunter, Central Coast and Illawarra regions	Predominantly associated with box-ironbark association woodlands, especially *Eucalyptus sideroxylon*, *E. albens*, *E. microcarpa* and *E. tereticornis*. Also inhabits open forests of smooth-barked gums, stringybarks, ironbarks and tea-trees, and River Red Gum (OEH 2013b).	High	Likely
Miniopterus australis	Little Bentwing-bat	V	~	This species occurs along the East coast and ranges of Australia from Cape York in Queensland to Wollongong in NSW.	Prefers well-timbered areas including rainforest, wet and dry sclerophyll forests, Melaleuca swamps and coastal forests (Churchill 1998). This species shelters in a range of structures including culverts, drains, mines and caves (Environment Australia 2000). Relatively large areas of dense vegetation of either wet sclerophyll forest, rainforest or dense coastal banksia scrub are usually found adjacent to caves in which this species is found (OEH 2013b). Breeding occurs in caves, usually in association with *M. schreibersii* (OEH 2013b).	Low	Unlikely

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Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	~	Eastern Bentwing-bats occur along the east and north-west coasts of Australia	Associated with a range of habitats such as rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grassland (Churchill 1998). It forages above and below the tree canopy on small insects (Dwyer 1995, Dwyer 1981). Will utilise caves, old mines, and stormwater channels, under bridges and occasionally buildings for shelter (Environment Australia 2000, Dwyer 1995).	High	Known
Mormopterus norfolkensis	Eastern Freetail-bat	V	~	The Eastern Freetail-bat is found along the east coast from south Queensland to southern NSW.	Most records of this species are from dry eucalypt forest and woodland east of the Great Dividing Range (Churchill 1998). Individuals have, however, been recorded flying low over a rocky river in rainforest and wet sclerophyll forest and foraging in clearings at forest edges (Environment Australia 2000; Allison & Hoye 1998). Primarily roosts in hollows or behind loose bark in mature eucalypts, but have been observed roosting in the roof of a hut (Environment Australia 2000; Allison & Hoye 1998).	Low	Unlikely
Myotis macropus	Large-footed / Southern Myotis	V	~	The Large-footed Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. It is rarely found more than 100 km inland, except along major rivers	Generally roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage. Forage over streams and pools catching insects and small fish by raking their feet across the water surface	Low	Unlikely
Neophema pulchella	Turquoise Parrot	V	~	The Turquoise Parrot's range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range.(OEH 2013b)	Steep rocky ridges and gullies, rolling hills, valleys and river flats and the plains of the Great Dividing Range compromise the topography inhabited by this species (Marchant & Higgins 1993). Spends much of the time on the ground foraging on seed and grasses (OEH 2013b). It is associated with coastal scrubland, open forest and timbered grassland, especially low shrub ecotones between dry hardwood forests and grasslands with high proportion of native grasses and forbs (Environment Australia 2000).	High	Known

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Ninox connivens	Barking Owl	V	~	The Barking Owl is found throughout continental Australia except for the central arid regions. Although common in parts of northern Australia, the species has declined greatly in southern Australia and now occurs in a wide but sparse distribution in NSW. Core populations exist on the western slopes and plains (especially the Pilliga) and in some northeast coastal and escarpment forests (OEH 2013b)	Associated with a variety of habitats such as savanna woodland, open eucalypt forests, wetland and Riverine forest. Habitat is typically dominated by Eucalypts (often Redgum species), but can also be dominated by *Melaleuca* species in the tropics (OEH 2013b). It usually roosts in dense foliage in large trees such as *Casuarina cunninghamiana*, other *Casuarina* and *Allocasuarina*, eucalypts, *Angophora*, *Acacia* and rainforest species from streamside gallery forests (NPWS 2003). It usually nests near watercourses or wetlands (NPWS 2003) in large tree hollows with entrances averaging 2-29 metres above ground.	High	Known
Ninox strenua	Powerful Owl	V		It is endemic to eastern and south-eastern Australia, mainly on the coastal side of the Great Dividing Range from Mackay to south-western Victoria. In NSW, it is widely distributed throughout the eastern forests from the coast inland to tablelands, with scattered, mostly historical records on the western slopes and plains. Now uncommon throughout its range where it occurs at low densities	It inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. The species breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation comprising species such as Turpentine, Black She-oak, Blackwood, Rough-barked Apple, Cherry Ballart and a number of eucalypt species	Low	Unlikely
Nyctophilus timoriensis (South-eastern form) *Nyctophilus corbeni*	Greater Long-eared Bat South-eastern Long eared Bat	V	V	The distribution of the south eastern form coincides approximately with the Murray Darling Basin with the Pilliga Scrub region being the distinct stronghold for this species.(OEH 2013b)	It inhabits a variety of vegetation types including mallee, bulloke and box eucalypt dominated communities. However, it is more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland. Roosts in tree hollows, crevices and under loose bark.	High	Known

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Oxyura australis	Blue-billed Duck	V	~	The Blue-billed Duck is endemic to south-eastern and south-western Australia. It is widespread in NSW, but most common in the southern Murray-Darling Basin area. Birds disperse during the breeding season to deep swamps up to 300 km away. It is generally only during summer or in drier years that they are seen in coastal areas. (OEH 2013b)	The Blue-billed Duck prefers deep water in large permanent wetlands and swamps with dense aquatic vegetation (OEH 2013b). The species is completely aquatic, swimming low in the water along the edge of dense cover (OEH 2013b). They are partly migratory, with short-distance movements between breeding swamps and over-wintering lakes with some long-distance dispersal to breed during spring and early summer (OEH 2013b).	Low	Unlikely
Pachycephala inornata	Gilbert's Whistler	V	~	This species occurs across most of NSW's semi-arid and arid regions. The eastern population extends from the central NSW mallee (Yathong, Nombinnie and Round Hill NRs), south and east through the Cocoparra Range to Pomingalama Reserve (near Wagga Wagga) then north through the South West Slopes east as far as Cowra and Burrendong Dam, to the Goonoo reserves (with scattered records as far north as Pilliga (OEH 2013b).	This species occurs in arid and semi-arid timbered habitats in mallee shrubland, and occasionally in box-ironbark woodlands, Cypress Pine and Belah woodlands and River Red Gum forests. Within mallee the species often occurs in association with an understorey of Spinifex and low shrubs of acacias, hakeas, sennas and grevilleas. In woodland habitats, the understorey contains areas of dense shrubbery (OEH 2013b).	Moderate	Potential
Petaurus australis	Yellow-bellied Glider	V		This species is found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland, through NSW to Victoria	This species occurs in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. Forest type preferences vary, with mixed coastal forests to dry escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south. Their den sites are in hollows of large trees. They can occupy large home ranges between 20 to 85 ha to encompass dispersed and seasonally variable food resources	Low	Unlikely
Petaurus norfolcensis	Squirrel Glider	V	~	The species is widely though sparsely distributed in eastern Australia, from northern Queensland to western Victoria. (OEH 2013b)	Associated with dry hardwood forest and woodlands (Menkhorst et al. 1988; Quin 1995). Habitats typically include gum barked and high nectar producing species, including winter flower species (Menkhorst et al. 1988). The presence of hollow bearing eucalypts is a critical habitat value (Quin 1995).	High	Likely

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Petrogale penicillata	Brush-tailed Rock-wallaby	E1	V	The range of this species extends from south-east Queensland to the Grampians in western Victoria, roughly following the line of the Great Dividing Range. However the distribution across its original range has declined significantly in the west and south and has become more fragmented. In NSW they occur from the Queensland border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit (OEH 2013b).	This species occupies rocky areas (escarpments and outcrops) in a variety of habitats, typically north facing sites with numerous ledges, caves and crevices (Strahan 1995). They generally browse on vegetation in and adjacent to rocky areas, eating grasses and forbs as well as the foliage and fruits of shrubs and trees.	Moderate	Unlikely
Petroica boodang	Scarlet Robin	V	~	The Scarlet Robin is found from SE Queensland to SE South Australia and also in Tasmania and SW Western Australia. In NSW, it occurs from the coast to the inland slopes. After breeding, some Scarlet Robins disperse to the lower valleys and plains of the tablelands and slopes. Some birds may appear as far west as the eastern edges of the inland plains in autumn and winter.	The Scarlet Robin is primarily a resident in forests and woodlands, but some adults and young birds disperse to more open habitats after breeding. It lives in dry eucalypt forests and woodlands with an understorey that is usually open and grassy with few scattered shrubs. It can live in both mature and regrowth vegetation with an abundance of logs and fallen timber an important component of its habitat.	High	Potential
Petroica phoenicea	Flame Robin	V	Mar	The Flame Robin is endemic to SE Australia, and ranges from near the Queensland border to SE South Australia and also in Tasmania. In NSW, it breeds in upland areas and in winter, many birds move to the inland slopes and plains. It is likely that there are two separate populations in NSW, one in the Northern Tablelands, and another ranging from the Central to Southern Tablelands (OEH 2013b).	It breeds in upland tall moist eucalypt forests and woodlands, often on ridges and slopes. The species prefers clearings or areas with open understoreys. The ground layer of the breeding habitat is dominated by native grasses and the shrub layer may be either sparse or dense. It occasionally occurs in temperate rainforest, and also in herbfields, heathlands, shrublands and sedgelands at high altitudes (OEH 2013b).	Low	Unlikely

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Phaethon rubricauda	Red-tailed Tropicbird	V	Mar	This species of Marine bird occurs throughout tropical and subtropical zones of the Indian and West Pacific Oceans. Breeding occurs on oceanic islands, with the largest breeding site occurring on Lord Howe Island. Vagrant birds occur in coastal water of NSW, and occasionally inland, particularly after storm events (OEH 2013b)	It is a Marine species that breeds in coastal cliffs and under bushes in tropical Australia. It nests on cliffs of the northern hills and southern mountains on the main island at Lord Howe Island (OEH 2013b)	Low	Unlikely
Phascolarctos cinereus	Koala	V	~	The Koala has a fragmented distribution throughout eastern Australia from north-east Queensland to the Eyre Peninsula in South Australia. In NSW it mainly occurs on the central and north coasts with some populations in the west of the Great Dividing Range. It was briefly historically abundant in the 1890s in the Bega District on the south coast of NSW, although not elsewhere, but it now occurs in sparse and possibly disjunct populations. Koalas are also known from several sites on the southern tablelands (OEH 2013b).	Associated with both wet and dry Eucalypt forest and woodland that contains a canopy cover of approximately 10 to 70% (Reed et al. 1990), with acceptable Eucalypt food trees. Some preferred *Eucalyptus* species are: *Eucalyptus tereticornis*, *E. punctata*, *E. cypellocarpa* and *E. viminalis.*	High	Known
Phascogale tapoatafa	Brush-tailed Phascogale	V		The Brush-tailed Phascogale has a patchy distribution around the coast of Australia. In NSW it is mainly found east of the Great Dividing Range although there are some records west of the divide (OEH 2013b).	It prefers dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter, but can also inhabit heath, swamps, rainforest and wet sclerophyll forest. It nests and shelters in tree hollows, with entrances 2.5 - 4 cm wide and can use many hollows over a short time span (OEH 2013b).	Low	Unlikely
Polytelis anthopeplus	Regent Parrot			Once recorded between Adelaide and the central coast of QLD, its range has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland. There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding woodlands.	The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. It is a generalist forager, which mainly feeds on the nectar from a wide range of eucalypts and mistletoes. Key species include Mugga Ironbark, Yellow Box, Blakely's Red Gum, White Box and Swamp Mahogany. (OEH 2013b)	Moderate	Unlikely

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Polytelis swainsonii	Superb Parrot	V	V	The Superb Parrot is found throughout eastern inland NSW. On the South-western Slopes their core breeding area is roughly bounded by Cowra and Yass in the east, and Grenfell, Cootamundra and Coolac in the west. Birds breeding in this region are mainly absent during winter, when they migrate north to the region of the upper Namoi and Gwydir Rivers. The other main breeding sites are in the Riverina along the corridors of the Murray, Edward and Murrumbidgee Rivers where birds are present all year round.	The Superb Parrot inhabits box-gum woodland, Box-Cypress-pine and Boree Woodlands and River Red Gum Forest. It forages at or near the ground and nest in hollows in small colonies (OEH 2013b).	Moderate	Potential
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	~	This species has two distinctive subspecies that intergrade to the south of the Gulf of Carpentaria. West of here the subspecies *rubeculus*, formerly considered a separate species (Red-breasted Babbler) is still widespread and common. The eastern subspecies (*temporalis*) occurs from Cape York south through QLD, NSW and Vic and formerly to the south east of SA. This subspecies also occurs in the Trans-Fly Region in southern New Guinea. In NSW, the eastern sub-species occurs on the western slopes of the Great Dividing Range, and on the western plains reaching as far as Louth and Balranald. It also occurs in woodlands in the Hunter Valley and in some locations on the north coast.	This species is found in open woodlands dominated by mature eucalypts with regenerating trees, tall shrubs, and an intact ground cover of grass and forbs (OEH 2013b). This species avoids very wet areas (Blakers et al. 1984).	High	Known

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Pseudomys pilligaensis	Pilliga Mouse	V	V	Distribution restricted to the Pilliga region of New South Wales. Fox and Briscoe first described this species in 1980 (Fox and Briscoe 1980).	This species of small rodent occurs in Pilliga Scrub on an isolated area of low-nutrient deep sand predominantly in recently burnt moist gullies, areas dominated by Broombush and areas containing an understorey of Kurricabah (Acacia burrowii) with a *Corymbia trachyphloia* overstorey in the Pilliga region of NSW. They seem to prefer areas with a high species diversity and dense low shrub layer. The species is thought to live in burrows and is nocturnal. (OEH 2013b).	High	Known
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Grey-headed Flying-foxes are found within 200 km of the eastern coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria. They show a regular pattern of seasonal movement with much of the population moving to northern NSW and QLD during May and June where they exploit the winter flowering trees such as *Eucalyptus robusta*, *E. tereticornis* and Paperbark (OEH 2013b).	This species roosts in camps generally located within 20 km of a regular food source and are commonly found in gullies, close to water and in vegetation with a dense canopy. This species is known to forage in areas supporting subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps on the nectar and pollen of native trees, in particular eucalypts, melaleucas and banksias.	Moderate	Potential
Rostratula benghalensis australis	Painted Snipe (Australian subspecies)	E1	V, Mar, M CAMBA	The Australian Painted Snipe has been recorded at wetlands in all states of Australia. It is most common in eastern Australia, where it has been recorded at scattered locations throughout much of Queensland, NSW, Victoria and south-eastern South Australia. It has been recorded less frequently at a smaller number of more scattered locations farther west in South Australia, the Northern Territory and Western Australia.	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber (OEH 2013b). Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds (*ibid.*). Breeding is often in response to local conditions; generally occurs from September to December (OEH 2013b). Roosts during the day in dense vegetation (OEH 2013b). Forages nocturnally on mud-flats and in shallow water (OEH 2013b). Feeds on worms, molluscs, insects and some plant-matter (*ibid.*).	Low	Unlikely

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Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	~	The Yellow-bellied Sheathtail-bat is a wide-ranging species found across northern and eastern Australia. In the most southerly part of its range - most of Victoria, south-western NSW and adjacent South Australia - it is a rare visitor in late summer and autumn. There are scattered records of this species across the New England Tablelands and North West Slopes.	Found in almost all habitats, from wet and dry sclerophyll forest, open woodland (Churchill 1998), open country, mallee, rainforests, heathland and waterbodies (SFNSW 1995). It roosts in tree hollows and may also use caves. The species has also been recorded in a tree hollow in a paddock (Environment Australia 2000) and in abandoned sugar glider nests (Churchill 1998). It is dependent on suitable hollow-bearing trees to provide roost sites, which may be a limiting factor on populations in cleared or fragmented habitats (Environment Australia 2000).	High	Known
Sminthopsis macroura	Stripe-faced Dunnart	V	~	Throughout much of inland central and northern Australia, extending into central and northern NSW, western Queensland, Northern Territory, South Australia and Western Australia. They are rare on the NSW Central West Slopes and North West Slopes with the most easterly records of recent times located around Dubbo, Coonabarabran, Warialda and Ashford. (OEH 2013b)	Native dry grasslands and low dry shrublands, often along drainage lines. During periods of hot weather they shelter in cracks in the soil, in grass tussocks or under rocks and logs (OEH 2013b)	Low	Unlikely
Stagonopleura guttata	Diamond Firetail	V	~	The Diamond Firetail is endemic to south-eastern Australia, extending from central QLD to the Eyre Peninsula in SA. It is widely distributed in NSW, with a number of records from the Northern, Central and Southern Tablelands, the Northern, Central and South Western Slopes and the North West Plains and Riverina. Not commonly found in coastal districts, though there are records from near Sydney, the Hunter Valley and the Bega Valley. This species has a scattered distribution over the rest of NSW, and is rare west of the Darling River	Typically found in grassy eucalypt woodlands, but also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities (OEH 2013b). It is often found in riparian areas and sometimes in lightly wooded farmland (OEH 2013b). Appears to be sedentary, though some populations move locally, especially those in the south (OEH 2013b).	High	Known

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Stictonetta naevosa	Freckled Duck	V	~	The Freckled Duck is found primarily in south-eastern and south-western Australia, occurring as a vagrant elsewhere. It breeds in large temporary swamps created by floods in the Bulloo and Lake Eyre basins and the Murray-Darling system, particularly along the Paroo and Lachlan Rivers, and other rivers within the Riverina (OEH 2013b)	This species prefers permanent freshwater swamps and creeks with heavy growth of Typha, Lignum or Tea-tree. During drier times they move from ephemeral breeding swamps to more permanent waters such as lakes, reservoirs, farm dams and sewage ponds. They generally rest in dense cover during the day in deep water. They feed at dawn and dusk and at night on algae, seeds and aquatic grasses and sedges and small invertebrates. Nesting usually occurs between October and December but can take place at other times when conditions are favourable (OEH 2013b).	Low	Unlikely
Tyto longimembris	Eastern Grass Owl	V	~	Eastern Grass Owls have been recorded occasionally in all mainland states of Australia but are most common in northern and north-eastern Australia. In NSW they are more likely to be resident in the north-east. Eastern Grass Owl numbers can fluctuate greatly, increasing especially during rodent plagues (OEH 2013b).	This species is found in areas of tall grass, including grass tussocks, in swampy areas, grassy plains, swampy heath, and in cane grass or sedges on flood plains. They rest by day in a 'form' - a trampled platform in a large tussock or other heavy vegetative growth. They breeds on the ground and nests are found in trodden grass, and often accessed by tunnels through vegetation OEH 2013b.	Low	Unlikely
Tyto novaehollandiae	Masked Owl	V	~	Extends from the coast where it is most abundant to the western plains. Overall records for this species fall within approximately 90% of NSW, excluding the most arid north-western corner. There is no seasonal variation in its distribution. (OEH 2013b)	The species is associated with forest with sparse, open, understorey, typically dry sclerophyll forest and woodland (OEH 2013b) and especially the ecotone between wet and dry forest, and non forest habitat (Environment Australia 2000). The species is known to utilise forest margins and isolated stands of trees within agricultural land (Hyem 1979) and heavily disturbed forest where its prey of small and medium sized mammals can be readily obtained (Kavanagh & Peake 1993).	High	Likely
Underwoodisaurus sphyrurus	Border Thick-tailed Gecko	V	V	The Border Thick-tailed Gecko is found only on the tablelands and slopes of northern NSW and southern Queensland, reaching south to Tamworth and west to Moree (OEH 2013b). Most common in the granite country of the New England Tablelands (OEH 2013b).	The Border Thick-tailed Gecko is found in rocky hills with dry open eucalypt forest or woodland (OEH 2013b). Favours forest and woodland areas with boulders, rock slabs, fallen timber and deep leaf litter (OEH 2013b).	Low	Unlikely

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Vespadelus troughtoni	Eastern Cave Bat	V	~	The Eastern Cave Bat is found in a broad band on both sides of the Great Dividing Range from Cape York to Kempsey, with records from the New England Tablelands and the upper north coast of NSW. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW, east of the ACT.	The species inhabits tropical mixed woodland and wet sclerophyll forest on the coast and the dividing range but extend into the drier forest of the western slopes and inland areas (Churchill 1998). It has been found roosting in sandstone overhand caves, boulder piles, mine tunnels and occasionally in buildings (Churchill 1998).	High	Known

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FLORA							
Acacia jucunda	Yetman Wattle	E1	-	The Yetman Wattle is found in the Yetman district near the Queensland border on the North West Slopes of NSW. It also occurs in Queensland where it is reasonably common (OEH 2013b).	The Yetman Wattle is mainly restricted to the dry eucalypt forests or woodlands on sandy to sandy-loam soils. It is associated with other species in NSW including, Western Silver Wattle (*Acacia polybotrya*) and Black Cypress Pine (*Callitris endlicheri*). The species is known to occur within the Border Rivers – Gwydir CMA area but mostly restricted to the Yetman area.	Low	Unlikely
Bertya opponens	Coolabah Bertya	V	V	Known from scattered sites in NSW including Coolabah, south of Narrabri on the North West Slopes (including Jacks Creek State Forest), Cobar and the North Coast.	Ranges from stony mallee ridges and cypress pine forest on red soils.	Moderate	Potential
Boronia granitica	Granite Boronia	V	E	Granite Boronia is known from scattered localities on the New England Tablelands and North West Slopes north from the Armidale area to the Stanthorpe district in southern Queensland	Granite Boronia grows amongst granite outcrops, often in rock crevices, north from Inverell district.	No habitat	No
Cadellia pentastylis	Ooline	V	V	This species occurs along the western edge of the North West Slopes from north of Gunnedah to west of Tenterfield with some records from in Queensland. The natural range of Ooline is from 24ºS to 30ºS in the 500 to 750 mm per annum rainfall belt.	Ooline occurs in low- to medium-nutrient soils of sandy clay or clayey consistencies, with a typical soil profile having a sandy loam surface layer, grading from a light clay to a medium clay with depth.	Low	Unlikely
Cyperus conicus	A sedge	E1		This species occurs rarely in the Pilliga area of NSW and is also found in Victoria, Qld, the NT and WA	The species grows in open woodland on sandy soil. In central Australia, it grows near waterholes and on the banks of streams in sandy soils. In Qld the species is usually found on heavy soils. It has been recorded from *Callitris* forest in the Pilliga area, growing in sandy soil with *Cyperus gracilis, C. squarrosus* and *C. fulvus*.	Moderate	Unlikely

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Desmodium campylocaulon	Creeping Tick-Trefoil	E1		Occurs chiefly in the Collarenebri and Moree districts in the north-western plains of NSW. Also occurs in the NT and Darling Downs district of south-eastern Queensland (OEH 2013b)	In NSW the species grows on cracking black soils in the Narrabri, Moree and Walgett local government areas. It is associated with other species including *Acacia harpophylla, Astrebla pectinata* and *Sorghum, Dichanthium* and *Panicum* species. It flowers summer and autumn (OEH 2013b)		Unlikely
Dichanthium setosum	Bluegrass	V	V	New England Tablelands, North West Slopes and Plains and the Central Western Slopes of NSW, as well as in Queensland and Western Australia.	Associated with heavy basaltic black soils. Often found in moderately disturbed areas such as cleared woodland, grassy roadside remnants and highly disturbed pasture.	Low	Unlikely
Digitaria porrecta	Finger Panic Grass	E1	E	Occurs in NSW and Queensland. In NSW it is found on the North West Slopes and Plains, from near Moree south to Tambar Springs and from Tamworth to Coonabarabran.	Habitat includes native grassland, woodlands or open forest with a grassy understorey, on richer soils.	Low	Unlikely
Diuris tricolor	Painted Diuris	V	V	Sporadically distributed on the western slopes of NSW, extending from south of Narrandera all the way to the far north of NSW.	Grows in sclerophyll forest among grass, often with native Cypress Pine (*Callitris spp.*). It is found in sandy soils, either on flats or small rises. Also recorded from a red earth soil in a Bimble Box community in western NSW. Disturbance regimes are not known, although the species is usually recorded from disturbed habitats.	Low	Likely
Haloragis exalata	-	V	V	Disjunctly distributed in the central coast, south coast and north-western slopes botanical subdivisions of NSW	Protected and shaded damp situations in riparian habitats.	Low	Unlikely
Homopholis belsonii	Belson's Panic	E1	V	North from the Warialda district and into Queensland	Habitat and ecology poorly known. Grows in dry woodland (e.g. Belah) on poor soils.	Low	Unlikely
Lepidium aschersonii	Spiny Peppercress	V	V	Not widespread, occurring in the marginal central-western slopes and north-western plains regions of NSW (and potentially the south western plains). A several populations recorded at Narrabri. Also known from the West Wyalong, Barmedman and Temora areas.	Found on ridges of gilgai clays dominated by *Acacia harpophylla* (Brigalow), with *Austrodanthonia* and/or *Austrostipa* species in the understorey. The species grows as a component of the ground flora, in grey loamy clays. Vegetation structure varies from open to dense Brigalow, with sparse grassy understorey and occasional heavy litter.	Low	Unlikely

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Lepidium monoplocoides	Winged Peppercress	E1	E	Widespread in the semi-arid western plains region of NSW. Recorded in previous ELA survey in Western Pilliga.	Known to occur on seasonally moist to waterlogged sites, on heavy fertile soils. In W Pilliga, it was found in White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion vegetation and associated with gilgais.	Moderate	Potential
Monotaxis macrophylla	Large-leafed Monotaxis	E1	~	Large-leaf Monotaxis is recorded from several highly disjunct populations in NSW: eastern edge of Deua NP (west of Moruya), Bemboka portion of South East Forests National Park, Cobar area (Hermitage Plains), the Tenterfield area, and Woodenbong (near the Queensland border). It is also in Queensland.	Grows on rocky ridges and hillsides. There is a great diversity in the associated vegetation within NSW (less though in Queensland), encompassing coastal heath, arid shrubland, forests and montane heath from almost sea level to 1300 m altitude.	Moderate	Unlikely
Myriophyllum implicatum		CE	~	This species was previously thought to be extinct in NSW; however the plant was recently discovered in the Pilliga National Park, south of Narrabri. It is known from QLD and is listed as 'Least Concern' under that States Nature Conservation Act (1992) (OEH 2013b).	The species occurs in moist situations, extending away from fresh water. A recent population was found in NSW in a large open partly inundated gilgai depression on cracking clay soil (OEH 2013b).	Low	Unlikely
Platyzoma microphyllum	Braid Fern	E1	~	Species records exist in NSW only in the Yetman district. However, the species is widespread across northern Australia, from WA to the NT, eastern Qld and just into central-northern NSW (OEH 2013b).	It grows in sandy or swampy soils, or in clay soils adjacent to streams and lagoons and subject to periodic flooding. It has been recorded in NSW at Bruxner Highway growing as one localised patch in deep sandy soil, with *Leptospermum* species, *Brachyloma daphnoides* and *Lomandra* species (OEH 2013b).	Low	Unlikely
Polygala linariifolia	Native Milkwort	E1	~	Found north from Copeton Dam and the Warialda area to southern QLD; also found on the NSW north coast near Casino and Kyogle, and there is an isolated population in far western NSW near Weebah Gate, west of Hungerford. This species also occurs in Western Australia.	Occurs in sandy soils in dry eucalypt forest and woodland with a sparse understorey. The species has been recorded from the Inverell and Torrington districts growing in dark sandy loam on granite in shrubby forest of *Eucalyptus caleyi, Eucalyptus dealbata* and *Callitris*, and in yellow podsolic soil on granite in layered open forest.	High	Known

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Pomaderris queenslandica	Scant Pomaderris	E1	~	Records are widely scattered, but not common in north-east NSW and in Queensland. It is only known from a few locations on the New England Tablelands and North West Slopes, including near Torrington and Coolatai, and also from several locations on the NSW north coast.	The species is found in moist eucalypt forest or sheltered woodlands with a shrubby understorey, and occasionally along creeks.	Low	Potential
Pterostylis cobarensis	Greenhood Orchid	V	V	It is known chiefly from the Nyngan-Cobar-Bourke district in the far western plains of New South Wales. Recorded districts include Narrabri, Nyngan, Cobar, Nymagee, Mt Gundabooka, Mt Grenfell and Mutawintji National Park. There are also records from the Darling Downs district of Queensland.	The Greenhood Orchid is found in Eucalypt woodlands, open mallee or *Callitris* shrublands on low stony ridges and slopes in skeletal sandy-loam soils.	Moderate	Known
Rulingia procumbens	-	V	V	The species is endemic to NSW and mainly confined to the Dubbo-Mendooran-Gilgandra region, but also in the Pilliga and Nymagee areas.	It grows in sandy sites, often along roadsides. Recorded in *Eucalyptus dealbata* and *E. sideroxylon* communities, *Melaleuca uncinata* scrub, under mallee eucalypts with a *Calytrix tetragona* understorey, and in a recently burnt Ironbark and *Callitris* area. It also occurs in *E. fibrosa* subsp. *nubila, E. dealbata, E. albens* and *Callitris glaucophylla* woodlands north of Dubbo.	High	Potential
Sida rohlenae	Shrub Sida	E1	~	It has a limited distribution in QLD, the NT, SA and WA. In NSW it has been recorded south of Enngonia, south of Bourke and north-west of Coonamble	It occurs in flood-out areas, creek banks and at the base of rocky hills. NSW specimens have been found along roadsides in hard red loam to sandy-loam soils.	Low	Unlikely
Swainsona murrayana	Slender Darling Pea	V	V	The species is found throughout NSW. It has been recorded in the Jerilderie and Deniliquin areas of the southern Riverine plain, the Hay plain as far north as Willandra National Park, near Broken Hill and in various localities between Dubbo and Moree.	The species has been collected from clay-based soils, ranging from grey, red and brown cracking clays to red-brown earths and loams. It grows in a variety of vegetation types including bladder saltbush, black box and grassland communities on level plains, floodplains and depressions and is often found with Maireana species.	Low	Unlikely

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Thesium australe	Austral Toadflax	V	V	Small populations are scattered across eastern NSW, along the coast, and from the Northern to Southern Tablelands. It is also found in Tasmania and Queensland and in eastern Asia.	Austral Toadflax occurs in grassland or grassy woodland and often found in damp sites in association with *Themeda australis* (Kangaroo Grass).	Low	Unlikely
Tylophora linearis	-	V	E	The species is found in the Barraba, Mendooran, Temora and West Wyalong districts in the northern and central western slopes of NSW.	It grows in dry scrub and open forest. Recorded from low-altitude sedimentary flats in dry woodlands of *Eucalyptus fibrosa*, *E. sideroxylon*, *E. albens*, *Callitris endlicheri*, *C. glaucophylla* and *Allocasuarina luehmannii*.	High	Known

TSC LISTED ECOLOGICAL COMMUNITY	TSC ACT	EPBC ACT	DESCRIPTION	AVAILABILITY OF HABITAT IN STUDY AREA	LIKELIHOOD OF OCCURRENCE IN STUDY AREA
ENDANGERED ECOLOGICAL COMMUNITIES					
Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions	EEC	E	The ecological community is a low woodland or forest community dominated by *Acacia harpophylla* (Brigalow), with pockets of *Casuarina cristata* (Belah) and *Eucalyptus populnea* subsp. *bimbil* (Poplar Box). The canopy tends to be quite dense and the understorey and ground cover are only sparse. It is found in the Brigalow Belt South Bioregion in NSW and as isolated occurrences in the Darling Riverine Plains and Nandewar Bioregions.	Low	Known
Cadellia pentastylis (Ooline) community in the Nandewar and Brigalow Belt South Bioregions	EEC	~	The Ooline community is an unusual and distinctive forest community with the canopy dominated by the tree *Cadellia pentastylis* (Ooline). Other canopy species include *Eucalyptus albens* (White Box), *E. beyeriana* and *E. melanophloia*, *E. chloroclada* (Dirty Gum), *E. pilligaensis* (Narrow-leaved Grey Box), *E. viridis* (Green Mallee) and *Callitris glaucophylla* (White Cypress Pine). The understorey is made up of a range of shrubs such as Wattles and grasses. It is now known from only seven main locations on the North West Slopes in NSW, between Narrabri and the Queensland border, and also in Queensland.	Not observed within study area	Unlikely
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	EEC	E	Represents occurrences of one type of semi-arid to humid subtropical woodland where *Eucalyptus coolabah* subsp. *coolabah* (Coolibah) and/or *Eucalyptus largiflorens* (Black Box) are the dominant canopy species and where the understorey tends to be grassy. The structure of the community may vary from tall riparian woodlands to very open 'savanna like' grassy woodlands with a sparse midstorey of shrubs and saplings. The ecological community is associated with the floodplains and drainage areas of the Darling Riverine Plains and the Brigalow Belt South bioregions.	Not observed within study area	Unlikely
Myall Woodlands in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW south western slopes bioregions	E	E	Occurs on red-brown earths and heavy textured grey and brown alluvial soils where annual rainfall is in the range 375 and 500 mm. The structure can varies from low woodland and low open woodland to low sparse woodland or open shrubland. The tree layer grows up to a height of about 10 metres and invariably includes *Acacia pendula* (Weeping Myall or Boree) as one of the dominant species or the only tree species present. The understorey includes an open layer of chenopod shrubs and other woody plant species and an open to continuous groundcover of grasses and herbs. The shrub stratum may have been reduced by clearing or heavy grazing. It is scattered across the eastern parts of alluvial plains of the Murray-Darling river system.	Not observed within study area	Unlikely

TSC LISTED ECOLOGICAL COMMUNITY	TSC ACT	EPBC ACT	DESCRIPTION	AVAILABILITY OF HABITAT IN STUDY AREA	LIKELIHOOD OF OCCURRENCE IN STUDY AREA
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	E	CE	The community has an overstorey dominated, or was once dominated by *Eucalyptus albens* (White Box), *E. melliodora* (Yellow Box) or *E. blakelyi* (Blakely's Red Gum) trees. It is characterised by a species-rich understorey of native tussock grasses, herbs and forbs. In the Nandewar Bioregion, *E. microcarpa* or *E. moluccana* may also be dominant or co-dominant. The tree-cover is generally discontinuous and consists of widely-spaced trees of medium height in which the canopies are clearly separated. The shrub layer can be non-existent. In NSW the community is found from the Queensland border in the north, to the Victorian border in the south along the tablelands and western slopes areas.	Low	Potential
Fuzzy Box Woodland on alluvial soils of the south western slopes, Darling Riverine Plains and Brigalow Belt South bioregions	E	~	The community is a tall woodland or open forest usually dominated by *Eucalyptus conica* (Fuzzy Box), which often grows with *E. microcarpa* (Inland Grey Box), *E. melliodora* (Yellow Box) or *Brachychiton populneus* (Kurrajong). *Allocasuarina luehmannii* (Buloke) is common in places. Shrubs are generally sparse and the ground cover moderately dense, but this can change with the season. It is found on the alluvial soils of the South West Slopes, Brigalow Belt South and Darling Riverine Plains Bioregions (mainly in the Dubbo-Narromine-Parkes-Forbes area).	Moderate	Known
TSC: Inland Grey Box Woodland in the Riverina, NSW south western slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions EPBC: Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of south-eastern Australia	E	E	The community is a woodland dominated by *Eucalyptus microcarpa* (Inland Grey Box). It is often found in association with *E. populnea* subsp. *bimbil*, *Callitris glaucophylla* (White Cypress Pine), *Brachychiton populneus* (Kurrajong), *Allocasuarina luehmannii* (Bulloak) or *E. melliodora* (Yellow Box), and sometimes with *E. albens* (White Box). It occurs in landscapes of low-relief such as flat to undulating plains, low slopes and rises and, to a lesser extent, drainage depressions and flats. The ecological community may extend to more elevated hillslopes on the fringes of its range where it intergrades with other woodland or dry sclerophyll forest communities. In NSW the community principally occurs within the Riverina and South West Slopes Bioregions and is also found in portions of the Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions.	Not observed within study area	Unlikely

TSC LISTED ECOLOGICAL COMMUNITY	TSC ACT	EPBC ACT	DESCRIPTION	AVAILABILITY OF HABITAT IN STUDY AREA	LIKELIHOOD OF OCCURRENCE IN STUDY AREA
TSC: Native Vegetation on Cracking Clay Soils of the Liverpool Plains EPBC: Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland	E	CE	The ecological community is mainly a native grassland community containing a range of small forb and herb species, but can be found with scattered / patchy shrubs and trees. The main grass species include *Austrostipa aristiglumis* (Plains Grass), *Dichanthium sericeum* (Queensland Bluegrass) and *Panicum queenslandicum* (Coolibah Grass). It occurs on flat to low slopes, of no more than 5 percent (or less than 1 degree) inclination. As slope increases, grassy woodlands dominated by trees such as *Acacia pendula* (Weeping Myall), *Eucalyptus coolabah* (Coolabah), *E. populnea* (Poplar Box) or *E. melliodora* (Yellow Box) occur. The ground layer component of these woodlands may be similar to the grassland but the soils will not be the same cracking clays as on the plains.	Not observed within study area	Unlikely
Semi-evergreen Vine Thicket in the Brigalow Belt South and Nandewar Bioregions	E	E	The community is a low, dense form of dry rainforest generally less than 10 m high, made up of vines and rainforest trees as well as some shrubs. The main canopy is dominated by rainforest species such as *Cassine australis* var. *angustifolia* (Red Olive Plum), *Geijera parvifolia* (Wilga), *Notelaea microcarpa* var. *microcarpa* (Native Olive) and *Ehretia membranifolia* (Peach Bush), with taller eucalypts and cypress pines from surrounding woodland vegetation emerging above the main canopy. *Carissa ovata* (Currant Bush) is often present and typical vines include *Parsonsia eucalyptophylla* (Gargaloo) and *Pandorea pandorana* (Wonga Vine). It has a scattered distribution near Gunnedah, Barraba, Bingara and north of Warialda on the NSW North West Slopes and Plains, and also in Queensland.	Not observed within study area	Unlikely
Marsh Club-rush sedgeland in the Darling Riverine Plains Bioregion	CE	~	The community is dominated by *Bolboschoenus fluviatilis* (Marsh Club-rush), which forms dense stands up to 2 m tall. The community is further characterised by an understorey including *Carex appressa* (Tussock Sedge), *Eleocharis plana* (Ribbed Spike Rush), *Lachnagrostis filiformis* (Blown Grass), *Paspalum distichum* (Water Couch) and *Ranunculus undosus* (Swamp Buttercup). It is distinguished from other surrounding communities by a lack of trees and the dominance of *Bolboschoenus fluviatilis* (generally over 40% of the vegetation cover) although the structure may vary depending on past disturbance. The community is associated with grey clay soils usually with a surface layer of organic matter several centimetres thick. The community has a very fragmented distribution and is mainly restricted to the Gwydir wetlands but may occur elsewhere in the Darling Riverine Plains Bioregion.	Not observed within study area	Unlikely

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Appendix 5

Pilliga Stygofauna Review – Santos Energy NSW CSG Exploration and Extraction Activities

PILLIGA STYGOFAUNA REVIEW

Santos Energy NSW Coal Seam Gas Exploration and Extraction Activities

Prepared for
Santos Limited
January 2014

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Executive Summary

Eco Logical Australia (ELA) was commissioned by Santos Limited (Santos) to conduct a review of stygofauna presence across the proposed Energy NSW Coal Seam Gas (CSG) Exploration and Appraisal Program (the program) near Narrabri in northern New South Wales. The purpose of the desktop review was to assess the likelihood of stygofauna occurring in the program area, and whether gas extraction activities are likely to pose a threat to stygofauna communities.

Stygofauna are known to occur in the Namoi River alluvial aquifer. This aquifer is not part of the project area but is a potential source of colonisation for stygofauna. Thin sedimentary aquifers associated with Bohena, Cowallah and Bibblewindi Creeks extend south into the Pilliga and are potentially suitable habitat for stygofauna. It is possible that communities may be present in permanently saturated parts of these aquifers, especially if they have an occasional hydrological connection to the larger Namoi alluvium.

Stygofauna may also be present in the shallower sandstone aquifers present on-site, such as the Pilliga Sandstone and Keelindi Beds (Orallo Formation). For these to be suitable for stygofauna, they would have to be fractured or weathered enough to allow stygofauna movement and a sufficient flux of water and organic matter. The suitability of these rock aquifers as stygofauna habitat diminishes with depth from the surface because:

- Stygofauna rely on organic matter derived from the surface. Without a good hydrological connection to the surface, there is not likely to be enough organic matter or oxygen present
- The space available for stygofauna movement is reduced significantly with increasing depth
- With depth, there is an overall decline in water quality.

Stygofauna may also be present, although with decreasing likelihood with depth below ground distance from alluvium, in weathered sections of sandstone with high secondary porosity, and in the deeper colluvial sediments.

CSG operations potentially create the following risks to stygofauna:

- impacting suitable habitat during drilling
- impacts to groundwater levels or water quality associated with trans-boundary flow between aquifers due to improper drilling and/or completion techniques
- Depressurisation of underlying aquifers that alters the physical structure of stygofauna habitat and subsequently changes groundwater levels or quality

The proposed exploration and appraisal program does not include exploration wells that require drilling through alluvial aquifers, significantly reducing the potential for impact to stygofauna.

Provided drilling, operation and closure activities are undertaken in accordance with the relevant guidelines and legislation, the proposed CSG Exploration and Appraisal Program activities are highly unlikely to pose a threat to any known or likely stygofauna habitat.

1 Introduction

1.1 BACKGROUND AND SCOPE

ELA was commissioned by Santos NSW (Eastern) Pty Ltd (Santos) to prepare a review on the presence of stygofauna and assess the potential for any impacts from proposed Coal Seam Gas (CSG) activities in the Pilliga region of New South Wales, south of Narrabri. This report reviews what is known of stygofauna communities in the Namoi alluvial aquifer, and assesses the suitability of aquifers in the Pilliga area as possible stygofauna habitat. An assessment is then made of potential impacts to stygofauna from CSG activities.

1.2 SUMMARY OF EXPLORATION & APPRAISAL PROGRAM

Santos is proposing to undertake the Energy NSW Coal Seam Gas (CSG) Exploration and Appraisal Program (E&A Program) in the Narrabri area within Petroleum Exploration Licence (PEL) 238 and Petroleum Assessment Lease (PAL) 2 (referred to as the program). The program commenced in 2013 and will take two to three years. The program consists of a series of CSG exploration and appraisal activities, including recommencing operation of several existing pilot wells, drilling and operating new pilot wells and constructing and operating water and gas management facilities to support the program.

The activities forming the E&A Program include:

- operation of the existing Bibblewindi Multi-Lateral Pilot (Bibblewindi 12, 13, 14, 15, 16, 17, 18H, 19H, 21H, 27, 28H and 29), the construction, drilling and operation of two additional pilot wells (Bibblewindi 31 and 32), and the operation of existing water flow lines from Bibblewindi Multi-Lateral Pilot to the Bibblewindi Water Transfer Facility
- operation of the existing Bibblewindi West Pilot (Bibblewindi 22, 23, 24, 25 and 26) and operation of existing water flow lines from the Bibblewindi West Pilot to the Bibblewindi Water Transfer Facility
- operation of the existing Dewhurst 13-18H Pilot (Dewhurst 13, 14, 15, 16H, 17H and 18H) and the construction, drilling and operation of additional lateral wells from well casing within Dewhurst 16H, 17H and 18H
- operation of the existing Tintsfield 2-7 Pilot (Tintsfield 2, 3, 4, 5, 6 and 7) and the construction and operation of a flare to support the pilot
- construction, drilling and operation of the Dewhurst 22-25 Pilot (Dewhurst 6, 22, 23, 24 and 25)
- construction, drilling and operation of the Dewhurst 26-31 Pilot (Dewhurst 26, 27, 28, 29, 30 and 31)
- construction of the Dewhurst Northern Water and Gas Flow Lines and operation the Dewhurst Northern Water Flow Line
- construction of the Dewhurst Southern Water and Gas Flow Lines and operation of the Dewhurst Southern Water Flow Line
- construction and operation of a produced water tank at the Bibblewindi Water Transfer Facility (Bibblewindi Water Transfer Tank) to facilitate the transfer of produced water from the pilot wells to the Leewood Produced Water Facility

- construction and operation of the Leewood Water Pipeline to transfer water produced by the operation of the above pilot wells from the Bibblewindi Water Transfer Facility to the Leewood Produced Water Facility
- construction and operation of the Leewood Produced Water Facility to store water produced by the operation of the above pilot wells
- transport of produced water from Leewood Produced Water Facility to an appropriately licensed facility
- construction and operation of ancillary and supporting infrastructure to facilitate the above activities and ongoing maintenance.

The proposed activities are necessary for the ongoing exploration, appraisal and evaluation of the CSG hydrocarbon potential in PEL 238 and PAL 2. The program will assist in gaining further knowledge of coal fines, gas composition and flow rates, the deliverability of the reservoir, and investigating well design, drilling and completion technologies. This information is essential to determine whether a commercial gas production project is viable and would be used in development planning for a potential commercial gas production project within the areas of PEL 238 and PAL 2.

CSG exploration, appraisal and production planning is an iterative process whereby the results of early stage activities are used to inform later stages of project development. As such, any future exploration, appraisal or production activities beyond the program will be proposed and assessed at a later stage.

1.3 OBJECTIVES OF THIS REVIEW

The principal objective of this desktop review was to determine whether suitable stygofauna habitat is likely to occur in the proposed Exploration and Appraisal Program area, and then determine whether the proposed CSG activities are likely to pose a threat to any stygofauna communities. The review does not consider the disposal or treatment of CSG water once it is extracted. The specific objectives of the stygofauna review were to:

- Determine whether there is any suitable or potentially suitable stygofauna habitat present
- Define the risks associated with the program on stygofauna communities
- Review the risks associated with the potential impacts associated with drilling and dewatering activities on overlying groundwater systems containing stygofauna

2 Overview of stygofauna habitat requirements

This section summarises the habitat requirements of stygofauna, and provides background to the stygofauna review.

2.1 FACTORS INFLUENCING BIOLOGICAL DISTRIBUTION IN AQUIFERS

Stygofauna are animals that live in groundwater. Recent estimates suggest there could be as many as 2680 species in the western half of the Australian continent, although only approximately 12 % of these have been described (Guzik et al 2011). It is difficult to estimate the diversity of eastern Australian aquifers, but they may be just as diverse as western aquifers.

As with all fauna, groundwater invertebrates require favourable conditions to inhabit an aquifer, but with this many species, there is a broad range of variability in ecological requirements. Not all aquifers are suitable for stygofauna, and those that are suitable may become unsuitable as a result of human activities or natural changes. Biological distribution in groundwater is influenced by historical, geological, hydrological, physico-chemical, and biological properties (Strayer 1994, Hancock et al 2005). There is still a lot being learned about stygofauna ecology, particularly in the eastern states where there have been relatively few surveys compared to Western Australia. Nevertheless, it is possible to briefly summarise what is already known about aquifer conditions likely to influence distribution.

2.1.1 Aquifer type

Stygofauna have been collected from many aquifer types, including fractured basalt, fractured sandstone aquifers, and pesolithic aquifers, but are most common in karstic and alluvial aquifers. Critical aquifer characteristics are the hydraulic conductivity, depth to water table, and porosity.

Generally, stygofauna occur more frequently in alluvial aquifers and karst than in other geological formations (Hancock et al 2005, Humphreys 2008). Alluvial aquifers occur beneath floodplains, which often provide the following conditions favourable to stygofauna:

- Water table is shallow, so there is recharge of infiltrating rainwater and organic matter, and the water table is accessible to floodplain tree roots
- There is often some degree of hydrological connectivity with surface rivers. This is particularly influential in regulated rivers where artificial flow releases from upstream dams may provide aquifer recharge of organic matter and oxygen in periods where natural surface flow would be absent
- Compared to deeper aquifers, water in alluvial aquifers is young and has a rapid flux.

2.1.2 Hydraulic conductivity

Hydraulic conductivity indicates how rapidly water flows through an aquifer. This is important to stygofauna communities because the flux of water through an aquifer often influences how rapidly organic matter and oxygen concentrations can be replenished. In aquifers, stygofauna diversity is generally higher in areas where hydraulic conductivity is also high provided all other habitat features are suitable (Datry *et al*. 2005).

2.1.3 Depth of water table

Depth to water table influences the amount of organic matter and oxygen that are available to aquifer foodwebs. With increasing depth below the land surface, the concentration of organic matter dissolved in infiltrating rainwater diminishes as it is absorbed in transit by soil bacteria and plant roots. Shallow water tables of less than 15 m have been found to favour high stygofaunal diversity in alluvial aquifers in eastern Australia (Hancock and Boulton 2008).

Another source of organic matter to aquifer invertebrates are phreatophytic trees (Jasinska et al. 1996). Root density is likely to be higher in shallower aquifers, and the resultant availability of organic matter provides food to stygofauna communities (Hancock and Boulton 2008).

2.1.4 Connectivity to recharge areas

A large proportion of the organic matter that fuels aquifer food webs has its origin at the surface and enters groundwater in particulate or dissolved forms. Therefore, sections of aquifers near recharge areas often have higher diversity and abundance than those that are further away, since the transfer of organic matter and oxygen is greater at these sites (Datry et al 2004).

2.1.5 A space for living

Stygofauna can only live in aquifers with enough space for them to move around in. Space is present in the solute cavities in karst, between pesolithic sediments in calcrete, and fractures in sandstone and basalt. For rock aquifers such as sandstone and basalt, it is the secondary porosity (that which is due to fracturing) rather than the primary porosity (in pores between sediment grains) that is important. In unconsolidated sedimentary aquifers such as alluvium, the size of pore space between particles often correlates to the size of the animals present, with larger species occurring in aquifers of coarser material (Strayer 1994).

Also important when considering the space available for living is the connectivity between pores, cavities, and fractures. These act as migration pathways to allow fauna to move around in the aquifer and are likely to be important in recolonising following disturbance.

2.1.6 Evolutionary history

Most stygofauna evolved from ancestors that once lived in surface freshwater or marine environments. As a result, it is possible that they have retained some of the traits and environmental tolerances of their ancestry. As an example, in coastal areas where ancestral stygofauna species may have come from a marine origin, contemporary taxa may be tolerant of high salinity (Humphreys 2008). Conversely, taxa with a freshwater ancestry may prefer lower salinities (Hancock and Boulton 2008).

2.1.7 Food availability

Stygofauna have adapted to the resource-starved conditions in aquifers and can tolerate low concentrations of organic matter (Hahn 2006, Strayer 1994). Food is available to stygofauna as particulate organic matter, groundwater bacteria, or as roots of phreatic trees. In its dissolved or fine particulate form, organic matter enters aquifers with recharging water. Dissolved organic matter is taken up by groundwater bacteria, which are then imbibed by smaller stygofauna. Most stygofauna are opportunistic omnivores.

2.1.8 Water regime

Local or regional climate and river-flow regimes can influence aquifer recharge, and so affect the organic matter flux in the aquifer. Periods of high, steady rainfall can increase hydrological connectivity between the land surface and the aquifer and can reduce depth to water table. Exchange between rivers, the hyporheic zone, and aquifers can be an important source of nutrients to stygofauna communities (Dole-Olivier et al 1994), so flow fluctuations that enhance hyporheic exchange can subsequently enrich stygofauna communities in deeper parts of the aquifer.

2.1.9 Salinity

Stygofauna in inland aquifers are generally restricted to fresh or partly brackish water. Hancock and Boulton (2008) suggest that most taxa collected from alluvial aquifers in NSW and Queensland prefer EC less than 5,000 μS/cm. In surveys of coastal areas and near salt lakes in Western Australia, stygofauna were collected from aquifers with salinities at or exceeding sea water (Watts and Humphreys 2004). *EPA Guidance Statement 54a* recommends 60,000 mg/L as the salinity above which stygofauna are unlikely (EPA 2007).

2.1.10 Dissolved oxygen

Stygofauna are able to tolerate very low concentrations of dissolved oxygen. Hahn (2006) observed a strong decrease in concentrations below 1.0 mg/L, but found some fauna in concentrations down to 0.5 mg/L. Some taxa are able to survive with virtually no oxygen for temporary periods for up to 6 months (Malard and Hervant 1999, Henry and Danielopol 1999). Aquifers can be heterogeneous environments, so may contain patches of water with sufficient oxygen concentration to be suitable for stygofauna. As dissolved oxygen is measured from water pumped from bores, it can be difficult to identify where these patches occur.

3 Suitability of aquifers in the Exploration and Appraisal Program area as habitat for stygofauna

3.1 STYGOFAUNA KNOWN FROM THE NAMOI RIVER ALLUVIUM AND ITS TRIBUTARIES

There has been a limited amount of sampling conducted for stygofauna in the Namoi River Alluvial aquifer and its tributaries. Nevertheless, previous surveys (summarised below) have established the Namoi as an aquifer with a relatively diverse stygofauna community. The presence of a large river with a well-developed alluvial aquifer make the Namoi comparable to other large rivers in Australia and overseas with diverse stygofauna communities (e.g. alluvial aquifers of the Hunter River, Pioneer River, Burnett River, Macquarie River – Hancock and Boulton 2008).

In 2013, Eco Logical Australia conducted a preliminary stygofauna survey for Santos at 2 bores at 'Leewood' and three bores along Bohena Creek. The Leewood bores had water tables of 21 and 26 m below ground level and sampled the lower section of saturated colluvial sediments, while the Bohena Creek bores had water only 2-3 m below ground level in the alluvial aquifer of the creek. None of the bores sampled had stygofauna.

Andersen (2008) reported at least 3 stygofauna taxa from the alluvial aquifer of Maules Creek, a tributary of the Namoi River. Stygofaunal syncarids, amphipods, and copepods have been collected from the Namoi alluvial aquifer by the NSW Office of Water, and the alluvial aquifer of the Peel River, a tributary of the Namoi, also has a rich stygofauna community with at least 20 species (Hancock and Boulton 2008).

In a study conducted between 2007 and 2008, Korbel (2012) collected at least 7 stygofauna taxa from 15 monitoring bores near Wee Waa, approximately 50 km west-northwest (and downstream) of Narrabri. The taxa collected included Ostracoda, Cyclopoida, Harpacticoida, Amphipoda, Oligochaeta, and three genera of Bathynellaceae.

A baseline survey of three bores at 'Rockdale' in the Pilliga collected three invertebrate taxa in 2012 (Stygoecologia 2013). Two families of worm (Oligochaeta) and one family of mite (Acarina) were collected from an unconsolidated sedimentary aquifer (Stygoecologia 2013). The aquifer sampled is variably referred to as the 'Pilliga Sands' or 'Pilliga Sandstone', so it is unclear whether the specimens come from the shallow colluvial/alluvial sediments or the underlying sandstone aquifers. There are some taxonomic groups known from groundwater samples in the region whose status as stygofauna needs to be interpreted with caution. While crustaceans such as bathynellids, amphipods, and isopods, are unambiguously groundwater obligates because of their aquatic ancestry and troglobitic morphological features, there are other taxa that are likely to be in groundwater accidentally. These are taxa that occur more commonly in the soil profile, but regularly fall into bores/wells and are collected during sampling and include worms and mites, and the larval stages of terrestrial insects. Soil fauna are not considered as significant as stygofauna because species are more widespread and have fewer incidences of short-range endemism.

3.2 SUITABILITY OF AQUIFERS FOR STYGOFAUNA

3.2.1 Shallow alluvial aquifers along creeks

There is a moderate chance that stygofauna occur in the alluvial aquifers of creeks in the Pilliga. The small alluvial aquifers associated with ephemeral creeks in the Pilliga consist of unconsolidated sands and fine gravels extending to depths of up to 40 m (Halcrow 2013). The main creeks in the study area are Bohena, Cowallah, Jacks, Bundock, and Bibblewindi Creeks, and all of these are dry for long periods of time. While parts of these aquifers potentially dry out after extended periods of no rainfall, there are likely to be sections that remain saturated because they hold a sufficient volume of water to resist evapotranspiration. These deeper saturated sediments may be suitable for stygofauna provided the water chemistry is suitable.

3.2.2 Colluvial sediments

Shallow colluvial sediments cover large sections of the northern part of the program area. These form temporary aquifers following periods of heavy rain, but the shallower sections often dry out (Halcrow 2013). It is unlikely that these aquifers have diverse stygofauna communities because they are shallow and probably dry out, however permanently saturated sections may have stygofauna if conditions are suitable. Given the homogenous nature of the colluvium, and the large area covered by colluvium between the program area and the Namoi River, there are unlikely to be any species endemic to the program area. These areas may provide suitable stygofauna habitat but communities are unlikely to have a high diversity. The colluvium is more likely to have stygofauna present in sections close to the Namoi River.

3.2.3 Sandstone aquifers underlying the program area

Pilliga Sandstone and the Keelindi Bed formations (inclusive of the Orallo Formation) underlie the superficial sediments in most of the program area. These have a low to moderate chance of providing suitable stygofauna habitat in the shallow sections where there is sufficient weathering and fracturing (i.e. a high secondary porosity). Habitat suitability increases with proximity to alluvial aquifers and recharge areas, and where there is a large amount of fracturing and interconnectedness between pore spaces. The chance of these sandstone strata being suitable for stygofauna diminishes with depth below ground surface.

4 Impact assessment

4.1 ASSESSMENT OF IMPACTS TO STYGOFAUNA FROM CSG DRILLING AND EXTRACTION

An assessment for the potential impacts to stygofauna from CSG drilling and extraction activities is included in **Table 1**.

Table 1: Risks and their likelihood of occurring as a result of CSG drilling in the Pilliga

Risk	Likelihood
Drilling through potential stygofauna habitat leads to changes in groundwater level or quality, impacting stygofauna	NEGLIGIBLE- While the colluvial and sandstone aquifers may have stygofauna, there are unlikely to be any species endemic to the impact area. Drilling will adhere to the *NSW Code of Practice for Coal Seam Gas Well Integrity*, which means that the risk of aquifer drainage will be negligible.
Drilling through potential stygofauna habitat creates preferential flow paths and cross-transfer of water between aquifers, impacting stygofauna.	NEGLIGIBLE- While the colluvial and sandstone aquifers may have stygofauna, drilling will adhere to the *NSW Code of Practice for Coal Seam Gas Well Integrity*. The use of proper drilling and grouting techniques will mean the risk of changes to water levels within aquifers is negligible.
Extraction of CSG from deep coal seams leads to drawdown or damage to stygofauna habitat	NEGLIGIBLE – Gas removal will occur at depths too great to have a significant impact on the physical structure of aquifers suitable for stygofauna. If stygofauna are present they are likely to occur in the upper 50 m. Depressurisation from extraction will occur much deeper than this and groundwater modelling to date suggest there will be no greater than 0.5m drawdown on alluvial (where present) and sandstone aquifers overlying the project area. The continuous monitoring of groundwater pressures in overlying shallow aquifers across the program area will assist in detecting any unexpected changes in ground, water level during operation of the exploration and appraisal program,
Pollution of shallow aquifers from chemicals used in drilling	NEGLIGIBLE –Drilling will adhere to the *NSW Code of Practice for Coal Seam Gas Well Integrity* and all precautions will be made to prevent contamination from chemicals used in drilling, as such the risk of drilling fluids having an impact on Stygofauna populations is considered negligible

5 Management and mitigation measures

The chance of any stygofauna species being endemic to the program area is low. The cumulative groundwater impact assessment for the Exploration and Appraisal Program shows that depressurisation of the target coal seam as a result of pilot activities indicates a negligible decline in water levels. Therefore the potential for CSG extraction to have a significant impact on stygofauna at the species level is considered negligible. Where risks may be present, **Table 2** provides a list of suggested mitigation measures, to further reduce these risks. An assessment of the potential for residual risks once the suggested mitigation has been implemented is also provided.

Table 2: Suggested mitigation measures.

Risk	Mitigation Measures	Residual risk to any endemic stygofauna populations
Disturbance to overlying aquifer systems during drilling process	Adopt the NSW Drilling Code of Practice. Ensure that aquifers are properly isolated during well drilling and construction, and that the integrity of the isolating barrier is maintained during operation.	NONE
Change to water chemistry in stygofauna habitat due to interconnectivity with aquifers	Adopt the *NSW Drilling Code of Practice.* Ensure that aquifers are properly isolated during well drilling and construction, and that the integrity of the isolating barrier is maintained during operation.	NONE
Structural damage, due to depressurisation, to stygofauna habitat or to the underlying strata of alluvial aquifers	The implementation of a shallow aquifer monitoring bore network across the program area to monitor for changes in water pressure. This will assist in identifying any unexpected changes in groundwater during the operation of the Exploration and Appraisal program.	NONE

6 Conclusions

The small alluvial aquifers flowing through the Pilliga, such as the Bohena Creek aquifer and its feeding streams and tributaries, are the most likely areas to have suitable stygofauna habitat, particularly in sections that remain permanently saturated and have a hydrological link to the main Namoi River aquifer. To date, there have been limited surveys of these aquifers because of restricted access and low bore numbers. Characteristics of the alluvial aquifers that make them suitable for stygofauna include:

- The water table is relatively shallow
- Electrical conductivity in the aquifers is likely to be low
- Sediments in the bed of the creek consist of coarse sand to medium gravel, which is likely to have sufficient porosity below the creek bed to have space for stygofauna.

Stygofauna may also be present, although with decreasing likelihood with depth below ground distance from alluvium, in weathered sections of sandstone with high secondary porosity, and in the deeper colluvial sediments.

The risks of impacting stygofauna through drilling activities includes changing groundwater quality or levels and introducing preferential flow pathways between aquifers. It is noted that the wells will be drilled and constructed in accordance with the methodology presented in the *NSW Code of Practice for Coal Seam Gas Well Integrity* and therefore the likelihood of this potential impact is considered to be negligible.

The cumulative groundwater impact assessment indicates that depressurisation of the target coal seam as a result of pilot activities will result in a negligible decline in water levels (less than 0.5 metres and within the natural range of annual fluctuations) in the Bohena Creek Alluvium and the Pilliga Sandstone groundwater. Therefore it is highly unlikely there will be any impacts to shallow aquifers that may contain stygofauna as a result of CSG extraction.

The monitoring of groundwater pressures in overlying shallow aquifers across the program area will assist in detecting any unexpected changes in ground, water level during operation of the exploration and appraisal program.

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