Bibblewindi Gas Exploration Pilot Expansion

Environmental Impact Statement (EIS)

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Application Subject Land Address:	Little Tighes Gully Road, Bibblewindi State Forest, Narrabri
Declaration:	I declare that this Environmental Impact Statement: (a) contains all available information that is relevant to the environmental assessment of the proposed activity to which this statement relates, and (b) that the information contained in this statement is neither false nor misleading. Name: Alan Feely Position: Manager Environment and Water – Energy NSW Signature: Date: 11.9.13

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Executive Summary

Overview

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

The proposed activity is classified as State Significant Development (SSD) under the State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP). Under schedule 1 of the SRD SEPP development for the purpose of drilling or operating petroleum exploration wells, not including '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 is SSD.'

The development of the proposed activity is for the purpose of drilling and operating more than five wells within a three kilometre radius within PAL 2 and is therefore deemed to be SSD under the SRD SEPP.

RPS Australia East Pty Ltd (RPS) has prepared this Environmental Impact Statement (EIS) to assess the potential environmental impacts of the proposed activity, in accordance with section 78A(8A) of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The proposed activity

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 3 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 footprint for the proposed new wells (Bibblewindi 31 and 32) will be contained on the existing well leases for Bibblewindi 14 and 19H respectively and construction access will be along existing access tracks. There will be no new disturbance beyond the lease areas and access tracks.

The proposed activity forms part of the Energy NSW CSG Exploration and Appraisal Program (E&A Program). The 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.

The E&A Program is necessary for the ongoing exploration, appraisal and evaluation of the CSG hydrocarbon potential in PEL 238 and PAL 2. 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 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.

Assessment under Part 4 of the EP&A Act

As the proposed activity is SSD under the SRD SEPP Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) applies to the proposed activity.

This EIS assesses the potential environmental impacts of the proposed activity in accordance with clauses 6 and 7 of Schedule 2 of the NSW *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) and the Director-General's Requirements (DGRs) issued by the NSW Department of Planning and Infrastructure (DP&I) on 20 May 2013. The DGRs were issued in accordance with clause 3 of Schedule 2 of the EP&A Regulation.

Benefits of the proposed activity

The proposed activity is consistent with *NSW 2021: A Plan to Make NSW Number One* (NSW Government, 2011) (NSW State Plan 2021), the *New England North West Regional Action Plan* (NSW Government, 2012), the *Strategic Regional Land Use Policy* (SRLUP) (DP&I, 2012) and the *Energy White Paper 2012* (Commonwealth Department of Resources, Energy and Tourism, 2012).

The proposed activity, as part of the E&A Program, 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 local and regional economy will benefit through direct and indirect employment opportunities. Approximately 7.6 equivalent full time jobs (5.6 during construction and 2 during operation) will be created. The proposed activity will also create an economic multiplier effect for the local and wider economy estimated to be $5.3 to $5.5 million or the creation of up to an additional 16 indirect jobs. This is based on a capital investment of $8.1 to $8.3 million.

Environmental impact assessment

The DGRs together with the results of an environmental risk assessment, guided the preparation of the EIS. An overview of the key environmental issues assessed in the EIS is provided below.

Land resources

The site is located within the Bibblewindi State Forest which is bordered by the Pilliga State Forest to the east, west and south and rural properties to the north. The nearest residences are over seven kilometres from the site.

Surface geology mapping indicates that the location of the proposed activity is underlain by a single geological formation known as Orallo formation. Soil characteristics of the site indicate moderate to severe limitations with low plant-available water capacity, low nutrient levels and sodicity that all limit agricultural production.

The site is not located on or near Biophysical Strategic Agricultural Land (BSAL) and/or a Critical Industry Cluster (CIC) as defined in the SRLUP. The nearest mapped BSAL is approximately 15 kilometres from the site and no CIC has been identified in the New England North West Region.

The proposed activity is considered low risk and will not have an adverse impact on the current or future agricultural production capacity or land resources in the Narrabri local government area (LGA). There will be little change to the surface area and erosion and sediment control measures will remain in place during operation. Drilling activities will produce drilling fluid and drill cuttings. These materials are unlikely to present an erosion hazard as drilling fluid and cuttings will be contained appropriately.

Water Resources

Groundwater

During operation, the expected groundwater extraction is estimated as 285,110 m^3 over three years for the Bibblewindi Multi-Lateral Pilot. The maximum rate of extraction is expected to be approximately 581 m^3 / day with the average 260 m^3/day. The target coal seam is located at a depth of approximately 900 to 1000 metres.

A cumulative groundwater impact assessment for the E&A Program was undertaken assuming concurrent operation of all existing and proposed pilot wells. Negligible aquifer interference to the alluvial groundwater sources of the Upper and Lower Namoi alluvium (NSW Upper and Lower Namoi groundwater source water sharing plan) or the Great Artesian Basin (GAB) Surat Pilliga Sandstone (NSW GAB groundwater source water sharing plan) is indicated by the modelling of the CSG water extraction activities.

A groundwater monitoring program will be implemented as part of the E&A Program.

Surface water

No surface water will be utilised for the proposed activity nor will any produced water be discharged into receiving waters. Potential impacts posed by soil erosion will be managed with the implementation of a range of erosion and sediment control mitigation measures.

Ongoing monitoring

A water monitoring program (surface and groundwater) is in the process of being implemented and will continue for the duration of the E&A Program. For groundwater it will include sampling and testing at registered bores as well as the installation of a number of both deep and shallow monitoring bores. Once installed, the aquifer monitoring bores will measure groundwater pressure and temperature within various strata and enable groundwater levels and flows to be monitored.

Surface water baseline data samples are collected monthly (when flows are present and sampling is possible) at a range of locations within the Upper Namoi Catchment both upstream and downstream of the proposed activity.

Biodiversity

No additional vegetation clearing or disturbance will be undertaken as part of the proposed activity. No threatened flora, fauna or migratory species listed under the *Threatened Species Conservation Act 1995* (TSC Act) or *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) were recorded within proximity of the existing lease areas or are considered likely to be directly or indirectly impacted by the proposed activity.

Air quality

Dust generated during construction will have the greatest potential impact on air quality and will be managed through the implementation of appropriate mitigation measures. Other emissions would occur from the exhaust of plant equipment required for drilling. These emissions are generally considered to be too low to generate any significant pollutant concentrations in the vicinity of the site and will not impact the nearest sensitive receiver located over seven kilometres from the site.

Emissions of carbon monoxide (CO) and nitrogen dioxide (NO_2) can be expected from the combustion and flaring of gas intermittently during operation when gas cannot be accepted at the Wilga Park Power Station. However these emissions are significantly below targets outlined in the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (NSW Department of Environment and Conservation, 2005) and impacts on air quality are predicted to be insignificant.

Greenhouse gases

The proposed activity will generate Scope 1 (direct) and Scope 3 (indirect) greenhouse gas (GHG) emissions as defined by *GHG Protocol Corporate Standard* (WBCSD and WRI 2004). These will occur both during construction and operation. During construction 568 Tonnes CO_2^e Scope 1 emissions will be produced whilst during operation 10,046 Tonnes CO_2^e/year will be produced.

Scope 3 emissions are very minor during construction (<35 Tonnes CO_2^e) and during operation, 84,867 Tonnes CO_2^e/year is expected. The use of produced gas in the Wilga Park Power Station is the dominant Scope 3 emissions source during operation. It is noted however that the use of gas in power stations has a significantly lower emissions profile compared to more traditional coal fired power stations (an emissions intensity of 51.33 kg CO_2^e/GJ compared to 88.43 kg CO_2^e/GJ for coal). Substituting gas for coal equates to an annual emissions reduction in the order of 68,500 tonnes of GHG for 20 MW of power. The Bibblewindi Multi-Lateral Pilot is estimated to generate around 1.2 MW of power.

Likely greenhouse gas emissions from the proposed activity are not considered to have significant impact on State or National emissions reduction targets. In addition, ongoing emissions associated with the proposed activity will be formally monitored and reported in accordance with legislative requirements

Noise

Noise impacts associated with drilling of Bibblewindi 31 and 32 and operation of the Bibblewindi Multi-Lateral Pilot are considered to be negligible and will not be audible at any of the closest five residences. Noise impacts from traffic generated by the proposed activity are considered negligible and will meet the *EPA Environmental Criteria for Road Traffic Noise* (NSW Environmental Protection Agency, 1999).

Traffic and transport

It is anticipated that there would be a minor increase (average 16 vehicles per day) in local traffic during the construction phase of the activity as a result of delivery and collection of plant, equipment and materials and personnel transport. Operational traffic movements will be minimal, with one vehicle arriving and departing the site each day.

These anticipated traffic volumes would present a negligible impact on existing traffic using State Forest roads and the Newell Highway and will not impact the capacity, functionality, efficiency or safety of the local road network.

Waste

The main wastes generated during construction will be drilling fluid (approximately 400 m^3) and drill cuttings (approximately 195 m^3). Drilling fluids will the transported to the proposed Santos operated Fluid Treatment Facility (FTF) in Narrabri for treatment and storage for future re-use in subsequent drilling activities. Should the FTF not be approved, drilling fluids would be transported to an alternative licensed facility.

Waste generated during operation of the Bibblewindi Multi-Lateral Pilot will consist predominantly of produced water. This will be stored at the Leewood Produced Water Facility for future treatment.

Waste management measures implemented for the proposed activity will encourage efficient resource use alternatives, re-use and recycling. Waste that cannot be re-used or recycled will be disposed of in accordance with statutory requirements.

Hazards

The proposed activity will require the use of chemicals, fuels and oils, particularly during drilling activities. All chemicals used during drilling will be non-toxic. No chemicals with added benzene, toluene, ethyl benzene, and xylenes (BTEX) will be used, nor will any fracking take place.

Diesel will be stored temporarily on site for use during drilling. Diesel is classed as an Australian Dangerous Goods Code 3 and as such is subject to the requirements under State Environmental Planning Policy 33 (SEPP 33). However given the relatively small volumes, the proposed activity is not defined as a potentially hazardous or offensive activity or industry.

Any impacts associated with hazardous materials are expected to be minor.

Social and Economic

The proposed activity will result in a number of positive economic impacts for the local, regional and State economies. This includes a mix of both local and fly in fly out jobs over the course of the proposed activity. The development of the proposed activity is in line with the goals and outcomes of both the *Narrabri Shire Economic Development Strategy* (Narrabri Shire, 2011) and the SRLUP for New England and the North West.

Santos is implementing a comprehensive community and stakeholder engagement program. This has involved a range of activities including: government and stakeholder forums, site tours, information sessions, establishment of a community consultation committee, one on one meetings and formal correspondence. Community feedback on the proposed activity has informed the development of the EIS.

Santos holds a Permit to Occupy the site in Bibblewindi State Forest from the Forestry Corporation of NSW (as the landowner).

Other impacts

A range of other impacts were considered during the impact assessment. This included cultural and European heritage, water quality, impacts to stygofauna and bushfire impacts. Impacts associated with all of these issues were considered negligible.

Cumulative impacts

The proposed activity has been assessed in conjunction with other activities proposed as part of the E&A Program within PAL 2 and Petroleum Exploration Lease 238 (PEL 238). In the case of biodiversity, this has also included consideration of previous CSG activities within the Pilliga and Bibblewindi Forests over the previous ten years.

For all environmental aspects the E&A Program is expected to have a negligible to minimal impact on the environment.

Conclusion

The proposed activity is temporary and minor in scale. The site of the proposed activity has been selected to avoid significant environmental constraints, and to minimise impacts to the surrounding community. The potential impacts of the proposed activity have been assessed and can be managed through the identified mitigation measures. On balance, the proposed activity will have a negligible to low adverse impact on the environment and the community however will contribute to the local and regional community through job creation and economic activity.

PART A

1.0 Introduction

1.1 Proposed activity overview

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 (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 EIS, prepared in accordance with Part 4 of the *Environmental Planning and Assessment* (*EP&A) Act*, addresses the impacts associated with the following proposed activity:

- construction: site preparation of the well leases and establishing necessary equipment, temporary structures and facilities on the existing 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 3 years and general maintenance activities
- post operation and rehabilitation: decommissioning and rehabilitation of pilot wells and ancillary infrastructure or suspension of the wells.

The EIS does not include the assessment of establishing the lease areas, the water and gas gathering system, access tracks and partial rehabilitation of the lease areas. These works were previously approved under Part 5 of the *EP&A Act* by the former NSW Department of Primary Industries (DPI), which approved drilling and operation of Bibblewindi 12 to 19H on 8 August 2008 and Bibblewindi 21H and 27–29 on 20 July 2009.

1.2 Assessment under Part 4

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

The EIS considers the potential environmental impacts of the proposed activity in accordance with clauses 6 and 7 in Schedule 2 of the NSW *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) and the Director-General’s Requirements (DGRs) issued by DP&I on 20 May 2013. The DGRs were issued in accordance with clause 3 of Schedule 2 of the EP&A Regulation. Appendix 1 provides a summary of the DGRs and cross references where each is addressed within the EIS.

1.3 Proponent

The proponent for the proposed activity is Santos NSW (Eastern) Pty Ltd, as the CSG operator, on behalf of the titleholders of PAL 2, Santos NSW Pty Ltd and EnergyAustralia Narrabri Gas Pty Ltd.

1.4 Background

Santos Limited is an Australian petroleum company established in 1954, which has been supplying natural gas to NSW since 1976. Santos Limited and its subsidiary companies have been involved in CSG activities in Queensland for 20 years and commenced CSG exploration in the north-west of NSW in 2008.

In November 2011, Santos Limited acquired Eastern Star Gas Limited (ESG) who was the operator of Petroleum Exploration Lease (PEL) 238, PAL 2 and Petroleum Production Lease (PPL) 3. Santos (the proponent), then became the operator of these tenements.

At the time of the acquisition, ESG's operations included six appraisal pilots, including the Bibblewindi Multi-Lateral Pilot in PAL 2, numerous water storage ponds, the Bibblewindi Water Treatment Facility, Wilga Park Power Station, and ancillary infrastructure in and around the Pilliga and Bibblewindi State Forests.

Following the acquisition, Santos carried out a full review of ESG's operations which identified a number of substandard practices and infrastructure. Santos suspended operations and commenced a program of decommissioning and rehabilitation works. These works included plugging and abandoning wells no longer needed, decommissioning and rehabilitating water storage ponds, decommissioning the reverse osmosis plant at the Bibblewindi Water Treatment Facility (now known as the Bibblewindi Water Transfer Facility) and commencing rehabilitation of approximately 30 hectares of land.

Santos purchased a property, known as Leewood, outside of the Pilliga forest for the purpose of developing a new water management facility. The new facility will have the best available technology, monitoring and environmental protection systems. The Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) approved the Leewood Produced Water Facility in March 2013 under Part 5 of the *EP&A Act*. The approval included construction of a water storage facility and associated infrastructure, transfer of produced water and brine stored at the Bibblewindi Water Treatment Facility to Leewood, and ongoing operation of the facility to store water from future exploration and appraisal activities.

Santos plans to continue exploration, appraisal and evaluation of the CSG hydrocarbon potential in PEL 238 and PAL 2 and has developed the Energy NSW CSG Exploration and Appraisal Program (E&A Program). The E&A Program will assist in gaining further knowledge of coal fines, gas composition, flow rates and deliverability, well design, drilling and completion technologies. The E&A Program will be conducted over the next two to three years and will include the proposed activity and:

- operation of the existing Bibblewindi West Pilot
- operation of the existing Tintsfield Pilot
- operation of the existing Dewhurst 13-18H Pilot 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
- construction, drilling and operation of the Dewhurst 26-31 Pilot
- 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 the Leewood Produced Water Facility and ancillary infrastructure
- gas and water management during operation of the E&A Program.

These activities are subject to separate environmental assessment and approval processes.

1.5 Structure of the EIS

The EIS has been structured into three sections as follows:

- Part A (Chapters 1-7). This section introduces the activity, justification and need and summarises consultation and legislative requirements. It provides background and context and describes in detail each element of construction, operation and post operation and rehabilitation.
- Part B (Chapters 8-19). This section provides an overview of the potential impacts of the proposed activity across a range of environmental issues identified in the DGRs, an environmental risk assessment and other issues raised through consultation. It describes the base line conditions, identifies the magnitude and scale of impacts and lists proposed mitigation measures. Assessment has been undertaken for the proposed activity and cumulatively for the E&A Program.
- Part C (Chapters 20-21). This section provides a concluding statement for the activity and a draft Statement of Commitments.
- Appendices (Appendix 1-7). This section provides the DGRs including a cross reference to where each DGR is addressed within the EIS, as well as the specialist assessments undertaken to support the EIS.

2.0 Need and Justification

2.1 Energy needs in NSW

NSW meets most of its energy demands from non-renewable sources including coal, petroleum and gas. Figure 2-1 compares energy consumption by sector and fuel type. Energy consumption is expected to grow in all sectors however it is expected that the mix of fuel types will change moving away from a reliance on coal (NSW EPA, 2012). According to forecasts developed by the Australian Energy Market Operator (AEMO, 2011a), gas is increasingly being used for electricity generation and the fuels share of electricity generation could increase from around 11% to 37% by 2030-31.

NSW currently sources 95% of its gas from interstate with contracted supplies falling from 2014 and reaching 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.

The NSW government recognises the importance of a domestic gas supply and the need to access affordable gas through the development of the State's reserves. In its submission on the Commonwealth's Energy White Paper the NSW Government stated:

'further delay in gas developments in NSW will contribute to a supply shortfall as early as 2014 and could have a direct impact on the State's consumers, through gas supply challenges and higher energy costs'.

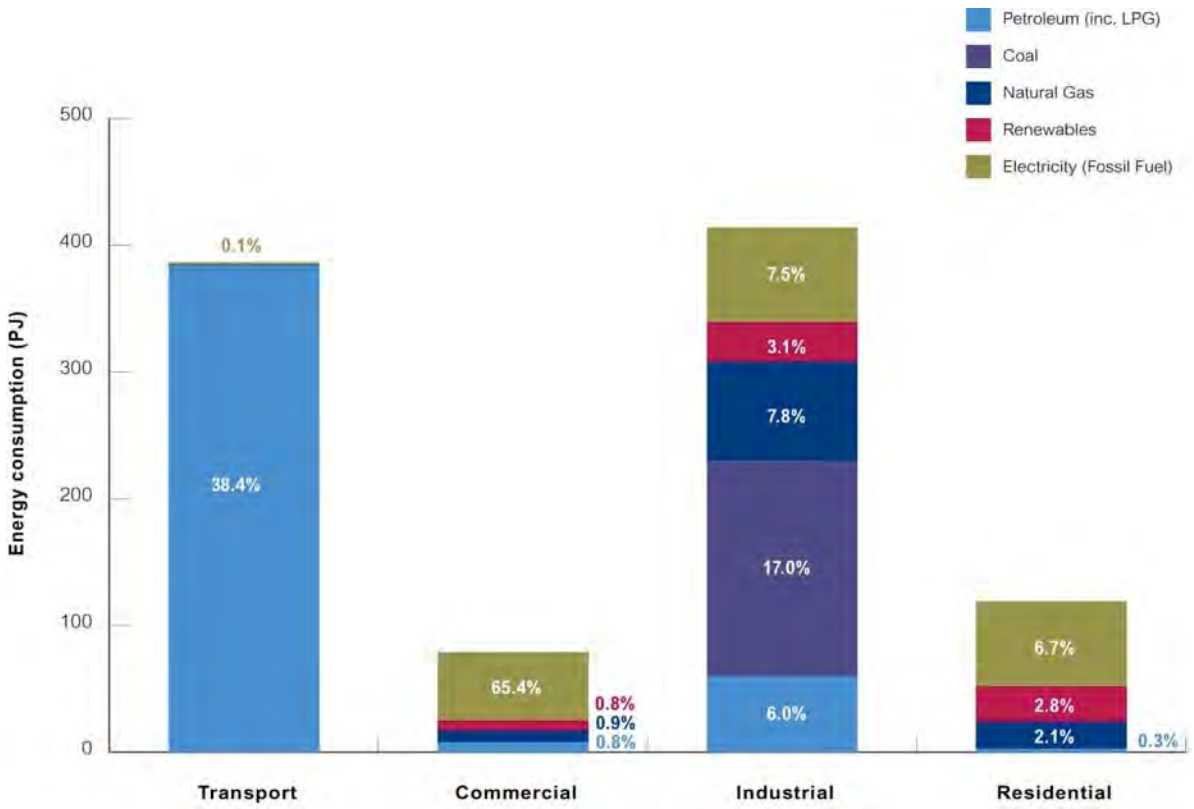


Figure 2-1 Fuel consumption in NSW

Source: NSW Statement of the Environment 2012

2.2 Interaction with key strategic planning and policy documents

2.2.1 NSW 2021

NSW 2021: A Plan to Make NSW Number One (NSW Government, 2011) (NSW 2021) presents the NSW Government's strategy to move the State forward over the next ten years and is based on five principal strategies with underlying goals. The five strategies are:

- rebuilding the economy
- returning quality services to NSW
- renovating infrastructure
- restore accountability to government
- strengthening the local environment and community.

Included in the Government's NSW 2021 plan are 19 regional action plans. These plans were created to support the action plan by identifying key priorities to be addressed and implemented across all 19 regions.

The New England North West Regional Action Plan (NSW Government, 2012) includes the Gunnedah and Narrabri LGAs. The communities within the region identified six priorities. Two of these priorities include the need to focus on growth and diversity of the region's economy and investment in regional and local infrastructure.

The development of the proposed activity within the Narrabri LGA would support these strategies and goals by providing both capital investment and economic benefits. It will provide a financial injection for the local economy both directly and indirectly and as part of the broader E&A Program.

The local and regional economy will benefit through direct employment opportunities as well as indirect employment with an estimated spend of $150,000 per employee per annum. The proposed activity will see approximately 7.6 full time equivalent jobs (5.6 during construction and 2 during operation) created and an additional eight full time equivalent jobs created in the local and wider economy.

An economic multiplier of $5.3 to $5.5 million is expected that could lead to the creation of a further 16 indirect jobs.

During the construction phase it is expected that some materials will be purchased and supplied locally. By sourcing local materials and contractors for the proposed activity it is estimated that a further $0.8 million will be spent locally on goods and services including vehicle hire, maintenance and fuel. This expenditure is likely to contribute both to the Narrabri and the wider northwest NSW region economy.

2.2.2 Commonwealth Energy White Paper 2012

The *Energy White Paper 2012* (DRET, 2012) sets out a strategic policy framework to address the challenges in Australia's energy sector and position it for long term transformation in the way we produce and use energy.

The policy framework is based on building a secure, resilient and efficient energy system that:

- provides accessible, reliable and competitively priced energy for all Australians
- enhances Australia's domestic and export growth potential
- delivers clean and sustainable energy.

The proposed activity as part of the E&A Program 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 will likely expose NSW to significant energy price increases.

In addition, further benefits can be realised through the use of gas in power stations. Gas has a significantly lower emissions profile compared to more traditional coal fired power stations (an emissions intensity of 51.33 kg CO_2^e/GJ compared to 88.43 kg CO_2^e/GJ for coal). Substituting coal for gas equates to an annual emissions reduction in the order of 68,500 tonnes of GHG for 20 MW of power. The Bibblewindi Multi-Lateral Pilot is estimated to generate around 1.2 MW of power through the Wilga Park Power Station.

2.2.3 Strategic Regional Land Use Policy

The NSW Government's *Strategic Regional Land Use Policy* (SRLUP) sets out a range of initiatives to better balance growth in the CSG industry with the need to protect important agricultural land and water resources. The *Strategic Regional Land Use Plan* (DP&I, 2012) for the New England North West region identifies the key challenges in the region and clear actions to address these challenges.

Strategic Agricultural Land (SAL) is highly productive land that has both unique natural resource characteristics as well as socio-economic value (DP&I, 2012a). Based on this definition there are two categories of SAL: Critical Industry Clusters (CIC) and Biophysical Strategic Agricultural Land (BSAL).

According to SAL mapping (DP&I, 2012a), Bibblewindi 31 and 32 and its surrounds are not classified as BSAL, with the closest mapped BSAL located 15 km from the site. No CIC has been identified in the New England North West Region.

The proposed activity is consistent with the SRLUP objectives.

A site verification report has been prepared and is provided in conjunction with this EIS. Advice from DP&I states that as the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (Mining SEPP) amendments are yet to be enacted, there is no statutory framework to apply for and receive a Site Verification Certificate. Therefore, Santos may lodge the site verification report (to satisfy the DGRs) as part of the overall EIS submission. The DP&I will then undertake the site verification assessment as part of the overall assessment.

2.3 Need for an exploration and appraisal program

CSG exploration and appraisal is required to inform the production planning process. As shown in Figure 2-2, there are many stages before a gas supply is proven and gas reaches the domestic market.

The E&A Program that has been developed for PEL 238 and PAL 2 is necessary for the ongoing exploration, appraisal and evaluation of the CSG hydrocarbon potential within the tenements. The E&A 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 commercial gas production is viable and would be used in development planning for a potential commercial gas production project within PEL 238 and/or PAL 2.

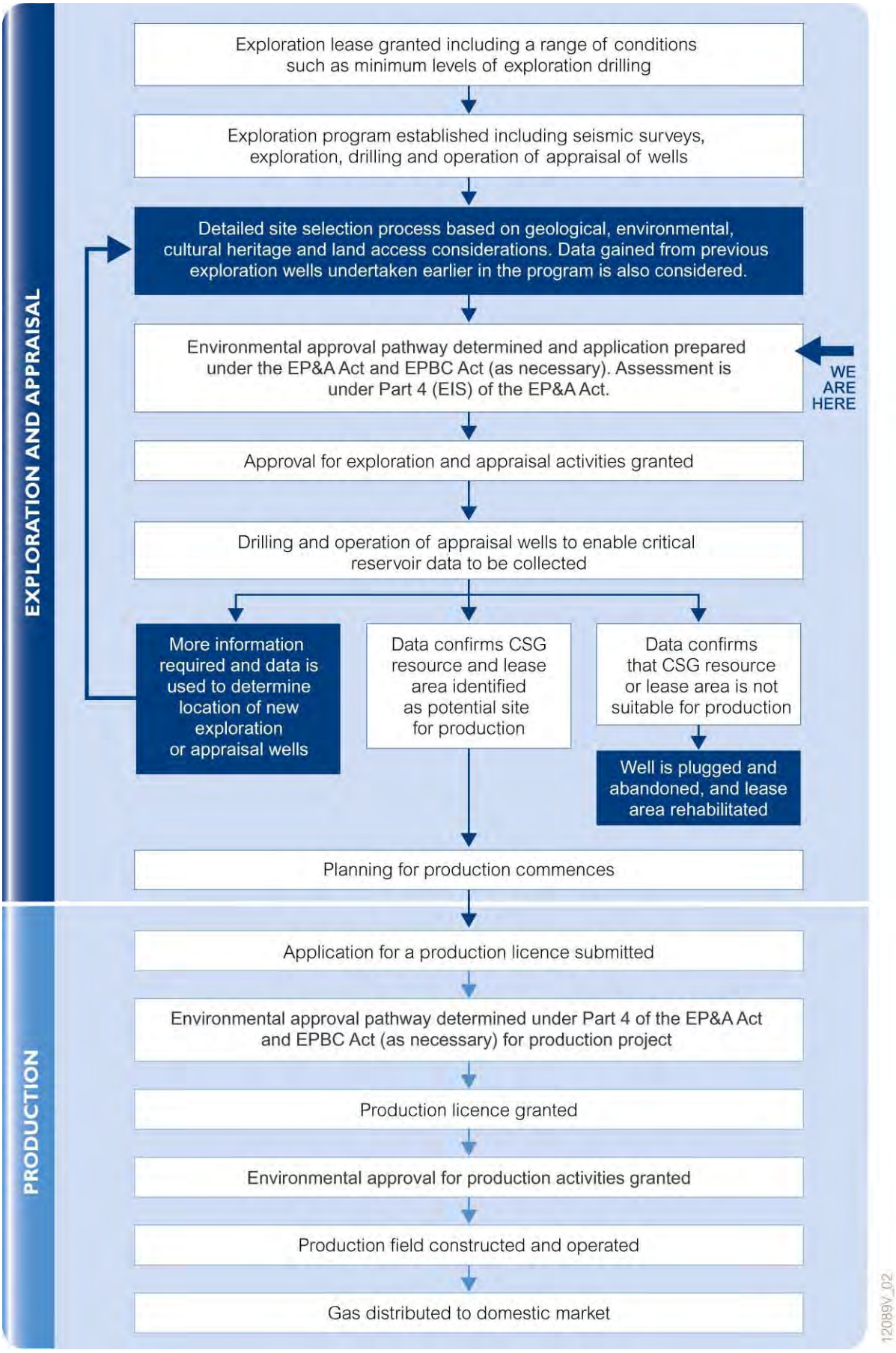


Figure 2-2 Stage of proposed activity with CSG exploration, appraisal and production planning process

2.4 Justification

The location (within existing lease areas) and operation (as part of the Bibblewindi Multi-Lateral Pilot) of the proposed activity balances the objectives of providing sufficiently accurate data in the right location and minimising surface footprint and environmental impact.

The wells will be designed and drilled in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRS, 2012). This will ensure that appropriate measures are in place to ensure well operations are carried out safely, without risk to health and without detriment to the environment.

The addition of two wells as part of the Bibblewindi Multi-Lateral Pilot improves the efficiency of water and gas recovery and enables the water and gas to be managed through existing infrastructure or new infrastructure proposed to support the E&A Program.

Safety and potential hazards for the activity will be managed through Santos standard risk and safety protocols including the Santos Emergency Response Plan.

The proposed activity is consistent with the principles of ecologically sustainable development (ESD) as describe in Table 2-1. ESD is a primary objective of the *EP&A Act* and is defined under section 4 of the *EP&A Act* as having the same meaning as section 6(2) of the *Protection of the Environment Administration Act 1991*.

Table 2-1 Consistency of proposed activity with ESD principles

Principle	Response
Precautionary principle	A precautionary approach was taken during the site selection process. Use of an existing lease area sought to avoid significant environmental constraints, thereby minimising the risk of serious or irreversible harm to the environment as a result of the proposed activity. Based on an environmental risk assessment and in combination with the DGRs, the EIS includes investigation into a range of issues to determine the full 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. Conservative 'worst case' scenarios are considered as part of the EIS. A range of mitigation measures will be put in place to minimise or prevent any environmental degradation as described in Chapter 20.
Intergenerational equity	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. Groundwater will be extracted but modelling indicates that this will have no impact on the upper aquifers including the Pilliga sandstone, registered bore users or groundwater dependent ecosystems. Drilling fluids, where possible, will be recycled for use at other drilling sites.
Conservation of biological diversity and ecological integrity	No clearing of vegetation is required to be removed for the proposed activity. Minimal short-term impacts are associated with the proposed activity, during both construction and operational activities. The primary potential impacts are indirect, as the proposed activity will be carried out within existing disturbance areas. No threatened species populations or ecological communities (or their habitats) listed under the TSC Act or the EPBC Act will be significantly impacted.
Improved valuation, pricing and incentive mechanisms	While clear and widely accepted standards have not yet been established for the application of this principle, Santos acknowledges and accepts the financial costs associated with all the measures required for the proposed activity to avoid, minimise, mitigate and manage potential impacts of the proposed activity.

2.5 Alternatives considered

Alternatives considered for the proposed activity included do nothing, alternative drilling locations but with operation as part of the Bibblewindi Multi-Lateral Pilot or establishment of a new pilot. On balance the proposed activity best meets the needs of the E&A Program whilst reducing surface disturbance. Each of these alternatives are briefly discussed below.

2.5.1 Do nothing

To date there has not been enough background information produced from the Bibblewindi Multi-Lateral Pilot to adequately assess the potential gas resource of the pilot. Doing nothing would not achieve the objectives of proposed activity or the overall E&A Program and is not a viable option.

2.5.2 Establishment of a new pilot

Establishment of a new pilot would require the establishment of lease areas (approximately one hectare in size), access tracks and supporting gas and water management facilities. This would require vegetation clearing and potential impacts on biodiversity and heritage.

2.5.3 Alternative location within the Bibblewindi Multi-Lateral Pilot

ESG originally proposed to add three new wells to the Bibblewindi Multi-Lateral Pilot. These wells were proposed to be located on new well leases to be established on vegetated areas adjacent to the existing well leases.

Since purchasing ESG, Santos has redesigned the proposal to avoid further surface disturbance and reduce potential impacts to biodiversity, heritage and the environment generally. This has included reducing the number of additional wells from three to two and siting the proposed new wells on existing well leases within the pilot. This requires the need for directional drilling and a small ‘S’ shape in the vertical Bibblewindi 31 well. This process will increase the cost of drilling however avoids the need for additional clearing for a new well lease.

By connecting the wells to the existing infrastructure servicing the existing Bibblewindi Multi-Lateral Pilot additional surface disturbance is avoided.

3.0 The Site and Context

3.1 Overview

3.1.1 Site footprint

The Bibblewindi 14 and 19H lease areas, where Bibblewindi 31 and 32 respectively will be drilled (the site) is located on Little Tighes Road. Access to the site will be via the Newell Highway, X-Line Road, Tighes Gully Road and Little Tighes Gully Road.

The construction footprint for the proposed new wells (Bibblewindi 31 and 32) will be contained on the existing well leases for Bibblewindi 14 and 19H (see Figure 3-1 and Figure 3-2) respectively with no new disturbance or vegetation clearing outside of the existing well leases proposed.

The approximate location of the wells is shown in Table 3-1 with the final co-ordinates confirmed on site during construction.

Table 3-1 Approximate well locations

Well	Easting	Northing	Lot description
Bibblewindi 31	754466.68	6603944.41	Crown Land State Forest
Bibblewindi 32	753647.23	6604983.47	Crown Land State Forest

Plates 3.1 and 3.2 show existing conditions of the existing well leases.




Plate 3-1 Existing Bibblewindi 14 lease area




Plate 3-2 Existing Bibblewindi 19H lease area



Figure 3-1 Bibblewindi 31 lease area



Figure 3-2 Bibblewindi 32 lease area

3.1.2 Bibblewindi Multi-Lateral Pilot

The existing Bibblewindi Multi-Lateral Pilot consists of 12 wells (Bibblewindi 12, 13, 14, 15, 16, 17, 18H, 19H, 21H, 27, 28H and 29). Each well is situated on a well lease area of approximately 0.8 hectares (100 by 80 metres). Surface infrastructure at the lease area includes well heads, skids, separators, generators and remote telemetry units. The well lease areas are connected via a series of access tracks branching off Little Tighes Road. The existing Bibblewindi Multi-Lateral and Bibblewindi 31 and 32 are shown in Figure 3-3.

Subsurface infrastructure comprises of a water and gas gathering system which follows the existing access tracks and collects at Bibblewindi 19H.

3.1.3 Natural features of the site

3.1.3.1 Topography

Topography of the site (see Figure 3-4) can be described as gentle with elevations ranging between 280 and 295 metres. Individual topographic characteristics of the existing lease areas are as follows:

- Bibblewindi 14 lease area – generally slopes in a north-west direction, with elevations ranging between approximately 286 and 288 metres (AHD)
- Bibblewindi 19H lease area – generally slopes in a north-west direction, with elevations ranging between approximately 278 and 281 metres (AHD).

3.1.3.2 Drainage

No watercourses intersect the site. The nearest watercourse is an unnamed ephemeral tributary of Mount Pleasant Creek located approximately 50 metres north east of the Bibblewindi 19H lease area (Bibblewindi 32). The closest watercourse to Bibblewindi 14 lease area (Bibblewindi 31) is the ephemeral Mount Pleasant Creek, located approximately 500 metres to the west.

3.1.3.3 Stratigraphy

The site is located in the central portion of the Gunnedah Basin where Jurassic and Cretaceous Surat Basin sediments unconformably overlie Permo Triassic Gunnedah Basin sediments.

Surface geology mapping of the site shows it to be underlain by a single geological formation known as Orallo formation with the dominate lithology being sandstone, which formed during the Mesozic Cretaceous period.

The stratigraphy of the Gunnedah Basin is illustrated in Figure 3-5.

3.1.3.4 Vegetation

The existing well leases are clear of vegetation. A minimal amount of native and exotic grasses have recolonised small patches of the lease areas and some rehabilitation has occurred, however the existing lease areas can be characterised as cleared areas. Stockpiles exist on both lease areas.

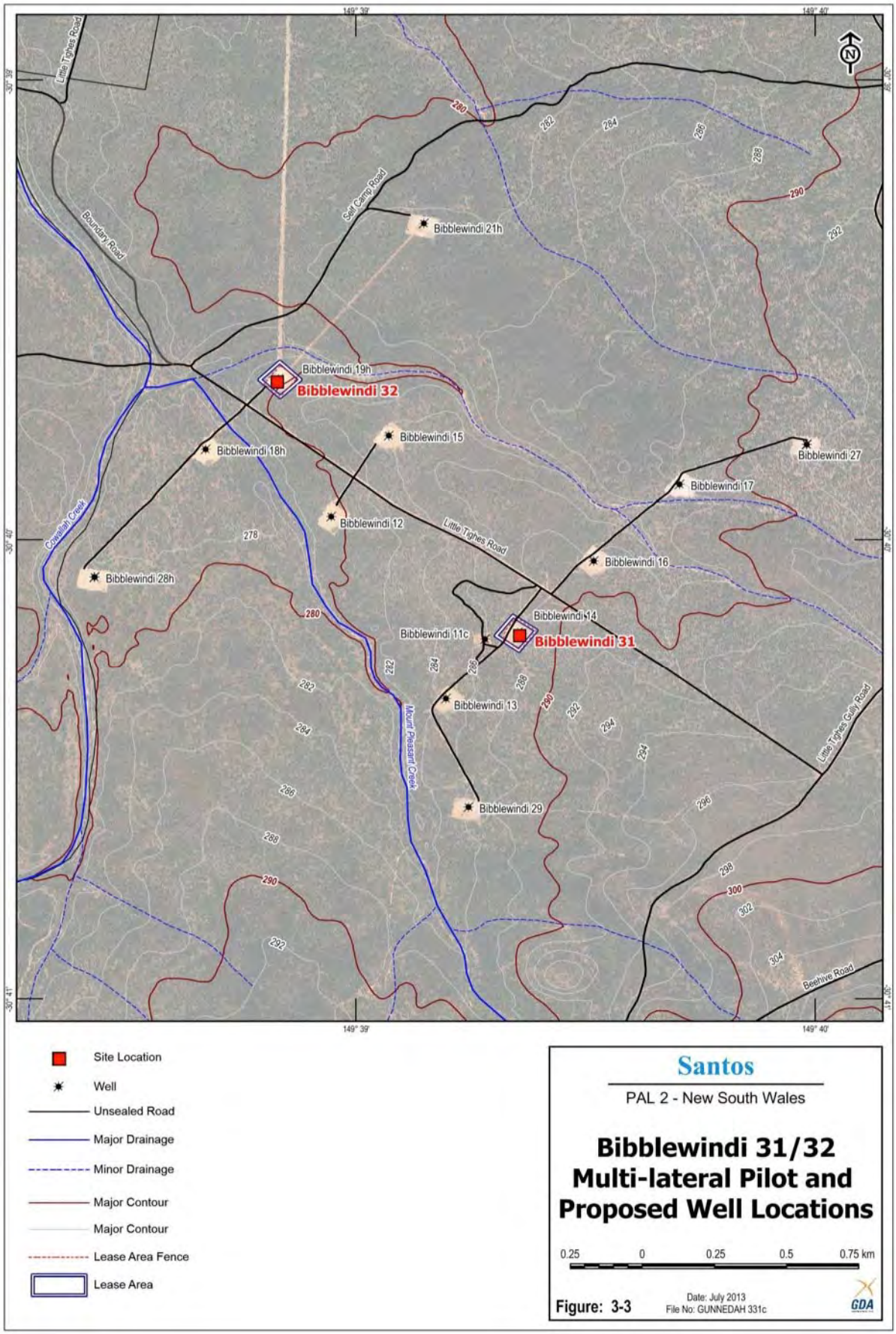


Figure 3-3 Bibblewindi Multi-Lateral Pilot and proposed wells

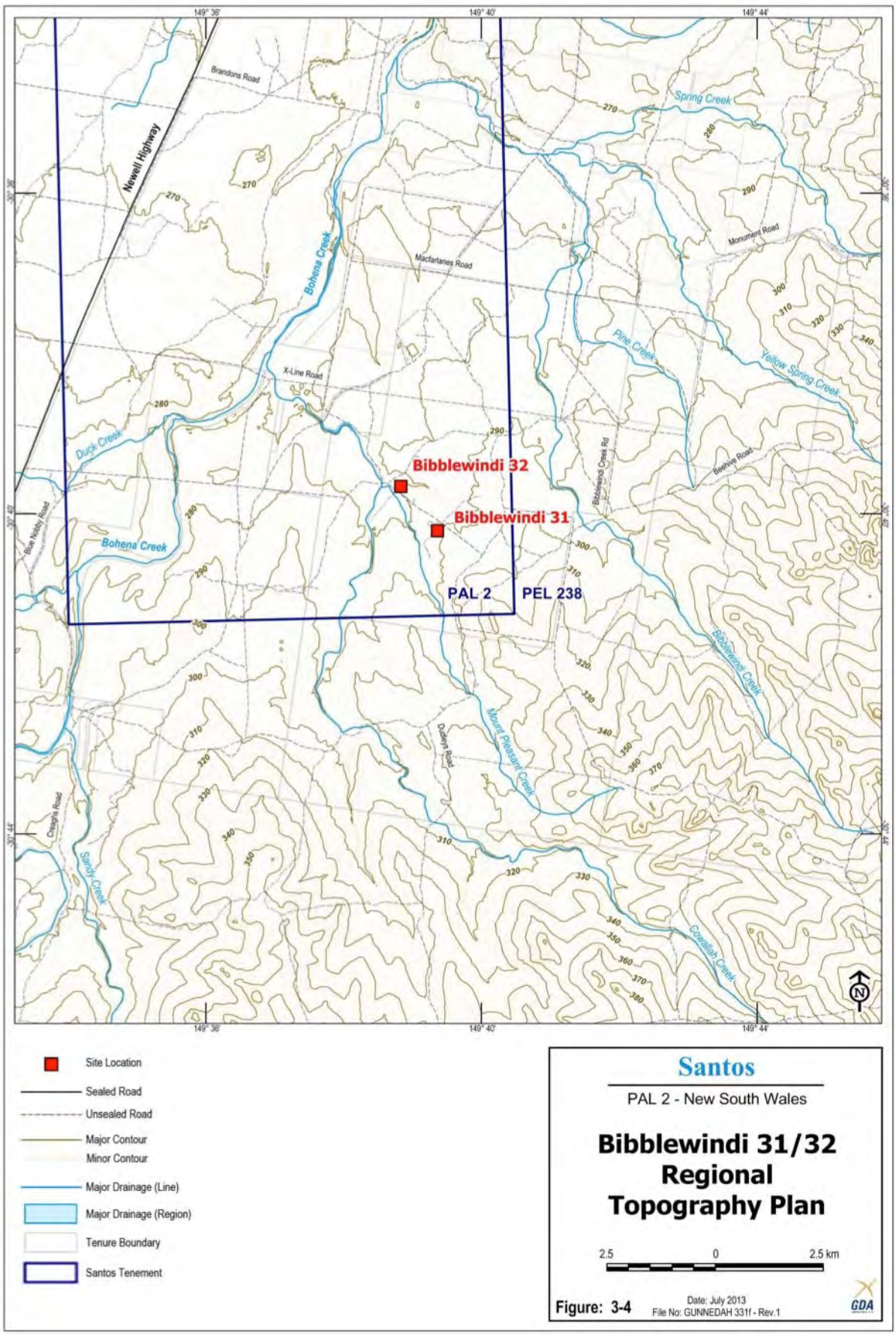


Figure 3-4 Regional Topography

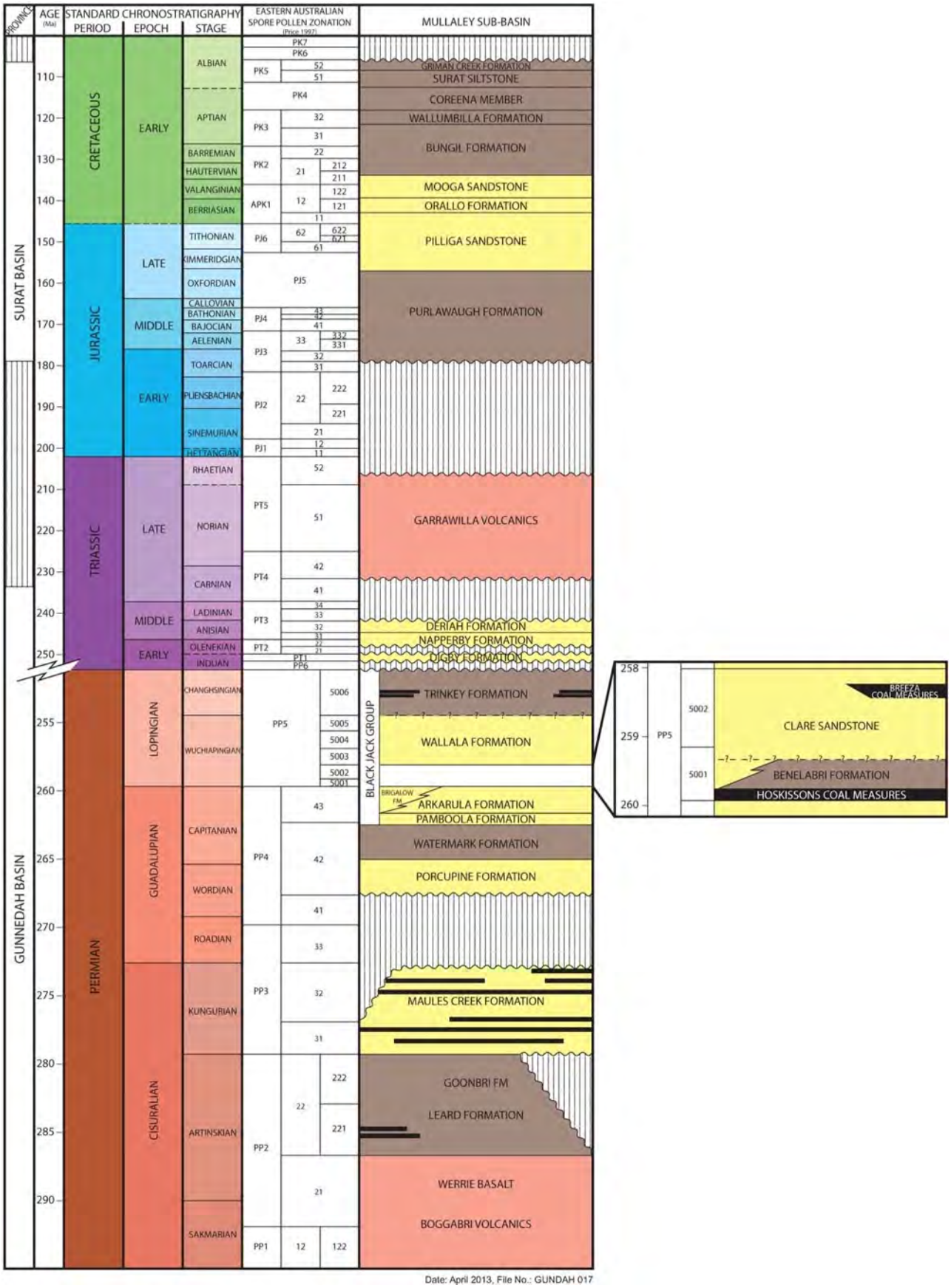


Figure 3-5 Stratigraphy of the Gunnedah Basin

3.2 Regional context

The site is located within the Narrabri LGA, which is located on the northwest slopes of NSW. The site is approximately nine kilometres from the Newell Highway, a major transport router connecting Coonabarabran with Narrabri.

The site is located within the central portion of the Bibblewindi State Forest approximately 40 kilometres south of Narrabri (see Figure 3-6). It is bordered by the Pilliga State Forest to the east, west and south. The nearest residences are over seven kilometres from the site and are shown in Table 3-2 and Figure 3-7.

The Bibblewindi State Forest is a 7,135 hectare area and forms part of a larger area of remnant vegetation known as the Pilliga Scrub. The Pilliga Scrub takes in numerous protected areas including the Pilliga Nature Reserve, Pilliga East State Forest, Pilliga East State Conservation Area, Jacks Creek State Forest, Rutley State Forest, Kerringle State Forest and Willala Aboriginal Area.

Table 3-2 Distance to nearest sensitive receptors

Resident ID / Sensitive receptor	Distance from the nearest lease area (km)
R1	8.3
R2	9.2
R3	9.5
R4	8.2
R5	7.5

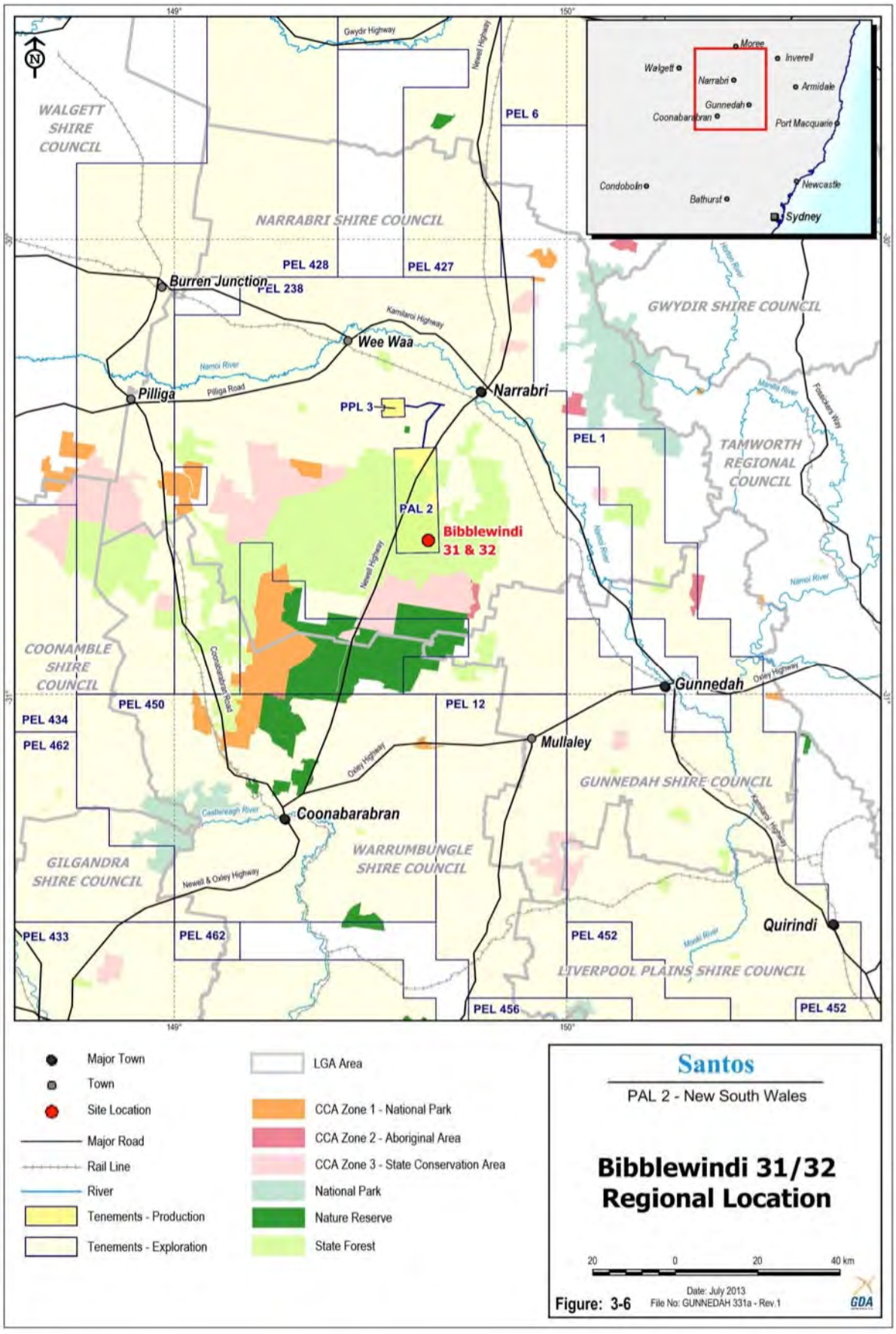


Figure 3-6 Regional location

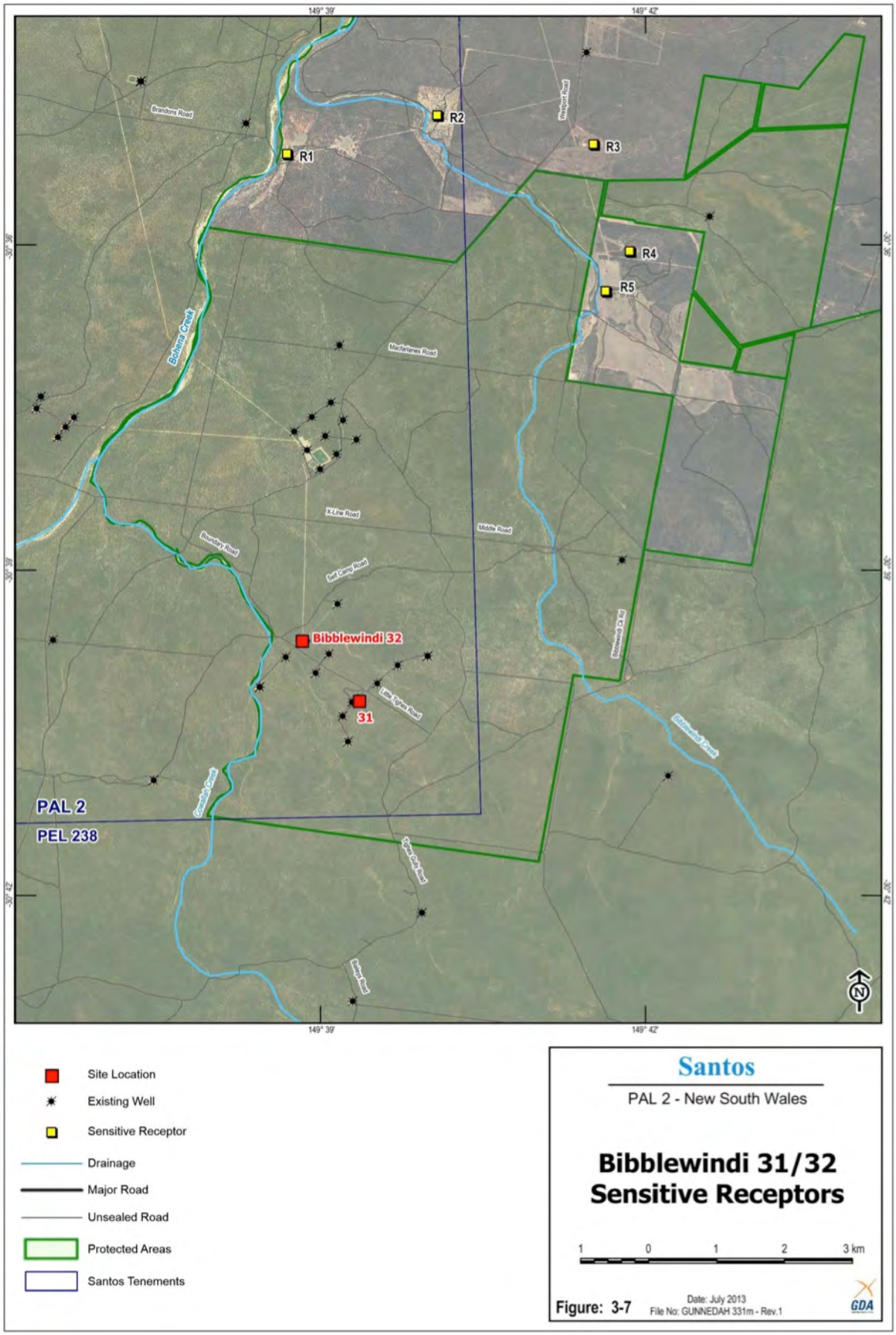


Figure 3-7 Sensitive receptors

3.2.1 Regional CSG infrastructure

Regional CSG infrastructure consists of a series Pilots, plugged and abandoned wells and water and gas management facilities. CSG infrastructure in PEL 238 and PAL 2 that relates to the proposed activity is described below with Figure 3-8 indicating infrastructure proximate to the proposed activity.

3.2.1.1 Existing water and gas flow lines

Existing water flow lines connect the Bibblewindi Multi-Lateral Pilot to the Bibblewindi Water Transfer Facility whilst gas flow lines connect to the Wilga Park Power station via the Bibblewindi Water Transfer Facility. Water and gas produced during operation will flow via these existing flow lines.

An existing flare is located at the Bibblewindi Water Transfer Facility that is used to manage gas supplied to the Wilga Park Power Station.

3.2.1.2 Bibblewindi water transfer and Leewood produced water facilities

The approved but not yet constructed Bibblewindi Water Transfer Tank, located at the Bibblewindi Water Transfer Facility, has been sized to accept water from the Bibblewindi Multi-Lateral including Bibblewindi 31 and 32. The Water Transfer Tank provides a short buffer (24 hours) period before produced water is transferred to the Leewood Produced Water Facility.

The two 300 megalitre ponds at the Leewood Produced Water Facility will be double lined and have a leak collection system. The liner system will comprise a primary polyethylene geomembrane liner, underlain by a leak detection system, underlain by a secondary liner. The secondary liner will be underlain by 300 millimetre of smooth clayey sub grade, free from obstructions or protrusions.

The proposed leak collection system will transfer any produced water collected below the liner directly back into the pond. The system will include an alarm to notify operational staff of any sudden changes in pump operational trends. The water level of each pond will be monitored continuously. Level sensors will be installed for management of pump controls and to provide protection against pond overflow. It is expected the sensor system will be monitored by means of telemetry. Similarly, this has been sized to accept water from the Bibblewindi Multi-Lateral including Bibblewindi 31 and 32.

3.2.1.3 Wilga Park Power Station

Wilga Park Power station is located north of the Pilliga Forest approximately 12 kilometres from Narrabri. Development consent for the construction and operation of the Wilga Park Power Station was issued to Narrabri Power Limited by Narrabri Shire Council in 2002. In 2008 approval was granted to expand the capacity of the power station to 40 Megawatts. The power station, when operating, supplies electricity to the local 66kv network through a substation located adjacent to the power station.

3.2.1.4 Narrabri Operations Centre

The Narrabri Operations Centre (NOC) is located five kilometres west of the Narrabri town centre at 300 Yarrie Lake Road, Narrabri. Development consent for the construction and operation of the NOC was issued to Santos by Narrabri Shire Council in 2007. In April 2013 development approval was granted to expand the existing operations to include a warehouse, storage building and additional office space, a hardstand pipe casing wash and storage area. The NOC will also include the Fluids Treatment Facility (FTF) subject to planning approval and obtaining an Environmental Protection Licence (EPL). The FTF will treat and store drilling fluids for future re-use in drilling activities.

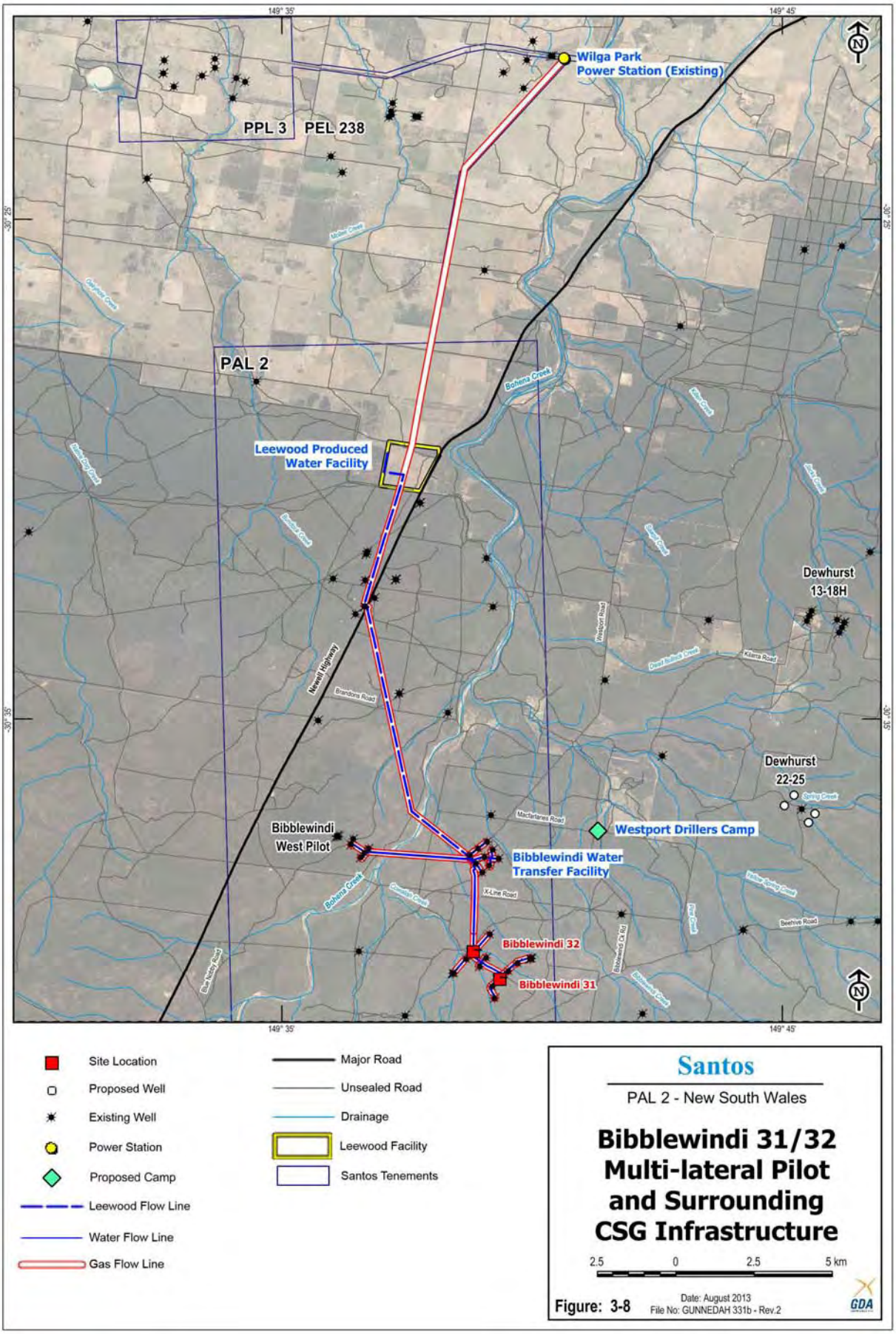


Figure 3-8 Pilot and surrounding CSG infrastructure

3.2.1.5 Westport Drillers Camp

Westport driller's camp is located approximately 30 kilometres south west of Narrabri and approximately seven kilometres north of the site. Development approval was issued in December 2012. The camp will accommodate between 24 and 64 persons at the site for up to 4 years. The camp will be used as needed for any proposed activities to occur as part of the E&A Program.

3.2.1.6 Other Pilots within the E&A Program

Other pilots within the E&A Program located near the Bibblewindi Multi-Lateral Pilot include:

- Bibblewindi West Pilot, approximately 5 kilometres west
- Dewhurst 13-18H Pilot, approximately 15.5 kilometres north
- Dewhurst 22-25 Pilot, approximately 10.5 kilometres north east
- Dewhurst 26-31 Pilot, approximately 3.5 kilometres south.

3.2.2 Land ownership

The proposed activity is located entirely on land managed by the Forestry Corporation of NSW. Santos holds a Permit to Occupy from Forestry Corporation of NSW and the State of NSW. The permit to occupy outlines a range of environmental mitigation strategies that Santos must implement as part of the agreement.

4.0 Description of the Proposed Activity

4.1 Overview

The proposed activity involves the expansion of the Bibblewindi Multi-Lateral Pilot through the drilling of two new wells (Bibblewindi 31 and 32) on existing well pads (Bibblewindi 14 and 19H respectively), installing surface infrastructure to connect the wells to the existing network of wells and associated water and gas gathering system and operating the expanded Bibblewindi Multi-Lateral Pilot including the management of water and gas produced during operation. All activities will occur on the existing lease areas and access tracks for Bibblewindi 14 and Bibblewindi 19H.

The proposed activity includes:

- construction: site preparation of the well leases and establishing necessary equipment, temporary structures and facilities on the existing 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 3 years and general maintenance activities
- post operation and rehabilitation: decommissioning and rehabilitation of pilot wells and ancillary infrastructure or suspended.

The works proposed during each stage, and estimated timing, are summarised in Table 4-1.

Table 4-1 Approximate duration of drilling and site activities

Activity	Approximate duration	Estimated timing
Construction		
Site preparation	20 days	Q2 2014
Drilling and completion	35 days	Q2 2014
Surface facilities	50 days	Q2/3 2014
Operation		
Operation of the pilot	up to 3 years	2014 to 2017
Post operation and Rehabilitation		
Post operation/rehabilitation	approximately six months after well abandonment where practicable and considering external factors such as weather	on completion of appraisal activities

The proposed activity does not include the assessment of the existing site establishment and construction activities for clearing and preparation of the lease areas, the water and gas gathering system, access tracks and partial rehabilitation of the lease areas, as these are the subject of existing approvals.

4.2 Pilot well design

4.2.1 Bibblewindi 31 and 32 wells

Bibblewindi 31 and 32 will be designed and constructed in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS 2012b).

Bibblewindi 31 will be constructed as a generally vertical well with a below ground level of approximately 1100 metres and a measured depth of approximately 1150 metres. The measured depth is slightly longer than the below ground level as the bottom of the well will have a slight incline and the well design includes a slight s-bend.

Bibblewindi 32 will be a single-lateral well and will have a below ground level of approximately 900–1000 metres vertically and a measured depth of approximately 2100 metres. The 'build zone', where the initially vertically drilled well is inclined to penetrate the Bohena coal seam laterally, will be between 930 and 990 metres below ground level. From here, the well will continue laterally in-seam for a distance of approximately 900 metres, where it will intercept Bibblewindi 31, including a short distance past Bibblewindi 31.

Table 4-2 summaries the key design criteria for each of the wells.

Table 4-2 Well design parameters

Design criteria	Bibblewindi 31	Bibblewindi 32
Direction	Vertical[1]	Lateral
Approximate Depth	1100 m	930-990 m
Well type	Appraisal pilot	Appraisal pilot
Target coal seam	Bohena	Bohena
Drilling technique	rotary drilling and coring	rotary drilling
Horizontal length		Approximately 900 m
Well head pump	progressive cavity pump or electrical submersible pump[2]	electrical submersible pump

Notes
[1]The vertical well includes a slight "S" shape to enable drilling on the existing Bibblewindi 14 lease area
[2]The pump type is to be confirmed based on the deviation of the well and recommendations from pump vendors.

Figure 4-1 shows the interaction between the two wells. Bibblewindi-31 is the red "S"-shaped well.

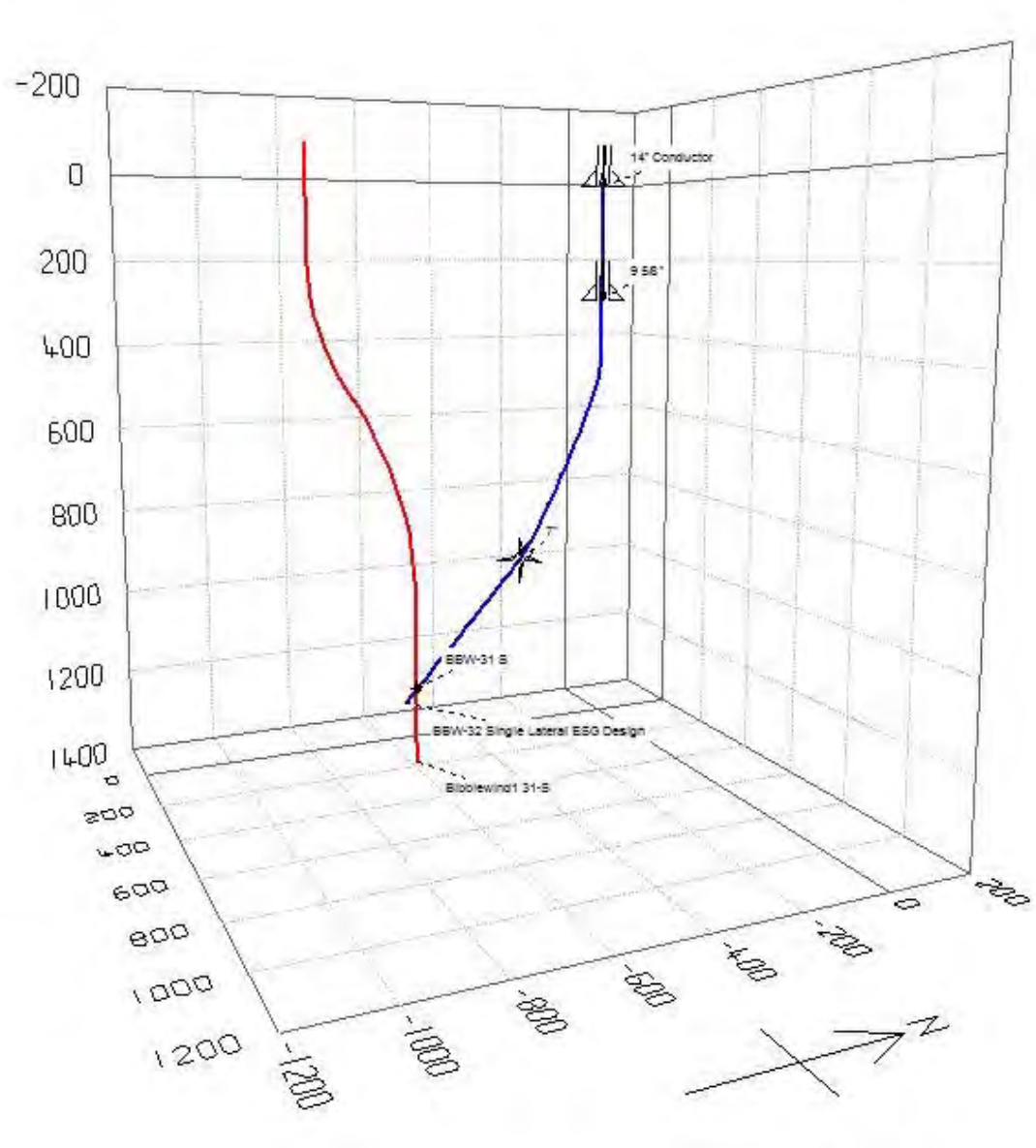


Figure 4-1 Well schematic showing intersection of the wells (units in metres)

4.2.2 Surface facilities

A wellhead separator and metering skids with associated power generation equipment (gas and diesel), motor control centre, pump and telemetry units will be installed at each pilot well. The wellhead separator at each pilot will be connected to the existing water and gas gathering system for the Bibblewindi Multi-Lateral Pilot. The tie-in point to the existing buried gathering system will be on the existing Bibblewindi 14 and 19H lease areas. There is sufficient capacity within the existing gathering system to carry additional water and gas produced by Bibblewindi 31 and 32.

A typical wellhead separator and metering skid is shown in Plate 4-1.



Plate 4-1 Typical wellhead separator and metering skid

4.3 Construction activities

4.3.1 Site preparation

Various works would be undertaken to prepare the site for the proposed activity, including minor clearing of grasses that have established within the existing lease areas, re-establishing temporary buildings, above-ground storage tanks and other facilities on the lease areas, excavating a cellar pit and drill cuttings pit and positioning the drill rig.

The drill cuttings pit will be lined with heavy grade impermeable plastic sheeting.

Temporary venting and flaring facilities would be located at each site during drilling and pump testing, but would be removed at the end of drilling activities.

Figure 4.3 shows a typical layout for a lease area during drilling.

The primary plant, equipment and temporary buildings to be used during drilling activities will include:

- drilling rig and supporting equipment (such as pipe handler and mud pump)
- surface tanks
- metal bins, baskets, skids and sea containers to house equipment
- mechanical vibrating screens
- power generator units
- lighting towers
- site offices.

The vent tank would be installed to capture fluids and gas from the wells if required. This tank is a re-enforced steel container, with internal baffles and piping to allow for the separation of gas and liquids. The tank will be designed to contain any fluids vented. This captured and contained fluid will be removed, as required, and disposed of by a licensed waste disposal company. Minor volumes of methane (CH_4) and carbon dioxide (CO_2) may be emitted from the vent tank from time to time.

Other equipment will be required on site during the course of the drilling activities, including wire line trucks, cementing trucks and service company vehicles.

4.3.2 Site access for construction

Access routes to the lease areas would be via existing roads as shown in Figure 4-3. For the majority of vehicles and equipment access to the site would be from the Newell Highway via X line Road, Tighes Gully Road and Little Tighes Road, which are all unsealed roads within the Forest.

Employees based at the drillers camp would also access the site from Forest roads including Middle Road, Macfarlane's Road, Garlands Road, Bibblewindi Creek Road, Self Camp Road and Tighes Gully Road.

Travel to and from Narrabri and the NOC/FTF will be via the Newell Highway, Mooloobar Street and Yarrie Lake Road once within Narrabri.

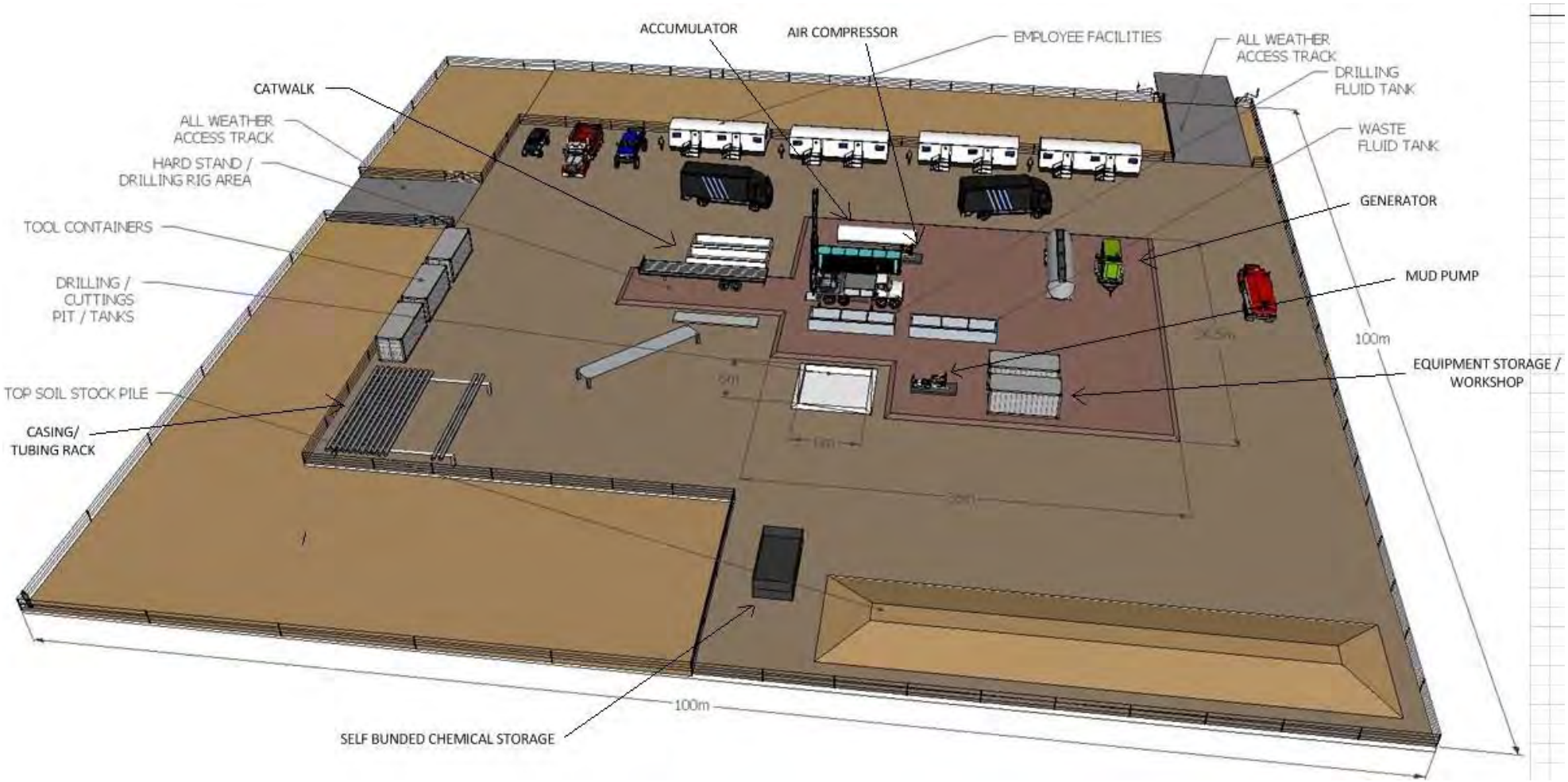


Figure 4-2 Conceptual lease layout during drilling

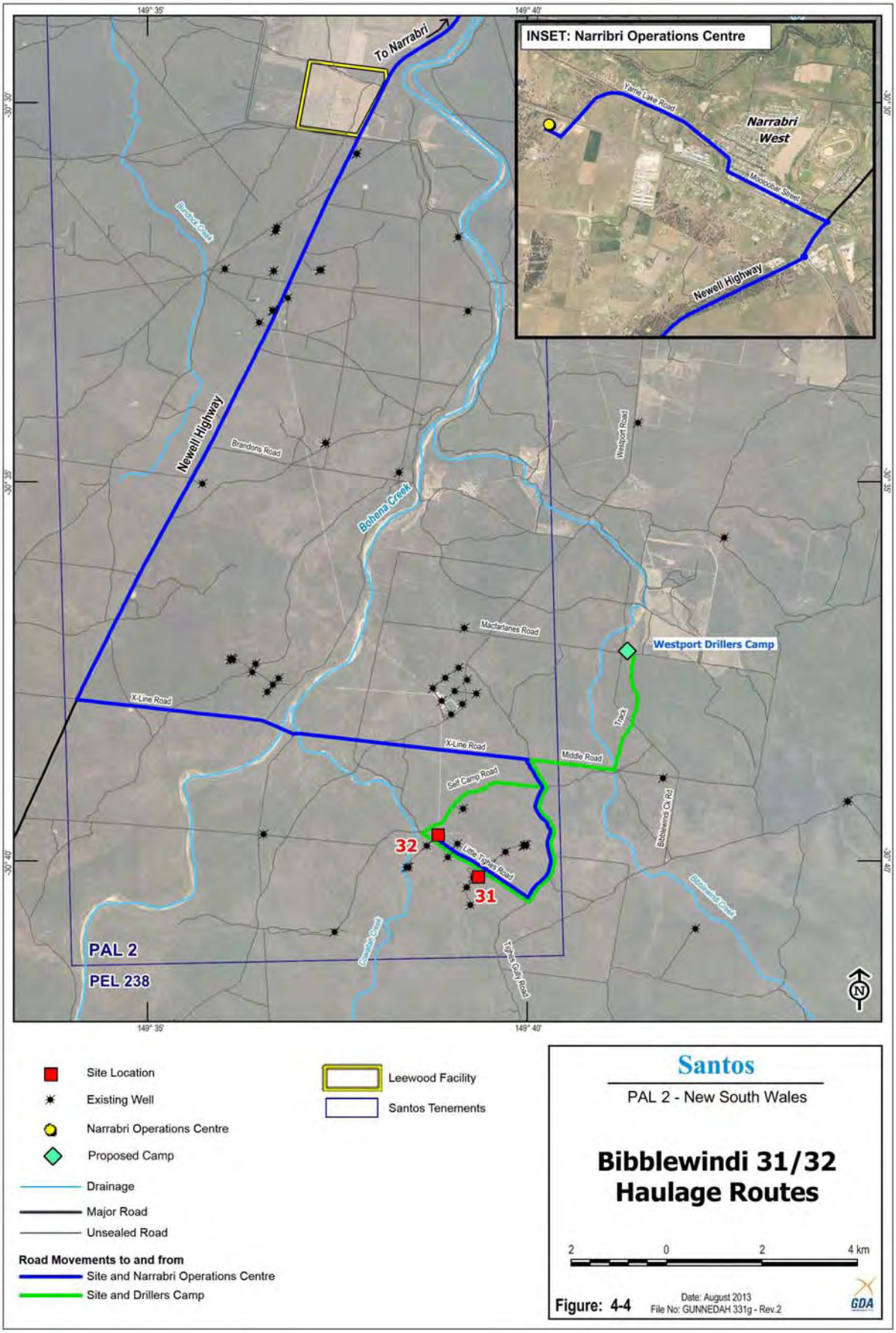


Figure 4-3 Bibblewindi 31 and 32 haulage routes

4.3.3 Drilling

4.3.3.1 Drilling process

Bibblewindi 31 will be drilled first, followed by Bibblewindi 32. Drilling and construction of the two wells will involve:

- drilling an open hole with an approximate diameter of 12¼ inches through alluvial and/or weathered rock material into competent rock (Purlawaugh Formation)
- installing 9⅝ inches steel casing and cementing in place back to surface. The surface casing would be set 290 to 330 metres below ground level
- installing a Blow Out Preventer (BOP) on top of the casing, drilling out the casing shoe using an 8½ inches rotary drilling assembly and drilling to the planned depth. During drilling, the circulating drilling fluid will establish a wall cake 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.
- installing production casing to the planned total depth just above the Bohena coal seam.

4.3.3.2 Drilling fluid and additives

Drilling fluids used for drilling of the two wells will be predominantly water-based and made up of two main drilling additives, salts and gels. Salts such as potassium sulphate (K_2S0_4) are used as a weighting agent to help control swelling clays, while gels such as CR-650 are used to lubricate and increase the viscosity of the drilling fluid.

Potential sources of make-up water for the drilling fluid include the Narrabri's town water supply, produced formation water from an operational pilot well in the region, or local industrial licensed water bores. The quality of make-up water will depend on the final source.

Chemicals will be mixed with the drilling fluid at the FTF prior to being transported to site (subject to planning approval and obtaining an EPL for the FTF). This will reduce the volume of chemicals required to be stored on site during drilling. The drilling fluid will be transported to the site in a trailer prior to the commencement of drilling and stored in surface tanks on site. Any chemicals on site will be stored in an elevated, bunded trailer for protection in the event of heavy rains or site flooding.

Chemicals that may be used in the drilling process or held on site during the drilling process and their purpose is summarised in Table 4-3.

Table 4-3 Drilling chemical additives

Chemical trade name	Description	Purpose
K2S04, Potassium Sulphate	Sulphuric Dipotassium Salt, Sulphate of Potash, Potash of Sulphur, Arcanite	Helps to keep the drilled clays dry and less sticky
Calcium Chloride 74-77%, Calcium Dichloride	Calcium Chloride	To speed up setting of cement and reduce waiting time
Xanthan Gum P, Flowzan	Corn Based biopolymer (polysaccharide)	Thickens the mud so it can carry the drilled rock out of the hole
Quickseal Medium, Kwikseal	Cellophane/wood /nutshells	Lost Circulation Material. Deposits against the wall of the hole to prevent or reduce mud lost down the hole

Chemical trade name	Description	Purpose
Rheopac, Rheopac-RD, Rheopac-LV, Rheopac-R, Drispac-R, Drispac-SL, PAC-R, PAC-L	Poly Anionic Cellulose	Reduces the amount of fluid seepage from the mud into the ground which can cause the hole to become sticky, unstable and less productive
JK – 261 / JK-161, CR-650, JK-261 LV, JK-161 LV	PHPA (Partially Hydrolised Poly Acrylamide)	Helps to keep the drilled clays dry and less sticky
Idcide – 20	Tetrakis Hydroxymethyl Phosponium Sulphate (THPS)	To prevent micro-organisms from attacking the mud and generating odours when stored
Sodium Bicarbonate	Sodium Hydrogen Carbonate (NaHC03)	Treatment against cement contamination of the drilling mud
Citric Acid	Citric Acid	To reduce pH
Soda Ash	Sodium Carbonate (Na2C03)	Control of Calcium Hardness
Fracseal – Fine	Micronised Cellulose fibre	Deposits against the wall of the hole to prevent or reduce mud lost down the hole
Sodium Formate	Formic Acid, Sodium Salt	To provide weight in the fluid and provide some clay inhibition
DEFOAM – E	Polyoxyethylene polyoxypropylene block copolymer	Prevent foaming of mud and problems with pumps
Barite, Rheobar, Aus-Bar	Barite, Barium Sulphate. Naturally occurring, insoluble mineral.	To prevent hole collapsing and high pressure gas or water from escaping. Legal requirement for well control

The Materials Safety Data Sheets (MSDS) for these chemicals are provided on the Santos website: http://www.santos.com/exploration-acreage/nsw-csg/reports-and-publications.aspx.

During drilling, the drilling fluid will mix with naturally occurring rock and soil (referred to as drill cuttings) and return these to the surface. The drilling fluid will pass through mechanical vibrating screens to separate out drill cuttings. The liquid component of the drilling fluid will flow into surface tanks for recirculation throughout the drilling process. Drill cuttings will be stored on site until drilling is completed.

Table 4-4 outlines the expected drilling fluids required for each well.

Table 4-4 Estimated drilling fluid transported to and from site

	Bibblewindi 31	Bibblewindi 32
Drill cuttings generated (m^3)	140	300
Drilling fluid transported to site (m^3)	225	250
Drilling fluid transported from rig to Fluid Treatment Facility (m^3)	100	150

Losing drilling fluid is undesirable as it is the primary means of controlling the drilled hole. In the event that losses are detected, a lost circulation material (LCM) will be mixed into the fluid to prevent further losses. LCM is made of cellulose or other natural material and works by blocking the pores in the permeable/fractured rock.

4.3.3.3 Treatment of drilling fluid

Once drilling of the wells is complete, Santos is proposing to transport and treat drilling fluid at the proposed FTF. The FTF will treat and store drilling fluids for future re-use in subsequent drilling activities. If required drill cuttings will be tested to determine the appropriate management and disposal methods.

It is expected that the FTF will be licenced and operational by the time Bibblewindi 31 and 32 is drilled. Drilling fluids will be mixed at the FTF and then transported to site. Approximately six tankers will be required to transport the drilling fluid to site prior to drilling each well.

In the event that the drilling fluids treatment facility at the Narrabri Operations Centre is not approved or operational, drilling fluid will be mixed in tanks on the well lease sites prior to drilling. Make-up water will be transported to the site from a licensed source in the area. Additives (potassium sulphate or potassium chloride, and polymers) will be transported to site from the supplier's warehouse in Roma or Brisbane. Approximately six tankers will be required to truck the make-up water from its source to the site prior to drilling each well. One truck will be required to transport drilling additives from the warehouse to site at the start of drilling each well.

Additional tankers will be required to truck either drilling fluids or make-up water throughout the drilling of each well (equivalent to approximately three to seven tankers, well design dependant, over the drilling period).

4.3.4 Cementing

Cementing operations will be in compliance with Section 4.3 of the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS 2012b) so as to:

- prevent groundwater migration paths and isolate the targeted zone from other formations
- protect beneficial aquifers from contamination
- maintain aquifer pressures and quality
- obtain and maintain well integrity
- protect the casing from corrosion.

The cementing of casing strings will be performed by a recognised professional cementing company who will provide bulk cement facilities, high pressure cementing pumps and mixing pumps to mix and pump the slurries required. The equipment will be operated in a manner that will minimise any spills. Pressure tested steel lines will connect the cementing unit to the well to allow fluids to be pumped to the well and these fluids will be positioned in the well following correctly formulated engineering design and good oilfield practice.

To ensure compliance with the Code of Practice, all casing strings will be cemented to surface. All batches of cement used in the cementing operation and associated chemicals for the recipe are tested prior to use in the wells to ensure that the cement has the right properties (i.e. setting time and compressive strength).

All cementing programs are designed, reviewed and signed-off by senior Santos drilling personnel and submitted, as part of the Well Drilling Program (Notification to Drill), to the Office of Coal Seam Gas (OCSG) for approval at least 30 days before the well can be commenced.

In addition, cementing reports, including all materials and compressive strength versus time graphs, cement pump charts and pressure records, logging reports and details of centraliser placing must be completed and submitted to the OCSG with the Well Completion Reports.

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.

4.3.5 Casing the well

Once each well has reached the total depth, geophysical wire-line logs would be run over the length of the hole (or as far as practicable in Bibblewindi 32) to identify major stratigraphic units, intersected coal seam depth and seam thickness. Further well testing may follow after completion of logging.

At near vertical in Bibblewindi 31, a combination of steel and fiberglass casing would be run in the hole and pressure cemented ensuring total isolation of the well bore to the surrounding coal seams and any potential aquifers. The combination casing design allows fiberglass to be placed over potential future lower Maules Creek coal seams whereas steel casing isolates all other non-target rock types in the upper section of the well including shallower, potentially mineable coal seams including the Hoskisson coal measure. The horizontal hole drilled from Bibblewindi 32 will intercept the fiberglass casing in the vertical well over the target coal sequences.

In Bibblewindi 32, steel casing will be run in the 8½ inch hole section to total depth at approximately 1130 metres measured depth. Steel casing will be used over the upper coal seams. The horizontal hole section will be left open and uncased

All casing design shall comply with the Santos Drilling Operations Manual in accordance with Santos (and other) oil industry standards to cater for potential casing failure mechanisms.

4.3.6 Well completion

The wells will be completed using a work over rig. This involves installing the down hole pump assembly and hydraulic drive head (wellhead) with additional support equipment.

4.3.7 Construction staff and hours

The number of employees present on the site at any one time is expected to be approximately 20 with short peaks during shift changeover. Drillers will be based at the Westport driller's camp with travel to and from site by minibus.

Construction hours will be up to 24 hours per day, seven days per week. Personnel movements to and from site will be minimised outside of a single shift change per day but may be necessary during specific activities or in the event of an incident.

4.3.8 Site water requirements

Approximately 0.02 megalitres per day of potable water will be required for facilities on each lease. This will be sourced from Narrabri's town water supply or local industrial licensed water bores and trucked to the site.

4.4 Operation of the pilot

4.4.1 Pilot testing

During the pilot test, pressures, water volumes, water levels, compositions and gas rates will be monitored. These will be reported in accordance with regulatory obligations.

Data collected on site from the well head and gathering system will be transmitted via a Remote Telemetry Unit (RTU) through the Next G network to Santos offices to enable operations personnel to remotely monitor and control the surface facilities. Security measures will also be installed.

The pilot wells will have automated shutdown systems that are triggered by pre-set operating envelopes. These operating envelopes are designed to minimise or prevent environmental, health or safety incidents.

4.4.2 Water management

A qualitative site water balance assessment was undertaken as there is no onsite water demand during general operation of the Bibblewindi Multi-Lateral pilot. There will be some minimal onsite water demand during work overs, as discussed below. For the majority of the time, the only water onsite will be the groundwater lifted from the wells during operation of the pilots.

For the vertical wells, a progressive cavity pump (PCP) will be installed just above the coal seam to transfer water to the surface through the well tubing. For the horizontal wells, an electrical submersible pump (ESP) will be located just above the depth of the target coal seams.

In order to conduct the pilot, water will be extracted from the target seams from all the (14) pilot wells simultaneously. The lifted water will be captured at each well head and will be disposed of from site through a network of pipes and treated. There will be no discharge to local receiving waters.

The water extraction rate is raised steadily over the first 30 days of the trial in order to protect the integrity of the well bore and casing. The estimated volumes of groundwater lifted at the Bibblewindi Multi-Lateral pilot is outlined in Table 4-5.

Table 4-5 Estimated groundwater extraction rates for the Bibblewindi Multi-Lateral pilot

Pilot	Total Extraction (m^3)	Max Extraction (m^3/day)	Average Extraction (m^3/day)
Bibblewindi Multi-Lateral Pilot	285,110	581	260

Table 4-6 shows the likely produced water composition based on existing water sampling data from existing wells drilled within Maules Creek Formation coal seams in the Narrabri region. As a baseline, rainwater typically has 20 milligrams per litre or less total dissolved solids (TDS). Fresh water from lakes, rivers, and groundwater is more variable, with TDS ranging from 20 milligrams per litre to approximately 1,000 milligrams per litre. Brackish water is, by definition, water with TDS exceeding 1,000 milligrams per litre and ranging as high as that of seawater, at approximately 35,000 milligrams per litre. The below results indicate that CSG water would be considered in the high brackish range and unsuitable for irrigation or drinking water without treatment.

Table 4-6 Quality of formation water within the Maules Creek Formation coal seams (based on data taken from existing wells within PEL 238 and PAL 2)

Parameter	Units	Minimum	Average	Maximum
Total Dissolved Solids (TDS)	mg/L	9,000	16,000	23,000
Temperature	° C	22.5	22.8	23.4
pH		7.1	7.5	8.0

The only onsite water demand during operation will potentially occur during work overs associated with maintenance activities, when the well is first killed (flushed with higher density fluid to prevent water rising), and then during the actual work over activities. Approximately three to four trailer-loads (75 to 100 cubic metres) of weighted brine from the FTF may be required to kill the well. The additional water will be sourced from the Narrabri's town water supply, local industrial licensed water bores or the Leewood Produced Water Facility and trucked to the site.

Approximately three to five trailer-loads (75 to 125 cubic metres) of groundwater may also be lifted during work over activities. This produced water will be trucked to the Leewood Produced Water Facility.

4.4.2.1 Water transfer and treatment

The water transfer and treatment process will be as follows:

- 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.

4.4.3 Gas management

Recovered gas from the wells will flow up the well annulus (separate to the water) with the gas stream entering the wellhead separator to remove any entrained water. Gas will collect at a central location at Bibblewindi 19H. A portion of the produced gas will be diverted for conditioning and use within the well site power generators (approximately 10%).

The remainder of the gas will be transferred via the existing flow line to the compressor station and flare located at the Bibblewindi Water Transfer Facility. Gas would then join the existing gas flowline and transfer to Wilga Park Power Station subject to approval for the gas to be consumed at Wilga Park Power Station.

Where gas volumes exceed demand at the Wilga Park Power Station, or in the event that approval is not granted, gas will be flared at the Bibblewindi Water Transfer Facility. Provided approval for the gas to be consumed at Wilga Park Power Station is gained, it is expected that this would be less than 5–10% of the gas produced.

4.4.4 Partial Rehabilitation of lease areas

Once the drilling activities are complete, any surplus lease area is proposed to be rehabilitated to an area of approximately twenty by twenty metres around each well head with appropriate mitigation measures and environmental safeguards implemented to minimise potential impacts. All rehabilitation works will be undertaken with maximum regard to environmental protection and rehabilitation, vegetation, subsoil and

topsoil management, weed control, erosion and sedimentation management and revegetation in accordance with the relevant statutory requirements.

4.4.5 Maintenance activities

Well maintenance and work over activities will occur from time to time at the wells for corrosion monitoring, mechanical repairs or other interventions as required. Work over activities could include maintenance of completion equipment, well cleanouts and/or repairs.

4.4.6 Maintenance staff and hours

During operation, staff movements to the site will be minimal. It is expected that the site will be visited by up to one vehicle per day for monitoring and minor maintenance. During well work over activities, an increase in staff would occur for a short period if a work over rig were required.

Generally monitoring and maintenance will occur during daylight hours although in some instances or should an incident occur, 24 hour operations may be required.

4.5 Post Operation and final rehabilitation

On completion of operations, wells and ancillary infrastructure would either be decommissioned with lease areas rehabilitated or wells will be suspended. Options considered include:

- Suspension for future use: exploration and appraisal activities confirm the CSG resource as commercially viable. If this occurred, production activities would be subject to further environmental assessment and government approvals. In the event that Santos decides to seek approval for a production project, the wells would be suspended until determination of the role, if any, the wells would play in a commercial gas production project
- decommissioning and rehabilitation: This would occur in the event that Santos does not pursue commercial gas production, or a well or supporting infrastructure is not a part of a commercial gas production activity for which approval is sought. In this scenario the wells and supporting infrastructure would be decommissioned and rehabilitated.

4.5.1 Pilot well decommissioning and lease area rehabilitation

Decommissioning of the wells would also be in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012b). This includes:

- sealing the wells from bottom to top by plugging with cement in approximately 200 metre increments
- pressure testing the cement plug across the surface casing shoe to ensure the wells are sealed
- removing the well heads and casing at a depth of greater than 1.5 metres below surface and installing a well head marker.

Surface infrastructure would be removed. Buried surface infrastructure, including the gathering systems, would be flushed, capped at each end and left in-situ in accordance with legislative requirements.

A rehabilitation strategy will be developed in conjunction with the landowner, Forest Corporation of NSW, and taking into consideration the conditions within the Permit to Occupy. The final landuse would be consistent with the surrounding area as state forest.

4.5.1.1 Rehabilitation objectives

The objectives for the rehabilitation program are to:

- stabilise the site to minimise erosion
- return the disturbed areas to a self-sustaining native forest condition, typical of adjacent reference forest ecosystems
- rehabilitate the disturbed areas to the satisfaction of the landholder (Forestry Corporation of NSW).
- facilitate natural re-vegetation

EcoLogical Australia recently conducted a review of the success of natural revegetation approach to rehabilitation. As part of the review, six sites were identified along the Wilga Park Gas Flow Line route that was constructed in 2007/8 and four lease areas (Dewhurst 2, Dewhurst 19, Bibblewindi 25 and Jacks Creek 1). The effectiveness of rehabilitation was measured in 2012 and again in 2013. At all locations, the number of native species increased over the year and were generally within 30% of the numbers observed in the reference sites. This demonstrates the rehabilitated areas are capable of sustaining reproducing populations of the species necessary for its continued stability and development within relatively short timeframes.

4.5.1.2 Rehabilitation methodology

The proposed rehabilitation methodology includes:

- identification of reference sites to assist in monitoring success
- removing perimeter fencing and all other infrastructure
- replacing sub-soil across the well leases, contouring to the landscape and partially compacting
- placing top-soil uniformly across the well leases
- revegetating well leases with native species from existing seed bank within top soil
- surface contouring, through ploughing and the creation of “hummock” and low relief features similar to the surrounding area
- spreading of retained woody material
- blocking of access tracks with timber to minimise disturbance of the site by vehicles and to maximise natural regeneration
- controlling weeds
- ongoing monitoring of success through comparison to identified reference sites.

Assisted planting would be considered in the event that natural regeneration is unsuccessful, in accordance with the criteria in the table below. Any assisted revegetation will utilise species that:

- are locally available to eliminate the introduction and establishment of foreign species from other areas of the Pilliga and/or weeds
- reduce erosion of sediment by wind or water by root mass created in rehabilitated soils
- enhance the speed of plant colonisation of rehabilitated soils beyond that expected from surrounding areas alone
- provide microsites for further natural species ingress into the rehabilitated areas, especially tree species which require some immediate low-level shelter, soil moisture and organic content
- provide wildlife habitat in the rehabilitated areas.

4.5.1.3 Rehabilitation completion criteria

Rehabilitation success will be assessed by establishing and assessing monitoring sites with reference to the existing (pre-disturbance) vegetation characteristics, outlined in Table 4-7 (referred to as the reference condition).

Table 4-7 Vegetation characteristics (reference condition)

Description	Corresponding community	Characteristics		
		Canopy	Shrub	Ground
Narrow leaved ironbark woodland	Ironbark Shrubby Woodland of the Pilliga Area, Brigalow Belt South	15 to 19 metres – a patchy to moderate 15 – 50% projected foliage cover. The dominant species was *Eucalyptus crebra* (Narrow-leaved Ironbark).	Variable height of 0.1 to 1.7 metres, 80 to 95% cover. Dominated by *Acacia caroleae* (Wattle) and, to a lesser extent, *Acacia spectabilis* (Mudgee Wattle), *Callistemon linearis* (Narrow-leaved Bottlebrush), and *Cassinia arcuata* (Sifton Bush).	Variable height of 0.1 to 0.8 metres, 50 to 65% cover. The ground layer was scattered and sparse and was dominated by *Dianella revoluta* (Blue Flax-lily), *Lomandra filiformis* (Wattle Mat-rush), *Aristida ramosa* (Purple Wire Grass), *Eragrostis brownii*, *Aristida vagans* (Threeawn Speargrass) and *Cheilanthes sieberi* (Mulga Fern).

Rehabilitation performance criteria and rehabilitation completion criteria for the E&A program have been developed based on PAL 2 conditions and the Permit to Occupy. These are summarised in Table 4-8 and Table 4-9.

Table 4-8 Rehabilitation performance criteria

Action	Outcome	Target	Timing
Decommissioning of site infrastructure	Cleared site	All plant, equipment, containers, waste materials and temporary buildings removed from the site. Fencing removed.	Within 6 months of abandonment
	Gathering system	Pipes flushed and capped each end.	Within 6 months of abandonment
Landform establishment	Topography to mimic the micro topographical undulations of the surrounding area.	Site graded and reshaped to reinstate, as far as practicable, the original contour and drainage. Erosion and sediment control implemented to minimise runoff channelling/erosion	Within 6 months of abandonment
Restoration activities by natural rehabilitation	Restored native plant diversity	Restore native plant species richness, and native canopy, mid-storey and grass cover to within 75% of reference condition. Achievement of target prior to elapsing of period to be assessed as development against the target trajectory.	Canopy: 15 years Midstory: 10 years Groundcover: 5 years

Action	Outcome	Target	Timing
Assisted restoration by seeding and/or planting where natural rehabilitation does not meet requirements within stated period	Restored native plant diversity	Restore native plant species richness, and native canopy, mid-storey and grass cover to within 75% of reference condition.	Ground cover: Where natural regeneration has produced no evidence of soil stabilisation after 6 months of rehabilitation. Midstorey: Where natural regeneration has produced less than 25% cover of reference condition after 2 years of rehabilitation.
Fauna habitat components reinstated (fallen logs and bush rock)	Increased fauna habitat complexity	Restore lengths of fallen logs and woody debris in accordance with advice from a suitably qualified ecologist.	3 months.
Weed management	Management of weed cover	Infestations of noxious weeds in right of way managed in accordance with requirements of Noxious Weeds Act 1993.	Until ground cover achieves target rehabilitation performance criteria, as per above.
Monitoring and reporting	Reporting to regulator	Report to be submitted to OCSG within DTIRIS following the completion of all rehabilitation activities (civil works, waste removal, etc.) in accordance with condition 3 of PAL 2.	At completion of rehabilitation.

Table 4-9 Rehabilitation completion criteria

Aspect/requirement	Objectives	Completion criteria
Ploughed in gathering system infrastructure	Gathering infrastructure to remain *in situ* on decommissioning	Decommissioning in accordance with APIA Code of Practice, Upstream PE Gathering Networks – CSG Industry, Version 2.0
Trenched gathering system infrastructure	Gathering infrastructure to remain *in situ* on decommissioning	Decommissioning in accordance with APIA Code of Practice, Upstream PE Gathering Networks – CSG Industry, Version 2.0
The proposed activity will be maintained in a stable and non-polluting condition at all times	The final landform is stable and not prone to slumping, mass movement or significant erosion	No areas of instability or slumping.
	The proposed activity will not be a source of pollutants	No areas of active erosion.
Landform development consistent with final land use (i.e. Forestry)	Landform suitable for final land use and compatible with surrounding landscape as sustainable native ecosystem Area accomplishes and remains as a healthy native woodland.	Rehabilitation in accordance with Table 2 Established species survive and/or regenerate after disturbance. Weeds do not dominate native species after disturbance or after rain.

5.0 Community and stakeholder consultation

5.1 Consultation objectives

Santos understands the importance of proactive and effective engagement with communities and stakeholders and is well established within the local community, with a local office and resident employees. Santos has commenced implementing a consultation strategy for the E&A Program.

Through this consultation, Santos aims to:

- increase overall awareness and understanding of the CSG industry and in particular the proposed activity
- Identify and keep informed landholders, neighbours, residents, and relevant local and state government agencies
- Build and maintain effective relationships with stakeholders and communities based on open communication, trust and understanding of the E&A Program
- ensure the interests of stakeholders are considered in the proposed activity design and implementation
- Provide timely, accurate and credible information to stakeholders and the broader community
- Identify potential issues and/or risks and strategies for mitigation and resolution.

Targeted consultation with the landowner for the proposed activity commenced in June 2013.

5.2 The consultation and community involvement process

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.

To achieve the consultation objectives, the framework is based on the following approach:

- program initiation and communication
- ongoing identification and profiling of key stakeholders and review and evaluation of those relationships
- risk management
- monitoring of stakeholder issues and responses
- adherence to relevant legislative framework requirements.

There are four levels of targeted engagement and consultation:

- Inform – Aimed at community, business and industry in the broader regional and state-wide context.
- Involve – Aimed at community groups, industry, business and residents not directly involved but living and operating within the local area. This includes residents of Narrabri, Gunnedah, Boggabri, Wee Waa and surrounding villages; landholders, government departments; non-government organisations, local industry and business.
- Consult – Aimed at key stakeholder groups directly involved. This includes neighbouring landholders; government departments listed as referral agencies; non-government organisations; community groups; local contractors and businesses.
- Collaborate – Aimed at individuals and entities that are directly impacted by the project and/or involved in project decisions. This includes landholders; government departments responsible for assessments and approvals; Narrabri Shire Council; native title claimant groups; and community consultative committees.

5.3 Stakeholder identification and communication tools

Santos uses a wide range of consultation tools to engage with various stakeholders as part of its overall consultation program. Implementation has included the provision of general information through the Santos website and media announcements; shopfronts at Narrabri and Gunnedah; monthly community site tours; information stands at local agricultural shows and community events; and implementation of a sponsorship program which supports community and sporting groups.

Questions and concerns raised by the broader community have been addressed through telephone contact (both through the Santos community 1800 line and by individual telephone calls made to the Narrabri Office staff), formal correspondence and on-site meetings where required.

Table 5-1 identifies relevant stakeholder groups and the consultation tools utilised.

Table 5-1 Stakeholder identification and consultation tools

Stakeholder	Consultation tools							
	website	1800 number	one on one meetings	project information centre	agency workshop	formal correspondence	information sessions and community tours	community consultation committee
Government Agencies	●		●		●	●	●	
Landowner (Forestry Corporation of NSW)	●		●		●	●	●	
Adjacent landowners	●	●	●			●	●	
Indigenous community	●	●				●	●	
Special interest groups (e.g. environment and conservation groups)	●	●					●	●
Local business and contractors	●	●	●					●
Broader community	●	●		●			●	●

5.3.1 Santos project website

Santos maintains a project website which identifies its activities in NSW – http://www.santos.com/exploration-acreage/nsw-csg.aspx. The website is regularly updated with general project information, photos and frequently asked questions.

5.3.2 Santos project 1800 number and email address

Santos maintains a free information and enquiries line and project email address: 1800 071 278.

The number of calls recorded between February and June 2013 is shown in Figure 5-1.

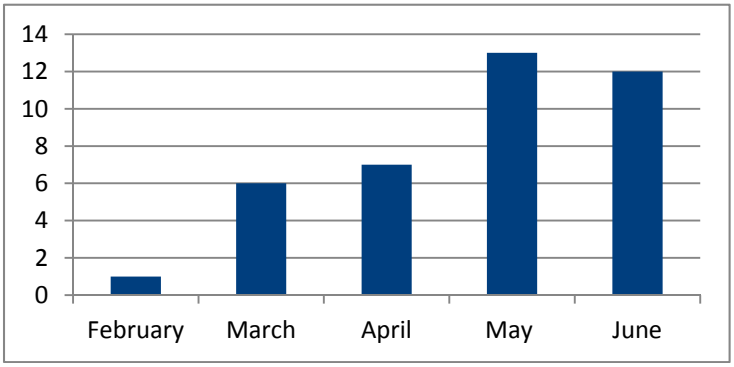


Figure 5-1 Record of calls to 1800 line (Feb – Jun 2013).

5.3.3 Santos Narrabri office and project information centre

Santos has an office and project information centre at 125 Maitland Street, Narrabri, which members of the community can visit and request information about the E&A Program. The office is attended from 9am to 5pm Monday to Friday.

5.3.4 Stakeholder and government agency workshops

Regular meetings are held with key stakeholders to provide information on current and ongoing activities. Meetings and workshops held in 2013 include:

5.3.4.1 Government Agencies

- Government Information Forum in Narrabri on 20 June 2013.

  Santos presented general information on the potential production project with specific information on the activities within the E&A Program. The presentation was followed by a field tour to the Leewood Produced Water Facility; and the Bibblewindi Water Transfer Facility. 25 government officers were in attendance, the majority of whom were locally or regionally based, with representation from:

  - Office of Coal Seam Gas
  - NSW Environment Protection Authority
  - Roads and Maritime Services
  - NSW Rural Fire Service
  - NSW Forestry Corporation
  - NSW Department of Trade and Investment (Crown Lands)
  - NSW Department of Primary Industries
  - NSW Office of Water
  - Namoi Catchment Management Authority
  - North West Livestock Health and Pest Authority
  - Narrabri Shire Council.

The Land and Water Commissioner also attended the Forum as well as industry representatives from the Australian Petroleum Production and Exploration Association (APPEA). An invitation was issued to NSW Health and the NSW Parks and Wildlife Service but a representative was unable to attend due to prior commitments. Both agencies indicated an interest in attending future Forums that may be held.

- Government Agency workshop in Sydney on 5 July 2013.

  Santos provided information on the E&A Program with a question and answer session following the presentation. This was attended by; The Department of Planning and Infrastructure, NSW Health, Office of Coal Seam Gas, The NSW Office of Water, Roads and Maritime Services, NSW Environment Protection Authority and Office of Environment and Heritage.

- Site visit with the NSW Office of the Chief Scientist and Engineer on 10 July 2013.

  The Chief Scientist attended the tour, accompanied by three staff from her office and a representative from the NSW Environment Protection Authority. The purpose of this meeting was specifically to inspect rehabilitation activities within the Pilliga Forest, however the briefing also provided information on the E&A Program.

- Site visit with Narrabri Shire Council on 19 July 2013.

  Whilst the purpose of the site visit was to inspect the proposed northern and southern flowlines, the meeting also provided opportunity to discuss the E&A Program.

- Site visit with OCSG and DP&I on 13 August 2013

  The site visit included the Bibblewindi Transfer Facility and existing well leases Bibblewindi 14 and 19H.

5.3.4.2 Indigenous Community

- Indigenous community forum held in Narrabri on 17 January 2013.

  Santos provided information on the CSG industry and the principles and approach to the E&A Program with a question and answer session following the presentation. The forum was attended by the Narrabri Local Aboriginal Land Council, 13 of the 19 native title applicants and NTSCORP Ltd (the Native Title Service Provider for Aboriginal Traditional Owners in NSW).

- Site tour on 13 March 2013

  A site tour was conducted for the Narrabri Local Aboriginal Land Council including the Leewood site and the Wilga Park power station to provide information on the E&A Program.

- Meetings held with the Narrabri Local Aboriginal Land Council on 19 July 2013 and 5 August 2013.

  The meeting discussed the issue of establishing a MOU between Narrabri Local Aboriginal Land Council and Santos around the sharing of cultural heritage information as it relates to Santos work in the Narrabri area.

5.3.4.3 Industry Groups

- Site tour on 3 July 2013.

  A field trip was undertaken with four representatives from NSW Farmers to inspect the Leewood Produced Water facility, rehabilitation areas within the forest and the Bibblewindi Water Transfer Facility. The purpose of this meeting was to provide information and answer questions in relation to the E&A Program and rehabilitation of sites within the forest.

5.3.5 Community information sessions and forums

Monthly site visits are held for the general community to present information on the E&A Program. Site tours are advertised in the local newspaper and the number of attendees each month is usually between 20 – 30 people. To date, there has been a broad representation of local business owners, landholders, community groups and other interested residents.

In addition, a farmer's forum was held in Narrabri on 23 May 2013 to brief on the potential gas development project as well as the E&A Program. Attendance at the Forum was limited to fourteen attendees due to weather conditions.

A Contractor Information Forum was held on 16 July 2013 for local businesses and contractors to provide information on the E&A Program and the rehabilitation of sites within the forest. There were approximately 85 business and contractor representatives in attendance. Santos has a commitment to work with local contractors, businesses and community groups where possible to ensure that economic benefits from project investment are realised by the communities in which Santos has operations.

5.3.6 Community consultation committee (CCC)

Santos has an independently chaired Community Consultative Committee that meets on a monthly basis in Narrabri with representation from a cross-section of interested parties within the community. Minutes and action items arising from these meetings are uploaded to the Santos website and also distributed by participants across their networks for broader community dissemination.

Meetings to date have focused on providing information relevant to the E&A Program with an emphasis on the overview of the CSG industry; drilling activities including well integrity, the environmental assessment process; activities that form part of the E&A Program and hydrogeological information. There has been extensive information dissemination and discussion in relation to water management.

5.3.7 Landowner meetings

Regular meetings have been held with the Forestry Corporation of NSW since 2011. Weekly and monthly reports are sent to Forestry representatives to provide information on activities proposed in the Forest.

A field trip was undertaken with two representatives of NSW Forestry Corporation to inspect the proposed activity site on 4 July 2013 and a meeting was held with senior officers of NSW Forestry Corporation on 1 May 2013 in Sydney to brief on planned activities in the Pilliga and Bibblewindi Forests.

5.3.8 Other

Meetings have also been held with the Commonwealth Department of Sustainability, Environment, Water, Population and Communities regarding the E&A Program.

5.4 Summary of issues raised during consultation

5.4.1 Government Agencies and Stakeholders

Key issues raised by government agencies and stakeholders are summarised in Table 5-2.

Table 5-2 Summary of issues raised by government agencies and councils

Agency	Corresp.	Workshops	Issue Raised	Response	Location of further information
Office of Agricultural Sustainability and Food Security	●		Water use and impact on agriculture	AIS prepared, NSW Office of Water consulted on water requirements, WAL to be sought	Section 6.2.3, Section 8.2.1 Appendix 2
Department of Primary Industries (Fisheries NSW and NSW Office of Water)	●		Need for an aquatic assessment including a description of waterways, habitat and any identified impacts.	The proposed activity will not impact on any waterways and there will be no removal of any riparian or aquatic habitat. The nearest waterway is an ephemeral unnamed tributary of Cowallah Creek located approximately 125 metres from Bibblewindi 32 and 580 metres from Bibblewindi 31. During operation, there is a small risk of a leak or spill that may impact on surrounding waterways however measures will be implemented (pressure gauges and automatic shutdowns) to limit any impact to the immediate area.	Section 11.3.3 and 11.5.3
	●	●	Need to comply with relevant legislation, policies and guidelines	The EIS has considered all relevant legislation for the proposed activity.	Chapter 6
	●		Impact on water sharing plan	The Bohena sub-catchment forms the Bohena Creek Water Source under the Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources. A search of the NSW Office of Water's website indicated that there are currently no records of any Water Access Licences under the *Water Management Act 2000* within this water source (NOW, 2013).	Section 9.4
NSW Environment Protection Authority	●		Waste Management – water minimisation and opportunities to reuse and recycle	Santos has plans to develop a FTF at its existing operations centre in Narrabri. Drilling fluids will be mixed at the FTF and then transported to site. This would reduce wastes associated with mixing chemicals on site (such as chemical containers).	Section 16.4.1
Hunter New England Local Health District	●	●	Groundwater and the management of produced water. The need for appropriate mitigation measures to prevent spills.	The water management process will be as follows: ▪ At each well, water produced will be pumped through the water gathering system to the 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. A range of mitigation measures are proposed to minimise any environmental incidents.	Section 4.4.2, Chapter 9 and Chapter 10

Agency	Corresp.	Workshops	Issue Raised	Response	Location of further information
	●		Impact of chemicals used in drilling	Chemicals that may be used in the drilling process have been identified in the EIS. No chemicals with added benzene, toluene, ethylbenzene, and xylenes (BTEX) will be used.	Section 4.3.3.2
	●		Noise impacts on sensitive receivers given 24 hour drilling.	A noise impact assessment has been prepared and there will be no impact on any sensitive receivers.	Chapter 14 and Appendix 6
	●		Psychological impacts associated with the perception of the proposed activity representing a significant expansion of the industry	The proposed activity is relatively minor in scale	
	●		Effectiveness of consultation	Santos is implementing a consultation program	Chapter 5
Office of Environment and Heritage	●		Cultural heritage	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. No Aboriginal objects or places recorded on the AHIMS were identified within 10 kilometres of the site. 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.	Chapter 19
	●		Biodiversity and the need for the assessment to consider the bio-banking assessment methodology	There will be no vegetation removed as part of the proposed activity	Chapter 11
Roads and Maritime Services	●		Traffic impacts during construction and operation including internal movements within the forest.	Impacts to the road network are considered negligible given the very low volumes of traffic generated by the proposed activity. No upgrade works will be required.	Chapter 15 Appendix 7,

Agency	Corresp.	Workshops	Issue Raised	Response	Location of further information
Narrabri Shire Council	●		Environmental performance of the CSG industry, the size of the industry, number of environmental incidents and any controls put in place to minimise incidents.	A range of mitigation measures are proposed for the proposed activity. Santos is committed to minimising any environmental impacts associated with CSG and is in the process of implementing a comprehensive rehabilitation program. Water management facilities have been relocated outside the Forest.	Chapter 20
	●		Hazards and risks associated with drilling chemicals and fuel	An assessment against SEPP 33 has been undertaken.	Chapter 17
Raised by more than one agency or in general discussion during workshops	●	●	Cumulative impacts	Cumulative impacts have assessed as part of the EIS and to support the E&A Program. The E&A Program will not have a significant impact. Discussion is included in each chapter of Part B of the EIS.	Chapter 8 to 19
	●	●	Impacts on local aquifers and details on monitoring program.	CH2M Hill has completed a groundwater impact assessment and flow model for the proposed activity. This has concluded that there will be no impact on local bore users or GDEs. A surface and groundwater monitoring program is being implemented as part of the E&A Program.	Appendix 3, Section 9.5.3 and Section 10.1.4
	●	●	Surface water impacts	An assessment of water impacts surface water has been undertaken and there will be minimal impacts.	Chapter 10
		●	Timing of stage 2 of Leewood addressing water treatment	The Leewood ponds (under construction) have a total storage capacity of 600 ML, being 2 ponds with 300 ML storage each. The total predicted groundwater extraction for the E&A Program is just over 1400 ML. Options for the treatment of the water are still being investigated by Santos.	
		●	The provision of offsets	Offsets are currently being investigated by Santos however the cumulative impact assessment has concluded that there will be no significant impact on any listed species.	
	●		Air Quality	An air quality and greenhouse gas impact assessment has been undertaken. Air quality at sensitive receptors will remain below guideline levels. Greenhouse gases produced represent less than 0.002 per cent and 0.007 per cent of the National and State emissions profiles respectively.	Chapter 12 and 13 and Appendix 5

5.4.2 Community

Key issues raised during the consultation process are summarised in Table 5-3.

Table 5-3 Summary of issues raised by the community

Use	Response	EIS chapter with further information
Chemicals used during drilling and potential for loss into the aquifer	Chemicals that may be used in the drilling process have been identified in the EIS. No chemicals used are toxic. There will be no chemicals with added benzene, toluene, ethylbenzene, and xylenes (BTEX) will be used.	Section 4.3.3.2
Potential for fluid loss into the aquifers during drilling	Losing drilling fluid is undesirable as it is the primary means of controlling the drilled hole. In the event that losses are detected, a lost circulation material (LCM) will be mixed into the fluid to prevent further losses. LCM is made of cellulose or other natural material and works by blocking the pores in the permeable/fractured rock.	Section 4.3.3
Risks of loss of drilling fluid in upper section of core hole	All wells will be drilled in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS 2012b) and accepted practices in the oil, gas and water well industries.	Section 4.3.3
Contamination of groundwater sources that are used for stock and domestic purposes	CH2M Hill has completed a groundwater impact assessment and flow model for the proposed activity. This has concluded that there will be no impact on local bore users or groundwater dependent ecosystems (GDEs). A detailed surface and groundwater monitoring program has been / will be implemented.	Appendix 3, Section 9.5.3 and Section 10.1.4
The need for the location of wells and lease areas to be better communicated	Locality maps will be prepared for the proposed activity and the E&A Program.	
Asset protection zones within the forest to assist in managing bushfire risks	Following completion of drilling, only partial rehabilitation of the lease area will occur. A bushfire management plan will be implemented.	Section 17.3.2
Is there a possibility for hydrant rises being installed along the fresh water pipe to allow greater water availability during fire operations.	This will be considered during design and in the context of the bushfire management plan.	
Area impacted for an exploration well	The proposed activity will occur on already cleared lease areas however lease areas are typically one hectare in size.	

5.5 Future and ongoing consultation

5.5.1 EIS Exhibition

The EIS will be on public exhibition for a minimum of 30 days in accordance with the requirements of Part 4 of the *EP&A Act*.

DP&I is responsible for the public exhibition of the EIS. Concurrently, Santos will make available the EIS on its website and at the project information centres in Narrabri and Gunnedah.

5.5.2 Consultation during construction

Consultation during construction will include:

- newspaper advertisements
- community updates and newsletters
- fact sheets
- community information sessions and display materials
- stakeholder meetings
- continued operation of the project information line, website and email address
- regular project website updates
- written notification to landowners and neighbours
- traffic management notifications
- monthly Narrabri Community Consultation Committee meetings
- continued operation of the Narrabri Office and Information Centre.

Table 5-4 identifies specific consultation activities which will be carried out prior to the proposed activity commencing.

Table 5-4 Specific consultation prior to commencement of proposed activity

Activity	Description	Planning timing
Landowner (Forestry Corporation of NSW)	Regular contact is maintained with the landholder and prior to the commencement of the proposed activity written advice will be provided to the landholder.	Advice to landholder will be provided 14 days prior to the proposed activity commencing
Neighbouring landowners	In general, ongoing consultation is held with landholders where proposed activities are directly adjacent to their property. Given that the nearest residents are in excess of 7.5 km from the site, and impacts will be negligible, specific consultation will not occur for the proposed activity. If however, an activity during construction or operation may have an impact on nearby landholders, they will be advised in writing and a follow up phone call will be made to ensure that letters have been received and respond to any questions.	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	The Narrabri Shire Council will continue to be consulted, provided with regularly updates and a six monthly look-ahead schedule.	Monthly
Broader community	Updates on the proposed activity will be provided to the Narrabri Community Consultation Committee.	Monthly
Advertisements	Advertisements will be placed in the local media of the up-coming exploration and drilling activities.	Monthly
Notification to local police	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

6.0 Planning and Statutory Framework

6.1 Assessment Framework

The overarching statutory framework for environmental planning approval in NSW is provided by the EP&A Act. Supporting this primary piece of legislation are the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) and a suite of environmental planning instruments, including State Environmental Planning Policies (SEPP) and Local Environmental Plans (LEPs).

6.1.1 State significant development

Section 89C(2) of the EP&A Act provides that a SEPP may declare any development or any class or description of development, to be SSD. The *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP) identifies development which is SSD for this purpose. Clause 8 of the SRD SEPP provides that development is SSD if the development is not permissible without development consent under Part 4 of the EP&A Act, and the development is specified in Schedule 1 or 2 of the SRD SEPP.

Under clause 7(2) of the Mining SEPP, development consent is required for the purposes of drilling or operating a set of more than five wells that is more than three kilometres from any other petroleum well (other than an abandoned petroleum well) in the same petroleum title.

Clause 6 of Schedule 1 of the SRD SEPP identifies 'Petroleum (oil and gas)' and classifies 'development for the purpose of drilling and operating petroleum exploration wells, not including… a set of five or fewer wells that is more than three kilometres from any other petroleum well (other than an abandoned petroleum well) in the same petroleum title' as SSD.

The proposed activity will result in more than five petroleum wells, other than abandoned wells, within a three kilometre radius within PAL 2 and is therefore SSD. Under section 89D of the EP&A Act, the Minister for Planning and Infrastructure is the consent authority.

6.1.2 Director-General's requirements and Statement of Commitments

The Director General requirements (DGRs) for the proposed activity were issued on 20 May 2013 and are provided in Appendix 1 including cross references to sections within the EIS where each has been addressed. A draft Statement of Commitments is provided in Chapter 20.

The EIS process described in Division 4.1 of Part 4 of the EP&A Act is shown in Figure 6-1.

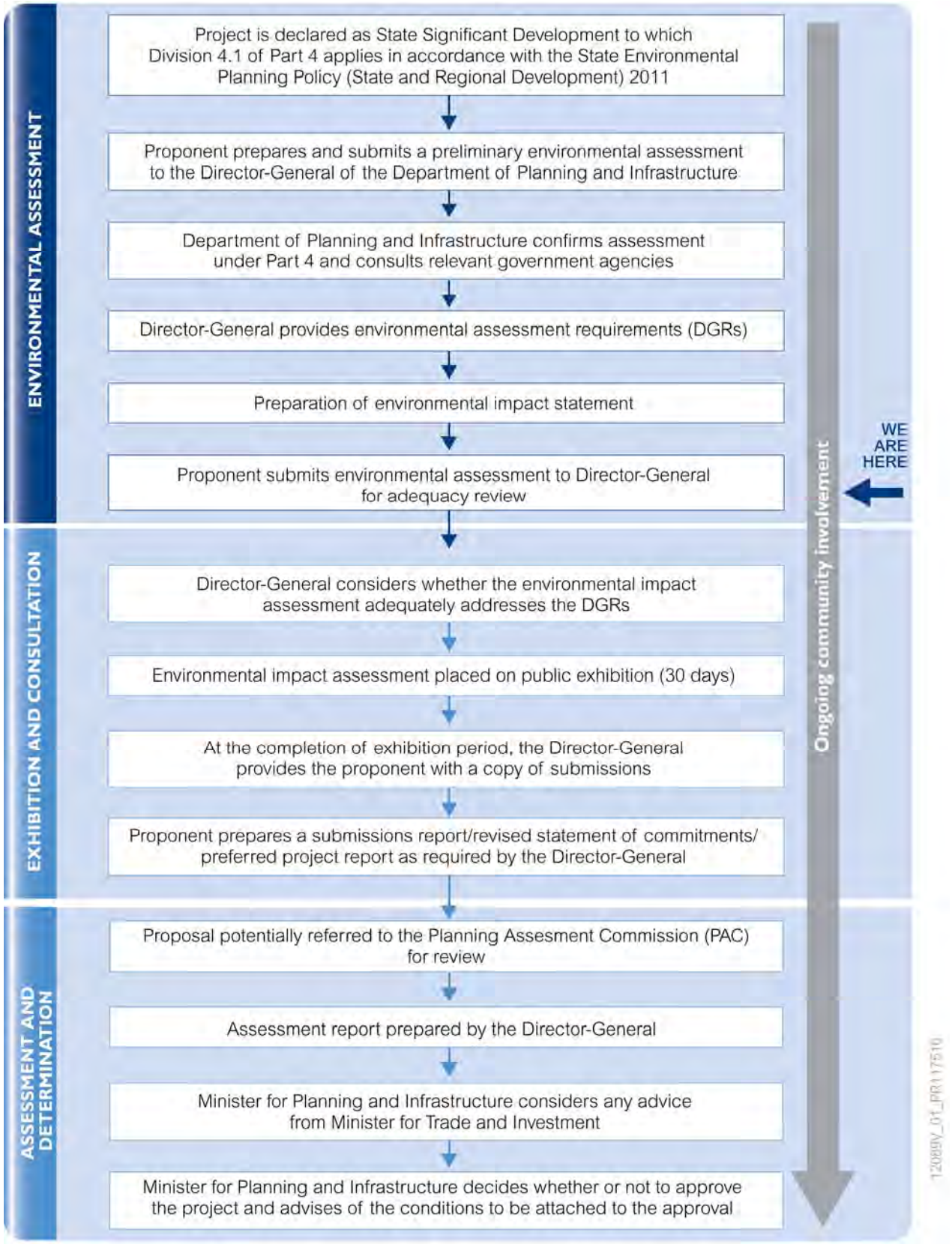


Figure 6-1 The environmental impact assessment process

6.1.3 Section 79C requirements

Section 79C of the EP&A Act applies to the determination of SSD and requires the consent authority to take into consideration a range of matters as identified in Table 6-1.

Development consent may not be granted if the development is wholly prohibited by an environmental planning instrument. The activity is not prohibited by any environmental planning instruments.

Table 6-1 Matters for consideration under section 79C of EP&A Act

Matter for consideration	Response
(i) any environmental planning instrument	The EIS considers all relevant matters within applicable environmental planning instruments. These are discussed within this chapter.
(ii) any proposed instrument that is or has been the subject of public consultation under this Act and that has been notified to the consent authority	Exhibition of draft amendments to the Mining SEPP ended in April 2013 with the amendment under consideration. Amendments include the establishment of a new Gateway process for State significant mining and petroleum activities located on Strategic Agricultural Land (SAL) under the SRLUP (DP&I 2012). While the project is not located on SAL, as detailed under the draft amendments to the Mining SEPP, Santos has applied for a site verification certificate for the proposed activity in accordance with the DGRs.
(iii) any development control plan	In accordance with Clause 11 of the SRD SEPP, development control plans do not apply to the activity as it is deemed to be SSD.
(iiia) any planning agreement that has been entered into under section 93F, or any draft planning agreement that a developer has offered to enter into under section 93F	No planning agreements or draft planning agreements have been entered into or offered for the activity.
(iv) the regulations	There are no relevant matters prescribed by the regulations.
(v) any coastal zone management plan (within the meaning of the Coastal Protection Act 1979), that apply to the land to which the development application relates	There are no coastal zone management plans relevant to the site.
(a) the likely impacts of that development, including environmental impacts on both the natural and built environments, and social and economic impacts in the locality	Impacts of the proposed activity on natural and built environment, and social and economic impacts are assessed, and measures identified in Chapter 8 to 19.
(b) the suitability of the site for the development	Justification for selecting the proposed site is provided in Section 2.4.
(c) any submissions made in accordance with this Act or the regulations	Any submissions received during the statutory exhibition period would be considered by the Minister prior to determination of the application.
(d) the public interest.	The public interest would be served through the application of all relevant planning controls and objectives.

6.2 NSW legislation

6.2.1 Petroleum (Onshore) Act 1991

The *Petroleum (Onshore) Act 1991* (Petroleum Act) regulates the onshore exploration for and production of petroleum. Under the Petroleum Act, petroleum means:

> *(a) any naturally occurring hydrocarbon, whether in a gaseous, liquid or solid state, or*
>
> *(b) any naturally occurring mixture of hydrocarbons, whether in a gaseous, liquid or solid state, or*
>
> *(c) any naturally occurring mixture of one or more hydrocarbons, whether in a gaseous, liquid or solid state, and one or more of the following, that is to say, hydrogen sulphide, nitrogen, helium, carbon dioxide and water,*

and includes any substance referred to in paragraph (a), (b) or (c) that has been returned to a natural reservoir, but does not include coal or oil shale or any substance prescribed to be a mineral for the purposes of the Mining Act 1992.

The holder of a petroleum assessment lease (PAL) has the right to prospect for, and to assess any, petroleum on the land within the lease area. If approved, the proposed activity would be undertaken within PAL 2 granted under the Petroleum Act. Activities allowed under PAL 2 are identified in a Petroleum Operations Plan (POP) that has been approved by the Director-General of NSW Trade & Investment (or delegated authority).

Within PAL 2, activities that are undertaken within an ‘exempted area’ as defined in Section 70 of the *Petroleum (Onshore) Act 1991* require further approval from the Minister prior to carrying out the activity. Land dedicated as State forest is defined as an ‘exempted area’. As the proposed activity will be undertaken within an 'exempted area', Santos will require a Section 70 approval which applies to the proposed activity.

The proposed activity is allowed under the POP, but as identified in Section 6.1.1, the activity is deemed to be SSD and would require development consent under Part 4, Division 4.1, of the EP&A Act.

6.2.2 Environmental Planning and Assessment Act 1979

Section 89C(2) of the EP&A Act provides that a SEPP may declare any development or any class or description of development, to be SSD. The SRD SEPP identifies development which is SSD for this purpose. Clause 6 of Schedule 1 of the SRD SEPP identifies ‘Petroleum (oil and gas)’ and classifies ‘development for the purpose of drilling and operating petroleum exploration wells, not including… a set of five or fewer wells that is more than three kilometres from any other petroleum well (other than an abandoned petroleum well) in the same petroleum title’ as SSD.

The proposed activity will result in more than five petroleum wells, other than abandoned wells, within a three kilometre radius within PAL 2 and is therefore SSD. Under section 89D of Divisions 4.1 Part 4 of the EP&A Act, the Minister for Planning and Infrastructure is the consent authority for SSD.

Section 78(8A) of the EP&A Act requires an environmental impact statement (EIS) assessing the proposed activity to be submitted. This document has been prepared for the purpose of assessing the potential environmental impacts of the proposed activity.

6.2.3 Water Management Act 2000

The *Water Act 1912* (Water Act) and *Water Management Act 2000* (WMA) are the key pieces of legislation regulating access and impacts to surface and groundwater resources in NSW. Where a water sharing plan is in place, the WMA governs the issuing of water access licences (WALs) and water management and activity approvals. As water sharing plans are in place for the surface and groundwater sources at or surrounding the site, the WMA applies to the proposed activity.

6.2.3.1 Water sharing plans

Water sharing plans (WSPs) are designed to provide long-term environmental protection and sustainability of the surface water and groundwater resources as well as directing how water will be allocated and shared among the various water users. WSPs apply the goals and principles of the *NSW State Groundwater Policy (DLWC, 1998)* at a local and regional level.

The *Water Management Act 2000* (WMA) provides for a system of assessment and licensing and approvals relating to the equitable take of water from water sources, in addition to works and activities occurring within or affecting these water sources. Each WSP sets out Water Sharing Rules and Management Rules for aquifer interference activities within each water source that operate under these water management principles.

The following WSPs apply to water sources beneath or in the vicinity of the site:

- NSW Great Artesian Basin (GAB) Groundwater Sources WSP
- NSW Murray-Darling Basin (MDB) Porous Rock Groundwater WSP
- NSW MDB Fractured Rock Groundwater WSP
- NSW Upper and Lower Namoi Groundwater Sources WSP
- NSW GAB Shallow Groundwater Sources WSP
- Upper Namoi and Lower Namoi Regulated River WSP.

The proposed activity will need to comply with the rules developed for the affected water sources within the relevant WSPs outlined above.

6.2.3.2 Water access licences

Under Part 2 of Chapter 3 of the WMA, it is an offence to take water from a source regulated by the WMA unless in accordance with a WAL.

Water used for the construction and operation of the proposed activity will be sourced from Narrabri or Gunnedah's town water supply or local industrial licensed water bores and trucked to the site. Alternatively, production water from pilot wells will be used when available for the preparation of drilling fluid.

A WAL is also required for the taking of groundwater, whether for consumption or incidentally, unless an exemption applies. Any new mining and petroleum exploration activities that take more than three megalitres per year from groundwater sources will need to hold a WAL.

The volume of water to be abstracted during operation of the Bibblewindi Multi-Lateral Pilot is estimated to be approximately 285 megalitres of groundwater over three years from the Gunnedah-Oxley Basin. Santos will obtain a WAL for this water take.

6.2.3.3 Aquifer interference approvals

Under section 91F of the WMA, it is an offence to carry out an aquifer interference activity without an aquifer interference approval. Aquifer interference activities include any of the following:

- the penetration of an aquifer
- the interference with water in an aquifer
- the obstruction of the flow of water in an aquifer
- the taking of water from an aquifer in the course of carrying out mining, or any other activity prescribed by the regulations
- the disposal of water taken from an aquifer.

However, section 91F of the WMA does not currently apply. Section 88A provides that Part 3 of Chapter 3 (including section 91F) applies to each part of the State or each water source and each type or kind of approval that relates to that part of the State or that water source that is declared by proclamation.

At the time of the EIS, no proclamation has been made declaring that Part 3 of Chapter 3 of the Act applies in relation to aquifer interference approvals.

Accordingly, an aquifer interference approval will not be required for the proposed activity.

6.2.3.4 Flood work approval

Under section 90 of the WMA, a flood work approval is required to construct and use flood work at a specified location. Flood work is defined within the WMA and includes a work (such as a barrage, causeway, cutting or embankment) in the vicinity of a river or within a floodplain (as declared under the *Water Management (General) Regulation 2011* (WM Regulation)) that is of such a size or configuration that it is likely to have an effect on the flow of water to or from a river or the distribution or flow of floodwater in times of flood. Clause 13 of Schedule 9 of the WMA provides that any land that was designated as a floodplain under Part 8 of the Water Act is taken to be a floodplain for the purposes of the WMA.

There are a number of floodplains declared under the Water Act located nearby but not on the site. The closest is the Namoi River, Karroll to Boggabri floodplain located approximately 37 kilometres to the east of the site. The proposed activity is considered unlikely to affect the flow of water to or from any river, or the distribution or flow of floodwaters. Therefore, a flood work approval is not required for the proposed activity.

6.2.3.5 Controlled activity approval

Under section 91E of the WMA, it is an offence to carry out a controlled activity in, on or under waterfront land without a controlled activity approval for that activity. Waterfront land is taken to mean land within 40 metres of a water body. Controlled activities include the removal of vegetation or material, or deposition of material.

Clause 39 of the WM Regulation provides that activities specified in Part 2 of Schedule 5 of the regulation are exempt from requiring controlled activity approvals under the WMA. Part 2 of Schedule 5 includes any activity carried out in accordance with a right in force under the Petroleum Act. Therefore, a controlled activity approval is not required for the proposed activity.

6.2.3.6 Water supply work approval

Under section 90 of the WMA, a water supply work approval is required to construct and use a specified water supply work at a specified location. Water supply works are defined within the WMA and includes works (such as a water pump or water bores) that are constructed or used for the purpose of taking water from a water source.

Under section 89J of the EP&A Act, a water supply work approval is not required for SSD for which development has been granted. Therefore a water supply work approval would not be required for the proposed activity.

6.2.4 Protection of the Environment Operations Act 1997

One of the primary objectives of the *Protection of the Environment Operations Act 1997* (NSW) (POEO Act) is to 'protect, restore and enhance the quality of the environment in New South Wales, having regard to the need to maintain ecologically sustainable development'. The POEO Act requires environment protection licences (EPLs) be obtained for the carrying out of 'scheduled activities' or to pollute waters.

All CSG exploration, assessment and production titles and activities are required to hold an EPL. Santos is in the process of obtaining an EPL for the proposed activity.

6.2.5 Additional NSW legislation

Additional NSW legislation that must be applied consistently to the proposed activity is presented in Table 6-2.

Table 6-2 Additional NSW legislation to be considered for the proposed activity

Legislation	Purpose	Application to proposed activity
Brigalow and Nandewar Community Conservation Area (BNCCA)Act 2005	The *BNCCA Act* was established to reserve forested land in the Brigalow and Nandewar area and provide for permanent conservation of land, protection of areas of natural and cultural heritage significance to Aboriginal people and sustainable forestry, mining and other appropriate uses.	The Bibblewindi State Forest is included within Zone 4 – *Forestry, recreation and mineral extraction*, under the BNCCA Act. The strategic aims for this zone, as identified by the *Brigalow and Nandewar Community Conservation Area Agreement*, include '*Provide for exploration, mining, petroleum production and extractive industry in accordance with the* Mining Act 1992 *and the* Petroleum (Onshore) Act 1991 *and associated Regulations and guidelines'.* The proposed activity is consistent with the intended use of Zone 4 land.
Contaminated Land Management Act 2008	To promote the better management of contaminated land.	The proposed activity is not expected to be carried out on contaminated land.
Crown Lands Act 1989	To provide for the administration and management of Crown land in NSW.	Santos has entered into a Permit to Occupy agreement with the Forestry Corporation of NSW.
Dangerous Goods (Road and Rail Transport) Act 2008.	To provide conditions for safety in the transport of dangerous goods by road and rail as part of the system of nationally consistent road and rail transport laws.	Any dangerous goods will be transported according to regulatory requirements.

Legislation	Purpose	Application to proposed activity
Fisheries Management Act 1994	To conserve key fish habitats including permanent and semi-permanent freshwater habitats.	The proposed activity does not require any new creek diversions, crossings, access tracks or land clearing therefore there will be no direct impact on watercourses. The nearest creek is an ephemeral unnamed tributary of Cowallah Creek approximately 125m from Bibblewindi 32. It does not support the endangered Murray Cod (*Maccullochella peelii*), as this species prefer slow flowing deep watercourses. The ephemeral nature of these creeks would likely only support common fish species during migration and breeding.
Forestry Act 2012	To provide for the dedication, management and use of State forests and other Crown-timber land for forestry and other purposes.	Proposed works within the State forest will be undertaken in accordance with the existing Permit to Occupy held by Santos and administered by the Forestry Corporation of NSW.
Heritage Act 1977	To encourage the conservation of the heritage of NSW.	No items of heritage significance listed under either the Narrabri LEP or on the NSW State Heritage Register occur on the site.
Native Title (NSW) Act 1994	To provide for native title in relation to land or waters.	In the area of PAL 2 the relevant native title claimant is the Gomeroi People. Further details of Native Title are discussed in Section 6.3.2.
National Parks and Wildlife (NPW) Act 1974	The NPW Act provides that a person must not harm any animal that is a threatened species, population or ecological community, pick any plant which is part of a threatened species, population or ecological community, damage any critical habitat or damage any habitat of a threatened species, population or ecological community without a licence being obtained under the NPW Act or *Threatened Species Conservation Act* or unless another exception applies.	The NPW Act does not apply where an action was essential for the carrying out of an activity in accordance with an approval of a determining authority under Part 4 of the EP&A Act, where the determining authority has complied with Part 4. This EIS has been prepared to assist the determining authority to comply with Part 4 of the EP&A Act.
	To conserve places, objects and features of significance to Aboriginal people.	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. No Aboriginal objects or places recorded on the Aboriginal heritage Information Management System (AHIMS) were identified within 10 kilometres of the site. 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. All staff will be made aware of their obligations under the NPW Act and Heritage Act with all works to comply with Part 6 of the NPW Act.
Native Vegetation (NV) Act 2003	To encourage revegetation and rehabilitation of land with appropriate native vegetation.	Under Section 25(m), the NV Act does not apply to any clearing authorised under the Petroleum Act.

Legislation	Purpose	Application to proposed activity
Noxious Weeds Act 1993	To ensure that the Act is complied with within their boundaries, the landholder has an obligation under the Noxious Weeds Act to control any declared weed on their property.	No noxious weeds or introduced flora species were identified during the field survey as part of the Ecological Assessment.
Roads Act 1993	To make provision with respect to the roads of New South Wales.	The proposed activity does not involve any works in public roads.
Threaten Species Conservation Act 1995	To provide a framework for the listing of threatened species, populations and ecological communities, and key threatening processes in NSW, and the preparation and implementation of recovery plans and threat abatement plans.	The proposed activity does not involve any clearing as all works will be contained on existing lease areas and access tracks. A generalised application of the 7-part test concluded that the proposed activity is not likely to have a significant effect on the seven threatened ecological communities, seven threatened flora and 26 threatened fauna species listed under the TSC Act that are considered to have the potential to occur within the site and surrounding 20m buffer. Further details are provided in Chapter 11.
Waste Avoidance and Resource Recovery Act 2001	To provide a legal framework concerning the minimisation, recycling and reuse of waste in NSW.	All wastes generated by the proposed activity will be collected, classified and removed from site for recycling or disposal at a licensed waste facility if required. Given the short term nature of the construction, only minor quantities of waste will be produced.
Work Health and Safety Act 2011	To secure the health, safety and welfare of persons at work.	The proposed activity will be carried out in accordance with all health and safety requirements.

6.2.6 State environmental planning policies (SEPPs)

6.2.6.1 Strategic Regional Land Use Policy (SRLUP)

The SRLUP identifies and protects more than two million hectares of strategic agricultural land, protects valuable water resources, and provides greater certainty for companies wanting to invest in mining and coal seam gas projects in regional NSW.

As a result of this policy, all State significant mining and coal seam gas proposals that extend beyond an existing lease area on strategic agricultural land (SAL) must go through an independent, scientific assessment of their potential agricultural land and water impacts before a development application can be lodged.

Two types of SAL exist. The proposed activity is not located on BSAL or a CIC mapped under the *Strategic Regional Land Use Plan New England North West Region* and is unlikely to impact on agricultural resources.

A site verification report has been prepared and is provided in conjunction with this EIS. Advice from DP&I states that as the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (Mining SEPP) amendments are yet to be enacted, there is no statutory framework to apply for and receive a Site Verification Certificate. Therefore, Santos may lodge the site verification report (to satisfy the DGRs) as part of the overall EIS submission. The DP&I will then undertake the site verification assessment as part of the overall assessment.

6.2.6.2 Mining SEPP

The Mining SEPP aims 'to provide for the proper management and development of mineral, petroleum and extractive material resources for the social and economic welfare of [NSW]'. Clause 7 of the Mining SEPP relates to development that is permissible with development consent. As the proposed activity will result in more than 5 wells within 3 kilometres (other than an abandoned petroleum well) in the same petroleum title, Clause 7 applies and consent is required. As outlined above the proposed activity is classified as SSD (section 6.1.1), and requires development consent under Part 4, Division 4.1, of the EP&A Act.

The proposed activity will not be carried out on an environmentally sensitive area of State significance.

6.2.6.3 Other SEPPS

Other SEPPs relevant to the proposed activity are summarised in Table 6-3.

Table 6-3 Environmentally sensitive areas

SEPP/LEP	Purpose	Application to proposed activity
SEPPS		
SEPP 44 Koala habitat protection	To support the conservation and management of koala habitat	No 'potential' koala habitat, as defined by SEPP 44, will be removed as part of the proposed activity – nor does any occur within close proximity to the site and immediate surrounding area.
SEPP 55 Remediation of Land	To ensure land is developed appropriately and contaminated land is managed.	A search of the contaminated land record database maintained by the Environmental Protection Authority (EPA) indicated records of seven contaminated sites within the Narrabri Shire LGA. None of these contaminated sites are located near the site.
SEPP 33 Hazardous and Offensive Development	To presents a systematic approach to planning and assessing potentially hazardous and offensive development.	Diesel will be stored temporarily on site for use during drilling. Diesel is classed as an Australian Dangerous Goods Code 3 and is subject to the requirements under SEPP 33. However given the relatively small volumes, the proposed activity is not defined as a potentially hazardous or offensive activity or industry. Section 17.2 provides more detail on the assessment.

6.2.6.4 Narrabri Local Environmental Plan 2012

As the project is deemed SSD, development consent is granted under Part 4, Division 4.1, of the EP&A Act. Nevertheless, consideration has been given to the relevant land use zone objectives under the Narrabri LEP. The site is zoned RU3 Forestry zone.

The proposed activity is a non-forestry use that will not restrict the use of other land for forestry purposes. The natural resource base relied upon by the industry within the area will not be significantly affected by the proposed activity. The proposed activity will not affect the development of forestry or forestry-related enterprises in the area nor will it result in the fragmentation or alienation of resource lands. The proposed activity will not result in conflict between land uses within the RU3 Forestry zone or land uses within adjoining zones. Therefore, the proposed activity is considered to be a suitable activity within the RU3 Forestry zone.

6.3 Commonwealth legislation

6.3.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) provides for the protection of certain Matters of National Environmental Significance (MNES) listed under the Act, which include:

- World Heritage Areas
- National Heritage Places
- Ramsar wetlands of international importance
- Commonwealth listed threatened species and ecological communities
- listed migratory species
- Commonwealth marine areas
- Great Barrier Reef Marine Park
- nuclear actions.

Under the EPBC Act, Commonwealth approval is required from the Minister of Sustainability, Environment, Water, Population and Communities (Minister) for any action that will have or is likely to have a significant impact on a MNES, or on the environment of Commonwealth land or on the environment if the action is proposed to be taken by a Commonwealth agency (known as a 'controlled action').

A person proposing to take a controlled action must refer the proposed development to the Minister for determination. A person proposing to take an action that the person thinks is not a controlled action may refer the proposed development to the Minister for the Minister's decision whether or not the action is a controlled action.

An EPBC Act Protected Matters Search was undertaken using the online database to generate a list of those MNES species potentially occurring within the site and surrounding 20 metre buffer (SEWPaC 2013). This data, combined with other local knowledge and records, was used to assess whether the proposed activities will have, or are likely to have, a significant impact on MNES. The findings of this assessment are outlined in Table 6-4 and discussed further in Chapter 11.

Table 6-4 Matters of national environmental significance

MNES	Overview
World Heritage Properties	The proposed activity is not located in or within close proximity to a World Heritage area.
National Heritage Places	The proposed activity is not located in close proximity to a National Heritage Place.
Wetlands protected by international treaty (the RAMSAR convention)	The proposed activity is not located within a RAMSAR listed wetland area.
Nationally listed threatened species and ecological communities	No threatened species or ecological communities are present within the site and immediate surrounding areas, therefore no impacts to EPBC listed threatened species or ecological communities are likely to occur as a result of the proposed activity.
Migratory species	No EPBC Act listed migratory species are considered likely to be directly or indirectly impacted upon as a result of the proposed activity.
Commonwealth marine areas	The proposed activity will not impact any Commonwealth marine areas.
Great Barrier Reef Marine Park	The proposed activity will not impact the Great Barrier Reef Marine Park.
All nuclear actions	The proposed activity does not involve a nuclear activity.

MNES	Overview
Water Resources	The findings of the cumulative groundwater impact assessment show that depressurisation of the target coal seam as a result of pilot activities indicate a negligible decline in water levels (less than 0.5 metres) within the Namoi Alluvium and the Pilliga Sandstone groundwater sources. Consequently there will be no impact on groundwater dependent ecosystems (GDEs), GDE terrestrial vegetation or registered water supply bores.

Santos has made a Referral to the Commonwealth in June 2013 that included the proposed activity. The Referral included an assessment of MNES, across a number of exploration and appraisal activities that have occurred in the recent past or proposed in the future. The assessment concluded that there would not be a significant impact on MNES and that the activities would not constitute a controlled action.

The Referral is currently under assessment by SEWPaC (at the time of writing).

6.3.2 Native Title Act 1993

The objectives of the *Native Title Act 1993* (Native Title Act) are to:

- Recognise native title rights and sets out basic principles in relation to native title in Australia
- Provide for the validation of past acts which may be invalid because of the existence of native title
- Provide for a future act regime in which native title rights are protected and conditions imposed on acts affecting native title land and waters
- Provide a process by which native title rights can be established and compensation determined
- Provide processes for negotiations and determinations about whether future acts, including grants and activities carried out under those grants, can be done over native title land and waters
- Provides for a range of other matters, including the establishment of a National Aboriginal and Torres Strait Islander Land Fund.

In the area of PAL 2 the relevant native title claimant is the Gomeroi People (NSD2308/2011). PAL 2 was granted in 2007 and no further native title process is required for activities authorised under PAL 2. Should Santos apply for a production lease in the area of PAL 2, Santos understands that the Native Title Act requires completing the right to negotiate process under Subdivision P of Division 3 of Part 2 of the Act or concluding an Indigenous Land Use Agreement with the Gomeroi People.

6.4 Summary of approval requirements

The proposed activity requires the following approvals:

- Assessment and determination of the proposed activity including development consent under Part 4 of the EP&A Act
- An EPL under the *Protection of the Environment Operations Act 1997*
- A WAL under the *Water Management Act 200*.
- An approval under section 70 of the *Petroleum (Onshore) Act 1991*.

7.0 Environmental risk analysis

7.1 Risk assessment methodology

A preliminary environmental risk assessment of the proposed activity was undertaken to identify and prioritise issues requiring further assessment in the EIS. Potential environmental issues associated with the proposed activity were identified based on desktop investigations, preliminary ecological and archaeological field investigations, knowledge of the statutory planning and regulatory requirements, and considering the nature and scale of the project.

The risk assessment was conducted by a multi-disciplinary project team in accordance with the Santos risk assessment framework. The focus is on the inter-relationship between people, equipment, methods of work, the environment and the community. Risks are identified from health and safety, natural environment, reputation and financial perspectives. In particular, environmental risks were identified for each environmental aspect during key stages of the project. Each risk was given an inherent risk ranking based on the likelihood and potential consequences of the risk with and without mitigation measures being applied.

The proposed wells have been located on existing well leases within the Bibblewindi Multi-Lateral Pilot to avoid the need for further vegetation clearing or disturbance. Impacts associated with establishing the Bibblewindi 14 and 19H well leases were assessed previously and have not been included.

Risks were considered in relation to the following aspects:

- Land resources
- Water resources
- Biodiversity
- Air quality
- Greenhouse gases
- Noise
- Traffic and transport
- Waste management
- Hazards to the community
- Social and economic environment
- Heritage

7.2 Environmental risk findings

Table 7-1 outlines the key risks during construction. Mitigation measures have been identified to address risks with the resultant risk rating shown in the table. The potential for a traffic accident and community and reputational risks associated with insufficient community engagement are considered the major risks for the proposed activity. All other risks can be mitigated to a risk rating of 2 or less based on detailed technical studies and implementation of the mitigation measures outlined in the following sections of this report.

Table 7-2 outlines key risks during operation.The main risk during operation is associated with bushfire. All other risks can be mitigated.

Table 7-1 Key identified risks during construction

Risk Area	Cause	Impact	Assessment	Mitigation	Risk Rating
Traffic and transport	Increase in traffic on local road network	Reduced road safety for community/other road users leading to accidents	Chap 15 Appendix 7	Traffic movements to be minimised, staff bussed to site	3
Other	Community not appropriately consulted	Poor community relations	Chapter 5	Implement community engagement program as outlined in Chapter 5.	3
Land resources	Chemical, fuel or oil spills	Soil contamination	Chapter 8 Appendix 2	Amount of fuels and chemicals on site to be minimised, fuels and chemicals to be stored above ground, spill kits available and vacuum truck to be on standby during drilling.	2
Water resources – surface water	Saline water being released from the formation and discharging into drainage lines or waterways	Degradation of surface water	Chapter 10	Surface tanks will capture any fluids that are released during drilling, over balance drilling techniques to be adopted	2
Water resources – ground water	Loss of drilling fluid into the formation	Reduction of groundwater quality	Chapter 9 Appendix 3	Wells to be drilled in accordance with *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS 2012).	2
Biodiversity	Spread of weeds by construction activities	Weed infestation and loss of biodiversity	Chapter 11 Appendix 4	Vehicles to be washed and cleaned where exposed to noxious weeds or unwanted plants.	2
Biodiversity	Drilling through aquifers where stygofauna may be present	Impact to stygofauna	Appendix 3	Wells to be drilled in accordance with *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS 2012).	2
Traffic and transport	Increase in traffic on local road network	Wear and tear on the road surface	Chapter 15 Appendix 7	Construction vehicles to utilise nominated routes	2
Traffic and transport	Increase in traffic on local road network	Reduced road safety for community/other road users leading to fatality	Chapter 15 Appendix 7	Traffic movements to be minimised, staff bussed to site	2
Waste	Illegal dumping of waste or lack of suitable containment of waste	Pollution, contamination and/or littering of land or water	Chapter 16	All waste to be classified on site and if required disposed at a licenced facility	2
Waste	Generation and mismanagement of potentially hazardous wastes	Contamination of land or water, human health effects	Chapter 16	Amount of fuels and chemicals on site to be minimised, fuels and chemicals to be stored above ground, spill kits available and vacuum truck to be on standby during drilling.	2

Risk Area	Cause	Impact	Assessment	Mitigation	Risk Rating
Hazards	Accidental ignition during construction activities	Bushfire resulting in loss of life, property or biodiversity	Chapter 17	All vehicles to remain on cleared access tracks and lease area	2
Hazards	Introduction of chemicals to the environment	Build-up of chemicals in groundwater, surface water, soils, flora or fauna, exposure of chemicals to humans and potential toxicological effects	Chapter 17	Wells to be drilled in accordance with *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS 2012).	2
Heritage	Disturbance of previously unidentified Aboriginal heritage items	Loss of heritage values	-	A Preliminary Heritage Assessment has been prepared for the site, including a visual inspection (pedestrian survey) of the site undertaken on 27 November 2012. No objects, places, landscape features or culturally modified trees were identified. All staff are to be made aware of their obligations under the NPW Act and Heritage Act with all works to comply with Part 6 of the NPW Act.	2
Heritage	Indirect impacts to identified Aboriginal heritage sites	Loss of heritage values	-		2
Other	Disturbance beyond authorised area of impact	Non-compliance with approval	-	Site will be fenced to clearly delineate work area	2

Table 7-2 Key identified risks during operation

Risk Name	Cause	Impact	Assessment	Mitigation	Risk Rating
Hazard and risk	Accidental ignition as a result of inadequate bushfire protection zones for flares.	Bushfire resulting in loss of life, property or biodiversity	Chapter 17	Exclusion zone to be maintained at flare	3
Land resources	Changing land use	Incompatible land use with surrounding area.	Chapter 8 Appendix 2	On-going consultation with Forestry to identify and resolve any issues if they emerge	2
Land resources	Major infrastructure failure (pipes and tanks)	Contamination of land, water, vegetation dieback	Chapter 8 Appendix 2	Pressure gauges and remote monitoring to measure any changes at the well head and transfer tanks. Remote shut down facilities to be incorporated into design.	2
Water resources – surface water	Altered surface flows within drainage line adjacent to Bibblewindi 17 lease area	Localised flooding, scouring or sediment deposit within the drainage line	Chapter 10	Sediment control measures will be implemented	2
Water resources – groundwater	Water production during pilot operation	Negative impacts on environmental values i.e. registered users and GDEs due to drawdown effects, water quality, etc.	Chapter 9 Appendix 3	Water modelling has indicated that there will be no impact to GDE's and registered bore users. Ongoing monitoring program to be implemented	2
Biodiversity	Ongoing habitat fragmentation and edge effects	Longer term reduction in ecosystem functions.	Chapter 11 Appendix 4	Partial rehabilitation to occur where possible	2
Traffic and transport	Increase in traffic on local road network	Reduced road safety for community/other road users leading to fatality	Chapter 15 Appendix 7	Santos vehicles to be fitted with an in vehicle monitoring system to influence driver behaviour	2
Waste	Illegal dumping of waste or lack of suitable containment of waste.	Pollution, contamination and/or littering of land or water	Chapter 16	Produced water will be stored at the Leewood Produced Water Facility. Sufficient capacity exists within the ponds to accommodate expected volumes from the proposed activity	2
Hazards	Minor infrastructure failure (pipes and tanks) i.e. small leak	Contamination of land, water, vegetation dieback	Chapter 17	Pressure gauges and remote monitoring to measure any changes at the well head and transfer tanks. Remote shut down facilities to be incorporated into design.	2
Community	Community not appropriately consulted	Poor community relations; community backlash	Chapter 5	Ongoing consultation to occur through Santos's exploration and appraisal consultation program	2

7.3 Approach to assessment

Assessment of impacts as a result of the proposed activity has been based on a combination of key risks and the DGRs. The assessment has separated impacts associated with construction and drilling (approximately 105 days) and operation (up to 3 years) as the duration of activities is a key input to identifying the impacts.

Whilst the majority of impacts occur during drilling when the intensity of activity is greatest, this is a short term activity and generally confined to the lease area. Key issues during construction and drilling include:

- Potential spills of chemicals or fuels
- Minor earthworks during construction of the cellar pit and drill cuttings pit
- Drilling through multiple aquifers
- Use of chemicals during drilling
- Noise and emissions of vehicles and equipment
- Traffic movements
- Waste management
- Hazards and public safety

During operation, the intensity of activity is much less with the lease areas visited daily by one vehicle. Key issues include:

- Groundwater extraction and
- Greenhouse gas emissions

A cumulative impact assessment has been undertaken for the E&A Program described in Section 1.4 for all environmental aspects. Given that many of the impacts are localised and wells are dispersed (see Figure 7-1), cumulative impacts are generally minor and the discussion provided is brief. The exception is ground water, biodiversity and greenhouse gas emissions. A groundwater model has been developed and is described further in Section 9.2. Biodiversity impacts have been assessed based on vegetation cleared as a result of previous and proposed CSG activities. Given the proposed activity does not include any vegetation clearing, its contribution to cumulative impacts is negligible. Greenhouse gas emissions are discussed in section 13.4.

A range of mitigation measures including water quality monitoring programs are proposed to address identified potential impacts. These are outlined within each section and summarised in Chapter 20.

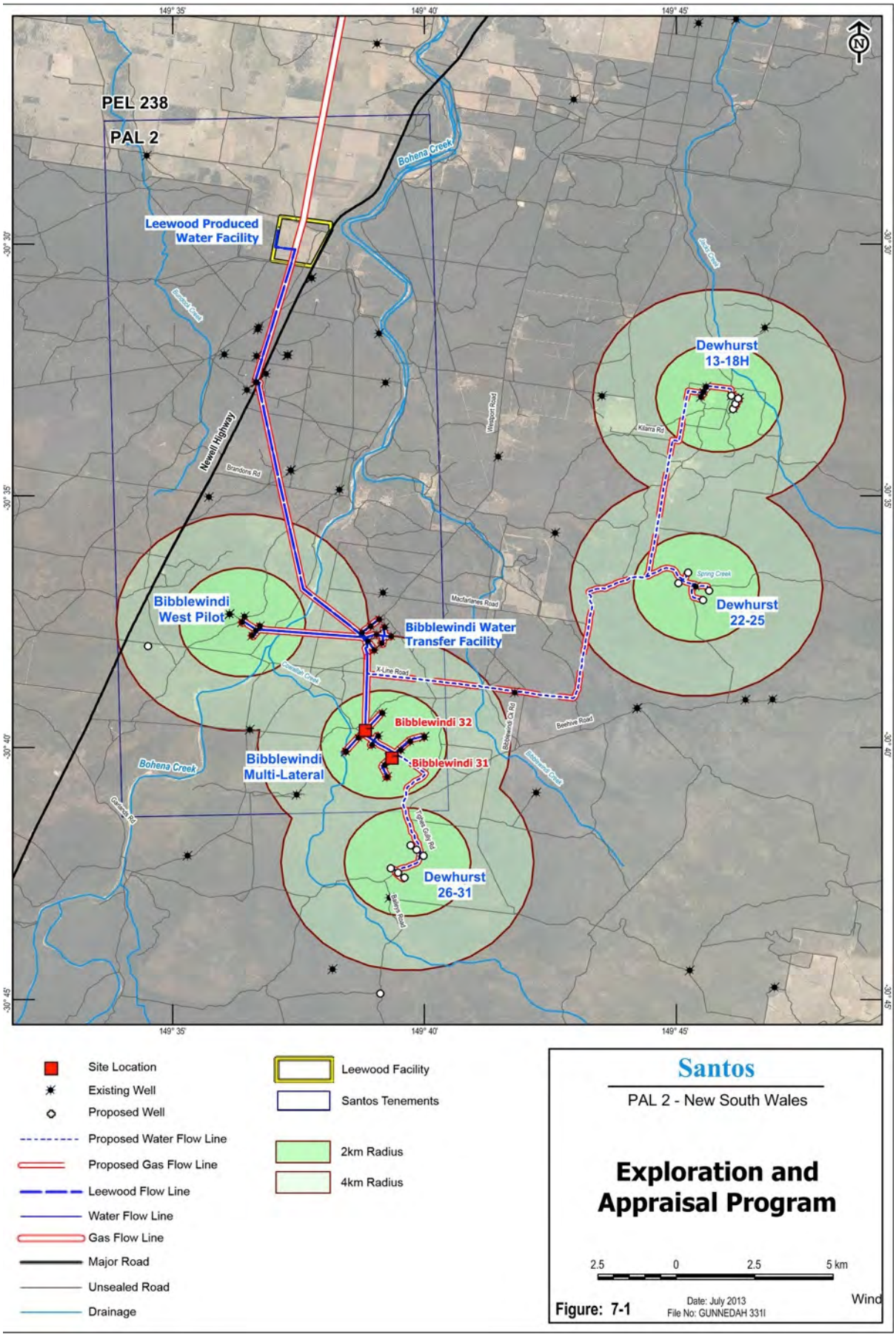


Figure 7-1 Proximity of activities within the E&A Program

PART B

8.0 Land Resources

An Agricultural Impact Statement (AIS) has been prepared in accordance with the requirements of *Guidelines for agricultural impact statements* (DP&I, 2012b) and *Guidelines for agricultural impact statements at the exploration stage (*DP&I, 2012c) and is provided in Appendix 2. The following section summarises relevant findings from the AIS.

8.1 Existing environment

The site is located within the Bibblewindi State Forest with surrounding land utilised for forestry purposes. This includes recreational activities such as bushwalking, camping and bird watching and other minor activities such as apiary uses (beekeeping) and timber harvesting. The site and its surrounds comprise of similar landscapes offering minimal land use value for intensive agricultural purposes. Figure 8-1 describes the soil type of the site.

The SRLUP identifies the site and surrounding land as having high CSG resources and underground coal exploration potential. Both CSG and coal mining are growing industries within the region with numerous existing CSG wells, and a number of existing mines are located within 100 kilometres of the site.

Extensive areas of land reserved for conservation and forestry lay in the middle of the catchment south of Narrabri. The proposed activity is not located within any conservation zone or an environmentally sensitive area of state significance, or within any mining titles as described in Figure 8-2.

8.1.1 Agriculture enterprise and resources

The Agricultural Impact Statement (AIS) identifies that the dominant land use in the Namoi catchment is sheep and cattle grazing (51 per cent). Other agricultural activities within the surrounding Narrabri LGA include wheat, cotton and other broad acre crops which are commonly grown along the alluvial floodplains in the area.

Due to the scale, diversity and productivity of agricultural enterprise within the Narrabri Shire, processing companies, research and development facilities, transport and warehousing and other service industries have been established in the Narrabri Shire (DP&I, 2012a), including:

- livestock selling centre
- farm management services
- grain and cotton processing centres
- grain and field bean merchant wholesalers
- agricultural research facilities
- crop harvesting selling centres.

The proposed activity is not located on or in the vicinity of any travelling stock routes (TSR). The nearest TSR is located 16 kilometres north of the site.

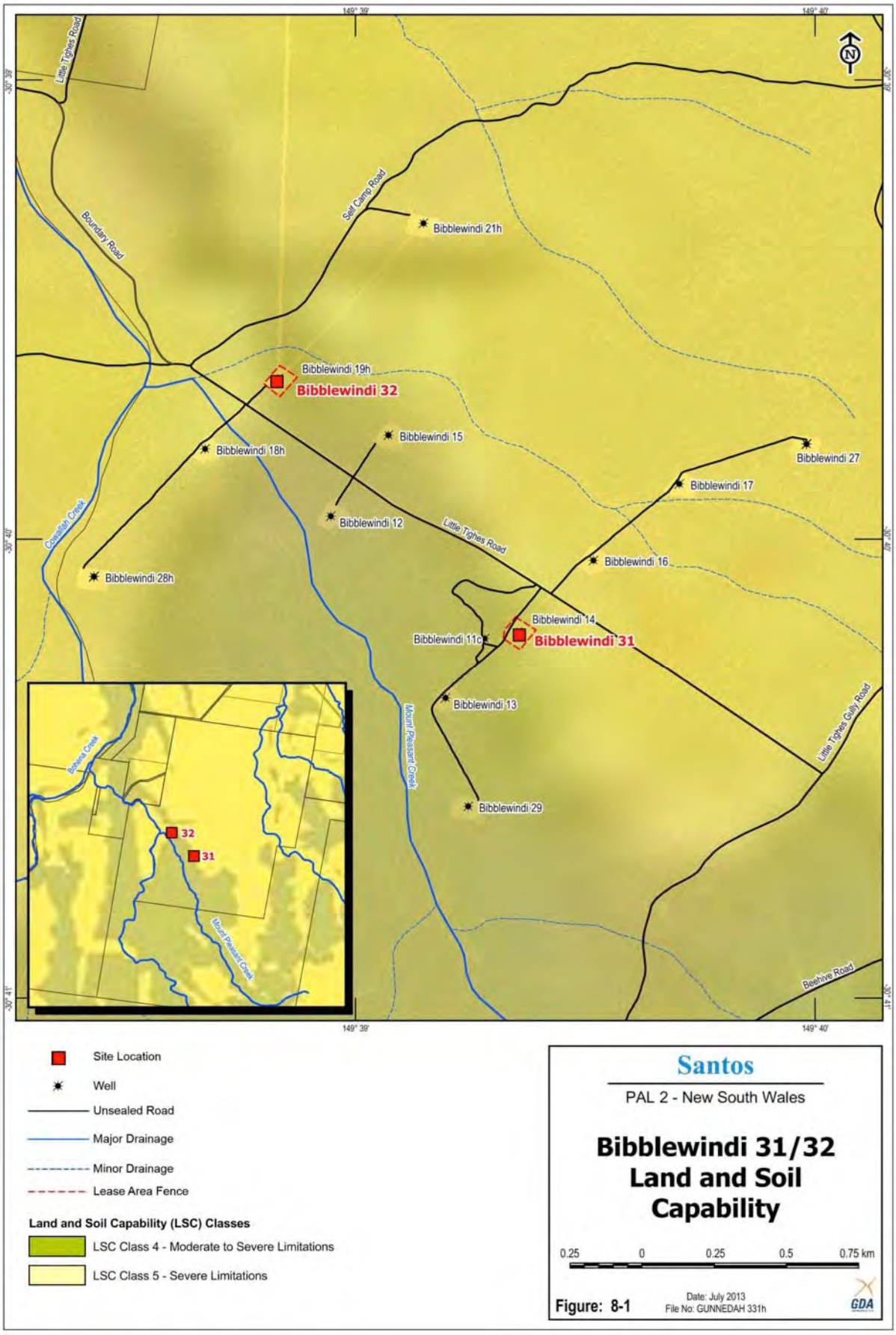


Figure 8-1 Land and soil compatibility

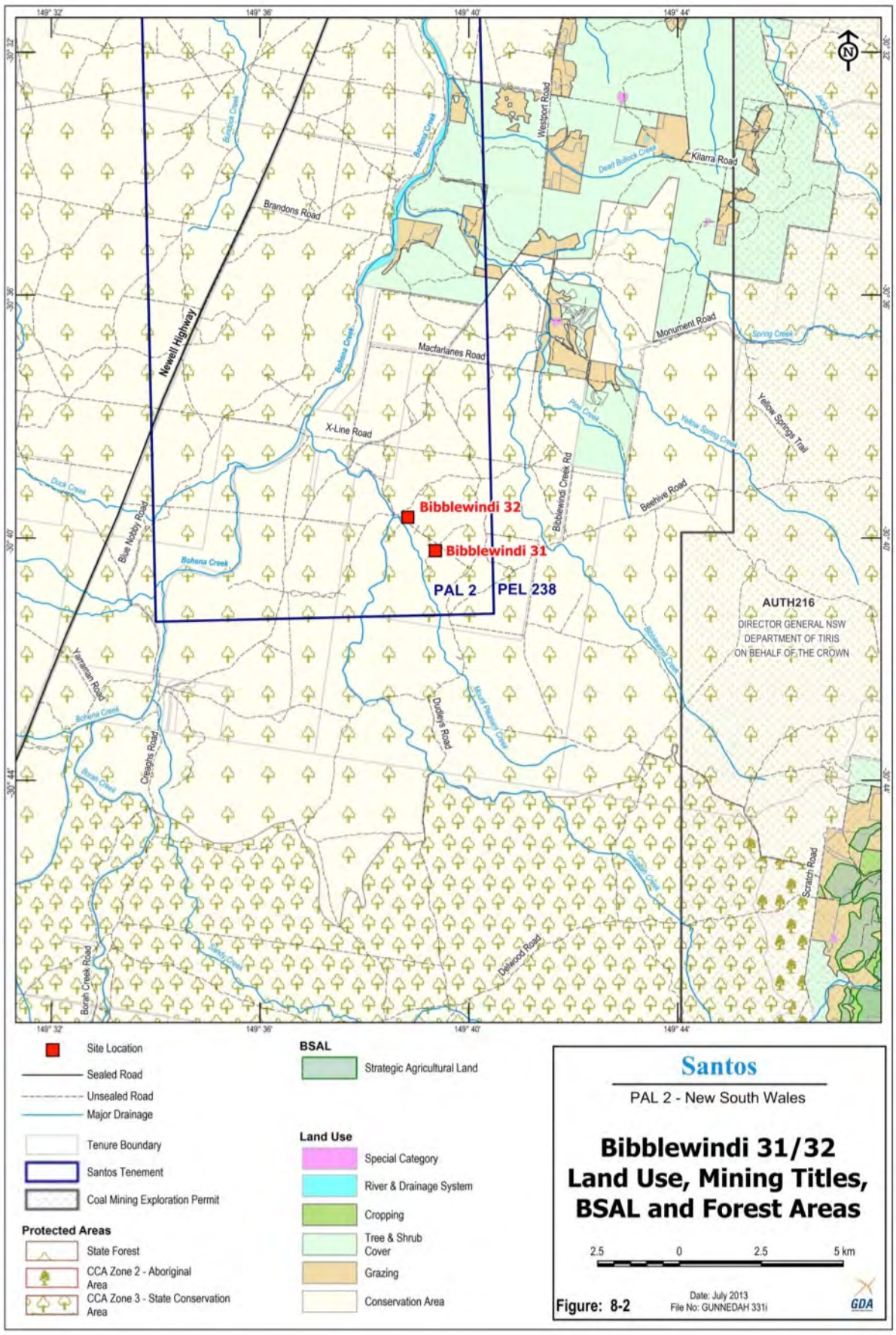


Figure 8-2 Land use, mining titles, BSAL and forest areas

8.1.2 Climate and weather

The closest operating weather station is located approximately 16 kilometres west of Boggabri (Boggabri Neotsfield – station 55273). Climate in this area is regarded as semi-arid, due to hot summers and mild winters. Average (1900 – 2013) monthly maximum temperatures range from 16.6°C (July) to 33.4°C (Jan) and maximum temperatures have not exceeded 40°C. Frost can occur in all low lying parts of the region. Frost events generally occur between June and August though can begin as early as May. Table 8.1 describes climatic conditions recorded for the region.

Average annual rainfall at Boggabri is 594.5 millimetres. Pan evaporation exceeds rainfall throughout the year, indicating the regions reliance on irrigation and soil water storage during fallows.

Table 8-1 Mean climate data

Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	77.9	64.3	45.8	36	43.3	41.8	40.7	35.8	35.6	51.4	58.8	63.1
Maximum Temperature (°C)	33.4	32.5	30.2	25.9	21.1	17.4	16.6	18.6	22.4	26.2	29.7	32.4
Minimum Temperature (°C)	18.1	17.9	15.3	10.7	6.9	4.1	2.8	3.7	6.5	10.5	14	16.6
Pan Evaporation (mm)	272	217	198	133	87.1	59.7	64.4	91.8	131	184	228	273

8.1.3 Soils

The AIS provides a desktop assessment of the soils within the region and those that are likely to be present at the site. The findings of this assessment are summarised below.

The soils across the region vary depending on the local sediment source. Australian Soils Classification (ASC) mapping identify the site and much of the surrounding area as being characterised by Duplex soil (Sodosols). Separate soil profiles collected by ESG and RPS at various locations between approximately four and 7.5 kilometres from the proposed activity also found soils to be either Rudosols and Tensols or Sodosols. Sodosols are typical of those derived from the Pilliga Sandstone and are described as being highly siliceous with poor soil nutrient status, and low Plant Available Water Capacity (PAWC). Rudosols and Tenosols are also identified approximately 1.5 kilometres south-east of Bibblewindi 31 and are described as having a generally weak pedologic organisation.

In terms of erosional and sediment transport qualities, the AIS reports that areas within four to six kilometres to the north of the site were found to have slight dispersion between 0 – 0.14 metres in depth while subsoils (<0.14 metres) were found to have very high dispersion. Therefore, soils at the site are likely to be prone to erosion.

According to the *Draft Inherent Soil Fertility mapping of the New England – North West region* (OEH, 2012), the inherent soil fertility of the site is moderately low.

Soil characteristics of the site indicate moderate to severe limitations as the features of Sodosals such as low plant available water capacity, low nutrient levels and sodicity that all limit agricultural production.

The site is not expected to be contaminated. No spills or other incidents are known to have occurred during construction and previous operation of the site that may have caused contamination.

8.1.4 Land and soil capability

The soil limitations are consistent with BSAL and Land and Soil Capability Class (LSC class) mapping for the site.

SAL is highly productive land that has both unique natural resource characteristics as well as socio-economic value (DP&I, 2012a). BSAL is land with the best quality landforms, soil and water resources which are naturally capable of sustaining high levels of productivity with minimal management practices (DP&I, 2012a). A CIC is a localised concentration of interrelated productive industries based on an agricultural product that provides significant employment opportunities and contributes to the identity of the region (DP&I, 2012a).

As shown in Figure 8-2, the site is not located within land mapped as BSAL or CIC under the SRLUP. Based on the broad scale mapping provided in the SRLUP, the nearest BSAL is located approximately 15 kilometres east of the site.

In NSW, LSCs have been mapped for the New England – North West region (OEH, 2012b). 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. Class 1 represents land capable of sustaining most land uses including those that have a high impact on the soil (e.g. regular cultivation), whilst class 8 represents land that can only sustain very low impact land uses (e.g. nature conservation).

The site and surrounds have been mapped as LSC Class 4 and 5 (Figure 8-1). 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. 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).

8.1.5 Water resources

A detailed description of the groundwater resources in the area is provided in Chapter 9 and Chapter 10 describes surface water conditions.

8.2 Potential impacts

8.2.1 Land use

As the proposed activity lies within a State Forest, it will not prohibit any agricultural production within the region, and there will not be any consequent reduction in the permanent land capability of agricultural resources. Furthermore, moderate to severe limitation of the site for agricultural production and its location within the State Forest means that it is highly unlikely that the site would be used for agricultural production in the long term.

The proposed activity would be located on existing lease areas (previously cleared). As this area does not harbour trees such as the Pilliga Box, Yellow Box and Narrow Leaved Ironbark species which may be targeted by honey bees when flowering, any impact to the apiary industry would also be negligible. Similarly there would be no change to existing recreational tourism opportunities in Bibblewindi State Forest such as hiking, camping and bird watching. 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. During operation, the well heads and related surface infrastructure may be visible from Little Tighes Road.

No existing agricultural jobs will be lost as a direct result of the proposed activity. Therefore, the proposed activities will not result in a loss of agricultural employment opportunities in the Narrabri Shire LGA.

With respect to agricultural support services within the region, there may be a minor short term increase in traffic volumes on the Newell Highway during the construction phase. Significantly, these impacts will be temporary in nature and are not expected to cause significant delay or increase risks associated with the transport of agricultural products and services. Traffic impacts are discussed further in Chapter 15.

8.2.2 Soil quality and land stability

8.2.2.1 Erosion

The proposed activity would require minor earthworks (approximately 30 square metres) on the existing well lease area as part of drilling activities to establish the cellar pit near the location of the wells and the installation of sub-surface infrastructure to connect the well to the existing gas and water gathering system. Any topsoil and spoil generated during site preparation activities will be stockpiled on site for the duration of site preparation, drilling, testing and completion activities.

The proposed disturbance to the ground surface is entirely within existing lease areas and as such the site is not considered to be sensitive to disturbance.

While the existing lease areas are relatively flat, any earthworks will increase the site's erosion potential and may result in loss of topsoil/spoil, and sedimentation of waterways. Potential impacts to surface waters are further discussed in Chapter 10.

Drilling activities will produce drilling fluid and drill cuttings. These materials are unlikely to present an erosion hazard as drilling fluid and cuttings will be contained in lined pits, surface tanks or metal bins.

Delivery trucks and personnel vehicles exiting the sites may track sediment onto Little Tighes Road. Erosion and sedimentation will be reduced through the measures identified in Section 8.4.

Potential erosion impacts are expected to be very minor and only occur during the drilling stage. Ongoing erosion impacts during operation associated with the lease areas were assessed as part of previous approvals. Sediment controls already exist at each of the lease areas as part of works for Bibblewindi 14 and 19H.

8.2.2.2 Contamination

During site establishment, construction and drilling, the proposed activity could result in soil contamination as a result of spilled or leaked chemicals (such as drilling fluid additives), fuel or oil. Spills or leaks could occur during handling, use, storage or transit of chemicals, fuels and oils. Spills or leaks may also occur during refuelling or maintenance of plant or equipment.

There is minimal risk of soil contamination occurring due to the use of drilling fluid as this will be water-based and will contain non-toxic additives. Drilling fluids and cuttings are therefore unlikely to be contaminated.

Measures to reduce the risk of contamination as a result of the proposed activity are identified in Section 8.4.

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 Water Transfer Facility. 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.

8.2.2.3 Community use of natural resources

As the proposed activity is being undertaken on already cleared land, it will not further restrict forestry activities within the State Forest.

Natural resources required for the proposed activity include diesel for operation of plant and machinery. Quantities of fuel will not be significant. These are discussed in Section 17.

The proposed activity will not impact on existing coal mining operations. There are no known coal mines planned for the site and it is expected that the proposed activity will pose no threat to future coal mining operations.

8.2.2.4 Soil diseases

The proposed activity may contribute to the spread of soil diseases, particularly *Phytopthora.* These potential impacts will be managed through the measures identified in Section 8.4.

8.3 Cumulative impacts

The proposed activity will not contribute to the use of natural resources (particularly agricultural land) as part of the E&A Program as the proposed activity will occur within existing lease areas and utilise existing water and gas management infrastructure.

The current extent of agricultural land use within PEL 238 and PAL 2 is approximately 791,478 ha. None of the activities planned as part of the proposed E&A Program are located on agricultural land (major agricultural industries identified in PEL 238 and PAL 2 are cropping, grazing, horticulture and plantations). Although production forestry is mapped within PEL 238 and PAL 2, there is minimal exotic plantations. Rather, these areas include State forest used for timber harvesting and nature reserves (accounting for an additional 190,462 ha). Timber harvesting within the Pilliga has been reduced largely due to conservation efforts; therefore any impact on such enterprises are not considered significant.

Cumulative impacts of the E&A Program to natural resources will be negligible as the majority of agricultural land would be fully rehabilitated and available for agricultural activities following completion of exploration activities. Proposed activities will also not quarantine any Critical Industry Cluster (CIC) areas.

8.4 Mitigation measures

8.4.1 Site establishment

- Excess topsoil and subsoil generated during site preparation activities will be stockpiled on site and used as backfill following completion of drilling.
- Erosion and sediment controls will be implemented where necessary during site preparation activities, in accordance with best management practices (such as the Blue Book or IECA Guidelines). These controls will be maintained until disturbed areas of the site are stabilised.

8.4.2 Drilling

- The quantity of chemicals, fuels and oils stored on site will be minimised, where practicable.
- All additives, chemicals, fuels and oils stored on site will be kept in an appropriately secured, bunded storage shed in accordance with the relevant MSDS.
- Where there is a risk of contamination pits will be lined or material will be stored in surface tanks or metal bins.
- An MSDS register of all chemicals used or stored on site will be maintained.
- Maintenance of vehicles, plant and equipment will occur off site at an appropriately licensed facility unless deemed necessary and appropriate to conduct such maintenance on site.
- 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 the site for disposal at a licensed waste facility.
- Plant and equipment will be inspected daily to ensure these are properly maintained.

8.4.3 Operation

- Ongoing management and maintenance of remaining infrastructure on site 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.

8.4.4 Post operation

The site will be rehabilitated in accordance with Section 4.5.1 of the EIS.

9.0 Groundwater

A *Groundwater Impact Technical Report* has been completed by CH2M Hill for the proposed activity. The report is provided in Appendix 3 and the assessment is summarised below.

9.1 Existing environment

9.1.1 Hydrogeological setting

The Upper Namoi and Lower Namoi Alluvium form the principal aquifers of the Namoi River Catchment. According to the relevant water sharing plans for the region, the site does not sit within any mapped Upper Namoi and Lower Namoi Alluvium.

AGE (2006) indicates that Bohena Creek is associated with an alluvial aquifer, with minor thin veneers of alluvium in some tributary creeks. The alluvium of Bohena Creek and major tributaries consist of clean, medium to coarse quartz sands which are up to about seven metres thick. The alluvial sands form elongated deposits confined to the creek alignment and have an estimated average width of about 60 metres along Bohena Creek.

The water table in the alluvium of Bohena Creek varies from surface level following periods of creek flow, to an estimated two metres below surface level during dryer periods (AGE, 2006). It is considered that groundwater in the alluvium is perched on the finer grained sedimentary deposits of the Blythesdale Group, as the water level in the deeper Pilliga Sandstone aquifer is 20 to 30 metres below ground level in the area.

Recharge of the alluvium occurs primarily from infiltration of surface water during creek flow events and to a lesser degree by direct infiltration of rainfall on the sand deposits. Groundwater flow is to the north along the creek channel, with discharge eventually to the Namoi River and/or the major alluvial aquifers associated with the river.

The main aquifers surrounding the site are associated with underlying basement rock units, and include the following:

- Southern Recharge groundwater source, under the Water Sharing Plan for the NSW GAB Groundwater Sources.
- Gunnedah-Oxley Basin MDB buried groundwater source, under the Water Sharing Plan for the NSW Murray-Darling Basin Porous Rock Groundwater Sources.
- Lachlan Fold Belt MDB buried groundwater source, under the Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources.

The southern recharge zone of the GAB underlies the site. The GAB covers 1.7 million square kilometres and contains 8,700 million megalitres of artesian water. It consists of sedimentary sequences with layers of porous and permeable sandstones which alternate with low permeability shales, siltstones and mudstones. Aquifers of the GAB are unsuitable for irrigation use due to high levels of sodium; however, water from these aquifers is generally suitable for domestic and town water supply (GABCC, 1998).

Groundwater recharge takes place chiefly along the south and eastern fringe of the GAB. Groundwater enters the main Pilliga Sandstone aquifer directly through exposed outcrop, or at lesser rates, via overlying strata where there is potential for downward groundwater movement (DWE, 2009). The Pilliga Sandstone outcrops in the vicinity of the site, and underlies the area at a relatively shallow depth (20 to 30 metres). The Southern Recharge groundwater source, in which the site lies, is characterised by better quality groundwater than other zones of the GAB.

The Gunnedah-Oxley Basin MDB Groundwater Source covers a subcrop area of 28,600 square kilometres. It is the Permian and Triassic rocks associated with the Gunnedah Basin, and the overlying younger Jurassic and Cretaceous rocks associated with the Oxley Basin. The Gunnedah-Oxley Basin extends from the Mount Coricudgy Anticline (separating it from the Sydney Basin), the Hunter-Mooki Thrust to the east (forming the eastern boundary between the Gunnedah-Oxley Basin and the New England Fold Belt), the Lachlan Fold Belt to the west and a structural high to the north of Narrabri (NOW, 2012a).

The consolidated formations (e.g. hard rock aquifers) of the Gunnedah Basin comprise interbedded coals, sandstone and siltstones and are not considered major groundwater sources. These formations may be categorised into the following hydrogeological units (AGE, 2006):

- hydrogeologically 'tight' and hence very low yielding to essentially dry sandstone and lesser siltstone and shale that comprise the majority of the strata
- low to moderately permeable coal seams which are the prime water bearing strata within the Permian sequence.

The primary target CSG bearing formation for the proposed activity is the Bohena seam, a lower Permian coal within the Maules Creek Formation as shown in Figure 9-1.

Groundwater pressures determined from Drill Stem Tests (DSTs) during exploration by ESG indicated groundwater levels between 247 to 385 metres AHD within the Maules Creek Formation (including the Bohena Seam). All the groundwater levels derived from DST were found to be artesian and were significantly higher than groundwater levels in the alluvium (Golder, 2011). There was no coherent groundwater flow direction apparent from the DST-derived head measurements, partly due to the varied zones over which the DSTs have been conducted and also because the likely lack of discharge from the formation.

The Lachlan Fold Belt MDB Groundwater Source covers an area of 167,220 square kilometres. It consists of Cambrian to Lower Carboniferous rock successions, located deeper than the targeted CSG bearing formations. The eastern margin is truncated by the present coastline in the south and is overlapped by the Permo-Triassic succession of the Sydney Basin and its northern equivalents; the northern margin is overlaid by the Mesozoic Great Artesian Basin succession; the southern margin is truncated by the present Tasmanian coastline, and is overlaid by Permian and younger successions. The western margin is largely covered by the mainly Cainozoic Murray Basin successions (NOW, 2012b).

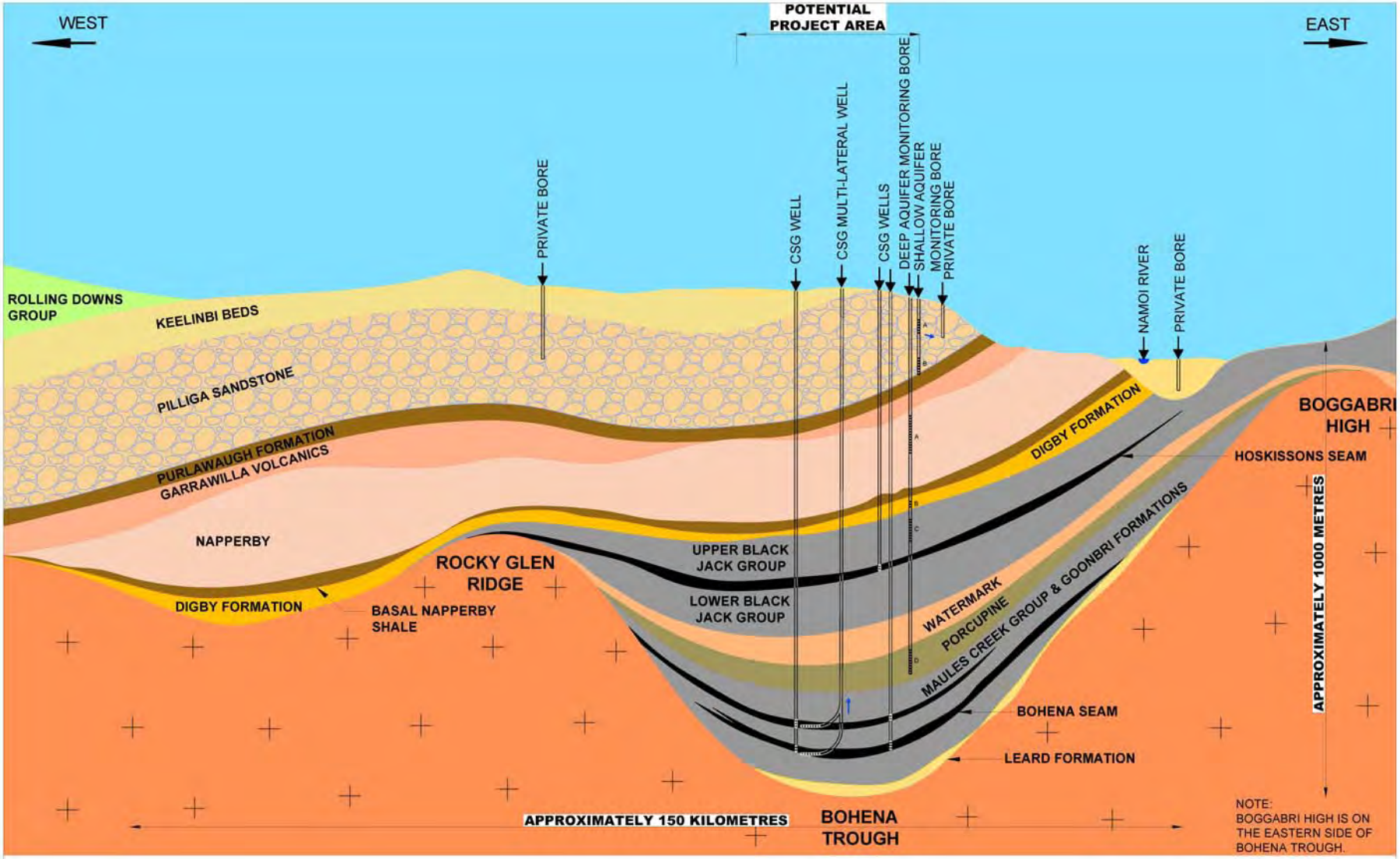


Figure 9-1 Schematic cross section through the Bohena trough (not to scale)

Source: Narrabri Groundwater Flow Model report (CH2M Hill, 2013)

9.1.2 Groundwater use

Groundwater in the Namoi River catchment supports the irrigation industry and also provides the water supply for many towns and intensive industries. There are a total of 700 groundwater license holders in the Namoi River catchment (NOW, 2011). As the Upper Namoi and Lower Namoi Alluvium form the principal aquifers of the Namoi River Catchment they are heavily used for irrigation (Schlumberger Water Services, 2012). The Namoi catchment is licensed to provide over 343,000 megalitres of groundwater entitlement per year.

Groundwater use in close proximity to the site is limited, due to both land use constraints arising from the site being located within the Pilliga scrub and lower yields associated with the consolidated rock units. The Maules Creek Formations (including the target Bohena seam) is not currently used for water supply due to depth, water quality and availability of good quality groundwater near the surface.

According to the Pineena database (NOW, 2010), there are five licensed groundwater bores within five kilometres of the proposed study area. Table 9-1 provides details of these registered groundwater bores. It is noted that salinity information was not provided within the database for any of the bores.

Table 9-1 Registered groundwater bores within five kilometres of the proposed activity

Bore ID	Easting	Northing	Max Depth (m)	GWMA	Authorised purpose	Water Bearing Zone (m)	Yield
GW021998	749,825	6,605,167	73.8	GAB	Oil exploration	38.7-43.5	-
						46.3-52.0	-
						56.6-69.7	1.52
GW967923	754,004	6,607,915	90.0	GAB	Industrial	65-73	-
				-	-	75-90	-
GW967935	754,134	6,609,085	93.0	GAB	Industrial (low security)	53-56	-
						65-81	-
						91-93	-
GW968789	757,680	6,609,400	84.0	GAB	Domestic/ Stock	61-84	25
GW970010	754,260	6,608,015	47.0	GAB	Test Bore	33 – 47	-

9.1.3 Groundwater Dependant Ecosystems

There are two high priority groundwater dependent ecosystems (GDEs) listed within the NOW GDE database. These are Eather Spring and Hardy's Spring, both located approximately 18 kilometres from the site. They are both located on or close to the junction of the Pilliga Sandstone and Purlawaugh Formation at outcrop.

Both springs are considered to represent recharge springs, sustained by rejection of rainfall recharge that doesn't enter the main GAB groundwater source. Recharge rejection occurs within the GAB intake beds when the rate of recharge to the shallow groundwater sources exceeds the capacity for deep drainage into the GAB intake beds, principally due to low hydraulic conductivity of Purlewaugh Formation acting as a regional seal.

9.1.4 Water quality

A water quality assessment has been undertaken that included 317 samples from 126 sources; 178 samples collected from production/exploration wells in the Gunnedah and Narrabri region and 139 samples from the Regional Bore Inventory for the Gunnedah area (Golder Associates, 2012). Groundwater samples were extracted from a number of formations including the Maules Creek (93 samples) and alluvial (11).

Overall, groundwater pH values in the E&A Program area ranged from 6.81 to 11.2. Coal seam water in the Maules Creek Formation is slightly alkaline, with a range of 7 to 9. Based on total dissolved solids (TDS) concentrations (measured at approximately 600 to 18,520 milligrams per litre), water from the coal seams can be classed as 'brackish to saline'. Alluvium and consolidated rock sources can be classed as 'fresh to brackish', with measured TDS between approximately 300 and 6000 milligrams per litre.

9.2 Assessment approach

A numerical groundwater flow model has been developed to simulate the potential cumulative impact on surface water and groundwater resources, and GDEs from the operation of the six pilot sites within the E&A program. Initial model development included:

- Data collation, literature review and gap analysis:
- Characterisation of the groundwater environment, including identification of environmental values associated with groundwater resources
- Development of the hydrogeological conceptual model (HCM)
- Development of a groundwater flow model to facilitate the assessment of the potential impacts of CSG water extraction on water resources.

The numerical groundwater model was constructed using MODFLOW-2005 and the graphical user interface (GUI) Groundwater Vistas interface V6.07 Build 18.

The model extends:

- Eastward beyond the Boggabri Ridge to the eastern side of the Namoi River
- Southward beyond the Walla Walla Ridge into the Bando Trough
- Westward to the Rocky Glen Ridge
- Northward beyond the Narrabri High and the Namoi River to the inferred location of the groundwater divide within the GAB (in accordance with groundwater level information presented in GABFLOW2000 (Welsh, 2000).

The modelling assumed that the operation of each pilot will occur for a three year period. The estimated volumes of groundwater extracted from the target seams which were applied within the modelled operation scenario are provided in Table 9-2.

Table 9-2 Estimated extraction rates for pilots

Pilot	Total Extraction (m^3)	Max Extraction (m^3/day)	Average Extraction (m^3/day)
Dewhurst 13-18 Pilot	331,121	397	302
Dewhurst 22-25 Pilot	285,140	273	260
Dewhurst 26-31 Pilot	413,801	448	378
Bibblewindi Multi-lateral Pilot	285,110	581	260
Bibblewindi West Pilot	92,940	209	85
Tintsfield 2-7 Pilot	25,162	43	23

There are no plans to use the process of hydraulic stimulation (also known as hydraulic fracturing or fracking) within the E&A Program.

Further details of the model and modelling process are provided in Appendix 3.

9.3 Potential impacts

9.3.1 Construction

Potential impacts to groundwater associated with construction may result from drilling, well installation or abandonment if not carried out correctly.

Potential impacts of drilling in mixed multi-aquifer systems include:

- creation of an artificial connection between water-bearing formations that bypasses aquitards (low permeability layers which restrict groundwater flow) or aquicludes (geological formations through which no groundwater flows) resulting in cross contamination of aquifers
- contamination of the aquifers by drilling fluids if these are lost in the formation
- groundwater discharge to the surface, which may cause flooding or impact on surface water quality depending on the discharge and receiving water qualities.

Human consumptive uses and aquatic ecosystems may be impacted from these potential risks. These risks are rated as minor and are considered unlikely to occur as wells will be designed and constructed in accordance with the *NSW Coal Seam Gas Code of Practice Well Integrity* (DTIRIS, 2012b) and over balance drilling methods will be employed.

Groundwater contamination could also occur due to spills of oil, fuels or chemicals if they are not cleaned up appropriately.

9.3.2 Operation

The assessment of potential groundwater impacts during operation was completed based on a cumulative approach, as outlined in Section 9.2. The outcome of this cumulative impact modelling is summarised in Section 9.4.5 below. The impacts of the Bibblewindi Multi-Lateral Pilot in isolation, while not modelled, can be assumed to be much lower than those predicted from this modelling.

9.4 Cumulative impacts

A detailed discussion of potential cumulative groundwater impacts, including relevant hydrographs and drawdown plots, is provided in the Groundwater Impact Technical Report. A summary of the key outcomes, in regards to the Aquifer Interference Policy (AIP) is provided below. Impacts would be confined to the NSW Murray-Darling Basin Porous Rock Groundwater Source WSP where the target seam is located. However water quality extracted from the target seam is highly brackish and unsuitable for drinking or irrigation without treatment.

9.4.1 Predicted impacts on the NSW Upper and Lower Namoi Groundwater Source WSP during operation of the pilot wells

The alluvial groundwater sources of the Upper and Lower Namoi alluvium (NSW Upper and Lower Namoi Groundwater Source WSP) are considered to be highly productive in the context of the AIP. The groundwater model predicts that there will be no decline in the water table or change in flux within these alluvial aquifers as a result of the operation of the E&A Program. This is due to the aquitard layers, including the Purlewaugh Formation, that separate the target coal seam from the alluvium.

9.4.2 Predicted impacts on the NSW GAB Groundwater Source WSP during operation of the pilot wells

The porous rock groundwater source of the GAB Surat Pilliga Sandstone (NSW GAB Groundwater Source WSP) is also considered to be a highly productive porous rock groundwater source in the context of the AIP. Groundwater modelling results indicate that there is no decline in groundwater level or change in flux within this aquifer during operation of the E&A Program. This is again due to the aquitard layers, including the Purlewaugh Formation, that separate the target coal seam from the GAB.

9.4.3 Predicted impacts on the NSW Murray-Darling Basin Porous Rock Groundwater Source WSP during operation of the pilot wells

The porous rock groundwater source of the Gunnedah Basin (GMA604) (NSW MDB Porous Rock groundwater source WSP), comprising the Triassic strata of the Digby, Napperby and Deriah formations and the Permian strata of the Black Jack Group down to and including the Maules Creek Formation, is considered within the context of the AIP to be a less productive porous rock groundwater source. These different strata are represented in the model as different layers with the CSG water extraction occurring in lowest layers. A decline in head of over 2 m within the lowest strata is indicated by the model outcomes. Given that the pilot CSG water extraction will occur within this AIP classified water source, the impact on hydraulic (pressure) head within the combined group of the three stratas and the fluxes developed within the groundwater source to meet the pilot CSG water demand are interpreted to comprise aquifer interference and will require licensing.

The zones of influence remain west of the outcrop of the Gunnedah Basin Permo-Triassic strata. Hence the registered bores within this region of the MDB Porous Rock (Gunnedah Basin GMA604) groundwater source WSP which extract from this groundwater source will not be impacted by the pilot CSG water extraction.

9.4.4 Predicted impacts on registered water supply bores

Of the five registered bores within five kilometre of the proposed activity, only one is used for stock and domestic purposes. All these bores extract water from the Pilliga Sandstone. The Pilliga Sandstone of the Surat Basin is considered the lowest (and most easterly) intake beds of the GAB. As stated above, this aquifer will not be significantly impacted by the proposed activity during either construction or operation.

There is no known registered extraction from bores in formations deeper than the Pilliga Sandstone across the E&A Program area. From the modelling result, the predicted cumulative impact on registered water supply bores across this extent will not be significant.

9.4.5 Predicted impacts on high priority Groundwater Dependant Ecosystems and related vegetation

Hardy's and Eather Spring are hydrogeologically associated with the Pilliga Sandstone. As there is no significant impact to the Pilliga Sandstone, there is expected to be no significant impact on the GDEs due to the proposed activity. Similarly, the model results indicate that there will be no significant impact on groundwater dependent terrestrial vegetation within the E&A Program area.

9.5 Mitigation measures

9.5.1 Construction

- The wells will be designed and constructed in accordance with the *NSW Coal Seam Gas Code of Practice Well Integrity* (DTIRIS, 2012b).
- 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 on site 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 two kilometres 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.

9.5.2 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 two kilometres 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.

9.5.3 Proposed groundwater monitoring program

The monitoring of groundwater is required to confirm the absence or onset (and magnitude) of any impact associated with CSG activities at both the deep and shallow aquifer level. Registered bore users extract water from the shallow aquifers and whilst modelling has concluded that this will not be impacted, long-term monitoring over the duration of the CSG operations is proposed.

Santos is currently implementing a comprehensive groundwater monitoring program. This program was presented and discussed with the NSW Office of Water and was approved by the OCSG on 9 July 2013.

The groundwater monitoring program proposes to include installation of shallow monitoring bores at eight locations and one deep aquifer monitoring bore over the next 12 months. The proposed location of these bores is provided in Figure 9-2, noting these are subject to change as required. A number of the monitoring locations already have relevant licences issued by the NSW Office of Water under the *Water Act 1912*.

Once installed, these monitoring bores will measure groundwater pressure and temperature within various strata and enable groundwater levels and flows to be monitored. Information will be transmitted via telemetry to a production database. The bores will not extract any groundwater beyond what is extracted during drilling and required for water quality sampling, where this occurs.

Baseline data gathered will include groundwater heads (pressures) within the hydraulically confined strata of the Gunnedah Basin and groundwater levels within these unconfined Permo-Triassic strata at or close to outcrop and subcrop. This will help to establish the baseline conditions prevailing before the commencement of any pilot trials within the wider region. The shallow monitoring bores will focus on:

- Demonstrating the baseline groundwater levels and the background flow pattern within the Pilliga Sandstone.
- Confirming the groundwater pressure in the Purlawaugh Formation.
- Verifying the confining characteristics of the Orallo formation overlying the Pilliga Sandstone.

The deep monitoring bore will focus on:

- Demonstrating the baseline groundwater pressures and the background flow patterns/existing hydraulic gradients within the hydrostratigraphic units of the Gunnedah Basin.
- Illustrating the absence or otherwise of vertical hydraulic continuity within the Gunnedah Basin strata.
- Enabling elaboration of the migration of groundwater depressurisation both laterally in the target seam and vertically above and below the target seam, following the commencement of CSG water extraction.

The proposed location of the monitoring network has been arranged to maximise the acquisition of beneficial data which can:

- Inform the absence or otherwise of potential impact to the regional GAB aquifers.
- Act as sentinel monitoring locations between the Narrabri Gas Field Area and groundwater abstractions in the Gunnedah Basin domain.
- Yield essential hydrogeological data comprising additional stratigraphic data, remote head and field testing data and cores for laboratory testing of hydraulic parameters.

9.5.4 Licensing

Under s60I of the WMA, a WAL is required to take water in the course of carrying out a mining activity. During its operation, the Bibblewindi Multi-Lateral Pilot is expected to extract a maximum of approximately 285 megalitres of groundwater over three years from the Gunnedah-Oxley Basin MDB groundwater source under the NSW MDB Porous Rock Groundwater Source WSP. Santos has been granted a ‘certificate of right to apply for an access licence’ of 600 unit shares from within the Gunnedah-Oxley Basin MDB groundwater source by the NSW Office of Water. An application for a WAL of 600ML per annum for this water source (one unit share is currently equal to one megalitre of water) has been made. Santos also currently holds a 20 unit share aquifer access licence entitlement for this same groundwater source. Santos has submitted an application for a Water Supply Works Approval for the Bibblewindi Multi-Lateral Pilot.

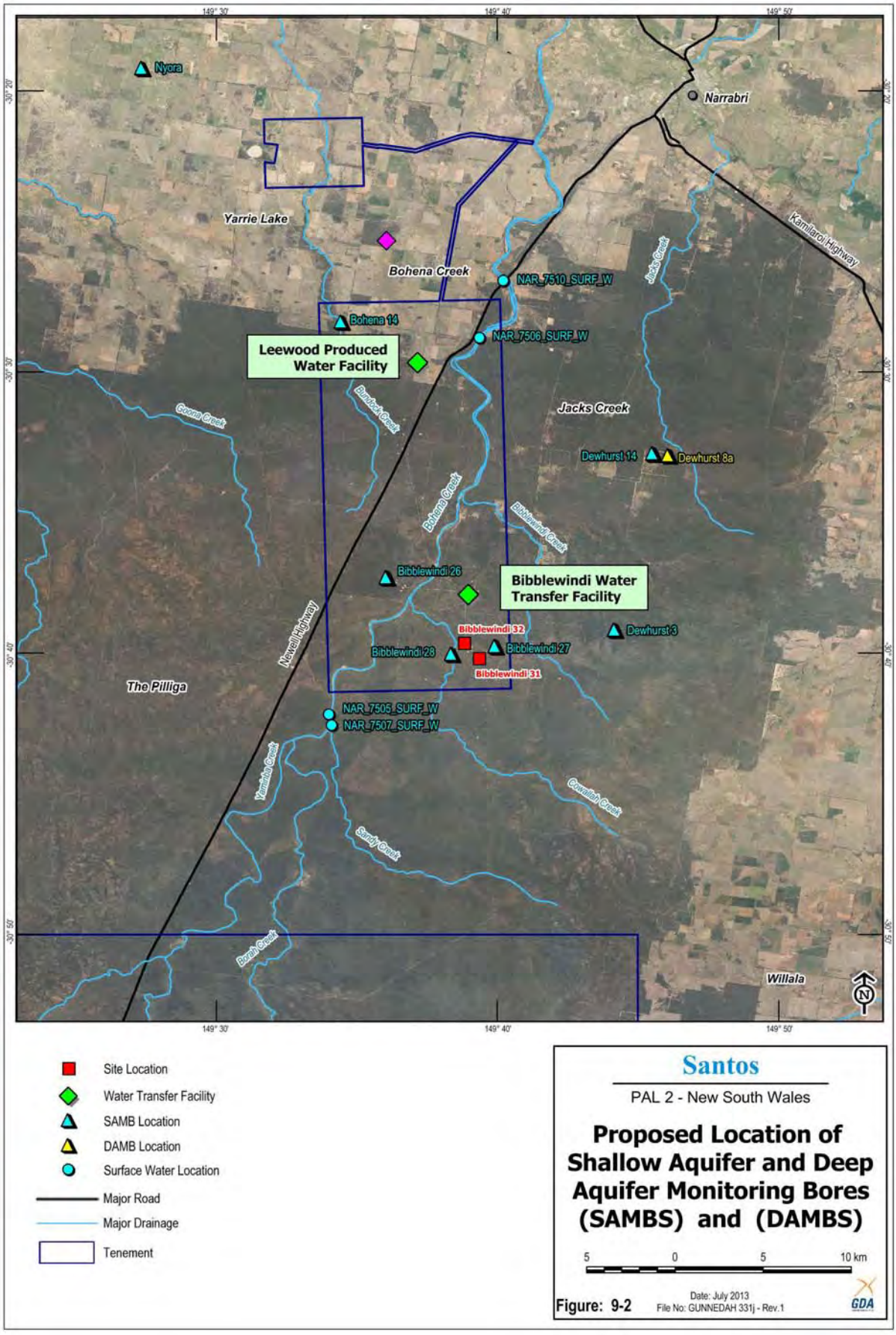


Figure 9-2 Proposed locations of shallow aquifer and deep aquifer monitoring bores

10.0 Surface water

10.1 Existing Environment

10.1.1 Surface water catchment

The site is located within the Namoi River catchment which covers an area of approximately 42,000 square kilometres stretching from Woolbrook in the east to Walgett in the west. The catchment is bounded by the Great Dividing Range in the east, the Liverpool Ranges and Warrumbungle Ranges in the south and the Nandewar Ranges and Mount Kaputar to the north. Major tributaries of the Namoi River include Coxs Creek and the Mooki, Peel, Cockburn, Manilla and Macdonald rivers, all of which join the Namoi River upstream of Boggabri with Pian, Narrabri, Baradine and Bohena Creeks joining below Boggabri (NCMA, 2013).

Given the dominant use of the land in the Namoi catchment as grazing and both dryland and irrigated cropping (refer Chapter 8); surface water quality within the catchment is likely to be influenced by agricultural runoff, spray drift, and vapour transport (NCMA, 2013).

The subject site is located within the Bohena sub-catchment of the Namoi River catchment. The sub-catchment covers an area of approximately 830 square kilometres south of Narrabri and is the northern extension of the Borah sub-catchment. The Bohena sub-catchment is drained by Bohena, Cowallah and Bibblewindi creeks (NCMA, 2013). Issues within the sub-catchment include soil erosion, biodiversity conservation, water quality and riparian management.

The Bohena sub-catchment forms the Bohena Creek Water Source under the *Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources* (NOW, 2012c) A search of the NSW Office of Water's website indicated that there are currently no records of any Water Access Licences under the *Water Management Act 2000* within this water source.

Bohena Creek and its tributaries are ephemeral watercourses that do not form significant topographical features within the landscape. They generally flow for short periods following significant rainfall or prolonged wet periods (WRM, 2006). Baseflow in these creeks are insignificant. Bohena Creek remains dry for extended periods between runoff events, sometimes for periods in excess of 12 months (WRM, 2006). It contributes little inflow to the Namoi under normal conditions; however during protracted wet conditions, significant flood inflows to the Namoi can be generated. Sedimentation in the catchment has resulted in extensive sand deposits in Bohena Creek and its tributaries. Due to the ephemeral nature of Bohena Creek, it can be inferred that the extensive sand deposits are caused by intense rainfall events that mobilise and rework sediment.

The Namoi Water Quality Project 2002-2007 (Mawhinney, 2011) incorporated a surface water monitoring station on Bohena Creek at the Newell Highway, downstream of the confluence with Bibblewindi Creek (station number 419905). The frequency of sampling throughout the program's five year life was once a month, however over the course of the five year monitoring period, a total of only five samples were collected at this site, always following heavy rainfall in the catchment area. This reflects the ephemeral nature of the watercourses in this area. Details of the water quality measured at this sampling location on Bohena Creek are provided in Table 10-1.

Table 10-1 Water quality measured on Bohena Creek (station number 419905) from 2002–2007

Parameter	Minimum	25th per centile	Median	75th per centile	Maximum
EC (µS/cm)	148	184	185	192	327
Turbidity (NTU)	17	57	76	82	130
Total Phosphorus (mg/L)	0.061	0.063	0.073	0.099	0.107
Total Nitrogen (mg/L)	0.52	0.57	0.62	0.78	0.91

10.1.2 Site drainage and local surface water sources

Figure 10-1 shows local drainage lines within the vicinity of the proposed activity. The existing pilot wells are located in the vicinity of Cowallah Creek and Mount Pleasant Creek, as well as unnamed tributaries of Mount Pleasant Creek and Bohena Creek as summarised in Table 10-2. All of these watercourses are ephemeral.

Table 10-2 Proximity to drainage lines and creeks

Water course	Stream order	Distance from Bibblewindi 14 lease area (km)	Distance from Bibblewindi 19H lease area (km)
Unnamed tributary of Cowallah Creek	2nd	0.58	0.125
Mount Pleasant Creek	3rd	0.5	0.225
Cowallah Creek	4th	1.5	0.45
Bohena Creek	5th	5.2	4

The closest watercourse to Bibblewindi 32 is an unnamed tributary of Mount Pleasant Creek located approximately 50 metres north east of the lease area (refer to Plate 10-1). The closest watercourse to Bibblewindi 31 is Mount Pleasant Creek, a tributary of Cowallah Creek, located approximately 500 metres to the west. Cowallah Creek flows into Bohena Creek approximately four kilometres downstream from the site.



Plate 10-1 An unnamed ephemeral creek 50 metres north west of Bibblewindi 32

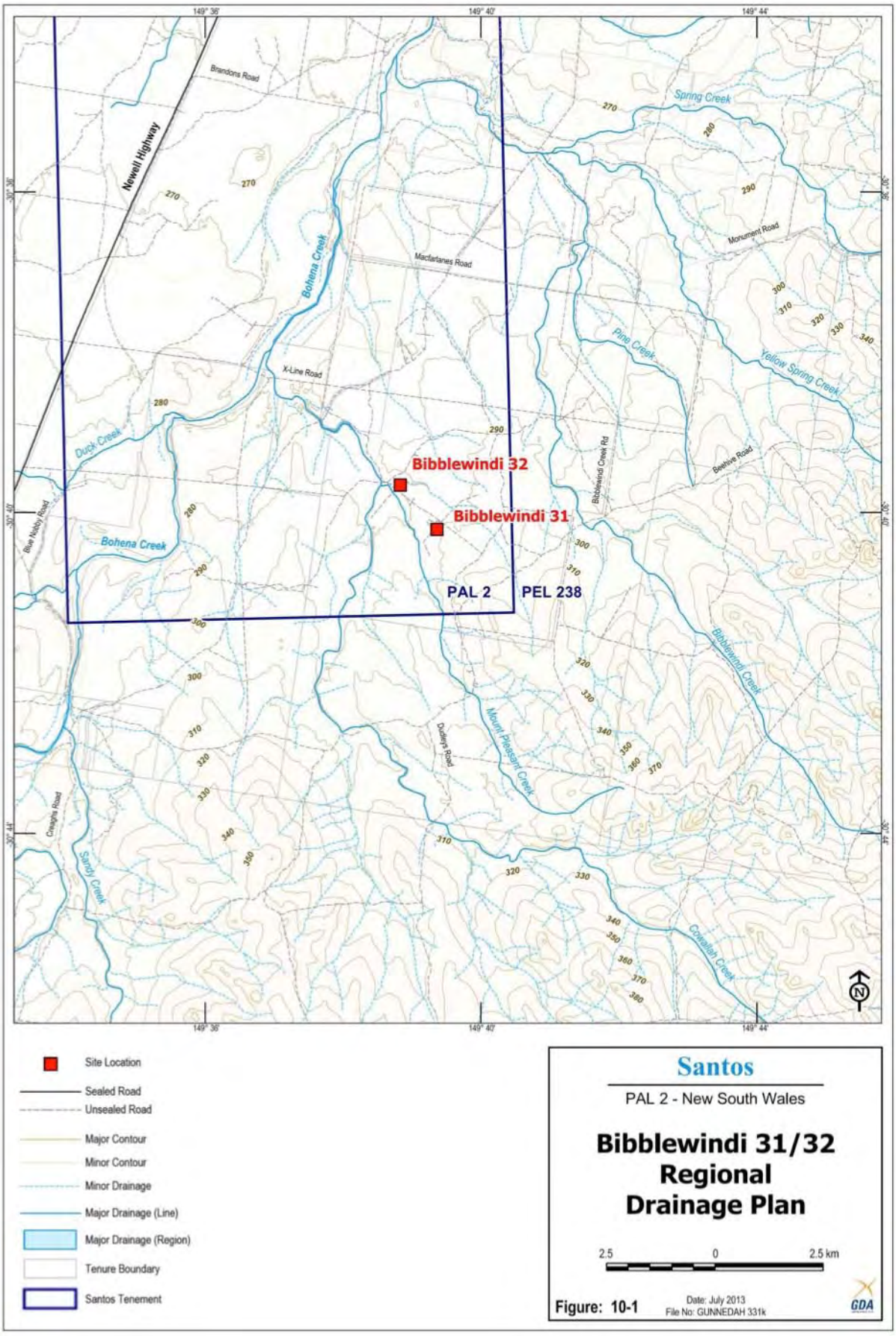


Figure 10-1 Regional drainage plan

According to a stream order classification assessment undertaken as part of the Ecological Assessment (Appendix 4), Bohena Creek is considered to be a fifth order watercourse (as defined under the *Water Management Act 2000*, using the Strahler System) which exhibits generally good landscape condition. Cowallah Creek is a relatively undisturbed fourth order watercourse, while Mount Pleasant Creek and the unnamed tributary of Cowallah Creek are third and second order watercourses, respectively. Stream Order was determined for the watercourses based on drainage lines captured from orthophotos at 1:50,000 and 1:25,000 scale.

The location of the proposed activity is within the Pilliga Outwash landscape unit as described in Lampert and Short (2004). An aggradational landscape of low lying, undulating alluvial sediments, the outwash is traversed by a number of south to northwest trending drainage lines, many being abandoned paleochannels. Most sediment within the watercourses of this landscape is derived from upstream Pilliga Sandstone plateaus or as a result of reworking of the broad outwash plain.

According to Lampert and Short (2004), Bohena Creek is representative of the 'low sinuosity, sand' river style. This river style does not retain surface water between flows. The channel will go through phases of incision, expansion and lateral migration and then recover through bench formation. Overbank flows, which occur every one to two years, activate flood channels, dissipating flow energy onto the floodplains.

Lambert and Short (2004) summarise the geomorphic units of the low sinuosity, sand river style as a single, laterally unconfined and relatively active channel set within a slightly undulating, wide and continuous floodplain. The channel bed is a relatively featureless, mobile sand sheet with scattered gravels, while the banks are composed of fine sands with some silt and organic matter.

The unnamed tributary of Cowallah Creek is characterised by a small, tightly sinuous ephemeral channel system that flows into Cowallah Creek. The tributary is two to three metres wide, with gentle banks characterised by sandy soils. Deposition was apparent and there was little evidence of active erosion during a site visit in November 2012. The banks are relatively stable and despite above average rainfall in the area, there was limited erosion observed in the channel.

The tributary does not appear to be connected with the local groundwater system. Water levels in the tributary are more likely to be affected by water backing-up the tributary, when water levels in Cowallah and Bohena Creeks are high, then by runoff flows within the tributary catchment. Only large catchment flows would activate erosion in this creek line and mobilise sediments.

There are a number of floodplains declared under the *Water Act* 1912 located nearby but not on the site. The closest is the Namoi River: Carroll to Boggabri floodplain, located approximately 37 kilometres to the east.

The site is not located within a drinking water catchment however surface water would filter to groundwater which is potentially used for drinking water in the surrounding areas.

10.1.3 Values of receiving waters

Water Quality and River Flow Objectives have been defined for uncontrolled streams within the Namoi catchment (DECCW, 2006). The relevant objectives and how the proposed activity will achieve these objectives are outlined in Table 10-3. The key indicators and trigger values provided as guideline levels within the Water Quality Objectives for the Namoi catchment are adopted from the Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 guidelines or *Australian Drinking Water Guidelines* (NHMRC and NRMMC 2011).

Table 10-3 Relevant water quality and river flow objectives for the site

Objective	Description of objective	How the proposed activity will meet objective
Water Quality Objectives		
Aquatic ecosystems	Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term	The site will be managed to ensure that no water used for drilling and operation is discharged to drainage lines and that existing salinity, turbidity and pH levels of surface waters are maintained.
Visual amenity	Aesthetic qualities of waters	The site will be managed to ensure that no water, oil/fuel or debris is discharged to drainage lines. The proposed activity is unlikely to introduce aquatic pests or weeds. Vehicle cleaning procedures will ensure that other weed species are not introduced to watercourses.
Livestock water supply	Protecting water quality to maximise the production of healthy livestock	Due to its ephemeral nature, surface water in the vicinity of the site is not used to supply livestock water. The Groundwater Impact Technical Report (Appendix 3) determined that the aquifers which may be used for livestock water supply would not be impacted upon by the proposed activity. The wells will be constructed in accordance with industry standards and will isolate aquifers.
Irrigation water supply	Protecting the quality of waters applied to crops and pasture	Due to its ephemeral nature, surface water in the vicinity of the site is not used to supply irrigation water. The Groundwater Impact Technical Report (Appendix 3) determined that the aquifers which may be used for irrigation water supply would not be impacted upon by the proposed activity. The wells will be constructed in accordance with industry standards and will isolate aquifers.
Homestead water supply	Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing	Due to its ephemeral nature, surface water in the vicinity of the site is not used to supply water for homesteads. The Groundwater Impact Technical Report (Appendix 3) determined that the aquifers which may be used for domestic water supply would not be impacted upon by the proposed activity. The wells will be constructed in accordance with industry standards and will isolate aquifers.
Drinking water – Disinfection only, or Drinking water – Clarification and Disinfection, or Drinking water – Groundwater	Refers to the quality of drinking water drawn from the raw surface and groundwater sources before any treatment	The proposed activity does not involve the drawing of potential drinking water from raw surface or groundwater sources.

Objective	Description of objective	How the proposed activity will meet objective
River Flow Objectives		
Protect pools in dry times	Protect natural water levels in pools of creeks and rivers and wetlands during periods of no flows	The proposed activity will not involve extraction from any surface waters.
Protect natural low flows	Protect natural low flows	The proposed activity will not involve extraction from any surface watercourses.
Protect important rises in water levels	Protect or restore a proportion of moderate flows ('freshes') and high flows	The proposed activity will not involve extraction from any surface watercourses.
Maintain wetland and floodplain inundation	Maintain or restore the natural inundation patterns and distribution of floodwaters supporting natural wetland and floodplain ecosystems	The proposed activity will not involve any additional disturbance beyond previously approved works.
Manage groundwater for ecosystems	Maintain groundwater within natural levels and variability, critical to surface flows and ecosystems	The Groundwater Impact Technical Report (Appendix 3) determined that the aquifers which may feed groundwater dependent ecosystems and baseflows would not be impacted upon by the proposed activity. The wells will be constructed in accordance with industry standards and will be isolated from intercepting aquifers.

10.1.4 Santos surface water monitoring program

Surface water monitoring is important in predicting and measuring the potential impact of CSG activities within the Namoi catchment. To enable this, the baseline water quality characteristics of the catchment must be understood, against which change can be measured and monitored.

URS has designed and implemented a baseline surface water sampling plan for Santos within the Narrabri Region, incorporating PAL 2. The sampling program commenced in February 2012, with approximately 30 locations considered to be 'regular' sites throughout the monitoring program period to date. Due to the ephemeral nature of tributaries within the Namoi catchment, including Bohena Creek, some locations are only able to be monitored periodically. The closest relevant regular monitoring points to the Bibblewindi Multi-Lateral Pilot are described in Table 10-4 and shown on Figure 9-2.

Table 10-4 Regular surface water monitoring locations

Monitoring ID	Site description	Easting	Northing	Number of samples (Feb 2012 – Jun 2013)	Distance from the site (km)
NAR_7505_SURF_W	Bohena Creek upstream of Bibblewindi site	745875	6600481	2	9
NAR_7506_SURF_W	Bohena Creek off Newell Hwy picnic area	755014	6625004	11	20
NAR_7507_SURF_W	Garlands Dam	746022	6599750	16	10
NAR_7510_SURF_W	Bohena Creek crossing, Newell Hwy	756470	6628742	11	24

Six locations were also monitored on an *ad hoc* basis, at the request of Santos. This monitoring is generally undertaken to quantify potential environmental impacts observed in the field, and/or to capture additional data during wet weather events. Most of the locations are situated on ephemeral tributaries which are known to flow only in prolonged wet periods, and are therefore not considered to be viable for long-term baseline monitoring on a regular basis. The closest additional monitoring points to the Bibblewindi Multi-Lateral Pilot are described in Table 10-5.

Table 10-5 Additional surface water monitoring locations

Monitoring ID	Site description	Easting	Northing	Number of samples (Feb 2012 – Jun 2013)	Distance from the site
NAR_7500_SURF_W	Tributary upstream of Bibblewindi WTF	754865	6604386	1	0.6
NAR_7501_SURF_W	Tributary downstream of Bibblewindi WTF	753042	6608471	1	4
NAR_7522_SURF_W	Bohena Creek downstream of confluence with Cowallah Creek	751182	6608728	1	5
NAR_7539_SURF_W	Bohena Creek upstream of confluence with Bibblewindi Creek	752086	6609903	1	5

Sampling is undertaken in accordance with the requirements of AS/NZS 566.6:1998, *Guidance on sampling of rivers and streams.*

In situ measurements for physico-chemical parameters are obtained at each monitoring location using a water quality meter. The following *in situ* parameters are recorded:

- pH
- Dissolved Oxygen (DO)
- Electrical conductivity
- Total Dissolved Solids (TDS)
- Water temperature.

Surface water samples are obtained using the grab sampling technique, a sample methodology set out in AS/NZS 5667.1:1998 and 5667.6.1998, and with consideration of ANZECC Guidelines and Water Quality Objectives in NSW. A suite of analysis is undertaken by a National Association of Testing Authorities (NATA) accredited laboratory.

Reporting is undertaken monthly following completion of the laboratory analysis and an annual characteristic report is currently being completed. As part of this report, the frequency and locality of the sampling is being reviewed based on the results to date. It is anticipated that surface water sampling will continue for the life of the CSG program to meet requirements of future regulation and environmental assessment.

Summaries of the data collected to date are provided in Table 10-6 and Table 10-7 for the regular and additional monitoring locations, respectively.

Table 10-6 Regular surface water monitoring locations – data summary

Parameter	NAR_7505_SURF_W			NAR_7506_SURF_W			NAR_7507_SURF_W			NAR_7510_SURF_W		
	Min	Med	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max
EC (µS/cm)	147	N/A	512	118	180.5	224	80	118	202	117	204.5	301
TDS (mg/L)	N/A	586	N/A	87	132.5	172	112	156	410	124	152	210
DO (mg/L)	7.58	N/A	9.38	4.29	7.5	9.47	4.76	6.94	12.79	5.7	7.16	8.4
Dissolved Organic Carbon (mg/L)	15	N/A	36	9	10.5	18	4	15	19	14	17	20
PAH (mg/L)	<0.0155	N/A	<0.0155	<0.0155	<0.0155	<0.0155	<0.0155	<0.0155	<0.0155	<0.0155	<0.0155	<0.0155
pH	7.12	N/A	8.03	6.71	7.36	7.69	7.38	7.54	8.25	6.9	7.39	7.57
Total N (µg/L)	700	N/A	1300	400	600	1100	400	1000	2000	800	1000	1100
Total P (mg/L)	0.11	N/A	0.17	0.02	0.04	0.2	0.01	0.06	0.18	0.01	0.09	0.15
Sum of BTEX (µg/L)	<1	N/A	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Turbidity (ntu)	109	N/A	165	2.5	18.6	101	18.1	44.1	83.6	13.1	38.5	167

Table 10-7 Additional surface water monitoring locations – data summary

Parameter	NAR_7500_SURF_W	NAR_7501_SURF_W	NAR_7522_SURF_W	NAR_7539_SURF_W
EC (µS/cm)	124	272	448	435
TDS (mg/L)	-	177	290	284
DO (mg/L)	5.5	2.64	7.17	7
Dissolved Organic Carbon (mg/L)	21	79	9	8
Polycyclic Aromatic Hydrocarbons (mg/L)	<0.0155	<0.0155	<0.0155	<0.0155
pH	7.02	7.55	7.9	7.97
Total N (µg/L)	1100	5200	500	500
Total P (mg/L)	0.11	0.76	0.1	0.08
Sum of BTEX (µg/L)	<1	<1	<1	<1
Turbidity (ntu)	203	709	37.2	36.5

10.2 Potential impacts

Potential surface water impacts are greatest during construction and drilling. During operation, potential surface water impacts would be limited to those associated with leakages from the gathering system.

10.2.1 Surface Water Flow Regimes

The proposed activity will not result in any change to the existing approved disturbed areas during construction or operation. Some minor redirection of flow already occurs as a result of sediment controls and drainage bunding on the existing Bibblewindi 14 and 19H lease areas.

Changes to the area, volume or flow of the surrounding surface watercourses, including Cowallah Creek and Mount Pleasant Creek, are unlikely to occur particularly during drilling as activities would not be undertaken during prolonged wet periods.

10.2.2 Surface Water Quality

Potential impacts of the proposed activity on surface water quality include the uncontrolled runoff during construction activities and/or release of contaminants, including leakage of produced water during operation.

Drilling fluids will be captured in tanks where it will be re-used or taken to the FTF. It is unlikely that drilling fluid will be spilled as all tanks will be fitted with high low sensors to detect levels.

Some fluids could be spilt as a result of tank failure, during the drilling process, or during transit to and from the site. This could result in pollution of drainage lines or watercourses with sediment and other contaminants, but this is considered unlikely given current over balance drilling techniques, the sensors fitted to tanks and the use of licensed waste transport operators. The proposed activity will only require small volumes of fluids to be transported to and from the site with the potential for spills and/or leaks being minor and likely to remain localised. In the event of an incident, appropriate measures to contain and remediate areas of impact will be initiated.

There is potential for chemicals, fuels or oils used or stored on site to leak or spill and enter drainage lines, including Cowallah Creek or Mount Pleasant Creek, and degrade local water quality. Pollutants or wastewater could also be discharged to these watercourses during general site activities such as vehicle washing or dust suppression. Litter from personnel on site may enter watercourses and degrade water quality. Surface runoff and gross pollutants will be captured through site bunding along the lease area.

During operation the groundwater lifted from the coal seam will need to be stored temporarily and disposed of in accordance with the proposed water management strategy, outlined in Section 10.3. An uncontrolled discharge to the environment could occur due a leak onsite at the lease areas or within the gathering system network. If this were to occur, there could be localised impacts to surface water. Due to the regular monitoring and inspection protocols that will be implemented, the extent of the impact will be minor, localised and short term.

Santos would operate the site in accordance with the requirements of an EPL.

10.2.3 Local surface water resources and users

There are no existing permanent surface water features, and hence resources, in the vicinity of the site. Water for the drilling and onsite requirements will be sourced from town water or a producing well, rather than a natural/local surface water body.

Due to the ephemeral nature of the creeks within the Bohena Creek catchment, there are currently no Water Access Licences issued within this water source. Therefore there are no registered surface water users that will affected by the proposed activity.

10.2.4 Flooding

The proposed activity will not result in any change to the existing disturbed areas. Therefore, there will be no additional impact to the extent, frequency or duration of flooding as a result of the proposed activity.

In addition, the site is not located within a designated floodplain and the proposed activity is unlikely to significantly affect the distribution or flow of floodwaters.

For these reasons a detailed flood impact assessment was not considered necessary as part of this EIS. There is still potential that sediment, contaminants or gross pollutants may be released into watercourses as a result of localised flooding and inundation of the site during construction although given the scale of the activity, this is likely to be minor.

10.3 Cumulative impacts

Due to the staggered implementation of the construction phase across the E&A Program and the distances between sites, cumulative impacts to surface water are considered to be negligible.

During operation, the water management strategy proposed as part of the E&A program includes a number of measures to reduce any impacts to surface water as a result of a spill or leak. This includes:

- Remote monitoring, sensors and pressure gauges at all well heads and along key infrastructure nodes
- Balance tanks to manage the volume and pressure of water
- The ability to remotely shut in wells at the well head if any leaks are detected
- A leak collection system at the Leewood Produced Water Facility
- Double lining of ponds at the Leewood Produced Water Facility
- Water level monitoring of ponds

No produced water from the Bibblewindi Multi Lateral Pilot will be transferred to the existing ponds at the Bibblewindi Water Transfer Facility.

Similar to construction, cumulative impacts to surface water during operation are considered to be negligible as any leakages that may occur will be localised and short term given the leakage detection and automated shutdown systems proposed.

10.4 Mitigation measures

The erosion and sediment control measures identified in Section 8.4 will minimise impacts to surface water and the site will be rehabilitated in accordance with Section 4.5 of the EIS. The following additional measures will be implemented:

10.4.1 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 the site by an appropriately licensed contractor.
- Fuel and lubricants will be stored on site only when necessary and maintained off site 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 millimetres will be maintained for any tanks or pits containing liquid waste.

10.4.2 Operation

- The surface infrastructure at the lease areas will be regularly inspected.
- The surface water monitoring program will be implemented

10.4.3 Licensing

As no water is proposed to be extracted from any surface water within the Bohena Creek water source during construction or operation, no water access licence under the *Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources (NOW, 2012c)* is required.

11.0 Biodiversity

An *Ecological Assessment* has been completed by RPS for the proposed activity (Appendix 4). The assessment included:

- database searches, including the EPBC Act Protected Matters Search Tool and Atlas of NSW Wildlife, for threatened species, populations and ecological communities within 10 kilometres of the site
- review of relevant photos and maps, including aerial photography and National Vegetation Information Systems mapping within the vicinity of the site
- a field survey by a qualified ecologist on 27 November 2012

For the ecological assessment the site refers to the two lease areas (Bibblewindi 14 and Bibblewindi 19H), the access tracks to the lease areas and a 20 metre buffer around each.

11.1 Existing environment

11.1.1 Vegetation

Only one vegetation community occurs within the immediate vicinity of the site, namely *Ironbark Shrubby Woodlands of the Pilliga area, Brigalow Belt South*.

The canopy of this community is generally 15 to 19 metres high, with a patchy to moderate 15 to 50 per cent projected foliage cover (PFC). It is dominated by Narrow-leaved Ironbark (*Eucalyptus crebra*).

A shrub layer of variable height (0.1 to 1.7 metres) occurs, with coverage of 80 to 95 per cent. It is dominated by *Acacia caroleae* (Wattle) and, to a lesser extent, *Acacia spectabilis* (Mudgee Wattle), *Callistemon linearis* (Narrow-leaved Bottlebrush) and *Cassinia arcuata* (Sifton Bush).

Ground cover also exhibits coverage of 80 to 95 per cent, with variable heights between 0.1 to 0.8 metres. It is dominated by *Dianella revoluta* (Blue Flax-lily), *Lomandra filiformis* (Wattle Mat-rush), *Aristida ramosa* (Purple Wire Grass), *Eragrostis brownii*, *Aristida vagans* (Threeawn Speargrass) and *Cheilanthes sieberi* (Mulga Fern).

This community adjoins the existing cleared lease areas and access tracks and is in poor to moderate condition. The majority of the native vegetation is of a young age, which limits the resources that the community can produce and hence the fauna species it can support.

The existing lease areas are largely devoid of flora species. During the site inspection, the lease areas exhibited some evidence of natural regeneration. The regeneration was still in its infancy and was dominated by native grasses (*Panicum effusum* and *Eragrostis brownii*). Some juvenile shrubs (*Dodonea viscosa*) were starting to encroach into the lease areas.

11.1.2 Listed ecological communities

11.1.2.1 Threatened Ecological Communities under the EPBC Act

Five Threatened Ecological Communities (TEC) listed under the EPBC Act were identified as potentially occurring within 10 kilometres of the site by the EPBC Protected Matters Search Tool. These are:

- Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions.
- Grey Box (*Eucalyptus microcarpa*) grassy woodlands and derived native grasslands of south-eastern Australia.
- Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland.
- Weeping Myall Woodlands.
- White Box – Yellow Box – Blakely's Red Gum grassy woodland and derived native grassland.

No TECs listed under the EPBC Act occur within the site or the immediate surrounding area.

11.1.2.2 Endangered Ecological Communities under the TSC Act

Seven Endangered Ecological Communities (EEC) listed under the TSC Act were identified as potentially occurring within 10 kilometres of the site, based on known or predicted communities occurring within the Namoi catchment (NSW Atlas of Wildlife Search). These are:

- Carex Sedgeland of the New England Tableland, Nandewar, Brigalow Belt South and NSW North Coast Bioregions.
- Coolibah-Black Box Woodland of the Darling Riverine Plains and the Brigalow Belt South bioregions.
- Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions.
- Inland Grey Box Woodland in the Riverina; NSW South Western Slopes; Cobar Peneplain; Nandewar and Brigalow Belt South Bioregions.
- Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions.
- Native Vegetation on Cracking Clay Soils of the Liverpool Plains.
- White Box – Yellow Box – Blakely's Red Gum Woodland.

No EECs listed under the TSC Act occur at the site or within the 10 kilometre surrounding area.

11.1.3 Flora

11.1.3.1 Threatened species

Threatened species database searches indicate10 threatened flora species listed under the EPBC Act and/or TSC Act were identified within the surrounding 10 kilometres of the site. These species, their threat status and their likelihood to occur at the site are identified in Table 11-1. Likelihood to occur assessments were undertaken based on a number of factors including habitat preferences, recent field investigations, background data and local technical knowledge.

Table 11-1 Threatened flora species within 10 kilometres of the site

Species	Listing[1]		Identified during field survey	Likelihood to occur within the siite[2]
	TSC Act	EPBC Act		
Bertya opponens	V	V	No	Possible
Diuris tricolor	V	-	No	Possible
Monotaxis macrophylla (Large-leafed Monotaxis)	E	-	No	Possible
Philotheca ericifolia	-	V	No	Possible
Polygala linariifolia (Native Milkwort)	E	-	No	Possible
Pomaderris queenslandica (Scant Pomaderris)	E	-	No	Unlikely
Pterostylis cobarensis (Cobar Greenhood Orchid)	V	V	No	Possible
Pultenaea setulosa	-	V	No	Unlikely
Rulingia procumbens	V	V	No	Possible
Tylophora linearis	V	E	No	Possible

[1]E = endangered, V = vulnerable
[2]Likely to occur at and within 10 kilometres of the site

11.1.3.2 Species recorded at the site

A total of 25 flora species were identified during the field survey, none of which are EPBC and/or TSC Act-listed species. No regionally significant flora was identified. The field survey included the site and the 10 kilometres surrounding the site.

A list of the flora species recorded is provided in the Ecological Assessment.

11.1.3.3 Weeds

No introduced species of flora were identified during the field survey.

11.1.4 Fauna

11.1.4.1 Threatened species

Sixteen threatened fauna species listed under the EPBC Act and 32 threatened species listed under the TSC Act were identified as potentially occurring at the site or within the immediate ten kilometres surrounding the site. The likelihood of occurrence of these species was assessed, based on broad habitat type within the surveyed area, as well as species distribution.

Table 11-2 outlines the threatened fauna species that have potential to occur, based on the likelihood assessment. For many species, the immediate surrounding area provides sub-optimal habitat that may provide foraging resources only. No unique habitat occurs on the site itself.

Table 11-2 Threatened fauna species with potential to occur at the site and the immediate 10 kilometres surrounding the site

Species	Listing[1]		Identified during field survey	Likelihood to occur at site[2]
	TSC Act	EPBC Act		
Anthochaera Phrygia (Regent Honeyeater)	CE	E	No	Possible
Calyptorhynchis lathami (Glossy Black Cockatoo)	V	-	No	Likely
Chthonicola sagittata (Speckled Warbler)	V	-	No	Likely
Climacteris picumnus victoriae (Brown Treecreeper)	V	-	No	Likely
Daphoenositta chrysoptera (Varied Sittella)	V	-	No	Possible
Glossopsitta pusilla (Little Lorikeet)	V	-	No	Likely
Lathamus discolour (Swift Parrot)	E	E	No	Possible
Leipoa Ocellata (Malleefowl)	-	V	No	Possible
Lophoictinia isura (Square-tailed Kite)	V	-	No	Possible
Melanodryas cucullata cucullata (Hooded Robin)	V	-	No	Possible
Neophema pulchella (Turquoise Parrot)	V	-	No	Likely
Ninox connivens (Barking Owl)	V	-	No	Likely
Polytelis swainsonii (Superb Parrot)	V	V	No	Possible
Pomatostomus temporalis temporalis (Grey-crowned Babbler)	V	-	No	Likely
Stagonopleura guttata (Diamond Firetail)	V	-	No	Possible
Tyto novaehollandiae (Masked Owl)	V	-	No	Possible
Hieraaetus morphnoides (Little Eagle)	V	-	No	Possible
Cercartetus nanus (Eastern Pygmy-possum)	V	-	No	Possible
Chalinolobus dwyeri (Large-eared Pied Bat)	V	V	No	Possible
Chalinolobus picatus (Little Pied Bat)	V	-	No	Possible
Nyctophilus corbeni (South-eastern Long-eared Bat)	V	V	No	Possible
Petaurus norfolcensis (Squirrel Glider)	V	-	No	Possible
Macropus dorsalis (Black-striped Wallaby)	E	-	No	Possible
Phascolarctos cinereus (Koala)	V	V	No	Possible
Pseudomys pilligaensis (Pilliga Mouse)	V	V	No	Possible
Saccolaimus flaviventris (Yellow-bellied Sheathtail-bat)	V	-	No	Possible
Vespadelus troughtoni (Eastern Cave Bat)	V	V	No	Possible

[1]CE = critically endangered, E = endangered, V = vulnerable
[2]Likely to occur at and within 10 kilometres of the site

11.1.4.2 Species recorded during surveys

A total of nine common native avifauna species were identified during the field survey, none of which are EPBC and/or TSC Act-listed species.

A list of the avifauna species recorded is provided in the Ecological Assessment (Appendix 4).

11.1.4.3 Migratory species

The EPBC Protected Matters Search Tool indicated that 11 migratory species listed under the EPBC Act were identified as potentially occurring within a ten kilometre radius of the site. An assessment of likelihood of occurrence was completed for each species, based on habitat preference and known species distribution. The assessment confirmed that five species have the possibility of occurring:

- *Anthochaera phrygia* (Regent Honeyeater)
- *Leipoa ocellata* (Malleefowl)
- *Hirundapus caudacutus* (White-throated Needletail)
- *Apus pacificus* (Fork-tailed Swift)
- *Merops ornatus* (Rainbow Bee-eater)

No migratory species were observed during the field survey.

11.1.4.4 Introduced species

No introduced species were recorded during the field survey. A number of pest species have been recorded opportunistically within the broader Pilliga forest including the Red Fox (*Vulpes vulpe*s), Goat (*Capra hircus*), Rabbit (*Oryctolagus cuniculus*), Brown Hare (*Lepus europaeus*), Cat (*Felis catus*) and Pig (*Sus scrofa*).

11.1.4.5 Habitat values

As the existing lease areas and access tracks are cleared they offer potential basking habitat for reptiles and, consequently, foraging habitat for some birds. However, they are generally of limited value to fauna species, due to the lack of habitat resources.

The surrounding vegetation contains open forest dominated by *Eucalyptus crebra* (Narrow-leaved Ironbark). The vegetation is primarily regrowth with many canopy trees being of a relatively young age. The canopy is fragmented, possibly as a result of selective logging practices. As a result of the maturity of the canopy, no hollow-bearing trees were observed during the field survey. Hollows are an important habitat attribute for a number of fauna species. The understorey also exhibits signs of regeneration after fire disturbance and some areas are almost completely dominated by *Acacia spectabilis*. This vegetation type may still provide habitats such as high, mid and low canopy, shrub and groundlayer vegetation. Other habitat attributes such as leaf litter, fallen timber, small exposed rocks and exposed soil/sand are also present.

11.1.5 Aquatic ecology

11.1.5.1 Riparian and aquatic vegetation

According to Namoi CMA (2010), four riparian vegetation communities occur in nearby creeks surrounding the site. These include:

- Blakely's Red Gum riparian woodland – located predominantly along Cowallah and Bohena Creek. A small patch also exists along the unnamed tributary of Cowallah Creek, upstream of Bibblewindi 32.
- Rough-barked Apple – Blakely's Red Gum riparian grassy woodlands – associated with the ephemeral drainage lines along Cowallah Creek and extends out to the border of Mount Pleasant Creek.
- Ironbark shrubby woodlands – associated with the unnamed tributary of Cowallah Creek nearby to Bibblewindi 31. This community is not considered a riparian vegetation community.
- Ironbark – Brown Bloodwood – Black Cypress Pine heathy woodlands, Brigalow Belt – associated with the ephemeral drainage lines. This community is not considered a riparian vegetation community.

Riparian vegetation, dominated by sparse grasses and graminoids such as *Juncus sp*., occurs as a narrow strip (approximately two metres wide) along the unnamed tributary of Cowallah Creek. Trees are present, but these are generally set back from the channel and are unlikely to create a source of woody debris in the short term. The tree canopy overhangs areas along the unnamed tributary line and thus would provide a source of detritus and food for some aquatic fauna.

No aquatic vegetation was identified at the site.

The Office of Environment and Heritage (OEH) (2006) wetland mapping identified no wetlands within a ten kilometre radius of the site.

11.1.5.2 Aquatic habitat values

Aquatic habitat is in poor to moderate condition. The cover of instream habitat (e.g. small and large woody debris, tree roots and aquatic vegetation) is limited, while was no evidence of log-jams along the unnamed tributary of Cowallah Creek (approximately 125 metres northeast of the Bibblewindi 19H lease area).

Due to a lack of suitable habitat (absence of slow flowing deep waters), the unnamed tributary is unlikely to support listed rare and threatened species such as the Murray Cod (*Maccullochella peelii peelii*). While Mount Pleasant and Cowallah Creek were not surveyed, they are also considered unlikely to contain suitable habitat for Murray Cod due to their ephemeral nature. No suitable habitat for turtles was identified.

Under prolonged wet conditions these creeks are likely to be characterised by shallow pools and runs with poor instream-diversity. The ephemeral nature of these creeks is more likely to support common fish species during migration and breeding, and potentially provide feeding areas for some aquatic fauna.

While these ephemeral waterways are small, they are an important component of ecological function, potentially providing breeding and habitat resources for species such as frogs and reptiles. They also provide for fauna movement throughout the broader landscape.

11.1.5.3 Waterway Classification

The stream order of the water courses in the vicinity of the site is provided in Section 10.1. The Strahler System provides a measure of system complexity and therefore the potential for fish habitat to be present. Third order streams and above are considered likely to display valuable fish habitat, and hence could support viable fish populations.

Although some exceptions apply, stream order can also correspond with the waterway classification, with Class 4 waterways generally being first and second order streams (and some third order streams), while Class 3 will generally be third order streams. Class 1 and 2 will be third order or above streams.

The stream order and waterway classification of the water courses in the vicinity of the site are provided in Table 11-3.

Table 11-3 Stream order and waterway classification of nearby water courses

Water course	Stream order	Waterway classification	Key fish habitat	Distance from Bibblewindi 14 lease area (km)	Distance from Bibblewindi 19H lease area (km)
Unnamed tributary of Cowallah Creek	2nd	Class 4	-	0.58	0.125
Mount Pleasant Creek	3rd	Class 3	Likely	0.5	0.225
Cowallah Creek	4th	Class 3	Likely	1.5	0.45
Bohena Creek	5th	Class 2	Likely	5.2	4
Source NSW Department of Primary Industries (2007) Key Fish Habitat mapping					

Applying the general correlation between stream order and waterway classification, the major creek systems identified include:

- Class 4 (unlikely fish habitat) – unnamed ephemeral drainage line.
- Class 3 (minimal fish habitat) – Mount Pleasant Creek.
- Class 3 (minimal fish habitat) – Cowallah Creek.
- Class 2 (moderate fish habitat) – Bohena Creek.

According to the Waterway Classification system outlined in Fairfull and Witheridge (2003), Mount Pleasant Creek, Cowallah Creek and the tributary of Cowallah Creek provide either unlikely or minimal fish habitat. Bohena Creek is considered to contain moderate fish habitat.

11.2 Assessment approach

The database searches undertaken as part of the Ecological Assessment identified threatened vegetation communities and flora and fauna species, as well as migratory fauna species, that have been recorded or that are considered likely to occur within 10 kilometres of the site. The probability of individual threatened species and vegetation community occurring within the site and surrounding 20 metre buffer was determined as being either unlikely, possible, likely or known, based on a range of criteria.

Once the likelihood to occur was determined, the likely level of impacts as a result of the proposed activity was considered for each species or community. They were assessed separately, based on their likelihood of occurrence, while recognising other parameters such as home range, habitat use, connectivity, as well as the scope of the proposed activity. Based on the outcome of the assessment, a decision was made as to whether further assessment was required.

11.3 Potential impacts

11.3.1 Vegetation clearing

The proposed activity has been designed to avoid any works being undertaken within the adjacent Ironbark Shrubby Woodland. No vegetation clearing outside of the lease area will occur as a result of the proposed activity. As such the proposed activity will not have an impact on the Bibblewindi State Forest, including impacts on conservation and recreational values. Some minor clearing of grasses may occur within the lease area in the immediate area surrounding the well. This is to remove any potential ignition sources during drilling.

11.3.2 Terrestrial impacts

Minimal short-term impacts are associated with the proposed activity, during both construction and operational activities. The primary potential impacts are indirect, as the proposed activity will be carried out within existing disturbance areas. Considerations of specific potential impacts are outlined in Table 11-4.

Table 11-4 Potential terrestrial impacts

Area of concern/impact	Overview
Impacts on threatened species and communities (under the TSC Act)	Section 5A of the EP&A Act lists seven factors (the 7-part test) that must be taken into account in the determination of the significance of potential impacts of proposed activities on 'threatened species, populations or ecological communities (or their habitats)' listed under the TSC Act. A generalised application of the 7-part test concluded that the proposed activity is not likely to have a significant effect on the seven threatened ecological communities, seven threatened flora and 26 threatened fauna species listed under the TSC Act that are considered to have the potential to occur within the site and surrounding 20m buffer. There is potential for indirect impacts during both the construction and operational phases of the proposed activity, in particular potential fauna strike associated with increased vehicle movements. However, provided the mitigation measures in Section 11.5 are implemented, there will be no direct or indirect impacts upon threatened species or their habitats as a result of the proposed activity. Therefore a Species Impact Statement (SIS) is not considered necessary for any of the threatened species, populations or ecological communities.
Impacts on threatened species and communities (under the EPBC Act)	No threatened Ecological Communities are present within the site and immediate surrounding areas. Five threatened flora and nine threatened fauna species listed under the EPBC Act are considered to have the potential to occur within the site and immediate surrounding area however these are considered to not be directly or indirectly impacted on as a result of the proposed activity including proposed mitigation measures. Five migratory species listed under the EPBC Act are considered to have the potential to occur within the site and immediate surrounding area however no species is likely to be directly or indirectly impacted upon as a result of the proposed activity including proposed mitigation measures.
Impacts on Bibblewindi State Forest	The proposed activity has been designed to avoid additional vegetation clearance. Provided the mitigation measures in Section 11.5 are adhered to, there will be no direct or indirect impacts upon the Bibblewindi State Forest. Furthermore, rehabilitation works will incorporate species native to the Forest.
Loss of fauna habitat	The proposed activity has been designed to avoid any works being undertaken within the remnant of Ironbark Shrubby Woodland, which offers potential habitat to a diversity of fauna species. No fauna habitat features located within the Ironbark Shrubby Woodland, such as hollow-bearing trees, will require removal as part of the proposed activity. No 'potential' koala habitat, as defined by SEPP 44, will be removed as part of the proposed activity – nor does any occur within close proximity to the site and immediate surrounding area.
Habitat fragmentation	As the proposed activity will be carried out within an area previously cleared and will not involve any further clearing, the existing vegetation surrounding the site will not be fragmented by the proposed activity.

Area of concern/impact	Overview
Introduction and spread of weeds	The proposed activity has the potential to create favourable conditions for the introduction and spread of weed species within the site through the movement of traffic to the site. However, provided the mitigation measures in Section 11.5 are adhered to, it is unlikely that this will occur as a result of the proposed activity.
Disruption of breeding cycle, roosting and sheltering behaviour	Given the poor habitat values within the site, it is considered unlikely that the proposed activity will impact upon the breeding cycle, roosting, sheltering and foraging behaviour of fauna species.
Noise, dust and light	The proposed activity may result in short-term increased noise and dust pollution as well as an increase in light, which has the potential to temporarily disrupt foraging and roosting behaviour of some native fauna species. However, the lack of intact overstorey vegetation lessens the potential impact, as few sensitive species are likely to occur within the site and 10 km surrounds.

11.3.3 Aquatic impacts

The proposed activity does not require any new creek diversions, crossings, access tracks or upgrades; therefore there will be no direct impact on identified watercourses. In addition, no riparian vegetation (and hence habitat) along identified watercourses will be cleared.

There are no proposed discharges to any watercourses during operation and therefore impact to water quality, flows or increases in bank and channel erosion are not anticipated for any watercourses in the immediate vicinity or downstream. As previously stated in Section 10.2, the potential exists for the leakage of produced water to occur during operation and enter waterways.

11.3.4 Key threatening process

The EPBC Act and TSC Act provide for the identification and listing of key threatening processes (KTPs). KTPs are defined as a threatening process 'if it threatens or may threaten the survival, abundance, or evolutionary development of a native species or ecological community' (SEWPaC, 2012).

KTPs under the EPBC Act and TSC Act that are relevant to the proposed activities are discussed in Table 11-5.

Table 11-5 Summary of key threatening processes

Key threatening process	Relevance to proposed activities
EPBC Act/TSC Act	
Competition and land degradation by feral European Rabbits	Rabbits were not observed within the site but are considered likely to occur. However, it is not anticipated that the proposed activity will increase opportunities for increase to the Rabbit population.
Competition and land degradation by unmanaged goats	Goats were not observed during the survey, but are considered likely to occur. However, it is not anticipated that the proposed activities will increase opportunities for increase to the goat population. Mitigation measures may be required at the completion of the project to ensure rehabilitation activities are not disturbed by unmanaged goats.
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi)*	There exists the potential for the importation of this pathogen on unclean vehicles and plant machinery.
Land clearance/removal of native vegetation	No clearing or removal of native vegetation is required.
Predation by European Red Fox	European Red Fox were not observed, but are considered likely to occur. It is considered unlikely that the proposed activity will result in increased predation by European Red Fox, as no additional clearing is proposed,

Key threatening process	Relevance to proposed activities
Predation by feral cats	Feral cats were not observed, but are considered likely to occur. If waste is not managed on site, there is the potential for an increase in the feral cat population.
Predation, habitat degradation, competition and disease transmission by feral pigs	Feral pigs were not observed, but are considered likely to occur. It is considered unlikely that the proposed activity will result in increased predation, habitat degradation, competition or disease transmission.
TSC Act	
High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition	The proposed activity will not result in high frequency fires. Fire prevention strategies are outlined in Chapter 17.
Removal of dead wood and dead trees	No removal of dead wood or dead trees is required.
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	No works are proposed to occur within any streams or wetlands. The proposed works will not alter the natural regimes of any rivers, streams and their floodplains and wetlands.
Predation and hybridisation by feral dogs, (*Canis lupus familiaris*)	Feral dogs were not observed, but are considered likely to occur at the site.
Loss of hollow-bearing trees	No loss of hollow-bearing trees will occur as a result of the proposed activity.
Invasion of native plant communities by exotic perennial grasses	There exists the potential for the invasion of native woodland and grassland communities by exotic perennial grass species, transferred via vehicles and site machinery.

11.3.5 Groundwater dependent ecosystems

Stygofauna communities (fauna that live in groundwater) may exist within aquifers and thus can also be classed as a GDE (Serov *et al.,* 2012). Slight changes in groundwater attributes (quality or quantity) may result in changes to the population assemblage.

Stygofauna are known to occur within the Namoi River alluvial aquifer. This aquifer does not underlie the site, 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 GAB sandstone aquifers present on-site, such as the Pilliga Sandstone. 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.

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.

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.

Neither of the proposed wells 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 drilling and extraction activities are unlikely to pose a significant threat to any known or likely stygofauna habitat.

In addition, as it is considered feasible that stygofauna populations may exist in the region, additional sampling will be undertaken to investigate presence or absence of stygofauna populations within PEL 238 and PAL 2.

11.3.6 Indirect impacts

The proposed activity has the potential to indirectly impact on flora and fauna including aquatic habitat. Potential indirect impacts include fauna strikes associated with increased vehicle movements, an increase in noise, dust and light impacts at the site and impacts to water resulting from spills or leaks and sediment laden runoff.

The potential for indirect impacts to flora and fauna as a result of the proposed activity are considered low given the exiting environment and the potential for flora and fauna to occur at the site. Provided mitigation measures for the proposed activity are adhered to , there will be no indirect impacts upon any TSC Act listed threatened species or their habitats as a result of the proposed activity during both construction and operation.

11.4 Cumulative impacts

As no vegetation clearing or disturbance is to be undertaken as part of the proposed activity, ecologically-related cumulative impacts are considered not to occur. A study on the cumulative effects of the E&A Program on biodiversity within PEL 238 and PAL 2 has been undertaken and is detailed in EcoLogical (2013).

The cumulative impact as a result of the proposed program and existing exploration and appraisal activities to vegetation within the PEL 238 and PAL 2 equates to the loss of:

- 237.36 ha which represents a loss of approximately 0.5% of consolidated vegetation within the E&A Program area and 0.045% of all vegetation within PEL 238 and PAL 2.
- Between 26.3 and 237.1 ha of potential foraging habitat (depending on species) for threatened fauna species which represents a loss of between 0.01% and 0.17% of the available breeding habitat available within PEL 238/PAL 2
- Between 12.3 and 159.9 ha of potential breeding habitat (depending on species) for threatened fauna species which represents a loss of between 0.05% and 0.11% of the available breeding habitat available within the PEL 238/PAL 2

Fragmentation of habitat as a result of the proposed program and existing exploration and appraisal activities is considered unlikely to adversely affect any EPBC or TSC Act listed species, 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 EPBC or TSC Act listed species.

Based on the above, the cumulative impact of the proposed E&A Program combined with existing exploration and appraisal activities is considered unlikely to have a significant impact as there is unlikely to be a long term decrease in population sizes, significant fragmentation or adverse disturbance to breeding cycles or critical habitat.

11.5 Mitigation measures

The following measures will be implemented during both construction and operation:

- 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.
- Weed monitoring will occur throughout all phases of the proposed activity. Weed removal will be carried out as necessary.

12.0 Air Quality

Wilkinson Murray has completed an Air Quality Impact Assessment for the proposed activity. It is provided in Appendix 5 and summarised below.

12.1 Existing environment

Regional air quality is likely influenced by mining activities, grazing, land clearing and soil preparation, sowing and harvesting of crops, vehicle and heavy machinery movements, bushfires, burn-offs and other residential activities.

12.1.1 Sensitive receptors

The nearest sensitive receptor is over seven kilometres from the site as shown in Table 3-2.

12.1.2 Air quality assessment criteria

Air quality criteria are targets set to protect the general health and amenity of the community in relation to air quality. The criteria that are relevant to the proposed activity are taken from the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (NSW DEC, 2005).

The air quality targets for the relevant criteria pollutants relate to the total pollutant burden in the air and not just the pollutants from the proposed activity. Therefore consideration of background pollutant levels is required when using these targets to assess potential impacts. Table 12-1 shows the impact criteria relevant to the proposed activity.

Table 12-1 NSW EPA air quality impact assessment criteria

Pollutant	Averaging Period	Impact	Criterion
Total suspended particulates (TSP)	Annual	Total	90 µm/m^3
Particulate matter > 10 µm(PM_{10})	Annual	Total	30 µm/m^3
	24-hour	Incremental	50 µm/m^3
Deposited dust (DD)	Annual	Total	2 g/m^2/month
	Annual	Incremental	4 g/m^2/month
Nitrogen dioxide (NO_2)	1-hour	Total	246 µm/m^3
	Annual	Total	62 µm/m^3
Carbon monoxide (CO)	15-minute	Total	100 mg/m^3
	1-hour	Total	30 mg/m^3
	8-hour	Total	10 mg/m^3

12.1.3 Particulate matter

Suitable particulate matter monitoring data was not available to quantify the existing ambient levels at the site. Therefore the nearest location with available data (Tamworth NSW EPA monitoring site, 132 kilometres from the proposed activity) was utilised to provide an approximation of air quality.

Due to the presence of human activity, including residential areas, traffic, major highways and industry, the data from the Tamworth monitoring location is conservative as it is likely to overestimate the likely levels of air pollutants at the site.

A summary of the annual average PM_{10} monitoring data collected during 2010-2012 at the Tamworth monitoring site is presented in Table 12-2. The monitoring data shows that the annual average PM_{10} concentrations at this monitoring site are below the 30µg/m³ criterion.

Table 12-2 Summary of Annual PM_{10} Concentrations from Tamworth NSW EPA Monitoring Site (µg/m³)

Year	PM_{10} Concentration
2010	12.0
2011	13.1
2012	15.9

There are no readily available site specific total suspended particulates (TSP) and deposited dust (DD) monitoring data for the proposed activity. The Tamworth NSW EPA monitoring site does not measure these components; however estimates of the background levels for the site are required to assess the impacts as per the NSW EPA criteria.

Estimates of the annual average background TSP concentrations were determined from a relationship with measured PM_{10} concentrations. Based on an annual average PM_{10} concentration of 15.9 µg/m³, an annual average TSP concentration of 39.7µg/m³ was estimated.

Estimates of the annual average dust deposition levels were determined from a relationship with the estimated TSP concentration. This relationship indicates a background annual average dust deposition of 1.8 g/m²/month for the area surrounding the proposed activity.

12.1.4 Nitrogen dioxide

Similar to particulate matter, suitable nitrogen dioxide (NO_2) monitoring data was not available to quantify the existing ambient levels at the site. Background ambient NO_2 data obtained from the Muswellbrook NSW EPA monitoring site (215 kilometres from the proposed activity) is the closest suitable site. Due to the presence of human activity, including residential areas, traffic, major highways and industry, data from the Muswellbrook monitoring location is likely to be conservative as it is likely to overestimate the likely levels of air pollutants at the site.

The maximum daily 1-hour average NO_2 concentrations from the Muswellbrook NSW EPA monitoring site from November 2011 to July 2013, indicates that there were no exceedances of the NSW EPA 1-hour average goal of 246µg/m³ during this period. The data indicates that levels of NO_2 are relatively low compared to the criterion level and show a seasonal fluctuation.

12.1.5 Carbon monoxide

The NSW EPA monitoring sites at Tamworth and Muswellbrook do not record ambient concentrations of carbon monoxide (CO). Combustion activities are the cause of CO emissions and spatially there is very little such activity in the vicinity of the site apart from power generation, motor vehicles and wood heaters. Therefore, ambient concentrations of CO are expected to be low.

NSW EPA air quality targets for CO are set at higher concentration levels than the NO_2 targets. Based on the NO_2 monitoring data which are low compared to the targets, and consideration of the typical mix of ambient pollutant levels, it can be assumed that ambient levels of CO would similarly also be well below the air quality targets.

12.2 Assessment approach

12.2.1 Emission estimation

12.2.1.1 Construction

Dust emission estimates from construction works have been made using emission factors developed both locally and by the US EPA. Appendix 5.

Table 12-3 presents the estimated TSP emissions for the construction works associated with the proposed activity. Further details regarding the emissions estimation techniques applied to estimate the TSP emissions are provided in Appendix 5.

Table 12-3 Estimated emissions for construction works

Activity	TSP emissions (kg/year)
Travel to site	12,774
Travel between Bibblewindi 31 and Bibblewindi 32	1,401
Excavating material	16
Drilling	5
Wind erosion of exposed areas	6,912
Total	**21,108**

12.2.1.2 Operation of the flare

During operation, some small amounts of gas may be flared at the Bibblewindi Water Transfer Facility if gas cannot be consumed at Wilga Park Power Station. Modelling of air emissions associated with the occasional use of the flare has been undertaken based on the flare exhaust flow rate and estimated stack concentrations (Table 12-4).

Table 12-4 Stack parameters and estimated emissions for flare

Parameter	Value	Units
Stack height	6.1	m
Stack diameter	0.206	m
Exit velocity	5.49	m/s
Exit temperature	750	°C
Peak gas flow rate	20.56	Am^3/s
Peak gas flow rate	5.49	Nm^3/s
NO_2 emission rate	0.027	g/s
CO emission rate	0.023	g/s

12.2.1.3 NO_X to NO_2 conversions

The NO_X to NO_2 conversion was estimated using a method outlined in the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (NSW DEC, 2005) and developed by Janssen *et al.* (1988).

It was determined that the predicted maximum NO_2 impacts were recorded approximately 0.43 kilometres from the source during summer. Based on this distance, the ratio of NO_2 to NO_x at nearby receptors due to the flare operations was calculated to be three per cent.

12.2.2 Modelling methodology

The AUSPLUME dispersion model in conjunction with a TAPM generated meteorological data file provided predictions of the ground level concentrations of pollutants based on the emission estimation provided in Section 12.2.1.

Sources for modelled during the construction scenario were modelled as volume sources, while source during the operation scenario were modelled as point sources.

Modelling has been undertaken for a full year to account for seasonality variables.

12.3 Potential impacts

12.3.1 Construction

Dust created during construction will have the greatest impact on air quality. Other emissions would occur from the exhaust of plant equipment required for drilling. These emissions are generally considered to be too low to generate any significant pollutant concentrations in the vicinity of the site and have not been assessed further.

Table 12-5 presents the predicted incremental and total impacts at each of the sensitive receptor locations (shown in Figure 3-7) for PM_{10} as an indicator of dust levels.

Table 12-5 Predicted incremental and total concentrations at sensitive receptors – construction for PM_{10}

Resident ID	Distance from site (km)	24-hr Average ($\mu g/m^3$)	Annual average proposed activity ($\mu g/m^3$)	Total impact ($\mu g/m^3$)[1]
NSW EPA Criteria		**50**	**30**	**30**
RR1	8.3	0.15	0.02	17.73
RR2	9.2	0.26	0.05	17.77
RR3	9.5	0.08	0.01	17.71
RR4	8.2	0.08	0.01	17.71
RR5	7.5	0.09	0.01	17.71

Notes
[1]Based on 2012 data measured at the Tamworth NSW EPA monitoring site

At all sensitive receptors PM_{10} is well below acceptable levels. When combined with estimated background data (noting that these are conservative as they are measured within a residential area in Tamworth) the predicted levels are also well below annual average criteria. Further, the impact on the nearby sensitive receptors is likely to be lower than predicted due to the vegetation between the site and receptors. Studies have shown that significant vegetation barriers can reduce dust emissions by up to 30% (Warren, 1973). The modelling completed for this assessment has not taken into account any mitigation from the vegetation buffer.

When averaged across a year, in accordance with the criteria, PM_{10}, TSP and dust deposition at any sensitive receptor is also well below accepted criteria and in most cases would be negligible.



Figure 12-1 Predicted maximum 24-hour average incremental PM_{10} concentrations (µg/m^3)

12.3.2 Operation

Emissions of carbon monoxide (CO) and nitrogen dioxide (NO_2) can be expected from the combustion and flaring of intermittent gas during operation. In addition to CO and NO_2 formation, a small amount of PM_{10} may be generated from the combustion operation however this is considered to be negligible and has not been assessed further.

Table 12-6 presents the predicted incremental NO_2 and CO impacts at the surrounding sensitive receptors when the flare is in operation. At all sensitive receptors this is well below acceptable levels.

Table 12-6 Predicted incremental concentrations at sensitive receptors – operation

Resident ID	Distance from the site (km)	NO_2 (µg/m^3)		CO (µg/m^3)	
		1-hr Average	15-min Average	1-hr Average	8-hr Average
NSW EPA Criteria		246	100	30	10
RR1	8.3	0.00594	0.00022	0.00017	0.00011
RR2	9.2	0.00741	0.00027	0.00021	0.00014
RR3	9.5	0.00617	0.00023	0.00017	0.00011
RR4	8.2	0.00827	0.00030	0.00023	0.00015
RR5	7.5	0.00836	0.00031	0.00023	0.00015

With the addition of the maximum 1-hour background NO_2 levels measured at Muswellbrook during November 2011 to July 2013 (86.48 µg/m³), the total predicted impact still does not exceed the NSW EPA criteria.

Site specific CO monitoring was not undertaken as part of this assessment. However, comparison of the predicted incremental CO concentrations with the NSW EPA criteria for CO shows that the contribution of the proposed activity would be significantly below the criteria. It is considered highly unlikely that existing background levels of CO would be approaching the criteria levels. Therefore the maximum CO impacts due to the proposed flare operation should not exceed the NSW EPA criteria in the vicinity of the site.

12.4 Cumulative impacts

In the vicinity of the proposed activity there are potentially other sources of NO_2 and CO emissions originating from on-site plant equipment, site vehicles, small generators and other flaring operations. These sources are unlikely to generate significant amounts of NO_2 and CO and would be located away from the nearby sensitive receptors to allow sufficient dilution.

Other flares proposed as part of the E&A Program would similarly generate low levels of NO_2 and CO concentrations and combined with the large spacing between the flares, any cumulative impact would be negligible.

12.5 Mitigation measures

The following mitigation measures will be implemented throughout the duration of proposed activity:

- 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 six months of abandonment.

13.0 Greenhouse Gases

13.1 Existing environment

Greenhouse gases (GHGs) are gases that absorb infrared radiation (heat) in the atmosphere. They occur naturally and are critical to maintaining the Earth's surface at liveable temperatures. When anthropogenic activities increase the concentrations of these gases this effect is accelerated, leading to the 'enhanced greenhouse effect'. It is the results of this enhanced greenhouse effect that are identified as 'climate change'.

Based on the current scientific consensus from the 2007 Intergovernmental Panel on Climate Change, there is a high degree of confidence that our current climate is changing due to human activities, with this rate of change likely to intensify into the future.

It is therefore important to consider, on balance, the GHG contributions and benefits of significant projects.

13.2 Assessment approach

In accordance with the *GHG Protocol Corporate Standard* (WBCSD and WRI, 2004), Scope 1 GHG emissions have been defined as direct emissions of GHGs (expressed as carbon dioxide equivalent) which are owned and/or controlled by Santos in relation to the proposed activity. Relevant inclusions are:

- Extracted gas consumed in the flare (when in use)
- Extracted gas vented (both fugitively and directly)
- Fuel use on site for power generation
- Fuel use on site for plant and equipment (including civil works and drill rigs)
- Vegetation clearing.

Scope 2 emissions cover those GHGs resulting from the purchase of energy (electricity or steam) originating from outside the proposed activity boundary. No scope 2 emissions are relevant to the proposed activity.

Scope 3 emissions have been defined as those indirect emissions which are a consequence of the proposed activity, but are not under the control, influence or authority of Santos. These emissions will form the scope 1 emissions of other organisations, so are considered separately and with discretion to avoid 'double counting' of the emissions profile.

The potential inclusions for Scope 3 emissions are extensive and often beyond quantification. For the EIS the inclusions have been limited with respect to the scale of the proposed activity and the available information, as consistent with the GHG Protocol methodology. Specific inclusions are:

- Use of sold products and services (CSG to the Wilga Park Power Station)
- Lifecycle emissions of materials and fuels where this information is consistent and readily in the public domain (such as the Infrastructure Sustainability Council of Australia (ISCA) materials calculator).

Emissions have been profiled over the construction and operation phases of the proposed activity, presented as both phase and annual totals as appropriate. Emissions intensity (relative to production) is also included.

13.2.1 Calculation methodology

The Greenhouse Gas Protocol outlines that a GHG inventory should be completed with regard to the following principles:

- Relevance
- Completeness
- Consistency
- Transparency
- Accuracy.

In the absence of relevant local data, emission factors for calculation have been sourced from the National Greenhouse Accounts (NGA) Factors (DCCEE 2012), with some supplementary inputs taken from the *American Petroleum Institute Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry* (the API Compendium) (URS 2009). The relevant emission factors applied in estimates are provided in Table 13-1.

Table 13-1 Relevant greenhouse gas emission factors

Emission source	Energy content		CO_2	CH_4	N_2O	Total	NGA Factors Reference
Emission factor (kg CO_2^e/GJ)							
CSG combustion	0.0377	GJ/m^3	51.1	0.2	0.03	51.33	Table 2; Page 13
Diesel combustion – Stationary Energy	38.6	GJ/kL	69.2	0.1	0.2	69.5	Table 3; Page 15
Diesel combustion – Transport	38.6	GJ/kL	69.2	0.2	0.5	69.9	Table 4; Page 17
Diesel combustion –Scope 3	38.6	GJ/kL	-	-	-	5.3	Table 39; Page 70
Emission factor (t CO_2^e /t gas flared)							
CSG flaring (exploration)			2.8	0.7	0.03	3.53	Table 8; Page 13
Emission factor (t CO_2^e /gas throughput)							
CSG leakage (production)			-	1.2×10^{-3}	-	0.0012	S 2.4.2.6; Page 29
Emission factor (t CO_2^e /km pipeline)							
CSG leakage (transmission)			0.02	8.7	-	8.72	Table 15; Page 30
Emission factor (t CO_2^e /drilling day)							
Water-based mud degassing			-	5.47	-	5.47	Converted from Table 5-17 API Compendium (@ 83.85% CH4)

13.3 Potential impacts

13.3.1 Scope 1 Emission Quantification

The bulk of scope 1 emissions from the proposed activity are expected to be derived from the use of diesel fuel for drilling and site operations, and the use of captured gas for minor on-site power generation.

The augmentation of the existing Bibblewindi gathering system will allow delivery of the bulk of the collected gas to Narrabri Power's Wilga Park Power Station. As this delivery involves a transfer of custody of the gas, emissions generated by the combustion of the fuel for power generation are not considered within Santos' direct emission scope.

Flaring will not be a regular source of GHG. It is estimated (based on existing operations data) that under the proposed operating regime whereby the gas is consumed at WPPS (subject to approval) less than five per cent of the produced CSG from Bibblewindi 31/32 will be flared. Flaring will always be undertaken in preference to venting when it is possible and safe to do so.

Flaring of gas will result in a net reduction of the GHG emissions when compared to venting. When the gas is flared methane is consumed in the process resulting in a significantly lower emission than from direct release to the atmosphere (as methane is recognised as having 21 times the global warming potential (GWP) of carbon dioxide). Consistent with Santos' Climate Change Policy, venting and flaring will only be employed where there is no feasible alternative. Such situations may include:

- disposing of air and any produced CSG (when air drilling)
- production testing the well
- drill stem testing
- in an emergency well control situation.

Minor amounts of gas may be emitted to the atmosphere as fugitive emissions during well development and operation, as well as from the gas gathering pipeline network and associated equipment. To assist in quantifying the extent of CSG fugitive emissions across the E&A Program, a monitoring program, including baseline monitoring, will be implemented. The monitoring program will be conducted in the general area of the E&A Program to monitor any changes in methane levels as an indicator of fugitive emissions during operation.

Venting and flaring rates, durations and volumes can vary significantly and depend on drilling technology, the number of gas zones and the distance between the zones. Santos intends to drill the wells using water based drilling fluids to minimise venting and flaring requirements during this phase. These emissions are therefore expected to be incidental however have been included in the estimate for completeness.

Forecasting suggests approximately 10 per cent of the captured gas will be used for electricity generation at the drill sites, avoiding the need to use more emissions intensive fuels (such as diesel) for this purpose.

Exhaust emissions from site-based vehicle movements, plant and machinery are based on initial traffic model inputs and information for the drill rigs. For the purpose of this assessment delivery of dedicated plant and equipment between Santos sites has been assumed to be a Scope 1 contribution.

As the site is completely within existing cleared/prepared areas, no clearing of vegetation is anticipated to be accounted in this GHG assessment.

Table 13-2 provides a summary of quantified Scope 1 emissions.

Table 13-2 Scope 1 greenhouse gas emissions profile

Component	Tonnes/CO_2^e/well	Tonnes/CO_2^e/year
	Construction Phase (2 wells)	Operation Phase[1] (14 wells)
Estimated total	568	10,046
Notes [1]Based on 4.5 + 0.25 million standard cubic feet per day (MMSCF/day)		

Based on the above operational emissions, the GHG intensity of the produced CSG is estimated to be approximately 5.5 kg CO_2^e/GJ.

13.3.2 Scope 2 Emission Quantification

Scope 2 (indirect GHG) emissions will not occur as there will be no purchases of electricity from the grid. What electricity is used on site will be generated from captured fuel gas, so is accounted for in the Scope 1 inventory.

13.3.3 Scope 3 Emission Quantification

The Scope 3 profile in Table 13-3 below excludes any Scope 3 components which cannot be reliably or predicably forecast, in line with the GHG Protocol.

The primary ongoing Scope 3 emission for the project is the consumption of the gas transmitted to the Wilga Park Power Station. Existing operations data suggests approximately 90 per cent of the available gas will be able to be provided to the facility.

Lifecycle emissions associated with the purchase of concrete, steel and HDPE pipe have been calculated using the ISCA materials calculator.

The emissions associated with the production of diesel for the drill rig and other on-site equipment has also been considered.

Table 13-3 Scope 3 greenhouse gas emissions profile

Component	Tonnes/CO_2^e/well	Tonnes/CO_2^e/year
	Construction Phase (2 wells)	Operation Phase (14 wells)
Estimated total	34	84,867

While the use of the extracted gas in the Wilga Park Power Station is the dominant operations Scope 3 emissions source, it should be noted that this fuel (per GJ) has a significantly lower emissions profile than more traditional energy sources such as coal (with an emissions intensity of 88.43 kg CO_2^e/GJ, compared to 51.33 kg CO_2^e/GJ for CSG). In this scenario this substitution would equate to an annual emissions reduction in the order of 68,500 tonnes of GHG by supporting an additional 20 MW of additional lower-emission generation capacity. The additional Bibblewindi 31 and 32 wells facilitate around 1.2 MW of this contribution.

13.3.4 Potential risks associated with greenhouse gas emissions

The primary risk associated with GHG emissions are their potential contribution to NSW and Australian GHG profiles.

Australia's GHG Inventory for 2011 (the most current data available at the time of writing) is provided in Table 13-4. The table shows the maximum expected emissions for the Scope 1 GHG emissions during operation phase of the proposed activity over a 12 month period. The potential GHG contribution of the

proposed activity to Australia's existing GHG profile is extremely minor, being less than 0.002 per cent and 0.007 per cent of the National and State emissions profiles respectively.

Based on these results the risk of the proposed activity to the local and national climate is considered very minor. The magnitude of emissions is not of a scale to indicate any directly attributable and measurable impacts on climate.

Table 13-4 Australian and NSW emission profiles

	GHG Emissions (Tonnes CO_2^e)
Australian Emissions (2011)	563,140,390
NSW Emissions (2011)	158,991,280
Maximum Estimated Proposed Activity Emissions (operations phase)	10,046

13.4 Cumulative impacts

Emission estimates for the operation of the E&A Program place the GHG profile at between 200 and 220 kT of CO_2^e annually (including flaring and onsite power generation). The Bibblewindi Multi-Lateral Pilot contributes in the region of five per cent of this total based on the proposed operating regime of the gas being predominantly consumed at WPPS.

13.5 Mitigation measures

13.5.1 Construction

The following measures will be carried out during construction to minimise the potential impacts associated with the Scope 1 GHG emissions from the proposed activity:

- 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 NGERS calculations).

13.5.2 Operation

On balance, the proposed activity provides significant GHG mitigation potential through the supply of CSG for power generation, which represents a 40 per cent emissions saving (per GJ) over more traditional large-scale energy sources such as coal.

In addition, the following measures will be carried out during operation to minimise the potential impacts associated with the scope 1 GHG emissions from the proposed activity:

- Regular monitoring and maintenance of equipment and pipes will occur to identify any leaks to minimise fugitive emissions.
- A fugitive emissions monitoring program will be implemented in the E&A Program area.
- Appropriate monitoring of emissions and consumables will be undertaken for legislative reporting requirements (such as to inform NGERS calculations).

13.6 Climate Change Policy

Climate change is a long-term issue, requiring urgent but informed action to stabilise atmospheric greenhouse gas concentrations. As a global stakeholder in the energy business, Santos recognises its social and environmental responsibility to pursue strategies that address the issue of climate change.

Santos is committed to working with government, industry and the community to address climate change with specific focus on addressing energy efficiency, adaptation strategies, the transition to lower emission technologies and reporting transparency.

Santos' Climate Change Policy outlines the organisations approach to climate change and realisation of the vision to 'lower the carbon intensity of its products'. The policy identifies the following commitments:

- continue to reduce the carbon intensity of Santos' products by focusing on energy efficiency, technology development and by embedding a carbon price in all activities
- use energy more efficiently by identifying opportunities to implement energy efficiency projects and report their progress
- examine the commercial development of low emission technologies, including storage solutions, which will contribute towards long-term emission reduction targets
- pursue no flaring or venting of associated gas, unless there are no feasible alternatives
- continue to publicly disclose Santos' greenhouse emissions profile and carefully examine forecast emissions
- understand, manage and monitor climate change risk and develop appropriate adaptation strategies for our business
- assist governments and engage with other stakeholders on the design of effective and equitable climate change regulations and policy
- inform employees about its commitment to climate change and ensure climate change initiatives continue to be implemented
- report progress against these commitments to the Board.

13.6.1 Emissions reporting

Santos has publicly reported its GHG emissions since 2004 with independent assurance provided annually, and as a result has established comprehensive governance processes which will ensure that the emissions associated with the proposed activity will be accurately reported under the *National Greenhouse and Energy Reporting Act 2007* (Cth) (NGER Act). Santos' governance system includes:

- annual independent assurance of GHG emissions
- regular audits in relation to implementation of the Environmental, Health and Safety Management System (EHSMS)
- risk-based internal audits are administered to ascertain conformance with, and effectiveness of the EHSMS Standards
- monitoring and review of energy efficiency opportunities
- other audits of compliance with internal policies and procedures related to GHG reduction through the internal audit program.

14.0 Noise

An assessment of the potential noise impacts was prepared to consider the construction and operational noise associated with the proposed activity. This chapter provides a summary of the Noise Assessment, provided in Appendix 6.

14.1 Existing environment

The nearest residences to the site are shown in Figure 3-7. The nearest residence (Receiver 5) is more than 7.5 kilometres north of the site, with four other residences (Receivers 1-4) located further north of Receiver 5.

Long-term unattended noise monitoring was conducted at two locations (Figure 14-1) to establish the existing noise environment:

- At the nearest sensitive receiver (ML1) between 14 November 2012 and 26 November 2012
- Within the forest (ML2) between 14 November 2012 and 15 November 2012

Results of the noise monitoring compared to rating background levels (RBLs) is provided in Table 14-1.

Table 14-1 Background noise levels for day, evening and night time periods at Receiver 5

Location	Rating background levels – LA_{90}			Ambient Noise levels – LA_{eq}		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
ML1	32	33	35	47	56	54
ML2	28	33	16	42	43	36

14.2 Assessment approach

The Noise Assessment was undertaken with reference to the relevant guidance documents:

- NSW Industrial Noise Policy (INP) (EPA, 1999a)
- Interim Construction Noise Guideline (ICNG) (DECC, 2009)
- Environmental Criteria for Road Traffic Noise (EPA, 1999b).

Noise modeling has been undertaken using SoundPLAN v7.0 and the prediction methodologies *ISO 9613-2 Acoustics-Attenuation of sound during propagation outdoors-Part 2: General method of calculation* (for 'neutral' conditions) and CONCAWE (for 'worst-case' conditions) with calculated sound power levels from field measurements taken in accordance with *AS1217.7-1985 Acoustics-Determination of sound power levels of noise sources* and ISO 3744:1994 *Acoustics-Determination of sound power levels of noise sources using sound pressure-Engineering method in an essentially free field over a reflecting plane* to derive sound power values for the activities. The calculations are made with an estimated uncertainty of ±3 dB(A) at 1000 metres. The sound levels calculated in this report are cross-checked with measured levels at 50 metres and with a variation of approximately 1 dB(A) this allows confidence in the prediction methodology and assumptions.

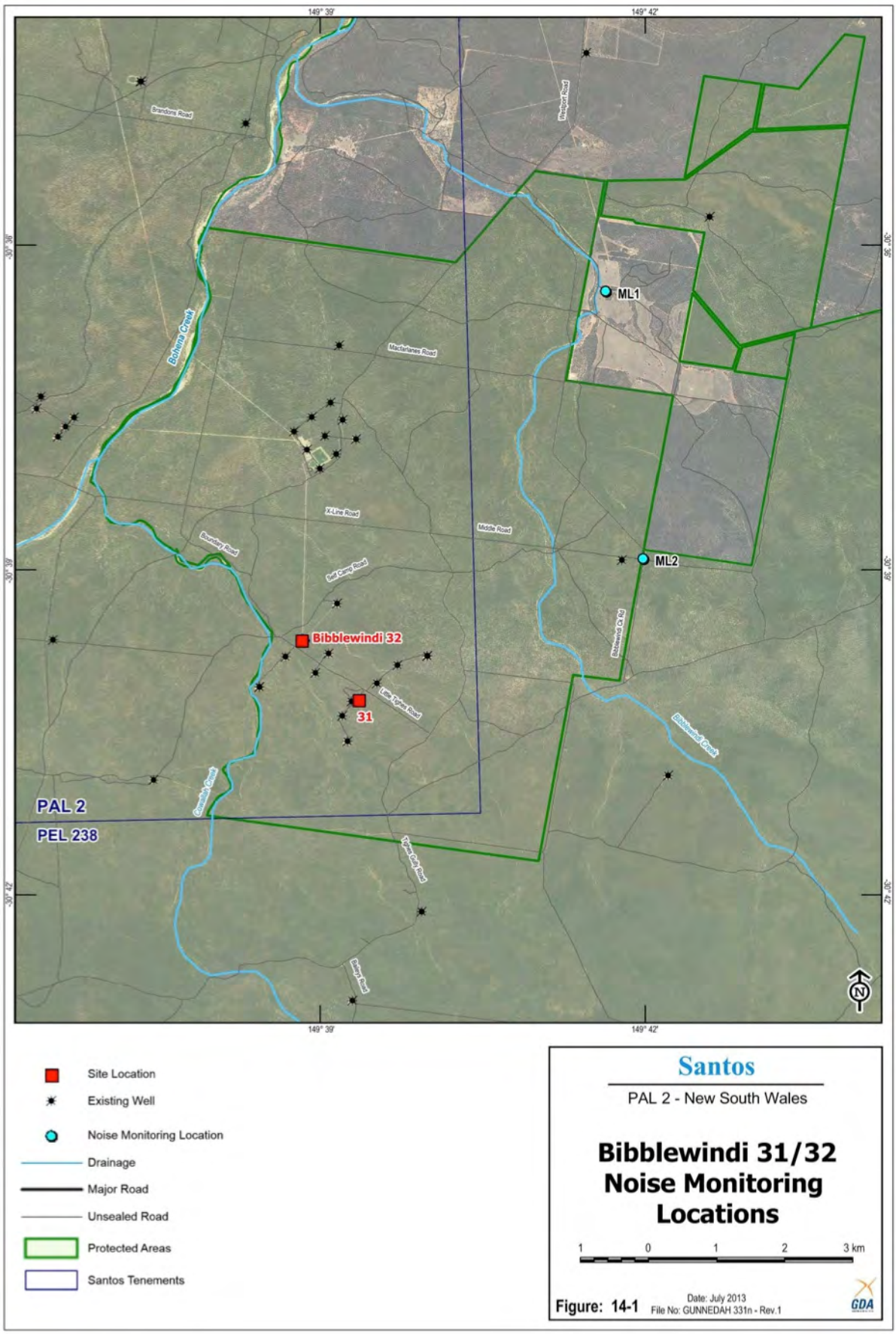


Figure 14-1 Noise monitoring locations (ML1 and ML2)

14.2.1 Noise assessment criteria

For the purpose of the Noise Assessment, the proposed activity has been considered a mining activity. In accordance with the ICNG, the construction activities for mining projects are to be assessed under the INP.

The INP assessment procedure for industrial noise sources has two components, which are:

- Controlling intrusive noise impacts in the short term for residences
- Protecting noise amenity for particular land uses and for residences

These two components are discussed below.

14.2.1.1 Intrusive noise impacts

The INP states that the noise from any single source should not intrude greatly above the prevailing background noise level. Industrial noises are generally considered acceptable if the equivalent continuous level of noise from the source, measured over a 15 minute period, does not exceed the RBL, measured in the absence of the source, by more than five dB(A). This is termed the 'intrusiveness criterion'. For the proposed activity, this is LA_{eq} 35 dB(A).

14.2.1.2 Protecting noise amenity

To limit continuing increases in noise levels, the ambient noise level resulting from industrial type noise sources should not normally exceed the acceptable noise levels specified in Table 2.1 of the INP. That is, the industrial noise level contribution should not exceed the level appropriate for the particular locality and land use. This is termed the 'amenity criterion'. Table 14-2 identifies recommended amenity criteria noise levels for different land uses. Most applicable to this assessment are the amenity criteria for residential receptors in a rural area and passive recreation areas.

The recommended maximum values provide guidance on an upper limit to the level of noise from industry and industrial type facilities. In all cases, it is expected that all feasible and reasonable mitigation measures would be applied before the recommended upper limit noise levels are referenced.

Table 14-2 Recommended LA_{eq} noise levels from industrial noise sources

Type of Receptor	Indicative noise amenity area	Time of day	Recommended LA_{eq} noise level dB(A)	
			Acceptable	Recommended upper limit
Residence	Rural	Day	50	55
		Evening	45	50
		Night	40	45
Area specifically reserved for passive recreation (e.g. National Park)	All	When in use	50	55

Although passive recreation areas are located in the surrounds of the site, public access to specific areas within the forest, where construction and operation works are proposed, would be restricted for safety reasons. Therefore State forest areas are not considered passive recreation areas for the purpose of this assessment.

14.2.1.3 Sleep disturbance criteria

The INP recommends an amenity criterion of 40 dB(A) LA_{eq} for night-time (10.00 pm to 7.00 am) at a residence in a rural area. The INP application notes recommend that the LA_1(1 minute) noise level outside a bedroom window should not exceed the LA_{90} background noise level by more than 15 dB(A) during the night-time period.

14.2.1.4 Construction noise criteria

The noise management level for works during the recommended standard hours is background plus an additional 10 dB(A). Above this noise level the proponent needs to implement all feasible and reasonable work practices, as defined in the ING, to minimise noise impacts.

14.3 Potential impacts

14.3.1 Modelling results

Noise modelling was undertaken for different weather scenarios both during construction and operation.

During construction, under all-weather scenarios, noise levels from construction will be less than 13 dB(A) beyond five kilometres from the drill rig. Given that all receptors are located beyond five kilometres construction noise would not be audible.

During operation, noise levels will also be well below guideline levels for intrusive noise (35 dB(A)), noise amenity (40-50dB(A)) and sleep disturbance (40 dB(A)) as summarised in Table 14-3.

Table 14-3 Noise modelling results during operation (LA_{eq})

Resident ID	Distance from the site (km)	Predicted noise levels dB(A)		
Scenario		Calm weather	Southerly winds	Temperature Inversion
RR1	8.3	16	24	17
RR2	9.2	15	23	16
RR3	9.5	15	23	16
RR4	8.2	17	25	18
RR5	7.5	18	26	19

14.3.2 Traffic noise

Noise levels associated with the increase in traffic due to the proposed activity would be minimal with all construction vehicles and equipment to be delivered during the beginning of the construction works and collected upon completion. Between these times, equipment will generally remain on site.

Offsite road impacts are therefore considered negligible (less than 0.1 dB(A)) and will meet the *EPA Environmental Criteria for Road Traffic Noise* (EPA, 1999).

During operation, traffic volumes would be less and would still be considered negligible.

14.4 Cumulative impacts

Noise impacts, are confined to a local area surrounding the well. Other wells within the E&A Program that will operate concurrently are all located at distances that would not create a cumulative impact.

During drilling, a maximum of two drilling rigs will be in operation. The E&A Program ensures that the two drill rigs will operate at sufficient distances to eliminate any cumulative noise impacts.

14.5 Mitigation measures

The following measures will be carried out prior to and during construction to minimise the potential noise impacts on receivers:

- Forestry Corporation of 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.

15.0 Traffic and Transport

An assessment of the potential traffic and transport impacts was prepared by GTA. This chapter provides a summary of the *Traffic and Transport Assessment*, with the report provided at Appendix 7.

15.1 Existing environment

15.1.1 Road Network

The existing road network that will service the site includes:

- Newell highway (State road)
- X-Line Road (unsealed forestry road)
- Tighes Gully Road (unsealed forestry road)
- Little Tighes Road (unsealed forestry road)
- existing unsealed access tracks located at the site.

Travel between the site, Narrabri and the drillers camp will occur during the proposed activity.

15.1.1.1 Westbourne drillers camp

Access to and from the drillers camp will be via Westport Road which intersects the Newell Highway (approximately 25 kilometres) north of X-Line Road. Alternate routes are via McFarlanes Road, Garlands Road, Boundary Road, Nickel Road, Bibblewindi Creek Road, Tighes Gully Road and X-Line Road to the south.

15.1.1.2 Narrabri Operations Centre

During the drilling of Bibblewindi 31 and 32 drilling fluid will be tankered to and from the NOC, located in Narrabri. The NOC is accessed via one driveway from Yarrie Lake Road. Yarrie Lake Road is identified as a local road and is aligned in a north southwest direction. The nearest State controlled road is the Newell Highway, located approximately 2.6 kilometres to the south east of the site.

Vehicle access between the NOC and the site will be via the Newell Highway.

15.1.2 Traffic volumes

Recent traffic volumes collected for the Newell Highway approximately 20 kilometres south of Narrabri and 20 kilometres north of X-Line Road are shown in Table 15-1. Traffic flows are relatively consistent across the day time period of 8 am to 4 pm and are in the order of 140 vehicles per hour. Full survey data is provided in Appendix 7.

Table 15-1 Traffic volumes for the Newell Highway

Detail	Volume[1]
Average daily traffic	1,860 vehicles
Proportion heavy vehicles	742 vehicles (39.9 %)
7 day average peak hour	134 vehicles
Highest average peak hour	156 vehicles

[1]Tube count data collected between September 2011 and November 2011
Source: Narrabri Shire Council

15.2 Assessment approach

A conservative approach was adopted to identify the potential impacts of the proposed activity. Traffic generation was calculated using estimated traffic volumes and adopting a theoretical peak period thought to occur on days where there would be worker rotation at the site in combination with construction vehicle deliveries. It was noted that the frequency of such peak events would be low and typical daily volumes would be significantly lower.

Traffic volumes and types of trips are provided in Table 15-2 and traffic routes in Figure 4-3. Now new river crossings or upgrades to existing crossings (as shown in Figure 4-3) are proposed as all movements will be confined to existing Forest roads. Vehicle types would typically be heavy vehicles with the largest vehicle equivalent to a 19 metre rigid truck. During operation, vehicle types would generally by 4WD or passenger size vehicles.

Table 15-2 Estimated construction traffic volumes for Bibblewindi 31 and 32

Construction Activity	Approximate duration	Maximum vehicle trips per day	Estimated vehicle trips per peak hour[1]
Site preparation	20 days	15[2]	<5
Drilling and completions	35 days	10	<5
Surface facilities[3]	50 days	5-10[3]	<5

1 Peak hour defined as the maximum number of vehicles likely to be generated in any given hour by construction related vehicles
2 Includes one trip generated by workers during the site preparation activity
3 Includes three trips generated by workers during the surface facilities activity. It is anticipated that three vehicles of 4 workers would be generated over the 50 day period.

15.3 Potential impacts

15.3.1 Construction

All construction vehicles and equipment will be delivered during the beginning of the construction works and collected upon completion. At these times delivery and collection of equipment will have an impact on the external road network. Between these times, equipment will remain on site.

Access to the site for all construction vehicles will be from the Newell Highway and a number of unsealed forestry roads including X-Line Road, Tighes Gully Road and Little Tighes Road. This access route currently exists and services the Bibblewindi Multi-Lateral Pilot.

15.3.2 Capacity

Capacity constraints generally occur at intersections where there are opposing traffic movements. As construction vehicles will enter the Forest via X-Line Road, the intersection with Newell Highway will be impacted. However given the low volumes of traffic, and capacity of Newell Highway to accommodate

additional vehicles, it is expected that the existing road network will accommodate the increase in traffic with minimal disruption.

The *Guide to Traffic Management Part 2: Traffic Theory* (Austroads, 2009) provides further guidance when assessing the impacts associated with increased traffic volumes, which has been referenced in assessing the anticipated increase in truck volumes at the intersection of the Newell Highway and X-Line Road. During a weekday peak period, a vehicle will pass X-Line Road along the Newell Highway every 20-30 seconds. A single vehicle exiting X-Line Road would require a gap of around 7-8 seconds to enter the Newell Highway traffic stream. On this basis the intersection would be capable of safely accommodating the anticipated increase in vehicles associated with the construction works.

15.3.3 Efficiency

Efficiency is a measure of the ease of travel between an origin and destination, primarily relating to travel times, delays and vehicle kilometres travelled. No changes to the operation of the local roads used (such as detours or realignment) are proposed. Construction traffic is proposed to use the most direct route(s) capable of accommodating the proposed activity. In combination with the existing low volumes of traffic on X-Line Road and Tighes Gully Road and the low volumes of traffic generated during construction, road network efficiency will not be reduced.

15.3.4 Functionality

Functionality relates to the geometry and surface of roads and intersections to accommodate heavy vehicles.

The existing intersection configuration at the Newell Highway and X-line Road is capable of accommodating vehicle sizes up to 19m. As such, the access to the site via X-line Road would be adequate to accommodate the proposed construction activity and an intersection upgrade at this location would not be required.

In addition to the above, no changes to the existing operation of intersections (such as turning movement restrictions) are proposed.

15.3.5 Safety

Additional traffic using forest roads could increase the occurrence of crashes. Safe driving methods will be implemented in the forest including:

- traffic speeds to be below 80 kilometres per hour unless otherwise signed
- an in vehicle monitoring system (IVMS) will be installed on all Santos vehicles to monitor driver behaviour.

All site staff and delivery drivers would receive the appropriate induction (consistent with Santos policies), which would include driver protocols and identification of any local hazards.

15.3.6 Operation

The pilot is anticipated to operate for up to three years, with a similar number of staff to current operations once the drilling of Bibblewindi 31 and 32 are complete. Typically one to two staff members will visit the site daily during operation for monitoring and maintenance activities.

Operational activities would be primarily between the hours of 7 am to 5 pm 7 days a week with the workforce located in the local Narrabri area.

Given the very low volumes, the existing road network will easily accommodate the additional traffic without any additional mitigation.

15.4 Cumulative impacts

Cumulative impacts would generate additional temporary traffic volumes during construction and operation of the E&A Program. Given the existing traffic volumes on the Newell Highway and the distribution of vehicles over the day, the anticipated traffic generation (typical and maximum) will have a minimal impact on the Newell Highway and the surrounding road network. As such it is predicted that the Newell Highway will continue to operate at or near a Level of Service B, with negligible ongoing delays to highway traffic as a result of the E & A Program.

15.5 Mitigation measures

15.5.1 Construction

- 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 the 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.

15.5.2 Operation

No site-specific mitigation measures are proposed or required.

16.0 Waste

16.1 Existing environment

The *NSW Waste Avoidance and Resource Recovery Strategy 2007* (DECC, 2007a) (Waste Strategy) sets out principles promoting the adoption of measures which avoid unnecessary resource consumption and encourage resource recovery, including reuse, reprocessing, recycling and energy recovery. Four key areas are identified where outcomes must be achieved in order to avoid and manage waste. These are:

- Preventing and avoiding waste
- Increasing use of recovery and use of secondary materials
- Reducing toxicity in products and materials
- Reducing litter and illegal dumping.

Waste management measures implemented for the proposed activity will encourage efficient resource use alternatives, re-use and recycling. Waste that cannot be re-used or recycled will be disposed of in an appropriate manner.

The EPA's *Waste Classification Guidelines* (DECCW, 2009) describe a number of waste streams and provide specific direction on the classification of wastes, based on chemical composition and associated environmental impacts. Waste streams require different management, transportation and disposal depending on their classification. The six waste stream categories are:

- Special waste (e.g. clinical and related, asbestos and tyres)
- Liquid waste
- Hazardous waste (e.g. waste with pH less than two, coal tar, lead paint waste)
- Restricted solid waste
- General solid waste (putrescibles) (e.g. household wastes, manure, food wastes)
- General solid waste (non-putrescible) (e.g. glass, plastic, rubber, garden waste)

16.2 Potential impacts

The proposed activity will generate a number of waste streams. Waste will predominantly be generated during the construction phase including:

- drilling activities
- site clean up
- general waste from contractors and personnel on site.

16.2.1 Construction

The main waste types and estimated volumes generated by the proposed activity during construction are identified and classified according to the Waste Classification Guidelines in Table 16-1. Where possible, waste will be reduced or recycled with waste separated into bins on the lease area to facilitate transfer to appropriate treatment facilities. Specific reuse activities will be put in place for drilling fluids and cuttings, these are described in detail in Section 4.3.

Potential impacts associated with the generation and disposal of these wastes include:

- leaching of chemicals and other pollutants into groundwater, soils or surface water
- pollution or contamination of land or water due to illegal dumping of waste, lack of suitable containment of waste
- littering of the site, surrounding properties or surface waters due to lack of suitable containment of waste
- odours caused by improper storage or treatment of putrescible waste
- addition to landfill.

Table 16-1 Classification of potential waste generated from the proposed activity during construction

Classification	Type	Estimated Volume	Disposal Option
Liquid waste	Drilling fluid	400 m^3	Transported by a licensed contractor to a Santos operated fluids treatment facility at Narrabri or an appropriately-licensed disposal facility.
	Drilling fluid-contaminated cement slurry	45 m^3	Transported by a licensed contractor to an appropriately-licensed disposal facility.
	Produced water	300 m^3	Transported by a licensed contractor to the Leewood Produced Water Facility or an appropriately-licensed facility.
	Fuels, engine coolant and hydrocarbon residuals	< 100 L	Transported by a licensed contractor to an appropriately-licensed disposal facility.
	Human waste including pump out waste and sewage[1]	<30 m^3	Transported by a licensed contractor to an appropriately-licensed disposal facility.
General solid waste (putrescible)	General waste including food waste from personnel and non recyclables	< 20 m^3	Transported to the Narrabri Waste Management Facility.
General solid waste (non-putrescible)	Drill cuttings[2]	195 m^3	Re-use on site (under Naturally Excavated Material (NEM) exemption) or transported by a licensed contractor to an appropriately-licensed disposal facility.
	Drained oil filters, empty oil containers and oil absorbent materials that do not contain free liquids, plastics (e.g. packaging, pipe caps), concrete wastes, cured resins, paints, glues, etc.	< 40 m^3	Transported by a licensed contractor to an appropriately-licensed disposal facility.
	Recyclables including glass, PET bottles, aluminium, scrap metal (e.g. pipe cuttings), rope spacers, paper and cardboard	< 20 m^3	Transported to the Narrabri Waste Management Facility for sorting and recycling.

[1]Sewage waste from toilet facilities provided for workers during their shift. Camp facilities will not be located on site.

[2] It is expected that drill cuttings will consist of Naturally Excavated Material (NEM) and can be used in site rehabilitation under the NEM exemption issued by the EPA on 19 October 2012. If required, drill cuttings will be tested using the bulk sampling technique for NEM, and if found to exceed the limits set by the NEM exemption, will be classified and treated as general solid waste (putrescible).

16.2.2 Operation

Waste generated during operation of the Bibblewindi Multi-Lateral Pilot will consist predominantly of produced water. The estimated maximum rate of produced water from the pilot is 581 cubic metres per day, while the estimated average rate is 260 cubic metres per day.

Potential risks associated with the generation and disposal of produced water relate to the treatment of this quantity of water, and the possibility of infrastructure failure and resultant potential impact of the produced water on groundwater, soils or surface water.

Some waste will be generated through the undertaking of maintenance works, including potential workovers of the wells as per standard industry practice. It is considered that the volumes of waste generated from these activities will be minimal. As an estimate, during a workover it is likely that 75 to 125 cubic metres of water would be produced per well. This would be trucked (approximately three to five trailer loads) to the Leewood Produced Water Facility or a suitably licensed facility.

16.3 Cumulative impacts

16.3.1 Construction

The main waste types and estimated volumes generated across the drilling program during construction are identified in Table 16-2.

Potential cumulative impacts associated with the generation and disposal of these wastes mainly relate to addition to landfill and capacity of management, disposal or recycling facilities to cope with the volumes produced.

Table 16-2 Estimated cumulative waste volumes during construction

Waste Type	Estimated Volume				
	Dewhurst 13–18	Dewhurst 22–25	Dewhurst 26–31	Bibblewindi Multi-Lateral	Total
Drilling fluid (m^3)	450	450	775	400	2,075
Drilling fluid-contaminated cement slurry (m^3)	115	115	160	45	435
Produced water	300	300	+200	300	1,100
Fuels, engine coolant and hydrocarbon residuals (L)	< 100	< 100	< 100	< 100	<400
Human waste including pump out waste and sewage (m^3)[1]	<30	<30	<30	<30	<120
General waste including food waste from personnel and non recyclables (m^3)	< 20	< 20	< 20	< 20	<80
Drill cuttings (m^3)[2]	150	780	880	195	2,005
Drained oil filters, empty oil containers and oil absorbent materials that do not contain free liquids, plastics (e.g. packaging, pipe caps), concrete wastes, cured resins, paints, glues, etc. (m^3)	< 40	< 40	< 40	< 40	<160

Waste Type	Estimated Volume				
Recyclables including glass, PET bottles, aluminium, scrap metal (e.g. pipe cuttings), rope spacers, paper and cardboard (m^3)	< 20	< 20	< 20	< 20	<80

[1]Sewage waste from toilet facilities provided for workers during their shift. Camp facilities will not be located on site.

[2] It is expected that drill cuttings will consist of Naturally Excavated Material (NEM) and can be used in site rehabilitation under the NEM exemption issued by the EPA on 19 October 2012. If required drill cuttings will be tested using the bulk sampling technique for NEM, and if found to exceed the limits set by the NEM exemption, will be classified and treated as general solid waste (putrescible).

16.3.2 Operation

As stated previously, produced water will form the main waste component during operation. The estimated volumes of produced water for the operation of the E&A program are provided in Table 16-3.

Potential cumulative impacts associated with this produced water relate to treatment and transportation capability, and the possibility of infrastructure failure and resultant leakages of the produced water into groundwater, soils or surface water.

Table 16-3 Estimated cumulative pilot extraction rates

Pilot	Max Extraction (m^3/day)	Average Extraction (m^3/day)
Dewhurst 13–18	397	302
Dewhurst 22–25	273	260
Dewhurst 26–31	448	378
Bibblewindi Multi-Lateral	581	260
Bibblewindi West	209	85
Tintsfield 2–7	43	23
Total	**1,951**	**1,308**

16.4 Mitigation measures

16.4.1 Construction

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.

The waste management plan will identify:

- types of waste generated
- waste management processes and procedures for each waste stream
- waste transport requirements
- monitoring requirements
- audit and inspection requirements
- record keeping and reporting requirements.

The most significant waste types and volumes will be generated during drilling, and would therefore be temporary in nature. The management approach for drilling fluid and solids (cuttings) has aimed to reduce waste to landfill as much as possible.

16.4.1.1 Drilling fluid management

It is expected that the FTF will be licenced and operational by the time Bibblewindi 31 and 32 are drilled. Drilling fluids will be mixed at the FTF and then transported to site. This will reduce wastes associated with mixing chemicals on site (such as chemical containers). Drilling fluid management is discussed in Section 4.3.3.3.

During drilling, used fluids will be separated into liquids and solids (cuttings) and fluids will be continuously reused throughout the drilling process. Once the well has been drilled the drilling fluid is displaced from the well by the cementation process or by production fluids.

Where the FTF is operational the residual volume of fluid will be tested prior to being removed from the site by a contractor licensed under the POEO Act to transport trackable wastes. It will be transported to a subsequent well for re-use or back to the FTF for storage and treatment. Before drilling fluid is used on a subsequent well the chemical and physical properties are tested and the fluid amended as required.

Advice from the EPA indicates that a resource recovery exemption will not be required where drilling fluid is reused in the drilling process (i.e. at a new drill site).

There will be a residual amount of waste from the treatment facility in Narrabri which will eventually need to be disposed of at a licensed waste facility.

If the FTF is not licenced and operational, used drilling fluids will be disposed of at Transpacific Industries' liquid and hazardous waste management facility in Newcastle, NSW or another appropriately licenced facility. Approximately eight tankers will be required to transport the used drilling fluid from each well to the facility and required waste tracking requirements will be undertaken.

16.4.1.2 Drill cutting management

It is expected that drill cuttings will consist of NEM and can be used in site rehabilitation under the *Resource Recovery Exemption for Naturally Excavated Material* (NEM exemption) issued by the EPA on 19 October 2012.

Advice from the EPA indicates that where excavated material generated as part of well establishment or drilling is re-used on site from which it was generated, the activity will not trigger any waste licensing requirements. Therefore, a resource recovery exemption is not required in this case.

Drill cuttings will however be tested, if required. Typically, drill cuttings will be reused onsite for backfilling or site shaping. This will reduce the need to import additional fill and will reduce material which may otherwise go to landfill.

16.4.1.3 General waste management

In addition, the following measures will be carried out to minimise waste and potential impacts associated with waste generation and disposal:

- Management of waste, including its transport, will comply with the POEO Act and POEO (Waste) Regulation.
- The 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 and stored in bins or skips within a designated waste transfer point within the lease area prior to transportation for disposal.

- Regulated waste will be collected by licensed contractors for off-site 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.
- Sewage waste will be removed from the site by a licensed contractor for treatment and disposal, as required.
- Appropriate waste receptacles will be provided on site including covered rubbish bins for disposal of domestic wastes. These will remain during drilling activities.
- The type and volume of all waste removed from the site will be recorded.
- All staff and contractors will be made aware of waste management procedures during the site induction and through toolbox talks.
- Chemical, fuel and oil containers will be managed according to the MSDS or manufacturers' directions to avoid potential impacts to the environment or human health.

16.4.2 Operation

The main waste stream during operation will be associated with water produced from the wells. 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, 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.

Waste generated during maintenance works, including potential workovers is considered to be minimal and will be managed and disposed of using the same relevant methods as to those used during construction.

17.0 Hazards

17.1 Existing environment

Fire plays a major role in the ecology of the Pilliga scrub, with many plant species depending on fire to regenerate. However in unfavourable conditions fire can be extremely intense, destroy entire ecosystems, spread very quickly and threaten nearby properties.

The magnitude of historical Pilliga bushfires correlates with the El Nino Southern Oscillation phenomena, with El Nino (dry) years having the most severe fires (NPWS, 2006). In 1997 a major fire burned almost half of the Pilliga scrub, while an extremely dry winter and spring in 2006 saw a number of large fires develop. In January 2013, large fires threatened the Pilliga forest.

17.2 Assessment approach

The *State Environmental Planning Policy No 33 – Hazardous and Offensive Development* (SEPP 33) presents a systematic approach to planning and assessing proposals for 'potentially hazardous' and 'potentially offensive' development for the purpose of industry or storage. The Hazardous and Offensive Development Application Guidelines – Applying SEPP 33 (SEPP 33 Guideline) (DP&I, 2011) provide guidelines to assist consent authorities and proponents to establish whether an activity would fit into such definitions and hence, come under the provisions of SEPP 33.

17.2.1 Potentially hazardous industry

For an activity to be classified as 'potentially hazardous industry' the policy establishes a comprehensive test by way of a preliminary hazard analysis (PHA) to determine the risk to people, property and the environment at the proposed location and in the presence of controls. Should such risk exceed the criteria of acceptability, the development is classified as 'hazardous industry' and may not be permissible, depending on the local zoning.

In order to determine whether the proposed activity is a potentially hazardous industry, the risk screening method outlined in the SEPP 33 Guidelines was applied. The risk screening method is based on the potential for, and consequences of an explosion, fire, or release of toxic substances. It takes the following factors into account:

- the properties of the substances being handled or stored
- the conditions of storage or use
- the quantity involved
- the location with respect to the site boundary
- the surrounding land use.

The SEPP 33 Guideline provides a three-step risk screening method to assist consent authorities in determining whether a proposed development is potentially hazardous as outlined below.

(1) Identify hazardous materials and the type of hazard

(2) Group hazardous materials and total by class, activity and location

(3) Compare with screening threshold.

Step 1 has identified that a small quantity of a hazardous material (diesel) will be transported to and stored on the site (refer to Table 17-1). None of the chemicals that may be used in the drilling process or held on site during the drilling process are listed on Australian Dangerous Goods Code (ADGC) and therefore, for the purposes of the risk screening method, are not considered to be hazardous.

Step 2 of the risk screening method requires the distance of the material group to the nearest boundary. The distance is to be measured from those materials in the group located closest to the boundary. Given the proposed activity is within the State forest with no adjoining sensitive receivers or development that would be likely to be affected by potential hazards on the site, a separation distance of 50 metres has been adopted for the activity.

Table 17-1 List, volume, packaging and transport details of hazardous materials to be stored on site

Material	Australian Dangerous Goods Code (ADGC)	Packaging Group I, II or III (according to ADGC)	Volume transported to site (litres)	Mode of storage
Diesel	3	III	<0.10 tonnes	Tank

Step 3 requires the total quantity of hazardous material to be compared against the screening threshold within the SEPP 33 Guidelines which is shown at Figure 17-1. Based upon a separation distance of 50 metres, the proposal would only be within the 'potentially hazardous region' if the quantity of diesel transported to the site was around 1100 tonnes. Therefore the proposal does not comprise a potentially hazardous industry and a PHA is not considered to be necessary.

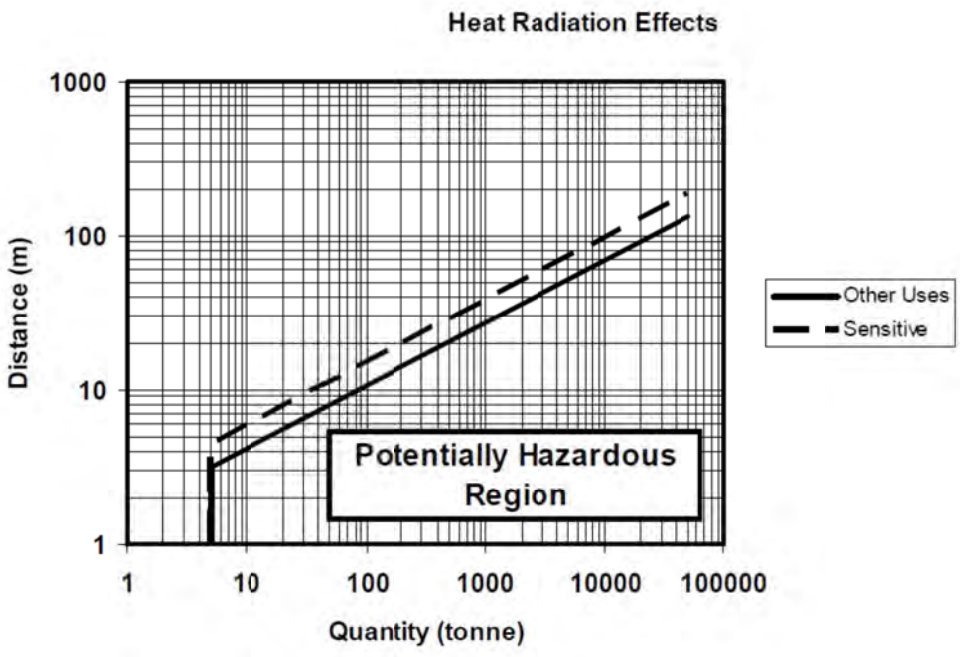


Figure 17-1 Screening threshold of the SEPP 33 Guidelines (DP&I, 2011)

17.2.2 Potentially offensive industry

The SEPP 33 Guidelines state that if a proposed activity requires a licence under any pollution control legislation the proposal should be considered to be potentially offensive. As discussed at Section 6.2.4, the proposed activity will require an EPL to be issued by EPA in accordance with the POEO Act. The key consideration in the assessment of a potentially offensive industry is that the consent authority is satisfied that there are adequate safeguards to ensure emissions can be controlled to a level at which they are not significant. If the consent authority is not satisfied, the proposal may be an offensive industry. The minimum test for such developments is meeting the requirements for licensing by EPA.

Santos is in the process of preparing the necessary applications for licensing under the POEO Act. The proposed activity will operate in accordance with the requirements of these EPLs. As such the proposal would not constitute an offensive industry and no further consideration of potentially offensive industry under SEPP 33 is required.

17.3 Potential impacts

17.3.1 Public safety and chemical use

The proposed activity will introduce a potential hazard to the site, such as moving vehicles, plant and machinery, and chemicals, fuels and oils. This could have safety implications for State Forest users.

The proposed activity will require the use of chemicals, fuels and oils, particularly during drilling activities. While these substances are not highly hazardous at the volumes which they are proposed to be used, potential impacts may occur due to their improper use, transport or storage, or in the event of an incident. Such impacts could include outbreak of fire, or pollution of land, water or air. Moving vehicles, plant and machinery may also introduce a potential hazard to the site, which may have safety implications due to the accidental ignition by vehicles or machinery.

Drilling fluid, containing a number of chemical additives, will be used during drilling as described in Section 4.3.3.2 of the EIS. The majority of chemicals would have no impact on the environment. Some of the chemicals to be used may have consequences to the environment if not used, stored or disposed of appropriately. However, the risk to the environment is considered to be low as chemicals will be stored on site in small quantities. Chemicals will be stored off the ground in an elevated trailer. The proposed activity will be short term and all chemicals will be used and disposed of in accordance with the relevant MSDS.

The risk to human health as a result of the chemicals is also considered to be low as site workers will wear and use the appropriate personal protective equipment and no members of the public will be able to enter the work area. Waste will be disposed of appropriately in accordance with relevant legislation.

No chemicals with added benzene, toluene, ethylbenzene, and xylenes (BTEX) will be used.

Dangerous goods will be transported according to regulatory requirements under the *Dangerous Goods (Road and Rail Transport) Act 2008.*

The impacts associated with spills and associated mitigation measures are covered in the discussion on soil quality (Section 8.4) and surface water quality (Section 10.4).

No radiation impacts are expected from the proposed activity.

As discussed at Chapter 16, a waste management plan will be prepared prior to construction to minimise potential from waste. Management of waste, including its transport, will comply with the *Protection of the Environment Operations Act 2007* (POEO Act) and *Protection of the Environment Operations (Waste) Regulation 2005* (POEO (Waste) Regulation).

17.3.2 Bushfire risk

Bushfire needs to be considered from two perspectives:

- the management activities required should a fire occur
- the risk that the proposed activity contributes to the lighting of a fire.

In the event of a bushfire a review and risk assessment will be conducted on drilling activities that have the potential to be exposed to the bushfire, with identified controls implemented to manage activity exposure. Santos has developed a bushfire management plan and an emergency response plan that details the broad responsibilities and duties of personnel during an emergency event such as a bushfire.

This bushfire management plan provides guidance on site responsibilities, actions, reporting requirements and resources required to ensure effective and timely preparedness is undertaken in the prevention of any bushfire incident or emergency at operations sites. The plan addresses the requirements of the Permit to Occupy which includes:

- Implementation of all reasonable precautions to minimize the risk of fire on the Occupation Permit Area and in particular in any facilities, building or structure on the Occupation Permit Area
- a fire tanker with capacity of not less than 400L on standby at all times together with adequate devices and appliances to prevent or retard the spread of fire
- any cleared vegetation other than merchantable logs is with the prior approval of Forestry Corporation of NSW removed from the occupation permit area and destroyed as directed by the Forestry Corporation of NSW
- no burning of timber, grass, cleared vegetation or other combustible matter is undertaken without the prior consent of the Forestry Corporation of NSW.

17.4 Cumulative impacts

Diesel will be used in plant during construction of the proposed activity and other activities as part of the E&A Program, and for maintenance activities during operation. There is potential for diesel to be spilled or leaked during transport, storage or use. However, these substances are stored and used in relatively small volumes and any spills or leaks are likely to remain localised. Therefore the potential for cumulative impacts as a result of hazardous substances is low.

There is potential for fire during the construction and operation phases of the exploration activities, particularly given the flammability of CSG, which could 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.

17.5 Mitigation measures

17.5.1 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 MSDS or manufacturers' directions to avoid potential impacts to the environment or human health.

17.5.2 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 (RFS), Fire & Rescue NSW (FRNSW) and Forestry Corporation of NSW will be implemented.

18.0 Social and Economic

18.1 Existing environment

18.1.1 Social and Demographic overview

Social and demographic data based on the 2011 Australian Bureau of Statistics (ABS) Census was reviewed to identify any specific characteristics for the Narrabri LGA compared to NSW averages.

Based on 2012 ABS Estimated Resident Population (ERP) the population of the Narrabri Shire is approximately 13,564 people. This is an increase of approximately 89 people from the 2011 ERP figure.

The age distribution in the Narrabri LGA is indicative of a mix of young families with children as well as an ageing population. The lower proportion of residents aged 25 to 54 (which make up the majority of the working population) compared to the NSW average is reflective of the possible lack of job/career opportunities for this age bracket within the LGA.

The growth in new industries such as mining, and the local services required to support this growth, will help to not only diversify the economic base which is largely reliant on the agriculture sector of the region, but will also increase local skills in line with new employment opportunities. In order to attract younger working families to the region, provision of closer employment opportunities as well as range of opportunities is necessary. Investment in the mining industry and the resulting employment, both directly and indirectly, will provide additional job and career opportunities for the local population. The mining industry also typically results in higher wages than other industries and as such the addition of further job opportunities in this industry may help raise the current average household income levels of the Narrabri LGA.

With unemployment in the Narrabri LGA currently higher than the NSW average the addition of further employment opportunities for local residents associated with the proposed activity will have a positive impact on the current unemployment levels.

The *Narrabri Shire Economic Development Strategy* (Narrabri Shire, 2011) outlined future opportunities for the Narrabri Shire to help diversify its economy. This included the opportunity to leverage the mining sector to create further investment in the area as well as expand value adding uses such as mining services businesses locating in industrial land in the Shire.

18.1.2 Santos' role in the local community

18.1.2.1 Regional community benefit fund

As part of its commitment to the Narrabri community, Santos takes part in a local sponsorship program that benefits the local community. Approximately $300,000 is contributed annually by Santos. This money goes towards a mix of community wellbeing and health, education and youth, indigenous engagement and industry and environment. This program aims to enhance a range of local community networks and facilities. Figure 18-1 provides an indication of who the sponsorship is distributed.

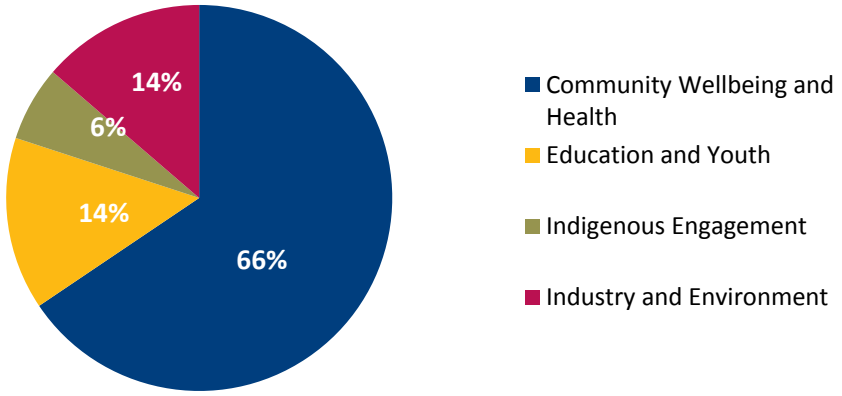


Figure 18-1 Santos sponsorship program

Moving forward, Santos has committed to contributing to the regional community benefit fund the equivalent of 5% of the royalty payment made to the NSW Government within the production licence area. This amount will then be matched by the Government. It is estimated that the fund could reach $300 million over the next two decades.

18.1.2.2 Social Infrastructure provision

Any additional population drawn to the area as a result of employment from the proposed activity is likely to be minimal, and catered for by the existing residential communities. Santos currently has 4 residences in the local area. These properties are rented to the local workforce.

The increased number of employees during drilling activities will be accommodated in the Westport Drillers Camp (refer Section 3.2.1.5). This is located approximately seven kilometres north of the proposed activity and will have capacity to accommodate 24 to 64 drillers at the camp site. The provision of this accommodation will help to mitigate any risks such as housing stress which could arise if the entry of these workers to the housing market started to limit housing supply and thus increasing rents.

18.1.2.3 Buy local program

Santos is implementing a buy local program that seeks to promote local contractors, services, equipment and products. Contractor forums have been held (refer section 5.3.5) to provide information of upcoming activities and to identify opportunities for local businesses.

Santos has estimated that approximately $0.8 million has already been spent in the last financial year on vehicle maintenance and leases, fuel and locally based contractors. This continued expenditure is likely to contribute both to the Narrabri economy and the wider northwest NSW region.

18.1.2.4 Employment

Santos employs 31 EFT people within its current operations in Narrabri and Gunnedah. All these staff are locally based. The local team are supported by employees within Sydney and Brisbane as part of Santos' Eastern Australia operations. On average an additional 12 employees visit the region per week.

18.1.2.5 Land access and compensation

Although not relevant to the proposed activity as it is located within the State forest, Santos has an established land access agreement protocol and a series of initiatives to support working with land owners.

18.2 Assessment approach

In order to determine the direct and indirect benefits of the proposed development RPS have devised 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 ABS in *Information Paper Australian National Accounts Introduction to Input-Output Multipliers* (Cat No 5246.0) (ABS, 1995) . The calculations utilise data from *Australian National Accounts: Input-Output Tables – Electronic Publication, 2007/08 Final* (Cat No. 5209.0.55.001) (ABS, 2007), namely Tables 5 and 20.

18.3 Potential impacts

18.3.1 Employment and other economic benefits

18.3.1.1 Direct employment

The proposed activity will see approximately 5.6 EFT direct jobs created during the construction and drilling phase of the project. This workforce is considered to comprise a mix of fly in fly out (FIFO) workers (4.2 EFT) as well as local residents (1.4 EFT) for the project. Once the proposed activity is operational an additional 2 EFT jobs for local residents will likely be created by the proposed activity. This workforce breakdown will see a much higher number of EFT jobs offered in the construction phases of the proposed activity compared to the operations stage of the proposed activity.

Any local based employees are anticipated to be sourced from Narrabri as well as nearby Gunnedah and Tamworth depending on the skills required for the job. Additional employment in the mining industry is in line with desired outcomes of the Narrabri Shire Economic Development Strategy and will provide employment opportunities for the growing local population.

18.3.1.2 Indirect employment

Based on capital investment of approximately $8.1 to $8.3 million the proposed activity is estimated to generate $5.3 to $5.5 million in output multiplier effect (ie. additional demand). This effect will lead to the creation of up to an additional indirect 16 jobs in the local and wider economy as part of this multiplier effect. It should be noted that these are preliminary projections and provide an indication of the potential additional economic and employment benefits the proposed development may have based on current inputs.

The proposed activity relies on a number of FIFO workers during drilling however this will still benefit the local and regional economy in a number of ways. The Westport Drillers camp will be serviced by local people and provisions, including food and fresh produce which are sourced locally. FIFO workers are also estimated to generate a local expenditure of approximately $25 per person per day on local businesses such as restaurants, cafes, cinema, hotels etc. This expenditure on local goods and services ensures that the benefits of the FIFO workforce of the proposed activity are passed along to local businesses and are not confined to the mining services sector.

18.3.1.3 Other impacts

The potential effects of the proposed on the economic and social fabric of Narrabri and its surrounding communities are summarised in Table 4 below. A ‘+’ indicates a positive effect, a ‘0’ a neutral or uncertain and a ‘-‘ a negative effect.

18.4 Cumulative impacts

The E&A Program will further increase local expenditure and employment opportunities. This would stimulate the local and regional economies through employment and investment in the region and contribute to diversifying the local economy. Santos is committed to working with local governments to ensure that these benefits are realised.

The proposed activity as part of the E&A program will lead to a net benefit for the local and regional community and possibly NSW as part of a growing CSG industry.

18.5 Mitigation measures

- Consultation activities will occur in accordance with Section 5 of the EIS.

Table 18-1 Proposed activity impact on economic and social indicators

Criteria			Impact	Comment
1	Economic Impacts	Increases or decreases retail and other services within the local area	0	No change to current situation
		Increases or decreases facilities within the local area	0	No change to current situation
		Better uses or makes redundant existing infrastructure	+	Makes use of existing infrastructure and is contained within existing development footprint
		Increases or decreases demand for local goods and services	+	Additional local jobs as part of the construction phase will increase household expenditure levels creating flow on economic benefits for local businesses and services
		Impact on existing economic land uses (commercial, tourism, etc)	0	No change to current situation
		Impact on existing energy supply	+	Proposed activity will contribute contribution to future domestic gas supply
2	Employment	Improves or reduces access to employment	+	Provision of more local employment during each phase of project
		Increases or decreases long term jobs (temporary or permanent)	+	Predominately short term employment opportunities during proposed activity however E&A Program may result in an increase in long term employment opportunities during production
		Impact on skills / education	+	Provision of local employment will assist in up-skilling, where education and qualifications are provided on-the-job.
		Safeguards or threatens existing jobs	+	Additional jobs will ensure existing mining related and supply services in Narrabri as well as the wider region have the opportunity to continue to employ people
4	Community Networks	Provides or reduces facilities or opportunities for social interaction	0	No change to current situation
		Improves or reduces community identity and cohesion	0	No change to current situation
		Improves or reduces existing residential amenity	0	No change to current situation
		Creates or removes physical barriers between homes and community facilities	0	No change to current situation.
		Impacts on disadvantaged social groups	+	Santos sponsorship program includes education and youth, and indigenous engagement
		Benefits or displaces disadvantaged groups	+	Sponsorship program benefits local youth and indigenous population through engagement and education

Criteria			Impact	Comment
		Consolidates or dislocates existing social or cultural networks	+	The sponsorship program will aim to engage and consolidate community and cultural networks through funding a variety of different categories
5	Public Realm	Safeguards or threatens heritage sites or buildings, or archaeological sites	0	No change to current situation
		Makes available / enhances or detrimental to public places / open space	0	No change to current situation
		Provides or displaces public facilities	0	No change to current situation
		Avoids or exhibits overdevelopment / large scale buildings	+	The proposed activity makes use of existing infrastructure and is entirely within the footprint of existing lease areas
6	Infrastructure	Increases or decreases housing stock	0	Drillers will be accommodated within the Westport drillers camp. Other FIFO workers will stay at local hotel/motel accommodation. As such no effect on local housing stock
		Increases or decreases stock of low income housing, or its affordability	0	No change to current situation
		Increases or decreases housing rental averages	0	No change to current situation
		Increases or decreases choice in housing	0	No change to current situation
		Increases or decreases provision of special needs housing	0	No change to current situation
		Increases or decreases the social mix of residents in the area	0	No change to current situation
7	Access	Decreases or increases distance from homes to local community facilities and services	0	No change to current situation
		Improves or reduces public transport services or access to such services	0	No change to current situation
		Improves or reduces access to local facilities for pedestrians, cyclists or the disabled	0	No change to current situation

19.0 Other issues

Whilst not identified as a key risk for the proposed activity, Cultural heritage was considered as part of the impact assessment.

19.1 Aboriginal cultural heritage

19.1.1 Existing environment

The REF prepared for the existing Bibblewindi Multi Lateral (ESG, 2008) included an assessment of risks to Aboriginal cultural heritage during establishment of the Bibblewindi 14 and 19H lease areas. The assessment included desktop searches of the Aboriginal Heritage Information Management System (AHIMS) maintained by OEH and the Aboriginal site register maintained by the Pilliga Forest Aboriginal Management Committee (PFAMC) and NSW Forestry, and the results of previous surveys of the broader PAL 2 area by PFAMC cultural heritage advisors. The assessment indicated that there was little risk of direct impacts to Aboriginal sites of significance as a result of the Bibblewindi Multi-lateral Pilot. To further minimise risks, ESG proposed that PFAMC heritage advisors survey each lease area prior to commencing works.

19.1.2 Assessment approach

An additional search of the AHIMS register and an archaeological inspection of the well leases and surrounding area were undertaken by RPS for due diligence purposes. The AHIMS search was undertaken on 15 October 2012. The archaeological survey was carried out by one archaeologist walking 5.0-10 metre wide transects on 27 November 2012.

The archaeological survey found that the Bibblewindi 14 and 19H well leases have been completely cleared of vegetation and topsoil. 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. No Aboriginal objects or places recorded on the AHIMS were identified within 10 kilometres of the site. 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.

19.1.3 Potential impacts

The proposed wells and ancillary infrastructure would be located entirely within the existing established Bibblewindi 14 and 19H well leases and would not impact on any previously identified Aboriginal cultural heritage sites or objects. There is very low potential for any previously unidentified Aboriginal sites or objects to be impacted.

19.1.4 Cumulative impacts

As cultural heritage impacts are site specific, there is no cumulative impact. The sites of proposed activities within the E&A Program will be/have been assessed for potential to impact Aboriginal cultural heritage.

19.1.5 Mitigation measures

The following measures will be implemented to reduce potential impacts on Aboriginal heritage:

- Project staff and contractors will be made aware of their statutory obligations to protect Aboriginal cultural heritage objects under the NPW Act, through the 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 OEH Enviroline 131 555 will be contacted. A suitably qualified archaeologist will be contacted so that the site can be assessed 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.

19.2 Non-Indigenous cultural heritage

19.2.1 Assessment approach

Database searches of the World Heritage List register, Australian Heritage Database and the NSW State Heritage Inventory indicated that there are no listed items of National, State or Local heritage significance within the site or surrounding area. No heritage sites, relics or places of non-Indigenous cultural heritage value, or vegetation with natural heritage values, were recorded on the site during the archaeological survey undertaken by RPS on 27 November 2012.

19.2.2 Potential impacts

The project would not impact on any listed non-Indigenous cultural or natural heritage. There is limited potential for previously unidentified non-Indigenous cultural heritage items or relics to be impacted during the works.

19.2.3 Cumulative impacts

As cultural heritage impacts are site specific, there is no cumulative impact. All proposed activities within the E&A Program will be/have been assessed for cultural heritage impacts.

19.2.4 Mitigation measures

If any previously unidentified potential non-Indigenous 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.

PART C

20.0 Statement of Commitments

Table 20-1 provides a statement of commitments for the proposed activity.

Table 20-1 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.
Community consultation	▪ Community consultation will be undertaken in accordance with Chapter 5 of the EIS ▪ Advice to landholder will be provided 14 days prior to the proposed activity commencing ▪ 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 up-coming 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 rig14 days prior to the drilling rig mobilising to site.
Land resources	Construction ▪ Excess topsoil and subsoil generated during site preparation activities will be stockpiled on site and used as backfill following completion of drilling. ▪ Erosion and sediment controls will be implemented where necessary during site preparation activities, in accordance with best management practices (such as the Blue Book or IECA Guidelines). These controls will be maintained until disturbed areas of the site are stabilised. ▪ The quantity of chemicals, fuels and oils stored on site will be minimised, where practicable. ▪ All additives, chemicals, fuels and oils stored on site will be kept in an appropriately secured, bunded storage shed in accordance with the relevant MSDS. ▪ Where there is a risk of contamination pits will be lined or material will be stored in surface tanks or metal bins. ▪ An MSDS register of all chemicals used or stored on site will be maintained.

Item	Commitment
	▪ Maintenance of vehicles, plant and equipment will occur off site at an appropriately licensed facility unless deemed necessary and appropriate to conduct such maintenance on site. ▪ 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 the 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 on site 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, 2012b). ▪ 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 on site 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 two kilometres 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 two kilometres 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 the site by an appropriately licensed contractor. ▪ Fuel and lubricants will be stored on site only when necessary and maintained off site 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 millimetres 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. ▪ 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 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 E&A Program area. ▪ Appropriate monitoring of emissions and consumables will be undertaken for legislative reporting requirements (such as to inform NGERS calculations).
Noise	▪ Forestry Corporation of 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 the 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.
Waste	▪ Management of waste, including its transport, will comply with the POEO Act and POEO (Waste) Regulation. ▪ The 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 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 off-site 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. ▪ Sewage waste will be removed from the site by a licensed contractor for treatment and disposal, as required. ▪ Appropriate waste receptacles will be provided on site including covered rubbish bins for disposal of domestic wastes. These will remain during drilling activities. ▪ The type and volume of all waste removed from the site will be recorded.

Item	Commitment
	▪ All staff and contractors will be made aware of waste management procedures during the site induction and through toolbox talks. ▪ Chemical, fuel and oil containers will be managed according to the MSDS 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 MSDS 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 (RFS), Fire & Rescue NSW (FRNSW) and Forestry Corporation of NSW will be implemented.
Social and Economic	▪ Consultation activities will occur in accordance with Section 5 of the EIS.
Other	▪ Project staff and contractors will be made aware of their statutory obligations to protect Aboriginal cultural heritage objects under the NPW Act, through the 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 OEH Enviroline 131 555 will be contacted. A suitably qualified archaeologist will be contacted so that the site can be assessed 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-Indigenous 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.

21.0 Summary and Conclusion

This EIS has assessed the environmental impacts of the proposed activity to construct and drill two new wells (Bibblewindi 31 and 32) on the existing Bibblewindi 14 and Bibblewindi 19H well leases respectively, install new surface infrastructure to connect the two wells to the existing Bibblewindi Multi-Lateral Pilot and operation of Bibblewindi Multi-Lateral Pilot including Bibblewindi 31 and 32 wells, and the management of the water and gas produced during operation of the 14 wells for up to three years.

21.1 Environmental considerations

Table 21-1 summaries the environmental impacts of the proposed activity.

Table 21-1 Environmental considerations

Aspect	Potential impacts	Potential impact category (with mitigation measures)
Land resources	▪ The site is not located on Biophysical Strategic Agricultural Land and/or a Critical Industry Cluster.	negligible impact
Surface water	▪ Sedimentation of surface waters due to increased erosion. ▪ Contamination of surface waters in event of a leak or spill. ▪ Pollution/contamination of surface waters in event of flooding and inundation of the site.	minimal impact
Groundwater	▪ Groundwater contamination due to mixing of aquifers, loss of drilling mud into the formation or inappropriate management of spills. ▪ Total water abstracted over 3 years, approximately 285,110 cubic metres. ▪ Negligible change in flux or drawdown in the upper layers, no impact to registered bore users or groundwater dependant ecosystems.	minimal impact
Flooding	▪ Area not within flood prone land.	negligible impact
Biological	▪ No additional vegetation clearing or disturbance will be undertaken as part of the proposed activity. ▪ No threatened flora, fauna or migratory species listed under the TSC Act and/or EPBC Act were recorded at the site and no threatened flora, fauna or migratory species assessed as having potential to occur at the site is considered likely to be directly or indirectly impacted upon as a result of the proposed activity.	negligible impact
Dust, odours and radiation	▪ Generation of dust and other particulates. ▪ Generation of noise, particularly during drilling activities which may occur up to 24 hours per day.	negligible to minimal impact
Greenhouse gases	▪ Total greenhouse gas emissions resulting from operation of the activity are estimated to be approximately 254,602 t CO_2^e per year. This represents approximately 0.2 per cent of the total greenhouse gas emissions from NSW in 2011 (158,991,280 t CO_2^{-e}). ▪ 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. ▪ Likely greenhouse gas emissions from the proposed activity are not considered to have significant impact on increasing greenhouse gas emissions.	minimal impact

Aspect	Potential impacts	Potential impact category (with mitigation measures)
Noise and vibration	▪ Noise levels will be below the NSW Industrial Noise Policy (EPA, 1999b). ▪ Operational noise impacts related to the activity are unlikely to be result in any audible impacts at nearby residences.	negligible impact
Traffic and transport	▪ Based on existing traffic volumes on the Newell Highway and the distribution of vehicles over the day, the anticipated traffic generation for the proposed activity (typical and maximum) both during construction and operation will have a minimal impact on the Newell Highway and the surrounding road network.	minimal impact
Waste	▪ The proposed activity is likely to result in the generation of wastes, in particular during the construction phase. Waste management procedures would be developed as part of the waste management plan for the activity which would ensure waste is handled and stored appropriately and ultimately reused, recycled or disposed of in accordance with legislative requirements and best practice. ▪ Reusable other materials would be managed and reused onsite or recycled where appropriate, including treated water. Waste requiring offsite disposal would consequently be minimised and residual waste would be disposed of in an appropriate manner. As such significant, residual impacts in relation to waste are not anticipated.	minimal impact
Hazards	▪ Land, water or air pollution, or fire, from improper use of hazardous substances or chemicals.	minimal impact
Social and economic	▪ The proposed activity will result in a number of positive economic impacts for the local, regional and State economies. This includes a mix of both local and fly in fly out jobs over the course of the proposed activity (5.6 Equivalent Full Time jobs at peak), a $5.3-5.5 million economic multiplier effect from capital expenditure, increase in local expenditure on goods and services as well as the potential to increase the NSW domestic gas supply. The development of the proposed activity is in line with the goals and outcomes of both the *Narrabri Economic Development Strategy* (DTIRIS, 2011) and the Strategic Regional Land Use Plan (SRLUP) for New England and the North West.	minimal impact
Cumulative impact	▪ The proposed activity has been assessed in conjunction with other activities proposed as part of the E&A Program. All impacts have been assessed from a cumulative aspect with a particular focus on biodiversity and groundwater. ▪ The E&A Program is expected to have a negligible to minimal impact on the environment.	minimal impact

21.2 Conclusion

Santos has a long term commitment to the development of new gas supplies to the growing NSW market. The proposed activity and the E&A Program have been developed taking into account environmental, economic and social considerations. The EIS has identified the potential environmental impacts together with measures mitigate those potential impacts.

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

The EIS assesses the potential environmental impacts of the activity in accordance with clauses 6 and 7 in Schedule 2 of the *NSW Environmental Planning and Assessment Regulation 2000* and the DGRs which were issued on 20 May 2013.

The proposed activity is temporary and minor in scale. The site of the proposed activity has been selected to avoid significant environmental and heritage constraints, and reduce impacts to the surrounding community.

In considering the likely environmental significance of the impacts from the proposed activity it has been predicted that:

- potential impacts are considered to be localised and temporary in nature
- the proposed activity is unlikely to have a significant effect on highly productive groundwater sources, registered groundwater users or groundwater dependent ecosystems
- the proposed activity is unlikely to have a significant effect on the environment or the community
- the proposed activity is unlikely to have a significant effect on threatened species, populations, ecological communities or their habitats
- the proposed activity is not on land that is, or part of, critical habitat

Based on the assessments undertaken within the EIS the impact of the activity would be kept to a minimum provided that the mitigation measures identified in the EIS are employed.

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23.0 Glossary

Term/abbreviation	Meaning
Abandonment	Decommissioning the well. A process which involves shutting down the well and rehabilitating the site.
ABS	Australian Bureau of Statistics
ADGC	Australian Dangerous Goods Code
AEMO	Australian Energy Market Operator
AGE	Australasian Groundwater and Environmental Consultants
AHD	Australian Height Datum
AHIMS	Aboriginal heritage Information Management System
AIP	Aquifer Interference Policy
AIS	Agricultural Impact Statement
Annulus	The space between the wellbore and surrounding pipe.
ANZECC	Australian and New Zealand Environment and Conservation Council
API	American Petroleum Institute
Aquiclude	Compacted geological formations through which no groundwater flows.
ASC	Australian Soils Classification
Aquitard	Low permeability formation which restricts the flow of groundwater.
BOP	Blow out preventer - one of several valves installed in a wellhead to prevent the escape of pressure either in the annular space between the casing and the drill pipe or in the open hole during drilling, completion and work over operations.
BoM	Bureau of Meteorology
BOP	Blow out preventer
BSAL	Biophysical Strategic Agricultural Land
BTEX	*A* group of chemicals comprising Benzene, toluene, ethylbenzene, and xylenes.
BNCCA Act	*Brigalow and Nadewar Community Conservation Area Act 2005*
Casing	A pipe placed in a well to prevent the wall of the hole from caving in and to prevent movement of fluids from one formation to another.
Casing collar	Coupling between two joints.
Casing coupling	Tubular section of pipe that is threaded inside and used to connect two joints of casing.
Casing head	A heavy flanged steel fitting connected to the first string of casing. It provides a housing for slips and packing assemblies.
CCC	Community Consultative Committee
Cementing	The application of a liquid slurry of cement and water to various points inside and outside the casing.
Cementing head	Component fitted to the bore for the use of cementing.
Cement plug	Portion of cement placed at some point in the wellbore.
CIC	Critical Industry Cluster
CO	Carbon monoxide
Coring	Process of cutting a vertical, cylindrical sample of the formations.
CSG	Coal Seam Gas
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAMB	Deep aquifer monitoring bore
DCCEE	Department of Climate Change and Energy Efficiency

Term/abbreviation	Meaning
DD	Deposited dust
DGRs	Director-General's Requirements
DO	Dissolved Oxygen
DP&I	NSW Department of Planning and Infrastructure
DPI	NSW Department of Primary Industries
DRET	Department of Resources, Energy and Tourism
Drill fluid/mud	Circulating fluid that can lift cuttings from the wellbore to the surface and to cool down the drill bit.
DST	Drill Stem Test
DTIRIS	Department of Trade, Investment, Regional Infrastructure and Services
E&A Program	Santos's NSW Exploration and Appraisal Program for PEL 238 and PAL 2.
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EEC	Endangered Ecological Communities
EFT	Equivalent Full Time
EHSMS	Environmental, Health and Safety Management System
EIS	Environmental Impact Statement
EPA	NSW Environmental Protection Authority
EPL	Environment Protection Licences
ESD	Ecologically Sustainable Development
ESG	Eastern Star Gas
FIFO	Fly in/fly out
flux	rate of volume flow across a unit area ($m^3/s /m^2$)
FTF	Fluids treatment facility
HDPE	High density polyethylene
K_2S0_4	Potassium sulphate
kPag	Kilopascal gauge
KTPs	Key threatening processes
GAB	Great Artesian Basin
GDE	Groundwater dependent ecosystems
GHG	Greenhouse gases
GJ	Gigajoule
GWP	Global Warming Potential
ICNG	Interim Construction Noise Guideline
IECA	International Erosion Control Association
INP	Industrial Noise Policy
ISCA	Infrastructure Sustainability Council of Australia
IVMS	In vehicle monitoring system
killing the well	Flushing the well with a higher density liquid
LA_{eq}	Logarithmic average noise level from all sources
LA_{90}	Also called L90 or background. An indicator of the quietest time of day and is calculated as the noise level equalled or exceeded for 90% of the measurement time.

Term/abbreviation	Meaning
LCM	Lost circulation material
LGA	Local government area
LSC	Land and soil capability class
m^3	Cubic metres
MDB	Murray-Darling Basin
ML	Mega litres
MNES	Matter of National Environmental Significance
MMscf	Million standard cubic feet
MSDS	Materials Safety Data Sheets
MW	Mega watt
$NaHC0_3$	Sodium Hydrogen Carbonate
NATA	National Association of Testing Authorities
NEM	Naturally Excavated Material
NV Act	Native Vegetation Act 2003
NGA	National Greenhouse Accounts
NGER Act	National Greenhouse Energy Reporting Act
NGERS	National Greenhouse Energy Reporting Scheme
NOC	Narrabri Operations Centre
NOW	NSW Office of Water
NO_2	Nitrogen dioxide
NPW	National Parks and Wildlife
NSW	New South Wales
NSW State Plan 2021	*NSW 2021: A Plan to Make NSW Number One*
NTSCORP Ltd	the Native Title Service Provider for Aboriginal Traditional Owners in NSW
NV	Native vegetation
OCSG	Office of Coal Seam Gas
OEH	Office of Environment and Heritage
Packer	Piece of down hole equipment that consists of a sealing device. Used to block the flow of fluids through the annular space between the pipe and the wall of the wellbore.
PAL	Petroleum Assessment Lease
PAWC	Plant Available Water Capacity
PEL	Petroleum Exploration Licence
PET	Polyethylene terephthalate
PFAMC	Pilliga Forest Aboriginal Management Committee
PFC	Projected foliage cover
PHA	Preliminary hazard analysis
PHPA	Partially Hydrolised Poly Acrylamide
Plug	Any object or device that blocks a hole or passageway.
PM_{10}	Measure of particles in the atmosphere with a diameter of less than 10 or equal to a nominal 10 micrometres
POEO	*Protection of the Environment Operations Act 1997*
POEO (Waste) Regulation	*Protection of the Environment Operations (Waste) Regulation 2005*

Term/abbreviation	Meaning
POP	Petroleum Operations Plan
RAMSAR	RAMSAR convention is an intergovernmental treaty to conserve wetlands of international importance
RBL	Rating background noise levels
REF	Review of Environmental Factors
RMS	NSW Roads and Maritime Services
RPS	RPS Australia East Pty Ltd
RTU	Remote Telemetry Unit
SAL	Strategic Agricultural Land
Santos	Santos NSW (Eastern) Pty Ltd
SEIA	Social and Economic Impact Assessment
SEPP	State Environmental Planning Policy
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities
SCADA	Supervisory Control and Data Acquisition
SIS	Species Impact Statement
SRD SEPP	State and regional development State Environmental Planning Policy
SRLUP	State and Regional Land Use Policy
SSD	State Significant Development
Surface casing	A drilled and cemented pipe used to provide blow-out protection, to seal off water/hydrocarbon sands and prevent the loss of circulation. Also used to seal off water sands, weak formations and/or lost circulation zones. In some cases surface and intermediate casing requirements are provided by the same string.
TAPM	Air population model developed by CSIRO
TCP	Traffic control plan
TEC	Threatened Ecological Communities
TDS	Total dissolved solids
THPS	Tetrakis Hydroxymethyl Phosponium Sulphate
TSC Act	*Threatened Species Conservation Act 1995*
TSR	Travelling stock routes
TSP	Total suspended particulates
Surface casing	A drilled and cemented pipe used to provide blow-out protection, to seal off water/hydrocarbon sands and prevent the loss of circulation. Also used to seal off water sands, weak formations and/or lost circulation zones. In some cases surface and intermediate casing requirements are provided by the same string.
WAL	Water access licence
Wall cake	Low permeability ‘skin’ around the wall of the hole.
Wellhead	The system of spools, valves and associated adapters that provide pressure control for production.
WMA	Water Management Act 2000
WPPS	Wilga Park Power Station
WSP	Water Sharing Plan
WTF	Water Transfer Facility

Appendix 1

Director-General's Requirements

Director-General's requirements	EIS Reference
General requirements	
▪ detailed description of the development, including	Chapter 4
- need for the proposed development	Sections 2.1, 2.2 and 2.3
- Justification for the proposed plan, including efficiency of resource recovery, safety and environmental protection	Section 2.4
- Likely staging of the development – including construction, operational stage/s and rehabilitation	Section 4.1, including Table 4-1
▪ consideration of all relevant environmental planning instruments, including identification and justification of any inconsistencies with these instruments	Chapter 6
▪ risk assessment of the potential environmental impacts of the development, identifying key issues for further assessment	Section 7.2, including Tables 7-1 and 7-2
▪ detailed assessment of the key issues specified below, and any other significant issues for further assessment, which includes;	Chapters 8 to 19
- a description of the existing environment, using sufficient baseline data	Section x.1 of chapters 8 to 19
- an assessment of potential impacts of all stages of the development, including any cumulative taking into consideration relevant guidelines, policies, plans and statutes	Sections 8.2, 8.3, 9.3, 9.4, 10.2, 10.3, 11.3, 11.4, 12.3, 12.4, 13.3, 13.4, 14.3, 14.4, 15.3, 15.4, 16.2, 16.3, 17.3, 17.4, 18.2, 18.3, 18.4, 19.1, 19.2
- a description of the measures that would be implemented to avoid, minimise and if necessary, offset the potential impacts of the development, including proposals for adaptive management and/or contingency plans to manage any significant risks to the environment	Sections 8.4, 9.5, 10.4, 11.5, 12.5, 13.5, 14.5, 15.5, 16.4, 17.5, 18.5, 19.1, 19.2
▪ consolidated summary of all the proposed environmental management and monitoring measures, highlighting commitments included in the EIS	Table 20-1
▪ a detailed calculation of the capital investment value (as defined in clause 3 of the Environmental Planning and Assessment Regulation 2000) of the proposal, including details of all the assumptions and components from which the CIV calculation is derived	Attached
▪ a close estimate of the jobs that will be created by the development during the construction and operational phases of the development	Section 18.3.1
▪ certification that the information provided is accurate at the date of preparation	Attached
Key Issues	
Land Resources	Specialist reports in Appendix 2, summarised in Chapter 8.
▪ an assessment of the potential impacts on	
- soils and land capability (including contamination)	Section 8.2.2
- soil erosion, sediment transport and regional salinity	Section 8.2.2
- agricultural land, including a Site Verification Certificate and Agricultural Impact Statement	Section 8.2.1 and Appendix 2
- land use, including forestry, conservation and recreational use, with particular reference to the Bibblewindi State Forest	Section 8.2.1
Water Resources	Specialist reports in Appendix 3, summarised in Chapters 9 and 10.
▪ adequate baseline monitoring for all surface water and groundwater sources and dependent ecosystems within and adjacent to the development	Sections 9.5.3, 10.1.4
▪ demonstrated compliance with the NSW Aquifer Interference Policy (2012)	Section 9.4

Director-General's requirements	EIS Reference
▪ detailed assessment of potential impacts on the quality and quantity of existing surface water and groundwater resources, including	
- detailed modelling of potential groundwater impacts including identification of any highly productive groundwater (as defined by the Aquifer Interference Policy) or groundwater dependent ecosystems, with particular reference to the Upper and Lower Namoi Alluvium and the southern recharge groundwater sources of the NSW Great Artesian Basin	Appendix 3, and Sections 9.1.3 and 11.5.3
- a description of any proposed hydraulic fracturing	No hydraulic fracturing is proposed
- impacts on riparian, ecological, geomorphological and hydrological values of watercourses or swamps, including environmental flows, with particular reference to Cowallah Creek and Mount Pleasant Creek	Section 10.2, 11.1.5
- cumulative impacts associated with existing developments as well as any currently approved developments or proposed future developments	Sections 9.4 and 10.3
- the quantity and quality of regional water supplies	Sections 9.1.4 and 10.1.1
- details of critical thresholds for negligible impacts to surface water and groundwater sources and dependent ecosystems	Section 10.1.3, Appendix 3
- affected licensed water users and basic landholder rights (including downstream water users)	Sections 9.1.2 and 9.4.4
▪ a detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures	Section 4.4.2
▪ a detailed description of the management of water at both the Bibblewindi Water Management Facility and the Leewood Produced Water and Brine Management Facility	Section 4.4.2
▪ identification of any licensing requirements, including existing or future Environment Protection Licences (EPLs) or Pollution Reduction Programs (PRPs), and approvals under the Water Act 1912 and/or Water Management Act 2000	Sections 6.2.3, 6.2.4 and 6.4
▪ a description of the casing of wells that ensures the protection of the integrity of all underground aquifers, prevents gas escape and maintains groundwater quality, in accordance with the Code of Practice for Coal Seam Gas Well Integrity	Sections 4.3.5
▪ demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plans (WSP) or water source embargo	Sections 4.3.8, 9.5.4 and 10.4.3
▪ a description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP	Section 9.4
▪ a description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts, including the use of above ground tanks to contain drilling fluids, adequate spill control measures, contingency planning and produced water management	Sections 4.4.2, 9.5.3 and 10.1.4
▪ an assessment of local flood risks, including appropriate mitigation measures	Sections 10.2.4 and 10.4
Biodiversity	Specialist report in Appendix 4, summarised in Chapter 11.
▪ estimates of any proposed vegetation clearing	Section 11.3.1
▪ an assessment of potential impacts of the development on any	
- terrestrial or aquatic threatened species or populations and their habitats, endangered ecological communities and groundwater dependent ecosystems	Sections 11.3.2, 11.3.3, 11.3.5. No EECs listed under the TSC Act occur at the site or within the surrounding 10 km.
- regionally significant remnant vegetation, or vegetation/wildlife corridors	Section 11.3.1

Director-General's requirements	EIS Reference
▪ impacts on the Bibblewindi State Forest, including impacts on conservation and recreational values	Section 11.3.1
▪ measures taken to avoid, reduce or mitigate impacts on biodiversity	Section 11.5
Air Quality	Specialist report in Appendix 5, summarised in Chapter 12.
▪ a quantitative assessment of potential	
- construction and operational impacts, with a particular focus on dust emissions including PM_{10} emissions and the dust generation from transport	Sections 12.3 and 12.3.2
- risk associated with potential discharges of fugitive and point source emissions for all stages of the proposal, including risk of environmental harm and risk to human health and amenity	Sections 12.3.1 and 12.3.2
- cumulative impacts associated with existing emission sources as well as any currently approved developments or proposed future developments	Section 12.4
- flaring and/or venting	Section 12.3.2
- monitoring and management measures, including real-time air quality monitoring	Section 12.5
Greenhouse Gases	Chapter 13
▪ a quantitative assessment of potential Scope 1, 2 and 3 greenhouse gas emissions	Section 13.3, there are no Scope 2 emissions as there is no purchase of energy from the grid.
▪ a qualitative assessment of the potential impacts of these emissions on the environment	Section 13.3.4
▪ an assessment of reasonable and feasible measures to minimise greenhouse gas emissions and ensure energy efficiency, including consideration of alternative power sources	Section 13.5
Noise	Specialist report in Appendix 6, summarised in Chapter 14.
▪ an assessment of potential	
- construction, operational and transport noise impacts	Sections 14.3 and14.4
- offsite road noise impacts	Section 14.3.2
- reasonable and feasible mitigation measures, including evidence that there are no such measures available other than those proposed	Section 14.5
- monitoring and management measures	Section 14.5
Traffic and Transport	Specialist report in Appendix 7, summarised in Chapter 15.
▪ an assessment of the project on the capacity, functionality, efficiency and safety of the local road network	Sections 15.3
▪ details of road transport volumes and types broken down into origin and destination, travel routes and peak hours for the construction, operation and decommissioning of the project	Section 15.2, Table 15-2 and Figure 4-4
▪ a description of the measures that would be implemented to maintain and/or improve the capacity, functionality, efficiency and safety of the road networks in the surrounding area over the life of the project	Section 15.5
▪ details of the location of all waterways crossings, including any new access tracks or existing waterway crossing upgrades	Section 15.2
▪ a description of the transfer of gas via pipeline and flowline to the Bibblewindi Water Management Facility and Wilga Park Power Station	Section 4.4.3
Waste	Chapter 16
▪ estimates of the quantity and nature of the potential waste streams of the development, including well cuttings, drilling fluids and produced water	Section 16.2, Table 16.1

Director-General's requirements	EIS Reference
▪ identification, characterisation and classification of all waste that is proposed to be disposed of to an offsite location, including proposed quantities and disposal locations	Table 16.1
▪ a description of measures that would be implemented to minimise production of other waste, and ensure that the waste is appropriately managed	Section 16.4
▪ outline contingency plans for any event that affects operations at the site that may result in environmental harm	Sections 8.4, 16.4 and 17.5.1
Hazards	Chapter 17
▪ attention to public safety, chemical use and including bushfires	Section 17.3
Social and Economic	Chapter 18.
▪ an assessment of the	
- potential direct and indirect economic benefits of the project for local and regional communities and the State	Sections 18.1.2 and 18.3
- an assessment of the costs and benefits of the development as a whole, and whether it would result in a net benefit for the NSW community	Section 18.4
Rehabilitation	
▪ proposed rehabilitation strategy for the site, having regard to the key principles in the Code of Practice for Coal Seam Gas Well Integrity, including:	Section 4.5
- rehabilitation objectives, methodology, monitoring programs, performance standards and proposed completion criteria	Section 4.5.1
- nominated final land use, having regard to any relevant strategic land use planning or resource management plans or policies	Section 4.5.1.1
- timeframes for exploration activities and subsequent rehabilitation	Table 4-1
- justification of criteria regarding completion of any rehabilitation program	Section 4.5.1.3
- the potential for integrating this strategy with any other rehabilitation strategies in the region	Section 4.5.1
Plans and Documents	
▪ The EIS must include all relevant plans, architectural drawings, diagrams and relevant documentation required under Schedule 1 of the Environmental Planning and Assessment Regulation 2000. ▪ These documents should be included as part of the EIS rather than as separate documents	Throughout EIS document
Consultation	
▪ During the preparation of the EIS, you must consult with relevant local, State and Commonwealth Government authorities, service providers, community groups and affected landowners In particular you must consult with the:	Chapter 5, in particular Tables 5-2 and 5-3
- Commonwealth Department of Sustainability, Environment, Water, Population and Communities	
- Office of Coal Seam Gas and Division of Resources and Energy within the Department of Trade and Investment, Regional Infrastructure and Services	
- Department of Primary Industries (including the NSW Office of Water, Forestry Corporation, NSW Agriculture and NSW Fisheries, and Catchments and Lands (Crown Lands Division))	
- Environment Protection Authority	
- NSW Health	
- Office of Environment and Heritage (including the Heritage Branch)	
- Namoi Catchment Management Authority	

Director-General's requirements	EIS Reference
- Transport for NSW (including the Centre for Transport Planning and Roads and Maritime Services)	
- Narrabri Shire Council	
- Rural Fire Services	
▪ The EIS must	
- describe the consultation process used and demonstrate that effective consultation has occurred	Sections 5.2 and 5.3
- describe the issues raised by public authorities, service providers, community groups and landowners	Tables 5-2 and 5-3
- identify where the design of the development has been amended in response to issues raised	Tables 5-2 and 5-3
- otherwise demonstrate that issues raised have been appropriately addressed in the assessment	Tables 5-2 and 5-3

Appendix 2

Agricultural Impact Statement

Bibblewindi Gas Exploration Pilot Expansion PAL 2, Gunnedah Basin, NSW

Agricultural Impact Statement

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Signature	Date
	27/08/2013

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1.0 Summary

An agricultural impact statement (AIS) has been prepared for the proposed Bibblewindi Gas Exploration Pilot Expansion. The AIS determines if any agricultural resources or associated agricultural infrastructure would be impacted by the proposed works.

In the context of the total area of the proposed activity and the wider agricultural uses of the region, the temporary and minor loss of land is considered to have low risk on agricultural resources and industries. Further, the proposed mitigation, management and monitoring systems in place suggest that the likelihood of impacts occurring would be unlikely or rare.

The proposed activity is not located on or near (the nearest mapped BSAL is 15 km east of Bibblewindi 31) Biophysical Strategic Agricultural Land (BSAL) or any Critical Industry Clusters (CIC). Further, there will be no pressure on agricultural support infrastructure including:

- Water supply or services;
- Railways;
- Travelling stock routes (TSR); and
- Processing facilities.

The proposed works will result in minor increases in traffic along X-Line Road, Tighes Gully Road and Little Tighes Road, throughout the duration of the proposed activity. This level of traffic could easily be accommodated by the existing road network. Further, there will be no disruption to agricultural rail networks or TSRs, as the proposed pilot sites are not located adjacent to any such infrastructure.

2.0 Introduction

In accordance with clause 6 and 7 in Schedule 2 of the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation), the Strategic Regional Land Use Plan New England North West (SRLUP) (Department of Planning and Infrastructure (DP&I, 2012a)) identifies and protects more than two million hectares of strategic agricultural land and valuable water resources, and provides greater certainty for companies wanting to invest in mining and coal seam gas (CSG) projects in regional NSW.

As a result of this policy, an agricultural impact statement (AIS) is required for exploration activities subject to approval for any state significant developments. The AIS is to form part of the Environmental Impact Statement (EIS) for assessment.

Santos NSW (Eastern) Pty Limited (Santos) proposes to drill two new wells (Bibblewindi 31 and Bibblewindi 32) on existing lease areas and operating the two new wells as part of the existing Bibblewindi Multi-Lateral Pilot. The proposed activity is located along Little Tighes Road within the Bibblewindi State Forest, approximately 40 km south of Narrabri, NSW (the proposed activity). The purpose of the proposed activity is to investigate the potential CSG resource of the Gunnedah Basin within Petroleum Assessment Lease 2 (PAL 2).

The purpose of the AIS is to assess the potential impacts of proposed works on agricultural resources and industries. The term 'agricultural resource' is used to describe the land on which agriculture is dependent and the associated water resources (quality and quantity) that are linked to that land. The AIS was prepared following the requirements of *'Guidelines for agricultural impact statements'* (DP&I, 2012b) and *'Guidelines for agricultural impacts statements at the exploration stage'* (DP&I, 2012c).

This document is an appendix of the EIS and should be read in conjunction with the EIS.

3.0 Project Description

3.1 Regional Location

The proposed activity is located in the south eastern section of PAL 2 (**Figure 3.1**). PAL 2 covers an area of approximately 267 km^2 and extends across the Narrabri local government area (LGA).

The proposal is located approximately 40 km south of Narrabri and approximately 37 km west of Boggabri, within the Bibblewindi State Forest. The State forest forms part of a large tract of bushland referred to as the Pilliga Scrub, which encompasses numerous protected estates, including:

- Pilliga East State Conservation Area located approximately 7 km south of Bibblewindi 31;
- Willala Aboriginal Area located approximately 13 km south-east of Bibblewindi 31; and
- Pilliga State Conservation Area approximately 25 km north-west of Bibblewindi 32.

3.2 Site Location

Bibblewindi 31-32 will be drilled on existing lease areas which are part of the Bibblewindi Multi-Lateral Pilot (Bibblewindi 12-21) (**Figure 3.2**). Bibblewindi 32 is located along Little Tighes Road, while Bibblewindi 31 is located approximately 1.3 km south east of Bibblewindi 32. The Newell Highway runs in a north-south direction 8.5 km to the west of Bibblewindi 32.

The site will be visible from Little Tighes Road and potentially X-Line Road and Boundary Road. The nearest dwelling is located at least 7.5 km to the north west of Bibblewindi 32. The site will not be visible from agricultural properties and they do not constitute a key view from any residential property.

3.3 Proposed Activities

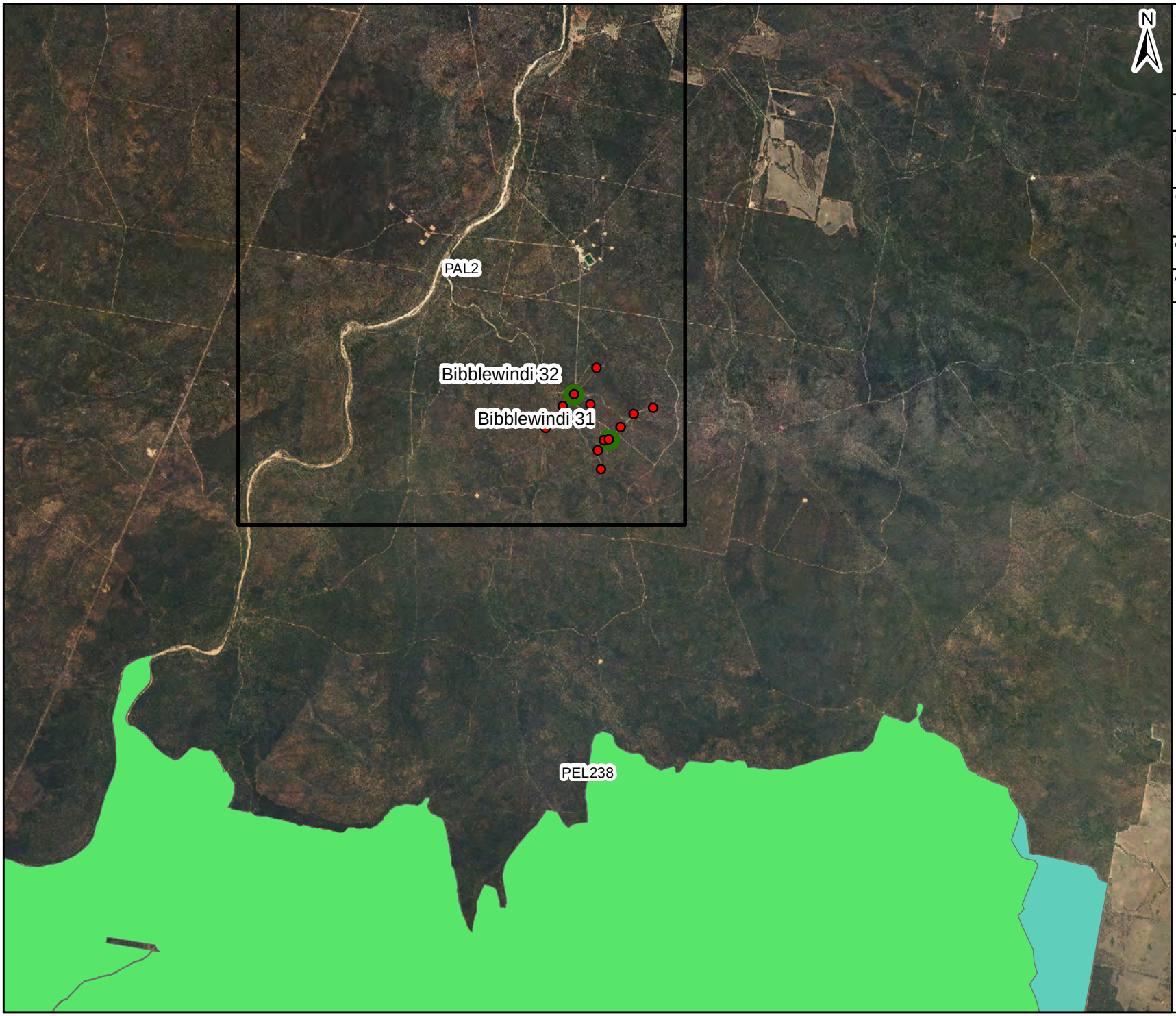
The proposed activity includes drilling two new wells (Bibblewindi 31 and Bibblewindi 32) on existing Bibblewindi 14 and 19H well leases respectively, installation of surface infrastructure to connect the two wells to the existing Bibblewindi Multi-Lateral Pilot and operation of the Bibblewindi 31 and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

The proposed activity includes:

- Construction: site preparation of the well leases and establishing necessary equipment, temporary structures and facilities on the existing lease areas to enable drilling; drilling one vertical (Bibblewindi 31) and one lateral (Bibblewindi 32) pilot well 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 3 years and general maintenance activities; and
- Post operation and rehabilitation: decommissioning and rehabilitation of pilot wells and ancillary infrastructure following well abandonment.

The proposed activity does not include the assessment of establishing the lease areas, the water and gas gathering system, access tracks and partial rehabilitation of the lease areas. These works were previously approved under Part 5 of the EP&A Act by the former NSW Department of Primary Industries (DPI), which approved drilling and operation of Bibblewindi 12 to 19H on 8 August 2008 and Bibblewindi 21H and 27 - 29 on 20 July 2009.

Reference to 'the site' includes the footprint for the proposed new wells (Bibblewindi 31 and 32) and the current Bibblewindi Multi-Lateral Pilot. The new wells will be contained on the existing well leases for Bibblewindi 14 and 19H respectively with no new disturbance beyond these lease areas.



NSW Estates and Petroleum Titles

Figure 3.1

Project:	Bibblewindi Gas Exploration Pilot Expansion
Client:	Santos
Compiled by: MM	Date: 08/07/2013
Approved by: JC	Date: 08/07/2013

Legend

- Existing Well Sites
- Proposed Well Sites
- Petroleum Titles

NSW Estates

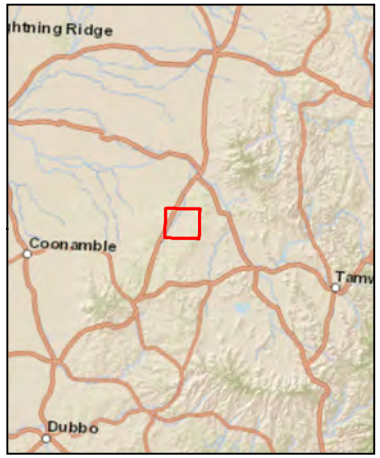
- ABORIGINAL AREA
- CCA ZONE 1 NATIONAL PARK
- CCA ZONE 2 ABORIGINAL AREA
- CCA ZONE 3 STATE CONSERVATION AREA
- NATIONAL PARK
- NATURE RESERVE
- STATE CONSERVATION AREA

Source: Imagery from Santos 2012
Infrastructure from Santos 2012
Other dats supplied from OEH 2012

0 1 2 4 km

Datum: GDA94
Scale 1:120,000 @ A4

RPS





Site Layout

Figure 3.2

Project:	Bibblewindi Gas Exploration Pilot Expansion
Client:	Santos
Compiled by: MM	Date: 08/07/2013
Approved by: JC	Date: 08/07/2013

Legend

- Existing Well Sites
- Proposed Well Sites
- Watercourses

Source: Imagery from Santos 2012
Infrastructure from Santos 2012
Other dats supplied from OEH 2012

0 0.15 0.3 0.6 km

Datum: GDA94
Scale 1:10,000 @ A4

RPS



4.0 Project Design Review / Alternatives

4.1 Analysis of alternatives

Alternatives considered for the proposed activity included do nothing, alternative drilling locations but with operation as part of the Bibblewindi Multi-Lateral Pilot or establishment of a new pilot. On balance the proposed activity best meets the needs of the program whilst reducing surface disturbance. Each of these alternatives are briefly discussed below.

4.1.1 Do nothing

To date there has not been enough background information produced from the Bibblewindi Multi-Lateral Pilot to adequately assess the potential gas resource in the area. Doing nothing would not achieve the objectives of the proposed activity or the overall program and is not a viable option.

4.1.2 Alternative location within the Bibblewindi Multi-Lateral Pilot

ESG originally proposed to add three new wells to the Bibblewindi Multi-Lateral Pilot. These wells were proposed to be located on new well leases within vegetated areas adjacent to the existing wells.

Since purchasing ESG, Santos has redesigned the proposal to avoid further surface disturbance and reduce potential impacts to biodiversity, heritage and the environment generally. This has included reducing the number of additional wells from three to two and siting the proposed new wells on existing well leases within the pilot. This requires the need for directional drilling and a small “S” shape in the vertical well. This process will increase the cost of drilling however avoids the need for additional clearing for a new well lease.

By connecting the wells to the existing infrastructure servicing the existing Bibblewindi Multi-Lateral Pilot additional surface disturbance is avoided.

4.1.3 Establishment of a new pilot

Establishment of a new pilot would require the establishment of lease areas (approximately one hectare in size), access tracks and supporting gas and water management facilities. This would require vegetation clearing and potential impacts on biodiversity and heritage.

5.0 Agricultural Enterprise and Resources

The proposed activity is located within the Bibblewindi State forest, with much of the surrounding area comprised of similar landscapes. Both the site and surrounds have minimal agricultural land uses. Since the site does not currently support any intensive agricultural industries, the following section identifies the agricultural enterprises that exist within the surrounding Narrabri LGA.

5.1 Agricultural Enterprise

In the Northern Plains, grain and cotton are the most significant crops, while beef and sheep grazing are also important. Moree and Narrabri LGAs produce 66% of NSW cotton from 4% of the state's area. These same LGAs also produce 5% of the gross value of NSW beef cattle. The area known as the Golden Triangle (350,000 ha between Bellata, North Star and Yallaroi), produces consistently high yields of prime hard (high protein) wheat (DP&I, 2012a).

There were an estimated 1,857 businesses registered in Narrabri Shire in June 2007. Agriculture, Forestry & Fishing is the largest industry, accounting for 49.8% of the total number of businesses (NSC 2007).

The dominant land use in the Namoi catchment is sheep and cattle grazing which accounts for 51% of land use by area (**Table 5.1** and **Figure 5.1**). Wheat, cotton and other broad acre crops are grown along the alluvial floodplains. Extensive areas of land for conservation and forestry occur in the middle of the catchment to the south of Narrabri. Together with other natural vegetation landscapes, these land uses account for over 24% of the catchment. Much of this area comprises the Pilliga Scrub, a significant area of remnant dry sclerophyll forest.

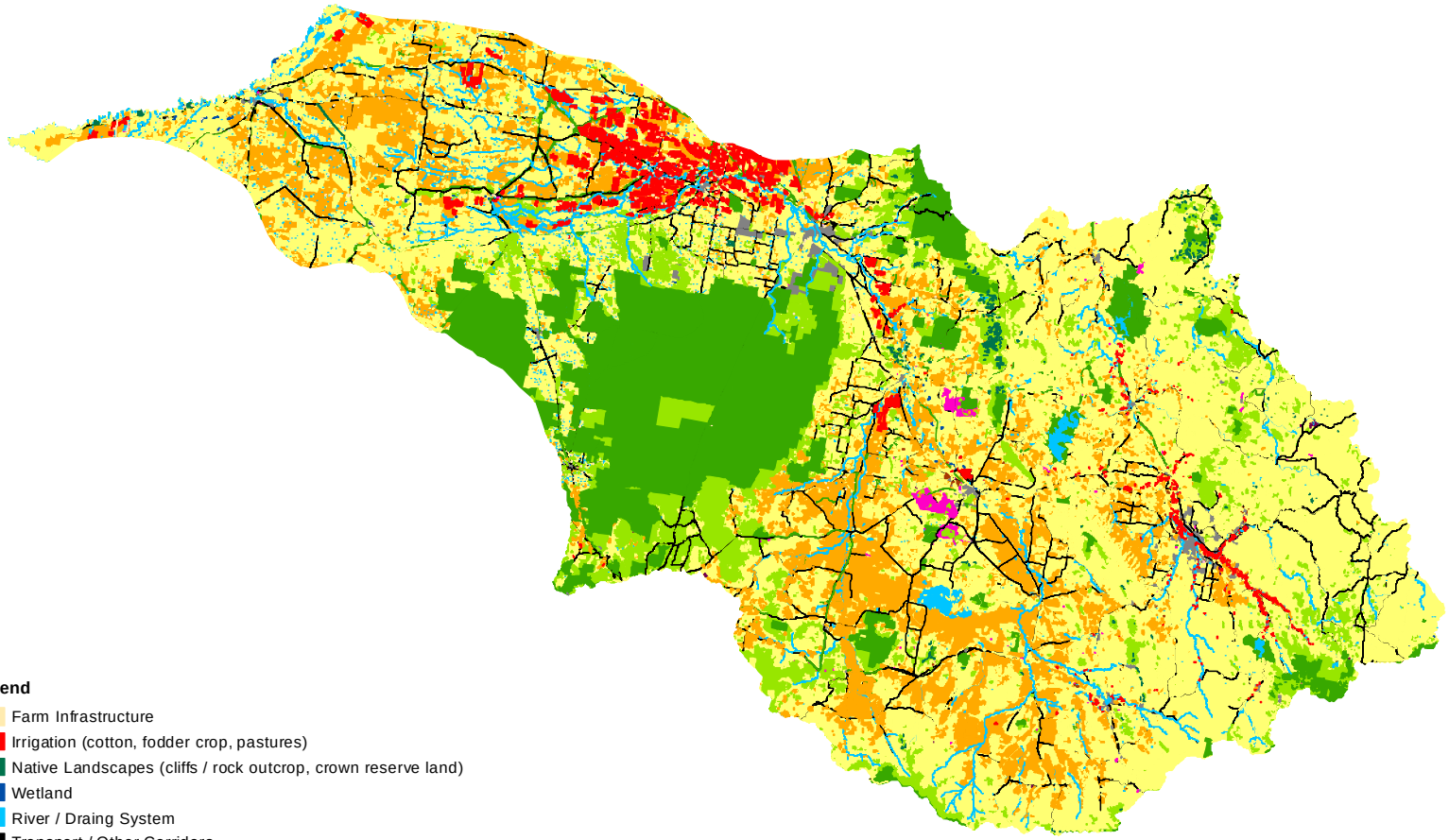
Table 5.1: Land use statistics for the Namoi catchment (source: NSW Department of Environment and Climate Change, 2011).

Land Use	Extent (ha)	Proportion of Catchment (%)
Wetland	2153	<0.1
River/drainage	61100	1
Transport/corridor	27032	1
Urban	35726	1
Cropping	848769	20
Irrigation (cotton, fodder crop, pastures)	80188	2
Grazing	2132230	51
Horticulture	1217	<0.1
Intensive Animal Production	1422	<0.1
Conservation Area	628999	15
Tree and Shrub Cover	369950	9
Mining/Quarrying	1923	<0.1
Power Generation	99	<0.1
Farm Infrastructure	2917	<0.1
Native Landscapes (cliffs / rock outcrop, crown reserve)	4637	0.1

The Bibblewindi Multilateral Pilot is located within Bohena sub-catchment. Cleared areas are mainly in the northern part of the sub-catchment and are predominantly used for sheep and cattle grazing of native and improved pastures.

The Bibblewindi Multilateral Pilot is located in the Bibblewindi State Forest, with much of the surrounding area comprised of similar landscapes. Both the site and its surrounds are not used for intensive agricultural purposes. Further, there is little evidence of exotic plantations; rather these areas include State forest used for timber harvesting and nature reserves. Timber harvesting within the Bibblewindi State Forest has been reduced largely due to conservation efforts; therefore such enterprises are not considered significant. Recreational activities in the Bibblewindi State Forest include hiking, camping and bird watching.

There are approximately 3,195 registered beekeepers in the state of NSW. Amateur beekeepers account for 77% of registrations in NSW. The 148 beekeepers owning over 500 hives may be termed professional beekeepers and constitute 4.6% of total apiary registrations in NSW (RIRDC, 2007). Current estimates with the Narrabri and Gunnedah LGAs indicate that a total of 7 people are employed as beekeepers (ABS, 2010). The Bibblewindi State Forest provides areas for beekeepers to carry out apiary activities. No artificial nesting hives were identified at defined project sites in the Pilliga. Further, as the proposed pilot sites would be located on existing lease areas (previously cleared) they do not harbour target honey trees such as the Pilliga Box, Yellow Box and Narrow Leaved Ironbark species which may yield honey from time to time.



N

Legend

- Farm Infrastructure
- Irrigation (cotton, fodder crop, pastures)
- Native Landscapes (cliffs / rock outcrop, crown reserve land)
- Wetland
- River / Draing System
- Transport / Other Corridors
- Urban
- Cropping
- Grazing
- Horticulture
- Intensive Animal Production
- Conservation Area
- Tree and Shrub Cover
- Mining / Quarrying
- Power Generation
- River Drainage systems

Namoi Catchment Land USe

Figure 5.1

Project: Bibblewindi Gas Exploration Pilot Expansion

Client: Santos

Compiled by:	JC	Date:	08/07/2013
Approved by:	DF	Date:	08/07/2013

Source: Imagery from Bing Maps 2012
Infrastructure from Santos 2013
other data from OEH2012 and DECC 2011

0 20 40 80 km

Datum: GDA94

RPS



5.1.1 Agricultural Production Value

Agriculture and agribusiness is worth $1.8 billion per annum to the New England - North West regional economy (ABS 2006 Census), which represents approximately 20% of the gross value of agriculture and agribusiness for the entire state. Sheep and cattle grazing, broad acre cereal crops, irrigated cotton, intensive livestock and plant agriculture and poultry production are the main contributors (DP&I, 2012a).

In 2009 / 2010 the Narrabri Shire recorded a Gross Regional Product (GRP) of $730 million, with agriculture, forestry and fishing contributing $115.3 million (15.8%) of total GRP (AEC, 2011), resulting in this sector being the second largest contributor to GRP in Narrabri Shire, behind the mining sector.

In 2006, gross value of agricultural production in Narrabri Shire was $260.50 million, with crop value contributing $215.10 million (82.5%) to total production value. Livestock slaughtering and livestock products contributed $41.40 million (15.9%) and $4.0 million (1.5%) to total production value, respectively.

5.1.2 Employment

The Narrabri Shire area sustains expansive cropping activities, with the two largest crops produced in the region being cotton and wheat. Other crops grown in the region include sorghum, sunflowers, cereal grains, oilseeds and legumes. Grazing of beef cattle, sheep and pigs is also a significant contributor to the agricultural productivity within the region (AEC, 2011).

Agricultural employment data recorded in 2009 / 2010 has been reproduced below to represent the diversity of agricultural enterprise across the Narrabri Shire (**Figure 5.2**). The data demonstrates that the largest agricultural enterprises in the region are cotton and grain industries, which employ approximately 47% of the agricultural workforce.

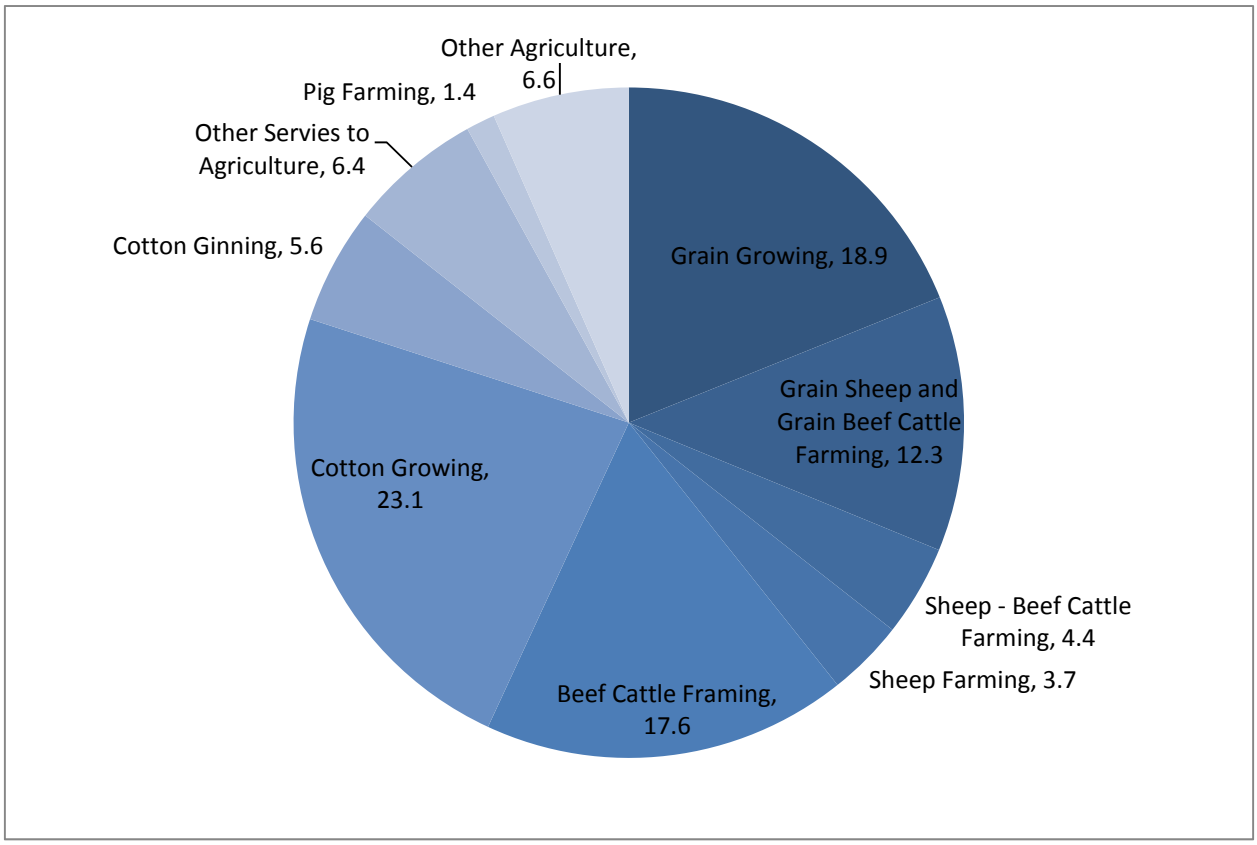


Figure 5.2: Agricultural Employment (%) by Place of Work (Reproduced from AEC, 2011)

5.2 Agricultural Support Infrastructure

Due to the scale, diversity and productivity of agricultural enterprise within the Narrabri Shire, processing companies, research and development facilities, transport and warehousing and other service industries have been established in the Narrabri Shire (DP&I, 2012a), including:

- Livestock selling centre;
- Farm management services;
- Grain and cotton processing centres;
- Grain and field bean merchant wholesalers;
- Agricultural research facilities; and
- Crop harvesting selling centres.

The Kimilaroi and Newell Highways run through Narrabri and provide access between the coast and inland NSW. The Newell Highway is part of the National Land Transport Network and forms a major linkage between regional centres in North West NSW to Brisbane and Melbourne (DP&I, 2012a). Approximately half of the traffic which utilises the Newell Highway consists of heavy freight of which 32% is B-doubles and road trains.

The Walgett railway services part of north-western New South Wales. Opened in 1908, it branches from the Main North line at Narrabri and passes through the towns of Wee Waa and Burren before terminating at Walgett. The line is used mainly for wheat haulage and runs adjacent to Culgoora Road.

There is no agricultural rail infrastructure near the site or in the surrounds of the proposed activity. The nearest railway line is located approximately 33 km east of the proposal. Further, the proposal is not located on or in the vicinity of any travelling stock routes (TSR). The nearest TSR is located approximately 16 km north of the site.

5.3 Tourism

Tourism in the Narrabri shire is led by its natural attractions. The Pilliga State Forest and Mount Kaputar National Park are two of the largest tourism interests of the region. Farm holidays, historical museums, Yarrie Lake, artesian bore baths, art shows and visiting cultural production further add to the region's tourism attractions.

5.4 Agricultural Resources

5.4.1 Climate

The closest running weather station is located at Narrabri West Post Office (station 053030); however below details the climatic data from Narrabri (station 54120) as Narrabri West does not include pan evaporation (mm). Climate in the Narrabri region is regarded as semi-arid, due to hot summers and mild winters (**Figure 5.3**). Average (1900 - 2012) monthly maximum temperatures range from 17.7°C (July) to 34.6°C (Jan) (**Table 5.2**). Maximum temperatures have historically exceeded 40°C. Frost can occur in all low lying parts of the region. Frost events generally occur between June and August though can begin as early as April. Narrabri has historically recorded frost events as late as October.

Average annual rainfall in Narrabri is 640.5 mm. Pan evaporation exceeds rainfall throughout the year, indicating the regions reliance on irrigation and soil water storage during fallow (**Figure 5.3**).

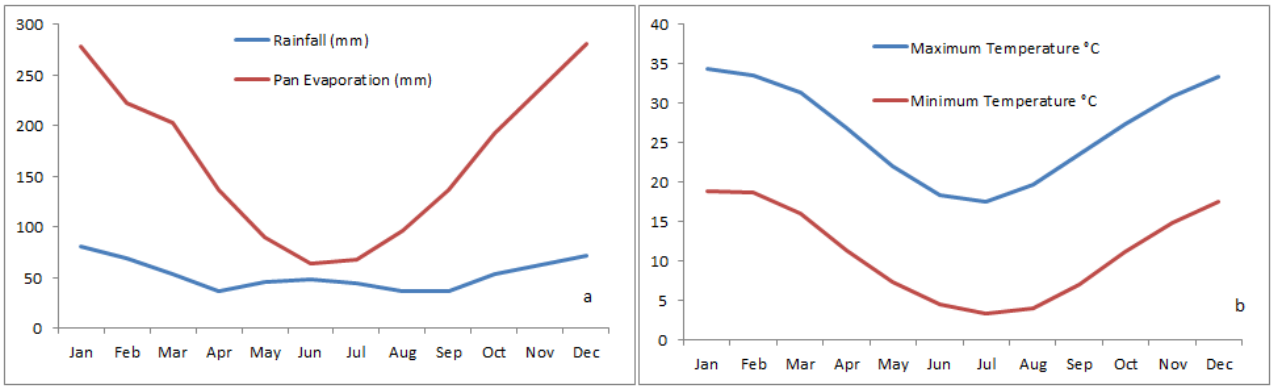


Figure 5.3: Mean maximum and minimum temperatures (°C) (a) and rainfall (mm) and Pan Evaporation (b) of Narrabri (1900 to 2012) (SILO, 2013).

Table 5.2: Climate statistics of Narrabri for years 1900 to 2012, weather station 54120 (SILO, 2013)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	79.7	64.1	48.4	35.8	42.9	42.9	42.1	34.1	34.2	48.6	57.9	60.4
Pan Evaporation (mm)	284	230	207	139	91.5	64.2	68.5	97.1	139	196	243	287
Maximum Temperature (°C)	34.6	33.7	31.4	27.1	22.3	18.5	17.7	19.9	23.8	27.7	31.1	33.7
Minimum Temperature (°C)	19.3	19.1	16.3	11.5	7.6	4.8	3.4	4.3	7.4	11.6	15.2	17.8

5.4.2 Geology

Detailed surface geology mapping indicated that the location of the proposed activity is underlain by a single geological formation, the Orallo formation. The lithological description is provided in **Table 5.3**.

Table 5.3 : Geological Formations (source: Geosciences Australia, 2011).

Formation Name	Map Symbol	Age	Dominant Lithology	Lithological Description
Geological Formation				
Orallo Formation	Qrxs1/JKlk	Mesozoic - Cretaceous	sandstone	Colluvial polymictic gravel, sand, silt and clay; may include some eluvial in situ regolith deposits overlies off-white, fine to coarse grained, poorly to well sorted, quartzose sandstone, pebbly sandstone and conglomerate interbedded with minor shale

5.4.3 Topography

Topography of the site can be described as gentle with elevations ranging between 280 and 295 m. Individual topographic characteristics of the existing lease areas are as follows:

- Bibblewindi 14 – generally slopes in a north-west direction, with elevations ranging between approximately 284 and 285 metres (AHD).
- Bibblewindi 19H – generally slopes in a north-west direction, with elevations ranging between approximately 283 and 285 metres (AHD).

There are no waterways intersecting the proposed well sites; however there are two waterways in the surrounding area. Mount Pleasant Creek and an unnamed tributary are located approximately 0.23 km west

and 0.13 km north-east of Bibblewindi 32 and 0.50 km west and 0.58 km east of Bibblewindi 31, respectively. These two waterways intersect the existing Bibblewindi Multi-Lateral Pilot at several points (**Figure 2.2**).

5.4.4 Soils

The soils across the region vary depending on the local sediment source. The BSAL site verification desktop assessment (**Section 2.5** of the BSAL Site Verification Report (RPS, 2013a)) concluded that the location of the proposed activity and much of the surrounding area are characterised by Sodosols. These soils are typical of those derived from the Pilliga Sandstone and are described as highly siliceous. Australian Soil Classification (ASC) map has been provided in **Figure 5.4** of the BSAL Site Verification Report (RPS, 2013a).

Eastern Star Gas (ESG 2008) commissioned a soil survey of their gas flow line corridor, which traverses the Pilliga and includes soil surveys within the Bibblewindi State Forest. There are six survey sites, approximately 4 to 6 km north of the proposed activity. Survey sites closets to the proposed activity are also described as Sodosols (Duplex soils). ESG (2008) described the Sodosols of the area to include:

- Soil excavated to 120-152 cm depth; surface condition loose, soft, firm or rarely hardsetting; surface stone absent;
- Topsoil: sometimes consisting of two distinct layers; top layer sand, clayey sand, sandy loam, fine sandy clay loam, sandy clay loam, clay loam, silty clay loam; sandy; roots common to many; no lime present; no manganese present; usually pH 4.5 , sometimes pH 5.0 to 6.0; gravel and stones absent; not mottled; not bleached; brown;
- dark brown, greyish brown, light reddish brown, pale brown, strong brown, yellowish brown, yellowish red dry, black, brown, dark brown, dark greyish brown, dark reddish brown, light brown, very dark greyish brown, moist; generally structured, peds rough- / smooth-faced or rough-faced, moderately [40%] to highly pedal [100%] [usually], polyhedral, <5-15 mm in size; weak, firm or very strong consistence dry; sometimes poorly structured, peds rough-faced, poorly pedal [20%], rounded polyhedral, 5-10 mm in size; weak consistence dry; sometimes massive or single grained in structure, weak to firm consistence dry; not hydrophobic; slightly hydrophobic or [more usually] hydrophobic;
- Subsoil: comprised of up to three horizons to excavated depth; clay textured; roots few, rarely common; usually no lime visible, sometimes lime nodules common; no manganese present; and
- pH 4.0 to 7.0, occasionally pH 7.0 to pH 9.5 to 10; gravel and stones absent; not bleached; usually whole coloured, sometimes mottled, soils brownish, yellowish and at times reddish coloured; massive or highly structured; usually not hydrophobic.

Refer to **Section 2.5** of the BSAL Site Verification Report (RPS, 2013a) for further soils information.

5.4.5 Soil Fertility

According to the *Draft Inherent Soil Fertility Mapping, Upper Hunter and New England North West Strategic Regional Landuse Areas* (OEH, 2012a), the inherent soil fertility of the site and their surrounds is moderately low (**Figure 5.5**).

5.4.6 Soil Erosion and Sediment Transport

5.4.6.1 Sodicity

Land Management Units in the Namoi Catchment (NCMA, 2009a) was a project commissioned by the Namoi Catchment Management Authority (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.

5.4.6.2 Dispersion

The Eastern Star Gas survey (ESG 2008) also analysed dispersion. The nearest site, Profile 6, was located 5.9 km north of the proposed Bibblewindi 32 site. Profile 6 was also identified as a Sodosols. The dispersion percentages identified that surface dispersions (0 – 0.14 m) was only slight (dispersion % = 6 – 30), while subsoils (<0.14 m) dispersion was very high (dispersions % = >65).

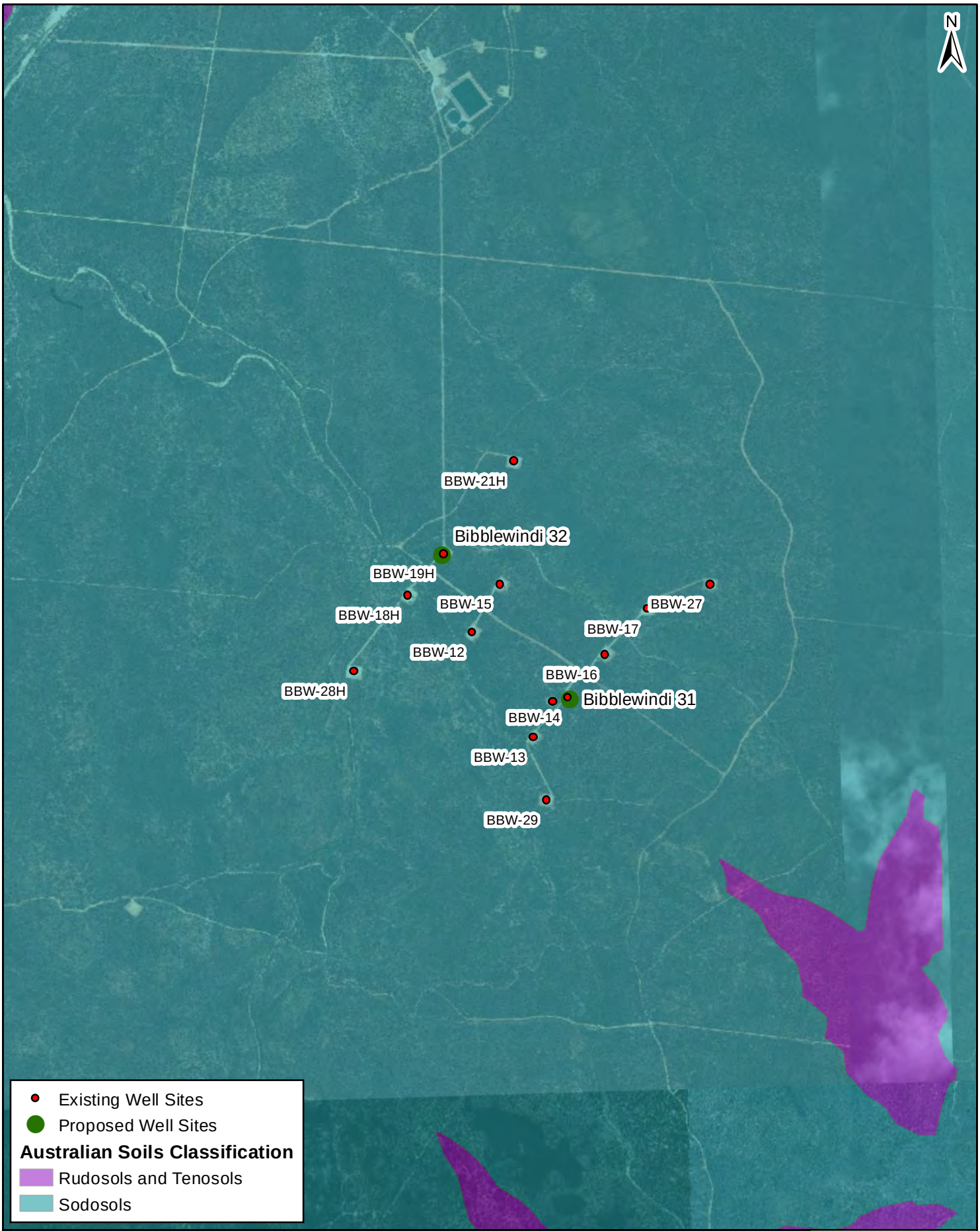
5.4.7 Soil Limitations

Soil characteristics of the sites indicate moderate to severe limitations, as the features listed in **Table 5.4** limit agricultural productions.

Table 5.4: Soil limitations of the proposed activity.

ASC	Salinity	PAWC*	Stoniness	Soil Depth	Nutrients	Sodicity
Sodosol	-	✓	-	-	✓	✓

*PAWC – Plant available water capacity



Client: Santos

Compiled by: BH | Date: 08/07/2013

Approved by: JC | Date: 08/07/2013

0 0.35 0.7 1.4 km

Datum: GDA94
Scale 1:34,500 @ A4

RPS

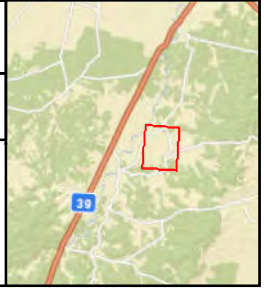
Australian Soils Classification

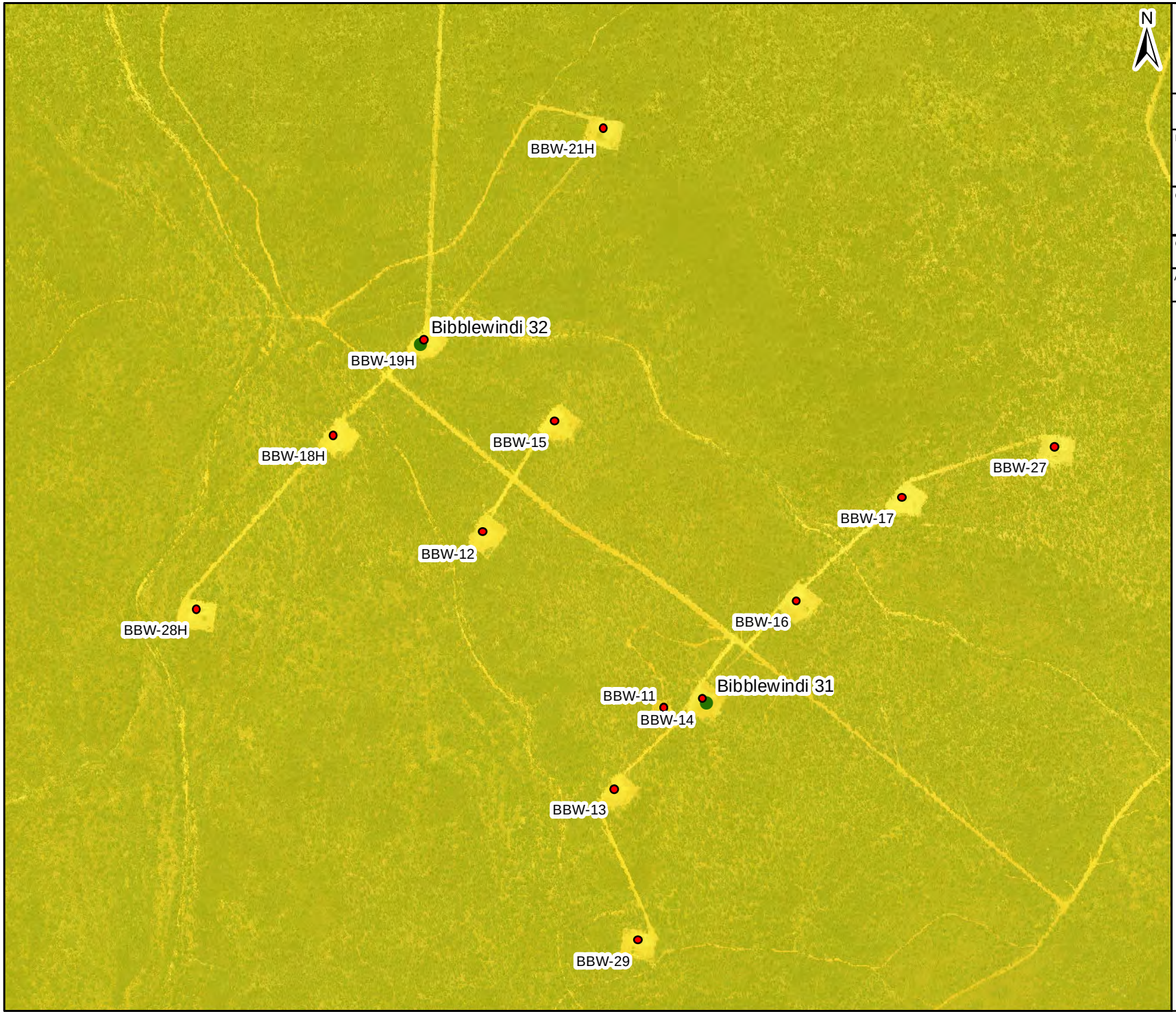
Figure 5.4

Project: Bibblewindi Gas Exploration Pilot Expansion

Source:Office of Environment and Heritage (OEH) (2012)

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from erroror omission. Please verify the accuracy of all information prior to use.





Soil Fertility

Figure 5.5

Project: Bibblewindi Gas Exploration Pilot Expansion

Client: Santos

Compiled by:	MM	Date:	08/07/2013
Approved by:	JC	Date:	08/07/2013

Legend

- Existing Well Sites
- Proposed Well Sites

Soil Fertility

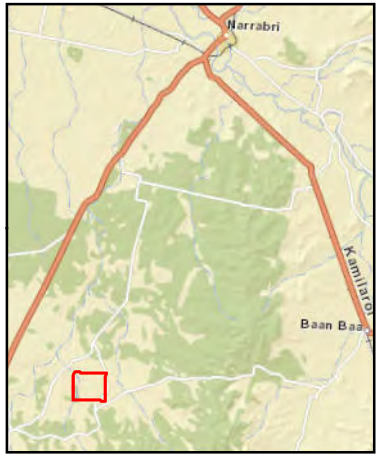
- High
- Moderately High
- Moderate
- Moderately Low
- Low

Source: Imagery from Santos 2012
Infrastructure from Santos 2012
Other dats supplied from OEH 2012

0 0.125 0.25 0.5 km

Datum: GDA94
Scale 1:15,000 @ A4

RPS



5.4.8 Land Capability and Agricultural Land Use Suitability

5.4.8.1 BSAL

Strategic Agricultural Land (SAL) is highly productive land that has both unique natural resource characteristics as well as socio-economic value (DP&I, 2012a). Based on this definition there are two (2) categories of SAL: CIC and BSAL.

BSAL is land with the best quality landforms, soil and water resources which are naturally capable of sustaining high levels of productivity with minimal management practices (DP&I, 2012a). A CIC is a localised concentration of interrelated productive industries based on an agricultural product that provides significant employment opportunities and contributes to the identity of the region (DPI, 2012a).

According to the DoP&I (2012a) SAL mapping, Bibblewindi 31-32 and its surrounds are not classified as BSAL. The nearest mapped BSAL is located 15 km east of Bibblewindi 31 (**Figure 5.6**). No CIC's have been identified in the New England North West Region (DP&I, 2012a).

5.4.8.2 Land and Soil Capability

In NSW, land and soil capability classes (LSC Classes) have been mapped for the New England - North West region (OEH, 2012b). 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. Class 1 represents land capable of sustaining most land uses including those that have a high impact on the soil (e.g. regular cultivation), whilst class 8 represents land that can only sustain very low impact land uses (e.g. nature conservation).

The site and surrounds have been mapped as LSC Class 4 and 5 (**Figure 5.7**). 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.

5.4.8.3 Land Capability as Mapped by SCS

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 Soil Conservation Service of NSW study classed the proposed site as a State forest and did not assign a land capability classification.

5.4.8.4 Agricultural Land Use Suitability

Similar to the SCS mapping (SCS 1986) land capability mapping the NSW Department of Primary Industries land use assessment has not assigned the Bibblewindi State forest and land use suitability class.



Strategic Agricultural Land

Figure 5.6

Project:	Bibblewindi Gas Exploration Pilot Expansion
Client:	Santos
Compiled by: MM	Date: 08/06/2013
Approved by: JC	Date: 08/06/2013

Legend

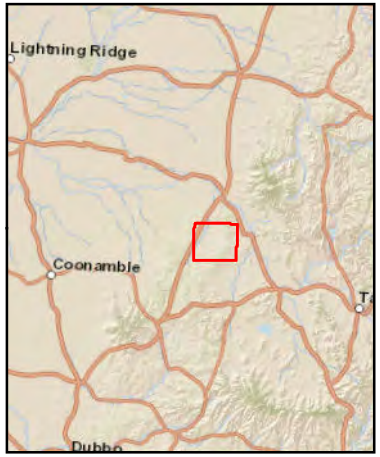
- Existing Well Sites
- Proposed Well Sites
- BSAL

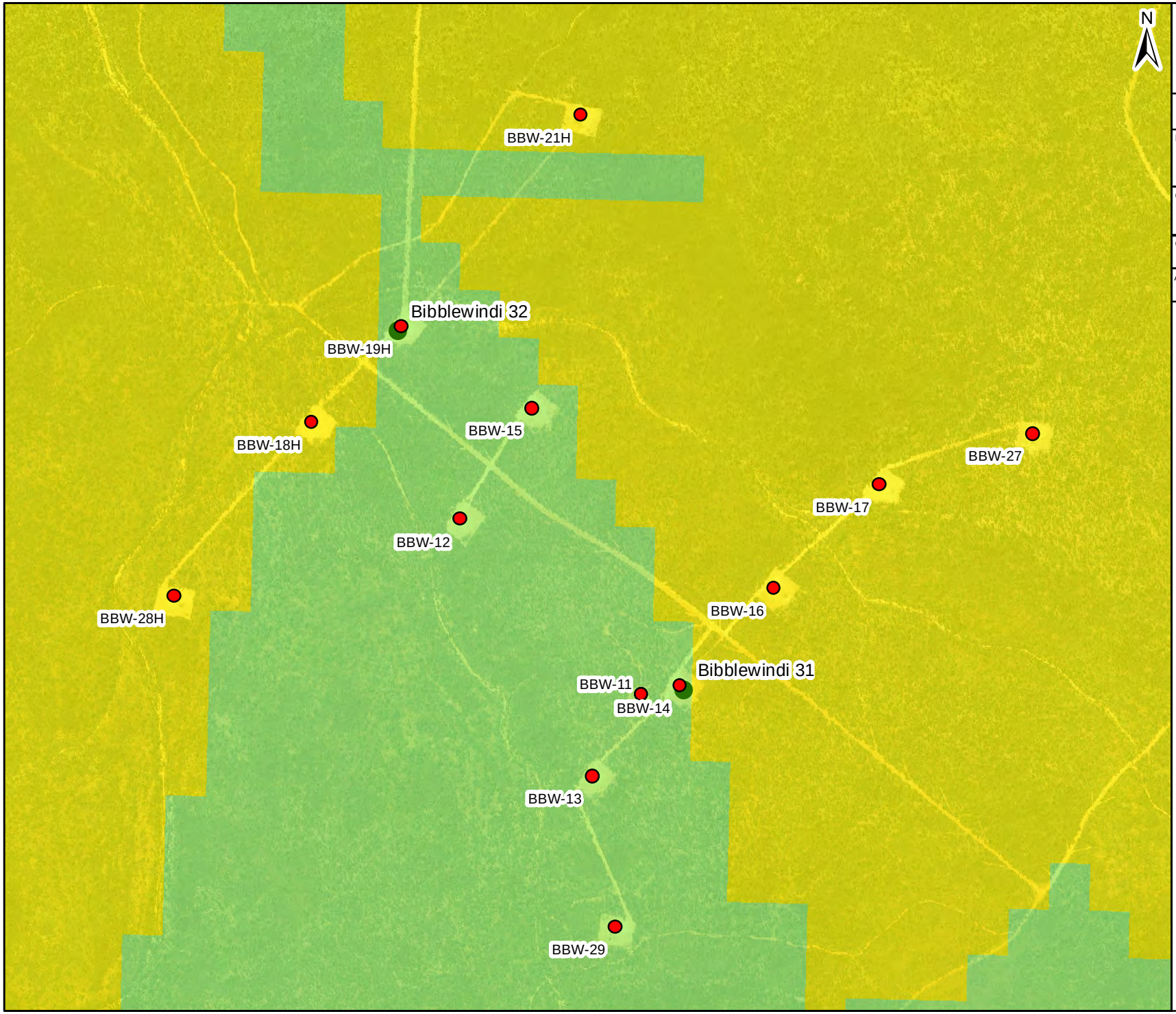
Source: Imagery from Santos 2012
Infrastructure from Santos 2012
Other dats supplied from OEH 2012

0 1.25 2.5 5 km

Datum: GDA94
Scale 1:150,000 @ A4

RPS





Land and Soil Capability

Figure 5.7

Project:
Bibblewindi Gas Exploration Pilot Expansion

Client:
Santos

Compiled by:	MM	Date:	08/07/2013
Approved by:	JC	Date:	08/07/2013

Legend

- Existing Well Sites
- Proposed Well Sites

Land and Soil Capability (LSC) Classes

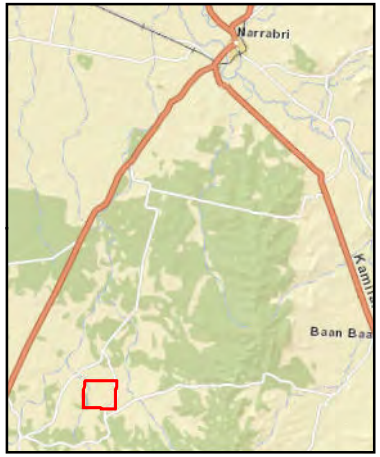
- LSC Class 1 *Very slight to negligible limitations*
- LSC Class 2 *Slight but significant limitations*
- LSC Class 3 *Moderate limitations*
- LSC Class 4 *Moderate to severe limitations*
- LSC Class 5 *Severe limitations*
- LSC Class 6 *Very severe limitations*
- LSC Class 7 *Extremely severe limitations*
- LSC Class 8 *Extreme limitations*

Source: Imagery from Santos 2012
Infrastructure from Santos 2012
Other dats supplied from OEH 2012

0 0.125 0.25 0.5 km

Datum: GDA94
Scale 1:10,000 @ A4

RPS



5.4.9 Water Resources

5.4.9.1 Surface water

The site is located within the Namoi River catchment which covers an area of approximately 42,000 km^2 stretching from Woolbrook in the east to Walgett in the west. The catchment is bounded by the Great Dividing Range in the east, the Liverpool Ranges and Warrumbungle Ranges in the south and the Nandewar Ranges and Mount Kaputar to the north. Major tributaries of the Namoi River include Coxs Creek and the Mooki, Peel, Cockburn, Manilla and Macdonald Rivers, all of which join the Namoi River upstream of Boggabri (NCMA, 2012).

Overall trends indicate a decline in surface water quantity and quality in the Namoi catchment. The Namoi River basin has one of the largest irrigated areas in the northern Murray Darling Basin, accounting for 15% of the total irrigated area in 2000-01 (MDBC, 2008 cited in CMA, 2009b). Average surface water availability in the Namoi Region is 965 GL/year, with 37% (357 GL) of this water being used. The high demand on surface water resources is attributed to surface water diversions (260 GL/year) and stream flow losses induced by groundwater use (99 GL/year) (NCMA, 2009b). Surface water quality within the catchment is influenced by agricultural runoff, spray drift, and vapour transport (NCMA, 2012). The water quality parameters which are of greatest concern for the Namoi catchment includes nutrients, salinity and turbidity.

The subject site is located within the Bohena sub-catchment of the Namoi River catchment. The Bohena sub-catchment covers an area of approximately 830 km^2 south of Narrabri and is the northern extension of the Borah sub-catchment. Bohena Creek and its tributaries are ephemeral, generally flowing for short periods following significant rainfall or prolonged wet periods.

Watercourses adjacent to the Bibblewindi 31-32 and in the surrounding area are largely ephemeral. Two watercourses, Mount Pleasant Creek and an unnamed tributary, run to the south and north of these proposed wells, respectively. These two waterways then join Cowallah Creek approximately 200 m downstream of the Bibblewindi 32 lease area. Cowallah Creek joins Bohena Creek approximately 4 km north west of Bibblewindi 32. Bohena creek is a major tributary of the Namoi River.

5.4.9.2 Groundwater

Groundwater is a significant resource in the Namoi catchment and has been extensively developed for irrigation, stock and domestic uses, with the catchment having the highest rate of groundwater use in NSW. Within the catchment there are alluvial, fractured rock and porous rock groundwater management areas. The highest yielding and most actively used bores being located in unconsolidated alluvial sediment aquifers associated with the Namoi River and its tributaries. The proposed alignment is located approximately 35 km south of the Namoi Groundwater Source.

The porous rock groundwater sources of the Great Artesian Basin (GAB) Surat Pilliga Sandstone underlies the Upper and Lower Namoi groundwater sources. Waters associated with this formation are more saline than the Lower and Upper Namoi and are generally used for stock purposes rather than irrigation. The Bibblewindi 31-32 will not be extracting from any of these sources. Bibblewindi 31-32 pilot wells will be extracting from the Maules Creek Formation, which is a less productive porous rock groundwater source.

As with surface water, over-allocation beyond sustainable extraction limits is a key concern for groundwater in the Namoi catchment. With over 700 licence holders, the Namoi region has the highest level of groundwater development in NSW and one of the highest levels of groundwater extraction in the MDB (NCMA, 2012a). Groundwater use is approximately 261 GL, which comprises about 15% of the MDB total (DWE, 2008 and CSIRO, 2007 cited in Namoi CMA, 2009b). Approximately 39% of this extraction is from the Upper Namoi Alluvium groundwater management unit (GWMU) and about 35% is from the Lower Namoi

Alluvium GWMU (CSIRO, 2007 cited in NCMA, 2009b). The proposed activity will not draw from any of these sources.

5.4.9.3 Licensed Water Use

The following Water Sharing Plans apply to water sources within the Multi-Lateral Pilot and surrounds:

- Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources 2012;
- Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2008;
- Water Sharing Plan for the NSW Murray Darling Basin (MDB) Porous Rock Groundwater Sources 2011; and
- Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011.

Surface water

Namoi Unregulated and Alluvial Water Sources

As drafting of the Namoi Unregulated and Alluvial Groundwater sources water sharing occurred recently (2012), little information is available for the groundwater source in terms of long term average annual extraction limits or primary use.

Groundwater

NSW Great Artesian Basin Groundwater Sources

Agriculture is the largest user of GAB groundwater sources. Surface water sources in the semi-arid landscape of the GAB are not reliable and the development of the pastoral industry has been made possible by the permanent supply of GAB groundwater. Agricultural use can be sub-divided into two categories: pastoral (stock) and irrigation (Eastern and South Easter regions only). The pastoral industry presently accounts for approximately 85% of the total GAB water use (total GAB water uses accounts to 123,500 ML); however this figure is gradually declining as free-flowing bores are capped and open bore drains are replaced with polyethylene piping supplying tanks and troughs under the Cap and Pipe the Bores Program.

NSW Murray Darling Basin (MDB) Porous Rock Groundwater Sources

There are approximately 40,746 shares of entitlement in the area covered by the MDB Porous Rock Groundwater sources water sharing plan. The majority of these licences are for irrigation purposes, with a significant proportion also used for industrial purposes. The long term average annual extraction limit of the MDB Porous Rock Groundwater sources is 790,821.54 ML/year

NSW Murray Darling Basin Fractured Rock Groundwater Sources

There are approximately 104,394 unit shares (excluding water extracted to meet basic landholder rights) of entitlement in the area covered by the MDB Fractured Rock Groundwater sources water sharing plan. The majority of these licences are for irrigation purposes, with a significant proportion also used for industrial purposes. The long term average annual extraction limit of the MDB Porous Rock Groundwater sources is 1,337,392.93 ML/year

6.0 Agricultural Impact Risk and Potential Consequences

The Project is required to support CSG exploration activities; therefore the potential agricultural impacts were evaluated in accordance with the *Guidelines for Agricultural Impact Statements at the Exploration Stage* (DP&I, 2012b). This system is designed to identify the risk of proposed exploration activities on agricultural resources or industries (**Table 6.1**). The risk ranking system includes probability of the event occurring and the associated consequence of the event. Descriptions of probabilities are provided in **Table 6.2**, while descriptions of consequences are provided in **Table 6.3**.

Table 6.1 indicates that all red and orange areas in the Agricultural Risk Ranking Matrix are high or medium risk activities. However, the *Guidelines for Agricultural Impact Statements at the Exploration Stage* (DP&I, 2012b) later states that high or medium risk exploration activities are those defined as risk rankings A1 - A3, B1 - B2, C1 - C2 and D1. At this stage there is some uncertainty as to what is considered a high or moderate risk activity, though for the purpose of this report those risk rankings (A1 - A3, B1 - B2, C1 - C2 and D1) detailed by the DoP&I (2012b) as high or moderate risk activities have been utilised. Other high or moderate risk activities identified by the DoP&I (2012b) include:

- Activities on or near BSAL or CIC;
- Significant concerns relating to the proposed activities in the agricultural community; and
- Exploration activities which include coal seam gas pilot testing.

Table 6.1: Agricultural Impact Risk Ranking Matrix.

Consequence \ Probability	A Almost Certain	B Likely	C Possible	D Unlikely	E Rare
1. Severe and/or permanent damage. Irreversible impacts.	A1	B1	C1	D1	E1
2. Significant and/or long term damage. Long term management implications. Impacts difficult or impractical to reverse.	A2	B2	C2	D2	E2
3. Moderate damage and/or medium-term impact to agricultural resources or industries. Some ongoing management implications which may be expensive to implement. Minor damage or impacts over the long term.	A3	B3	C3	D3	E3
4. Minor damage and/or short-term impact to agricultural resources or industries. Can be managed as part of routine operations.	A4	B4	C4	D4	E4
5. Very minor damage and minor impact to agricultural resources or industries. Can be effectively managed as part of normal operations.	A5	B5	C5	D5	E5

Where:

	= low risk
	= medium risk
	= high risk

Table 6.2: Agricultural Impact Risk Ranking – probability descriptors

Level	Descriptor	Description
A	Almost certain	Common or repeating occurrence
B	Likely	Known to occur or it has happened
C	Possible	Could occur or I've heard of it happening
D	Unlikely	Could occur in some circumstances but not likely to occur
E	Rare	Practically impossible or I've never heard of it happening

Table 6.3: Agricultural Impact Risk Ranking – consequence descriptors

Level: 1	Description	Example of Implications
Severe Consequences	▪ Severe and/or permanent damage to agricultural resources, or industries ▪ Irreversible ▪ Severe impact on the community.	▪ Long term (e.g. 20 years) damage to soil or water resources ▪ Long term impacts (e.g. 20 years) on a cluster of agricultural industries or important agricultural lands.
Level: 2	**Description**	**Example of Implications**
Major Consequences	▪ Significant and/or long-term impact to agricultural resources, or industries ▪ Long-term management implications ▪ Serious detrimental impact on the community.	▪ Water or soil impacted, possibly in the long term (e.g. 20 years) ▪ Long term (e.g. 20 years) displacement / serious impacts on agricultural industries.
Level: 3	**Description**	**Example of Implications**
Moderate Consequences	▪ Moderate and/or medium-term impact to agricultural resources, or industries ▪ Some ongoing management implications ▪ Minor damage or impacts but over the long term.	▪ Water or soil known to be affected, probably in the short – medium term (e.g. 1 – 5 years) ▪ Management could include significant change of management needed to agricultural enterprises to continue.
Level: 4	**Description**	**Example of Implications**
Minor Consequences	▪ Minor damage and/or short-term impact to agricultural resources, or industries ▪ Can be effectively managed as part of normal operations.	▪ Theoretically could affect the agricultural resources or industry in short term, but no impacts demonstrated ▪ Minor erosion, compaction or water quality impacts that can be mitigated ▪ For example, dust and noise impacts in a 12 month period on extensive grazing enterprises.

Level: 5	Description	Example of Implications
Negligible Consequences	▪ Very minor damage or impact to agricultural resources, or industries ▪ Can be effectively managed as part of normal operations.	▪ No measurable or identifiable impact on the agricultural resources on industry.

6.1 Bibblewindi Gas Exploration Pilot Expansion Related Impacts

The proposed mitigation, management and monitoring systems will reduce the likelihood of any impacts to agricultural resources or industries as described in **Sections 7.0** and **8.0**. Further, the Bibblewindi Gas Exploration Pilot Expansion EIS (RPS, 2013b) describes in full the mitigation, management and monitoring systems in place that will reduce the likelihood of potential impacts to agricultural resources and supporting infrastructure.

Table 6.4 details the nature of risk, likelihood and consequence of potential impacts on agricultural resources and industries. Based on the Agricultural Impact Risk Ranking System, the proposed activity has been classified as a low risk exploration activity due to the following:

- The proposed activity is not located on or near (<2 km radius) BSAL or CIC;
- No intensive agricultural activities are currently undertaken on the proposed pilots;
- The proposed activity is located on land with low potential for commercial agricultural land use;
- As Bibblewindi 31-32 are located on existing lease areas there will be no surface disturbances other than drilling;
- All surface disturbance areas will be fully rehabilitated to the pre-existing land condition or better. There will be no permanent land capability reduction of agricultural resources;
- There will be no lifting or discharges to surface waters;
- There will be no expected lifting or decline in head of agricultural groundwater resources (Ch2MHill, 2013); and
- Surface disturbance areas will be rehabilitated at well abandonment.

Table 6.4: Agricultural Impact Risk Ranking of Project

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Comments
Socio-Economic Impacts					
Agricultural Support Infrastructure	▪ Pressure on regional water supplies. ▪ Pressure on transport infrastructure. ▪ Impact on agricultural support industries (e.g. processing facilities).	E (Rare)	4 (Minor)	E4 (Low)	▪ Negligible consequence as the proposed works will not source or utilise agricultural support infrastructure. ▪ The proposed activity is not located on or within the surrounding area of any mapped CICs. ▪ There are no anticipated impacts on regional water supplies (surface or groundwater). ▪ Proposed activities will not impede on agricultural railways or processing facilities. ▪ The minor increase of traffic along Little Tighes Road, X-Line Road and Tighes Gully Road can easily be accommodated by the existing road network. ▪ Minor traffic delays may occur during the construction phase from vehicles utilising the Newell Highway.
Employment and Economic Development	▪ Reduction of current or future agricultural employment opportunities. ▪ Adverse impact to local tourism industry.	E (Rare)	5 (Negligible)	E5 (Low)	▪ No impacts to agricultural employment opportunities are anticipated as no intensive agricultural activities are being undertaken on or adjacent to the proposed activity. Also, the site is located on land with low potential for commercial agricultural use. ▪ The proposed wells would have no further disturbance footprint and are not anticipated to impact tourism opportunities in Bibblewindi State Forest.
Visual Amenity	▪ Disturbance of scenic quality and / or visual aesthetics.	C (Possible)	4 (Minor)	C4 (Low)	▪ The proposed activity would not change the existing scenario, which is a Multi-Lateral Pilot set. The site would not be visible from the Newell Highway.
Agricultural Resources					
Loss of land from agricultural use.	▪ Alienation of land from agricultural uses.	E (Rare)	5 (Negligible)	E5 (Low)	▪ Negligible consequences as the proposed pilots are not located on or near any intensive agricultural activities. ▪ The proposed activity is located on land with low potential for commercial agricultural use. ▪ The proposed activity is not located on or within the surrounding area of any mapped BSAL. ▪ The disturbed area will be fully rehabilitated once the wells are

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Comments
					abandoned.
Soil	▪ Soil erosion. ▪ Contamination due to groundwater discharge ▪ Contamination from fuel/oil spill during construction. ▪ Soil compaction.	D (Unlikely)	4 (Minor)	D4 (Low)	▪ Very minor damage or impact to agricultural resources or industries as mitigation and management measures outlined within Bibblewindi Gas Exploration Pilot Expansion EIS (RPS, 2013b) will minimise the likelihood of potential impacts.
Surface water	▪ Sedimentation of waterways. ▪ Impacts to water quality from sediment laden runoff or chemical spills. ▪ Contamination due to groundwater discharge.	D (Unlikely)	2 (Major)	D2 (Low)	▪ Minor or short term impact to surface water is unlikely. Potential impacts would be mitigated and managed as outlined within Bibblewindi Gas Exploration Pilot Expansion EIS (RPS, 2013b) will minimise the likelihood of potential impacts. ▪ Wells will be designed and drilled in accordance with the NSW code of practice for coal seam gas well integrity.
Groundwater	▪ Cross contamination of aquifers. ▪ Contamination by drilling fluids. ▪ Contamination due to spills, fuels or chemicals.	D (Unlikely)	2 (Major)	D2 (Low)	▪ These potential impacts can be readily managed and mitigated through standard construction site environmental and engineering controls outlined in Bibblewindi Gas Exploration Pilot Expansion EIS (RPS, 2013b). ▪ Groundwater modelling has indicated that there will be no impact on registered bore users linked to agriculture. Ongoing monitoring program will also be implemented.
Air and Noise	▪ Dust generation ▪ Exhaust emissions from, vehicle movements and plant and machinery operations ▪ Venting of methane (CH_4) and carbon dioxide (CO_2) during drilling ▪ Noise generation above agricultural background level of 30 dB(A)	C (Possible)	4 (Minor)	C4 (Low)	▪ Minor or short term impact to air given the short duration of the construction works (approximately 6 months). Impacts would be mitigated by the measures outlined in Bibblewindi Gas Exploration Pilot Expansion EIS (RPS, 2013b). ▪ No dust or noise sensitive receptors within close proximity to the proposed activity.
Weeds	▪ Introduction of weeds to	D (Unlikely)	4 (Minor)	D4 (Low)	▪ No intensive agricultural activities are being undertaken on or

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Comments
	area. ▪ Land degradation. ▪ Reduced agricultural productivity.				adjacent to the proposed activity. ▪ These potential impacts would be readily managed and mitigated through standard construction site weed hygiene measures.
Biosecurity	▪ Spread of *Phytophthora cinnamomi*	E (Rare)	5 (Negligible)	E5 (Low)	▪ Vehicles and plant from any known *P. cinnamomi* risk areas shall be washed down prior to entry to site. ▪ No intensive agricultural activities are being undertaken on or adjacent to the proposed activity. ▪ The proposed activity is located on land with low potential for commercial agricultural use.

7.0 Potential Construction and Operational Phase Impacts

7.1 Socio-Economic Impacts

7.1.1 Agricultural Enterprises and Support Services

The proposal and adjoining land is not currently used for intensive agricultural purposes. The proposed activity may be rehabilitated in the post operation phase, however use of the site for any future agricultural purposes will be severely limited due to the inherent poor soil attributes.

There will be no pressure on agricultural support infrastructure including:

- Water supply services;
- Railways;
- Travelling stock routes; and
- Processing facilities.

With respect to agricultural support services within the region, there may be a minor short term increase in traffic volumes on the Newell Highway during the construction phase of the wells. However, these impacts will be temporary in nature and are not expected to cause significant delay or increase risks associated with the transport of agricultural products and services. The potential traffic impact associated with the construction activities will be mitigated by the implementation of a Construction Traffic Management Plan. Further, it is considered that X-Line Road, Tighes Gully Road and Little Tighes Road, can easily accommodate any increases in traffic associated with the proposed works. Further, there will be no disruption to rail networks, as the site is not adjacent to any such infrastructure.

7.1.1.1 Mitigation Measures

- Implementation of Construction Traffic Management Plan.

7.1.2 Employment and Economic Development

No impacts to agricultural employment opportunities in the Narrabri region are anticipated as no intensive agricultural activities are being undertaken on or adjacent to the proposal. Also, the proposed activity is located on land with low potential for commercial agricultural use. It is noted that the construction phase of the wells is likely to generate local employment opportunities and contribute to the local economy through direct and indirect spend associated with the construction activities.

As the proposed activity is located in the Bibblewindi State Forest, no agricultural statistics exist. Further the proposed works would not quarantine any additional land or vegetation as the pilots would be located on existing lease areas which have been previous cleared. As such, the proposed works are not anticipated to have any impact to the apiary industry.

Mitigation Measures

- No mitigation measures required.

7.1.3 Tourism

The impact assessment has not identified any tourism opportunities within the site or surrounding areas on which agricultural enterprises are reliant. Therefore, it is not anticipated that the proposed activity will have any impact on agriculture-related tourism (e.g. wineries, farm vacation locations).

The proposed activity will have no additional disturbance footprint, which is not anticipated to reduce recreational tourism opportunities in Bibblewindi State Forest such as hiking, camping and bird watching.

7.1.3.1 Mitigation Measures

- No mitigation measures required.

7.1.4 Visual Amenity

The proposed activity will not require any further clearing. During construction, impacts on visual amenity are expected to be low due to the following:

- The site will not be visible from the Newell Highway;
- The site does not constitute a key view;
- The flat terrain of the area does not offer topographic vantage points to the public to view the site; and
- The nearest dwellings are more than 7.5 km from the site.

7.1.4.1 Mitigation Measures

- Visual impacts will be mitigated by keeping the site in a clean and tidy manner.

7.2 Agricultural Resource Impacts

7.2.1 Land Removed from Agricultural Use

The site and adjoining land are located within the Bibblewindi State Forest and are not currently used for intensive agricultural purposes. As both proposed pilot wells would be located on existing lease areas there will be no further land removed from agricultural use.

The site will be rehabilitated in the post operation phase and as such there will be no permanent land capability reduction. Furthermore, use of the Bibblewindi 31-32 for any future agricultural purposes will be severely limited due to the inherent poor soil attributes.

7.2.1.1 Mitigation Measures

- The existing lease will be appropriately fenced to ensure machinery is limited to the designated area. Where soil is disturbed or compacted, these areas will be partially rehabilitated in the short term with full rehabilitation as approved under the previous Bibblewindi Multi-lateral pilot.

7.2.2 Soils

During the construction phase of the proposed activity there is potential to impact soils due to:

- Soil erosion;
- Groundwater discharging to the surface, which might cause flooding or impact on sediment characteristics;
- Contamination from chemical spills (e.g. diesel spill during refuelling plant); and
- Soil compaction.

However, the risk of adverse impact to the soil resource during construction is considered low with the implementation of standard construction site environmental and engineering controls which are outlined in the Bibblewindi Gas Exploration Pilot Expansion EIS (RPS, 2013b) and below.

7.2.2.1 Mitigation Measures

- Plant and equipment will be inspected daily to ensure these are properly maintained;
- Ongoing management and maintenance of remaining infrastructure on site will occur, including water transfer area and well heads;
- The gathering system water pressure will be monitored;
- Given the very high potential dispersibility of subsoils at the sites, any exposed subsoils should be protected either with vegetation (high ground cover), appropriate matting or preferred surface protection measures during both;
- Any excavated surface and subsurface soils will be stockpiled separately to avoid profile inversion; and
- Any stockpiled subsoils should be covered to avoid compaction and water erosion.
- Refer to **Section 8.4** of the Bibblewindi Gas Exploration Pilot Expansion EIS (RPS, 2013b) for mitigation measures associated to potential soil contamination.

7.2.3 Water use

Water may be required for construction purposes. This will be sourced from Narrabri's town water supply or local industrial licensed water bores and trucked to the site. Water licensing requirements are discussed in the Bibblewindi Gas Exploration Pilot Expansion EIS (RPS, 2013b). There will be no extraction from surface or ground waters which are linked to agriculture during both the construction and operational phases of the project.

In order to conduct the pilot, water will be extracted from the targeted seams simultaneously.

Groundwater quality investigations undertaken in the Bibblewindi Gas Exploration Pilot Expansion that there will be no lifting or decline in head of groundwater sources linked to agricultural uses (Ch2MHill, 2013). Further groundwater quality investigations undertaken in the target seams of the Maules Creek formation indicate that the total dissolved solids (TDS) in produced water is outside the general ranges for irrigation (TDS= 650 – 5,200 mg/L) and livestock feed (TDS= 2,000 – 10,000 mg/L) use.

- Malues Creek Formation groundwater quality of individual target seams:
  - » Bohena seam - mean TDS= 18,752 mg/L, maximum TDS= 21,980 mg/L and minimum TDS= 13,159 mg/L;
  - » Namoi seam - mean TDS= 14,110 mg/L, maximum TDS= 15,740 mg/L and minimum TDS = 13,159 mg/L; and
  - » Rutley seam - no data.

As this groundwater is not used for agricultural purposes, waters lifted will not impact on agricultural supplies.

7.2.3.1 Mitigation measures

- No mitigation measures required.

7.2.4 Surface Water Quality

During the construction phase there is potential for adverse impacts to the quality of water resources in the local area due to:

- Soil erosion and sedimentation;
- Sedimentation of waterways;
- Groundwater discharging to the surface, which might cause flooding or impact on sediment

characteristics; and

- Contamination from chemical spills (e.g. diesel spill during refuelling plant).

However, the risk of adverse impact on water quality during construction is considered low with the implementation of standard construction site environmental and engineering controls which are outlined in the EIS.

7.2.4.1 Mitigation Measures

The measures identified in **Section 7.2.2.1** will minimise impacts to surface water. The following additional measures will be implemented:

- Erosion and sediment controls will be implemented during site preparation activities in accordance with best management practices (such as the Blue Book (Landcom, 2004) or Best Practice Erosion and Sediment Control Guidelines (IECA, 2008)). These controls will be maintained until disturbed areas of the site are stabilised.

7.2.5 Groundwater Quality

The wells will be designed and constructed in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity*. If the well is not constructed properly, potential impacts of drilling in mixed multi-aquifer systems include:

- Creating an artificial connection between water-bearing formations that bypasses aquitards or aquicludes resulting in cross contamination of aquifers;
- Contamination of the aquifers by drilling fluids or mud if these are lost in the formation; and
- Groundwater contamination due to spills of oil, fuels or chemicals if not cleaned up appropriately.

7.2.5.1 Mitigation Measures

- The wells will be designed and constructed in accordance with the *NSW Coal Seam Gas Code of Practice Well Integrity*;
- A driller that holds a license under the National Water Drillers Licensing Accreditation Scheme will be on site during drilling of the top hole and 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;
- A NSW Office of Water hydrogeologist will be notified at least 28 days prior to the commencement of drilling;
- 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 Bibblewindi Gas Exploration Pilot Expansion EIS (RPS, 2013b);
- Excessive drilling mud 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;
- The wells will be decommissioned as soon as they are no longer required;
- Data will be collected from the wells to measure permeability of the various strata;
- Pressure gauges will be installed adjacent to the pilot wells with monitoring points to assess impacts on overlying formations;
- The quality of incidental water lifted during proposed activities will be monitored daily and the results provided to the relevant authorities on a weekly basis; and

- Santos will make reasonable endeavours to establish a network of groundwater monitoring bores to monitor the impacts of the proposed activity and other pilots planned as part of the Exploration and Appraisal Program on groundwater sources.

7.2.6 Air and Noise

Regional air quality is likely influenced by mining activities, land clearing and soil preparation, sowing and harvesting of crops, vehicle and heavy machinery movements, bushfires and burn-offs.

The Bibblewindi Multi-Lateral Pilot Expansion EIS (2012) notes that the ambient noise levels calculated by Noise Measurement Services at 6 locations surrounding the proposed activity range between 16dB(A) and 35dB(A). The existing noise environment is influenced by birds, insects and other wildlife.

Potential air and noise emissions from the proposed activity will include:

- Dust generated during clearing, excavation and vehicle movements;
- Exhaust emissions from vehicle movements to and from the site;
- Exhaust emissions from plant and machinery operations on site;
- Venting of methane (CH_4) and carbon dioxide (CO_2) during drilling and operation; and
- Noise generated during site preparation and installation.

Minimal impacts to local air quality are anticipated as the proposed works require no clearing reducing dust generation. Provided that the mitigation measures are implemented, a negligible to low adverse impact on air quality and noise is expected.

7.2.6.1 Mitigation Measures

- 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; and
- In the event of a noise complaint, the noise source will be investigated and, where necessary, additional feasible and reasonable measures will be implemented.

7.2.7 Weed Management

No introduced species were identified at the survey scout. However, during the construction and operational phases there is the potential for the introduction of weed species to/from site due to the increase in vehicle and equipment traffic.

As weeds can displace native species, contribute significantly to land degradation, and reduce agricultural productivity they have the potential to impact agricultural resources and must be controlled according to the measures specified in a management plan published by the local control authority.

7.2.7.1 Mitigation Measures

- Weed monitoring will occur throughout the construction and operational phase, and weed removal will be carried out as necessary;
- Where plant and machinery are moving from the site, wash down procedures will be implemented in accordance with NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) Biosecurity Factsheet 1119 (DTIRIS, 2011);
- Further mitigation measures are outlined in **Section 19.0** of the Bibblewindi Gas Exploration Pilot Expansion EIS (RPS, 2013b).

7.2.8 Pest Animals / Biosecurity

Disease control is required due to the potential for particular plant / soil diseases to be spread, particularly *Phytopthora*. *Phytopthora* can be spread via unregulated exposure and movement of soils between areas of construction. Measures will therefore be implemented to avoid such disease facilitation and hence any potential impact to agricultural enterprises.

7.2.8.1 Mitigation Measures

A variety of mitigation measures will be adapted to minimise and control disease on and off the site:

- Wash down procedures are to be implemented as per **Section 7.2.7.1**;
- Construction personnel will be trained adequately in pest management and hygiene procedures;
- Sightings shall be reported to the relevant Invasive Species Officer at Industry and Investment NSW and an appropriate management strategy shall be employed following advice from the Invasive Species Officer; and
- All machinery will be cleaned of foreign soil and propagative matter to avoid the importation of *Phytophthora*.

8.0 Post Operational Phase Impacts / Rehabilitation

Apart from the Bibblewindi 31 and 32 wells and associated infrastructure, the proposed activity is not seeking the approval for the decommissioning and rehabilitation of the lease areas. These works were previously approved as part of the Bibblewindi Multi-lateral pilot (DPI, August 2008 and July 2009). Therefore only the assessment of the decommissioning of Bibblewindi 31 and 32 is relevant to this proposal.

8.1 Agricultural Resources

8.1.1 Land Removed from Agricultural Use

The proposed activities would not quarantine any agricultural land in the long term. At the end of the project life the subject site will be decommissioned. The project area would then be rehabilitated in accordance with the EIS.

8.1.1.1 Mitigation Measures

- No mitigation measures are proposed.

8.2 Socio-Economic Impacts

8.2.1 Agricultural Enterprises and Support Services

Subsequent to on-site infrastructure being decommissioned, the site will be returned to its pre-operational condition in accordance with the approval for Bibblewind Multi-lateral pilot (DPI, August 2008 and July 2009), following removal of surface infrastructure.

8.2.1.1 Mitigation Measures

- No mitigation measures required.

8.2.2 Employment and Economic Development

No impacts to agricultural employment opportunities in the Narrabri region are anticipated as the proposed activities are located on land with low potential for commercial agricultural use. As the proposed Bibblewindi 31-32 wells would be located on pre-disturbed areas, activities are not anticipated to reduce tourism opportunities in the Bibblewindi State Forest.

8.2.2.1 Mitigation Measures

- No mitigation measures required.

8.2.3 Visual Amenity

Following removal of surface infrastructure and adequate rehabilitation of disturbed areas, in accordance with the approval for Bibblewindi Multi-lateral pilot (DPI, August 2008 and July 2009).

8.2.3.1 Mitigation Measures

- No mitigation measures required.

8.3 Agricultural Resource Impacts

8.3.1 Soils

During the course of decommissioning works the potential for adverse impacts to the soil resource and appropriate mitigation measures are as per the construction phase of the project (**Section 7.2.2**). It will be essential, if erosion is to be prevented and rehabilitation to be successful, to maintain an adequate groundcover on the existing landscape and on the reformed landscapes after rehabilitation works are carried out.

8.3.1.1 Mitigation Measures

- Mitigation measures for potential soil resource impacts during the course of the decommissioning works are as per **Section 7.2.2.1**.

8.3.2 Surface water

During the course of decommissioning the potential for adverse impacts on surface waters are as per **Section 7.2.4**.

8.3.2.1 Mitigation Measures

- Mitigation measures for potential surface water impacts during the course of the decommissioning are as per **Section 7.2.4.1**.

8.3.3 Groundwater

The pilot well will be plugged and abandoned with permanent casing installed across the shallowest formations in accordance with current regulatory requirements of the NSW Well Integrity Code of Practice and specific well design in accordance with that Code of Practice.

During the course of decommissioning the potential for adverse impacts on groundwaters are as per **Section 7.2.5**

8.3.3.1 Mitigation Measures

- Mitigation measures during the course of the decommissioning are as per **Section 7.2.5.1**.

8.3.4 Air and Noise

No adverse impacts due to dust and noise emissions are anticipated during decommissioning works due to the remote location of the Project area and the current lack of nearby sensitive receptors. During the course of decommissioning the potential for adverse impacts on air and noise are as per **Section 7.2.6**.

8.3.4.1 Mitigation Measures

- During the course of decommissioning the potential for adverse impacts on air and noise are as per **Section 7.2.6.1**.

8.3.5 Weed Management

During the decommissioning phase there is the potential for the introduction of weed species due to the movement of vehicles to/from the Project area. Appropriate mitigation measures are as per the construction phase of the Project (**Section 7.2.7**).

8.3.5.1 Mitigation Measures

- During the course of decommissioning weed management will be as per **Section 7.2.7.1**.

8.3.6 Pest Animals / Biosecurity

During the decommissioning phase of the Project there is the potential for the introduction of pest or invasive species or pathogens due to earthworks and vehicle and equipment movements to/from the Project area. Appropriate mitigation measures are as per the construction phase of the Project (**Section 7.2.8**).

8.3.6.1 Mitigation Measures

- Mitigation measures during the course of the decommissioning are as per **Section 7.2.8.1**.

8.4 Buffers and Offsets

Due to the low impact nature of the proposed activity, buffers and / or offsets are not required for the decommissioning of the project and therefore no further impact to agricultural enterprises or support infrastructure are predicted.

9.0 Trigger Response Plan and Water Monitoring Program

9.1 Trigger Response Plan

The primary trigger response plans are highlighted in **Table 9.1**. Due the low impact nature and relative short duration of the proposed activity, no significant impact to agricultural resources or supporting infrastructure are anticipated.

Table 9.1: Trigger Response Plans

Trigger	Response
Pressure testing to identify if aquifers have been isolated	Remedial action to ensure the seal is competent
Loss of excess drilling fluids into the formation	Application of Loss Circulation Material
Spill of chemicals or fuels to land	Immediate application of spill kit and disposal of any contaminated material

9.2 Water Monitoring Program

The proposed groundwater monitoring program is discussed in **Section 9.5.3**, while the surface water monitoring program is discussed in **Section 10.1.4** of the Bibblewindi Gas Exploration Pilot Expansion EIS (RPS, 2013b).

10.0 Cumulative Impacts

Santos plans to continue exploration, appraisal and evaluation of the CSG hydrocarbon potential in PEL 238 and PAL 2 and has developed the Energy NSW CSG Exploration and Appraisal Program (the program). The program will assist in gaining further knowledge of coal fines, gas composition, flow rates and deliverability, well design, drilling and completion technologies. The program will be conducted over the next two to three years and will include:

- Operation of the existing Bibblewindi Multi-Lateral Pilot, and the construction, drilling and operation of two additional pilot wells (Bibblewindi 31 and 32) from existing well leases within the pilot (the proposed activity the subject of the EIS);
- Operation of the existing Bibblewindi West Pilot;
- Operation of the existing Tintsfield CSG Pilot;
- Operation of the existing Dewhurst 13-18H Pilot 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;
- Construction, drilling and operation of the Dewhurst 26-31 Pilot;
- 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 the Leewood Produced Water Facility and ancillary infrastructure; and
- Gas and water management during operation of the program.

These activities are subject to separate environmental assessment and approval processes.

The proposed activity forms part of the larger Santos PEL 238 and PAL 2 exploration project, however cumulative impacts to agricultural resources and industries are expected to be minimal as discussed below.

10.1 Agricultural Land Use Disturbance

Approximately 90 existing exploration and appraisal wells are located with PEL 238, PAL 2 and PPL 3. The majority of these have either been plugged and abandoned and rehabilitated, or suspended for future use.

The area of land that will be quarantined for exploration activities within PEL 238 and PAL 2 is approximately 107 ha, which includes 28 ha existing infrastructure and well sites to be retained and 79 ha of proposed infrastructure and well sites. This is approximately 0.013% of land within PEL 238 and PAL 2.

The current extent of agricultural land use within PEL 238 and PAL 2 is approximately 791,478 ha. At this stage defined projects within PEL 238 and PEL 2 are not located on any agricultural land (major agricultural industries identified in PEL 238 and PAL 2 e.g. cropping, grazing, horticulture and plantations). Although production forestry is mapped within PEL 238 and PAL 2, there is little evidence of exotic plantations; rather these areas include State forest used for timber harvesting and nature reserves (accounting for an additional 190,462 ha). Timber harvesting within the Pilliga has been reduced largely due to conservation efforts; therefore such enterprises are not considered significant.

Defined projects are anticipated to have a negligible impact on agricultural land as the disturbance footprint is not located on any intensive agricultural enterprises. Further, the majority of land disturbances would be fully rehabilitated following the completion of activities.

Based on the nominated gross margins (GM) and potential agricultural land use (LSC classes identified by the DP&I, 2012a for the New England - North West region), the PEL 238 and PAL 2 existing (2002-2012) and proposed (post 2012) exploration project has the capacity to generate an estimated gross margin of approximately $15,413 and $22,419 per annum, respectively. However, as there are no current agricultural enterprises on the well sites within PEL 238 and PAL 2, this amount is not applicable for both retained and proposed sites (**Table 9.1**). The amounts are based on the DTIRIS agricultural productivity data for agricultural enterprises suitable for each of the land classes that have been identified for the disturbance areas. For this assessment, the most productive agricultural enterprises have been selected to provide a "best case" scenario for impacted LSC classes.

Table 10.1: Agricultural productivity of the Santos PEL 238 and PAL 2 exploration project.

LSC Class	$/ha	Area Quarantined (ha)	GM based on the potential agricultural land use ($)	GM based on site with a current agricultural enterprise ($)
Existing infrastructure and well sites to be retained within each LSC Class				
2	712	-	-	-
3		9.0	6,480	-
4	450	3.29	1,481	-
5		16.56	7,452	-
Total		**27.85**	**15,413**	**-**
Proposed disturbance within each LSC Class				
2	712	-	-	-
3		-	-	-
4	450	37.02	16,659	-
5		12.23	5,504	-
Total		**49.61**	**22,419**	**-**

*LSC Classes 2 and 3 agricultural enterprises include: winter crop of short fallow no till wheat and summer crop of no till sorghum. While it is conceivable to produce two crops annually, a general agricultural enterprise in the north-west region of NSW is more likely to have a single successful crop (R. Freebairn personal comm 07/03/2013).

*LSC Classes 4 and 5 agricultural enterprises include: sheep Merino ewes (18 micron) referred to as rams by DTIRIS.

*The area quarantined in each LSC Class is based on knowledge and understanding at the time of writing (June 2013).

10.1.1 Apiary Industries

The proposed activity (Bibblewindi Gas Exploration Pilot Expansion) is located on pre-disturbed land and won't require the removal of any potential pollen trees. Therefore, the Bibblewindi Gas Exploration Pilot Expansion will have negligible cumulative impacts on the apiary industry.

10.2 Water Resources

10.2.1 Surface Water

No surface water will be utilised for any of appraisal and exploration activities. Potential impacts posed by soil erosion will be managed with the implementation of an erosion and sediment control plan, in accordance with best management practices (such as the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008).

10.2.2 Groundwater

The total quantity of water to be abstracted from the Maules Creek Formation seams is summarised in **Table 7.3**. While the total quantity of water to be abstracted from the Hoskissons seam (Tintsfield pilot investigations) is 28,700 m^3, equating to an average of 18 m^3/day over the duration of the pilot.

Table 10.2: Proposed extraction volumes for Maules Creek Formation

Name	Total abstraction (m^3)	Maximum abstraction (m^3 / day)	Average abstraction (m^3 / day)
Pilot set 1	331,121	397	302
Pilot set 2	285,140	273	260
Pilot set 3	413,801	448	378
Pilot set 4	285,110	581	260
Pilot set 6	92,940	209	85

No aquifer interference to either the alluvial groundwater sources of the Upper and Lower Namoi alluvium (NSW Upper and Lower Namoi groundwater source WSP) or the GAB Surat Pilliga Sandstone (NSW GAB groundwater source WSP) is indicated by the modelling of the CSG water extraction activities.

The findings of the cumulative groundwater impact assessment show that depressurisation of the target coal seam as a result of pilot activities indicate a negligible decline in water levels (less than 0.5 metres) within the Namoi Alluvium and the Pilliga Sandstone groundwater sources. This impact is generally not manifested for a considerable amount of time (>500 years), by which time the calculated fluxes generating these impacts and the extents of drawdown are diminished to magnitudes, undetectable within the natural range of annual fluctuations.

The groundwater modelling also indicates that the late Triassic to early Jurassic strata, including the Triassic Napperby and Deriah Formations and the Jurassic Garrawilla Volcanics, may experience very localised maximum drawdown in the range of 1.4 to 3.8 metres occurring after at least 400 years from inception of CSG water extraction. Water quality and accessibility within these formations is considered poor, and there are no known beneficial use abstractions within the program area. Modelling of the CSG produced water extraction from the target coal seams is required to depressurise the coal seams. Inevitably this results in higher hydraulic head reduction in the corresponding and overlying model layers surrounding the targeted coal seams

10.2.3 Groundwater Users

Groundwater use within the exploration area is limited. This is attributed to most activities occurring within the footprint of the Pilliga Forest and lower bore yields associated with the consolidated rock units.

It is understood from the PINEENA database and limited bore inventory data obtained within PEL 238 and PAL 2 that there are no extractions from formations deeper than the Pilliga Sandstone. The majority of bores are utilised for stock and domestic purposes. A town water supply is provided from abstraction bores in Narrabri, to the north of the project area.

The target strata for CSG extraction are the principal coal seams of the Maules Creek Formation, which is not currently utilised for water supply due to depth, water quality and availability of better quality groundwater near the surface.

Further, groundwater extracted during the exploration and appraisal program pilot operations in the Pilliga Forest (Maules Creek Formations) and the Tintsfield Pilot (Hoskissons seam) are outside the general TDS

ranges for irrigation (650 – 5,200 mg/L) and livestock (2,000 – 10,000 mg/L) use. For instance, water quality of the target seams is saline, as described below:

- Malues Creek Fomation target seams:
  - Bohena seam - mean TDS= 18,752 mg/L, maximum TDS= 21,980 mg/L and minimum TDS= 13,159 mg/L;
  - Namoi seam - mean TDS= 14,110 mg/L, maximum TDS= 15,740 mg/L and minimum TDS = 13,159 mg/L; and
  - Rutley seam - no data.
- Hoskissons seam - mean TDS = 12,880, maximum TDS= 14,000 and minimum TDS= 12,000.

10.3 Additional Risks to Agriculture

Additional risks to agricultural enterprises posed by the Santos PEL 238 and PAL 2 exploration project include:

- Dust and noise;
- Weed management; and
- Pest animals / biosecurity.

The above additional cumulative risks will be managed similarly to mitigation measures outlined in **Sections 7.2.6** (Air and Noise), **7.2.7** (Weed Management) and **7.2.8** (Pest Animals / Biosecurity).

11.0 Consultation

Santos undertakes consultation activities with relevant stakeholders and community in the areas within which they work. This includes consultation with landowners and adjacent landowners, Council, Aboriginal Land Councils and relevant State agencies. Santos has also established a Community Consultative Committee in Narrabri, which meets on a regular basis to discuss Santos' activities across the broader area.

A detailed overview of existing and proposed consultation for the proposed activity, as well as Santos' conflict resolution protocol, is provided in **Sections 5.0** and **19.0** respectively of the Bibblewindi Gas Exploration Pilot Expansion EIS (RPS, 2013b).

12.0 Conclusion

- There would be no further surface disturbances for the proposed Bibblewindi 31 and 32 wells, due to their locations on existing lease areas;
- The proposed activity is considered low risk and will not have an adverse impact on the current or future agricultural production capacity or resources in the Narrabri LGA due to the following considerations:
  - » There are no intensive agricultural enterprises at the Bibblewindi Multilateral Pilot area or adjoining lands. Therefore, the proposed development does not have an unreasonable impact on agricultural production at the subject site or within the Narrabri LGA.
  - » The Bibblewindi Multilateral Pilot area is characterised by Sodosols, which are not suited for intensive agricultural production;
  - » The site is not located on or within 2 km of BSAL and/or a CIC,
  - » The proposed activity will not impact ground or surface waters that are linked or appropriate for agricultural use;
  - » The proposed mitigation, management and monitoring systems will reduce the likelihood of any impacts to agricultural resources or industries in the surrounding areas.
- The main adverse cumulative impacts of the proposed activity could include pressure on existing agricultural infrastructure and depletion of agricultural resources. However, the risk of these impacts are considered very low likelihood and impact, provided that mitigation measures are followed and applied according to best known methods.

13.0 References

Australian Bureau of Statistics (ABS) (2010), viewed 18 September 2012 <http://www.abs.gov.au/>

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Appendix 3

Groundwater Impact Technical Report

Prepared for

Santos NSW (Eastern) Pty Ltd

Bibblewindi Multi-lateral Pilot EIS - Groundwater Impact Technical Report

Energy NSW Coal Seam Gas Exploration and Appraisal Program





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REPORT DETAILS

Title:	**Bibblewindi Multi-lateral Pilot EIS - Groundwater Impact Technical Report**
Author:	**CH2M HILL**
Client:	**Santos NSW (Eastern) Pty Ltd**
Client Contact:	**Peter Mitchley**
Client Reference:	**Energy NSW Coal Seam Gas Exploration and Appraisal Program, Bibblewindi Multi-lateral Pilot Expansion (Bibblewindi 31/32) Gunnedah Basin NSW**

Synopsis**:** This report presents an assessment of impacts to groundwater as a result of the operation of the Bibblewindi Multi-lateral pilot set within a cumulative impact assessment of six pilots within the Narrabri Program area, following expansion within the Energy NSW Coal Seam Gas Exploration and Appraisal Program, Gunnedah Basin, NSW.

Executive Summary

Santos is undertaking an assessment of the environmental impacts of the installation of the Bibblewindi 31 and 32 pilot wells and the operation of these two wells in conjunction with the existing Bibblewindi Multi-lateral Pilot within the Narrabri Program area in New South Wales. This groundwater technical report presents the findings of a cumulative groundwater impact assessment, based on numerical groundwater modelling, undertaken for the cumulative impact of the concurrent operation of six pilots within the program.

Amendments to the original regional model, developed by CH2M HILL on behalf of Santos, included grid refinement in the area surrounding the pilot sites, assigning DRN/WEL cells and extraction rates to all six pilot site locations and separation of extraction phases into three distinct transient models (historical, proposed and recovery).

Five pilot sites target the Maules Creek Formation coals (Layer 12), the sixth pilot site targets the Hoskissons Seam within the Black Jack Group (Layer 8). Applied extraction rates were calculated from data provided by Santos in proportion to the number of model DRN/WEL cells.

Three transient model simulations were run to cover historical extraction, predictive (proposed) extraction (all proposed extractions run for a 3 year period) and long term recovery over 1,500 years. The main outcomes of the model simulation were as follows:

1. The total volume of water to be abstracted from the Maules Creek Formation coals (five active pilot sites) is 1.41 GL. All six pilots extract groundwater for a total of three years with different proposed start dates. The total quantity of water to be abstracted from the Hoskissons Seam (one active pilot site, Tintsfield 2-7 Pilot) is 0.03 GL.
2. No aquifer interference to either the alluvial groundwater sources of the Upper and Lower Namoi alluvium (NSW Upper and Lower Namoi groundwater source WSP) or the GAB Surat Pilliga Sandstone (NSW GAB groundwater source WSP) is indicated by the modelling of the six pilot CSG water extraction activities;
3. A decline in groundwater head of over 2 m is indicated for the lower part of the porous rock groundwater source of the Gunnedah Basin (GMA604) (NSW MDB Porous Rock groundwater source WSP). This impact on hydraulic (pressure) head combined with the fluxes developed within the lower part of the groundwater source required to meet the pilot CSG water demand are interpreted to comprise an aquifer interference within the combined groundwater source and thus may require licensing and approval;
4. No impact to any identified high priority GDEs identified in the vicinity of the Narrabri Gas program area is predicted to occur as a consequence of the six pilot CSG extraction activities;
5. No impact on any registered water extraction bores identified in the vicinity of the Narrabri Gas Project area is predicted to occur as a consequence of the six pilot CSG extraction activities; and
6. It is therefore considered unnecessary to instigate mitigation measures beyond standard operational environmental management controls in relation to the proposed six pilot CSG extraction activities.

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1 Introduction

1.1 Background

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 will primarily target CSG reserves associated with the Early Permian coal seams of the Maules Creek Formation (MCF), located at depth in the northern portion of the Gunnedah Basin.

The production of CSG requires depressurisation of target coal seams to stimulate release of gas from the coal. Water extraction is required to achieve this depressurisation and this water extraction has the potential to impact on groundwater and surface water resources and groundwater dependant ecosystems (GDEs).

1.2 Study Objective

To support the Environmental Impact Statement for the Bibblewindi Multi-lateral Pilot activities, Santos has commissioned CH2M HILL to undertake an assessment of the potential cumulative impacts to groundwater resources from CSG exploration. This considers the operation of the Bibblewindi Multi-lateral Pilot (including Bibblewindi 31 and 32), Bibblewindi West Pilot, Dewhurst 13 to 18, Dewhurst 22 to 25, Dewhurst 26 to 31 and Tintsfield 2 to 7, and utilises the existing numerical groundwater flow model for the Narrabri Program area.

1.3 Scope of Work

The scope of this assessment is summarised as follows:

- Modification of the existing numerical groundwater flow model for the Narrabri program area to simulate the predicted water extraction rates from the six pilots;
- A description of existing baseline monitoring for all surface and groundwater sources and dependent ecosystems within and adjacent to the development, and a summary of proposed future monitoring;
- A demonstration of compliances with the NSW Aquifer Interference Policy; and
- An assessment of the potential impacts on the quality and quantity of existing surface water and groundwater resources; including:
    - Detailed modelling of potential groundwater impacts including identification of any highly productive groundwater (as defined in the Aquifer Interference Policy) or groundwater dependent ecosystem, with particular reference to the Upper and Lower Namoi Alluvium and the southern recharge groundwater sources of the NSW Great Artesian Basin;
    - A description of impacts on riparian, ecological, geomorphological and hydrological values on watercourses or swamps, including environmental flows, with particular reference to Cowallah Creek and Mount Pleasant Creek;
    - The presentation of the cumulative impacts associated with existing developments as well as currently planned developments or proposed future developments

(comprising six pilots consisting of Bibblewindi Multi-lateral, Bibblewindi West, Dewhurst 13-18, Dewhurst 22-25, Dewhurst 26-31 and Tintsfield 2-7);

- Affected licensed water users and basic landholder rights (including downstream water users); and
- Identification of mitigation measures to reduce impacts to groundwater sources.

The general limitations of this study are presented below.

1.4 Assumptions and Limitations

CH2M HILL was contracted by Santos to undertake an assessment of the potential impacts associated with the pilot activities on groundwater resources. This report is based on the information that has been made available to CH2M HILL from the sources listed in the report. The conclusions drawn in the report are based on the data available at the time of writing and any subsequent additional information may allow refinement of the conclusions. It should be noted that:

- This report has been prepared under the express instructions by, and solely for the use of Santos.
- The findings of this report represent the professional opinion of experienced Hydrogeologists, Numerical Groundwater Modellers and Environmental Scientists.
- All work carried out in preparing this report has utilised and is based upon CH2M HILL's current professional knowledge and understanding of current relevant Australian and New South Wales Government regulation and legislation.
- Changes in legislation and guidance may occur at any time in the future and cause any conclusions to become inappropriate or inaccurate. CH2M HILL does not accept responsibility for advising Santos or other interested parties of the facts or implications of any such changes.
- This report has been prepared using factual information contained in data, maps and documents prepared by others. No responsibility can be accepted by CH2M HILL for the accuracy of such information.

2 Proposed Action

2.1 Pilot Sites

This assessment considers the cumulative impact caused by the program, which consists of the exploration activities associated with 42 wells at six pilot sites. These comprise:

- Bibblewindi Multi-lateral Pilot, including Bibblewindi 12-21/27-29/31-32 (14 wells) – abbreviated as BBW 12-21;
- Bibblewindi West, includes Bibblewindi 22-26 (5 wells) – abbreviated as BBW 22-26;
- Dewhurst 13-18 (6 wells) – abbreviated as DWH 13-18;
- Dewhurst 22-25 (5 wells) – abbreviated as DWH 22-25;
- Dewhurst 26-31 (6 wells) – abbreviated as DWH 26-29; and
- Tintsfield 2-7 (6 wells) – abbreviated as TNT 2-7.

Table 2-1 details the pilot wells to be included within the cumulative assessment. The arrangement of the wells and location in relation to one another is presented on Figure 2-1. Figure 2-2 presents the pilot bores in relation to the proposed Shallow Aquifer Monitoring Bores (SAMB), proposed Deep Aquifer Monitoring Bores (DAMB), existing registered groundwater bores and current Water Sharing Plans (WSP).

Table 2-1: Pilot Wells to be included in the Proposed Action

Pilot ID	Pilot well	Easting	Northing	V / H	Pairing	Stacking	Target Seam
Dewhurst 13-18 Pilot	DWH13	764567	6616967	V			Maules Creek Formation (MCF)
	DWH14	765592	6616503	V			
	DWH15	764654	6617147	V			
	DWH16	765680	6616689	H	13 & 16	Lat triple	
	DWH17	764741	6617327	H	14 & 17	Lat triple	
	DWH18	765766	6616870	H	15 & 18	Lat triple	
Dewhurst 22-25 Pilot	DWH6	764249	6610018	V			
	DWH22	763704	6610149	V			
	DWH23	764471	6609505	H	22 & 23	Lat triple	
	DWH24	764025	6610531	V			
	DWH25	764792	6609888	H	24 & 25	Lat single	
Dewhurst 26-31	DWH26	754309	6599871	H	26 & 27	Lat triple	
	DWH27	754943	6600649	V			
	DWH28	754525	6599701	H	28 & 29	Lat triple	
	DWH29	755159	6600479	V			
	DWH30	755385	6600332	H	30 & 31	Lat triple	
	DWH31	754760	6599547	V			
Bibblewindi Multi-lateral Pilot	BBW12	753818	6604437	V			
	BBW13	754200	6603693	V			
	BBW14	754456	6603955	V			
	BBW15	754027	6604759	V			

Pilot ID	Pilot well	Easting	Northing	V / H	Pairing	Stacking	Target Seam
	BBW16	754728	6604238	V			
	BBW17	755033	6604538	V			
	BBW18H	753388	6604718	H	18 & 14	Lat single	
	BBW19H	753647	6604994	H	19 & 16	Lat single	
	BBW21H	754168	6605608	H	21 & 27	Lat single	
	BBW27	755478	6604689	V			
	BBW28H	752989	6604214	H	28 & 29	Lat single	
	BBW29	754273	6603234	V			
	BBW31	753647	6604994	V			
	BBW32	754456	6603954	H	31 & 32	Lat single	
Bibblewindi West Pilot	BBW22	749807	6609043	V			
	BBW23	750106	6608555	V	26 & 23		
	BBW24	750230	6608719	V	26 & 24		
	BBW25	750358	6608877	V	26 & 25		
	BBW26	749412	6609350	H x 3			
Tintsfield 2-7	TNT2	752539.4	6635898	H	2 & 5	Lat single	Hoskissons Seam
	TNT3	752489.7	6635904	H	3 & 6	Lat single	
	TNT4	752589	6635891	H	4 & 7	Lat single	
	TNT5	751650	6635915	V			
	TNT6	751721.2	6636128	V			
	TNT7	751767	6636399	V			

2.2 Operation

2.2.1 General Operation

Future operation of each appraisal well will occur for a three year period. Operation activities will include the extraction of water from the appraisal wells of the estimated volumes in Table 3-3. Figure 2-3 shows periodised, monthly average extraction data including both historical and proposed rates, as used in the model.

Table 2-2: Proposed Extraction Rates for Pilots

Pilot ID	Total Extraction (m^3)	Max extraction (m^3/day)	Average Extraction (m^3/day)
Dewhurst 13-18 Pilot	331,121	397	302
Dewhurst 22-25 Pilot	285,140	273	260
Dewhurst 26-31 Pilot	413,801	448	378
Bibblewindi Multi-lateral Pilot	285,110	581	260
Bibblewindi West Pilot	92,940	209	85
Tintsfield 2-7 Pilot	25, 162	43	23

During operation of the six pilots, groundwater levels will be monitored by shallow and deep aquifer monitoring bores (SAMBs and DAMBs respectively) as presented on Figure 2-2.

2.2.2 Hydraulic Stimulation

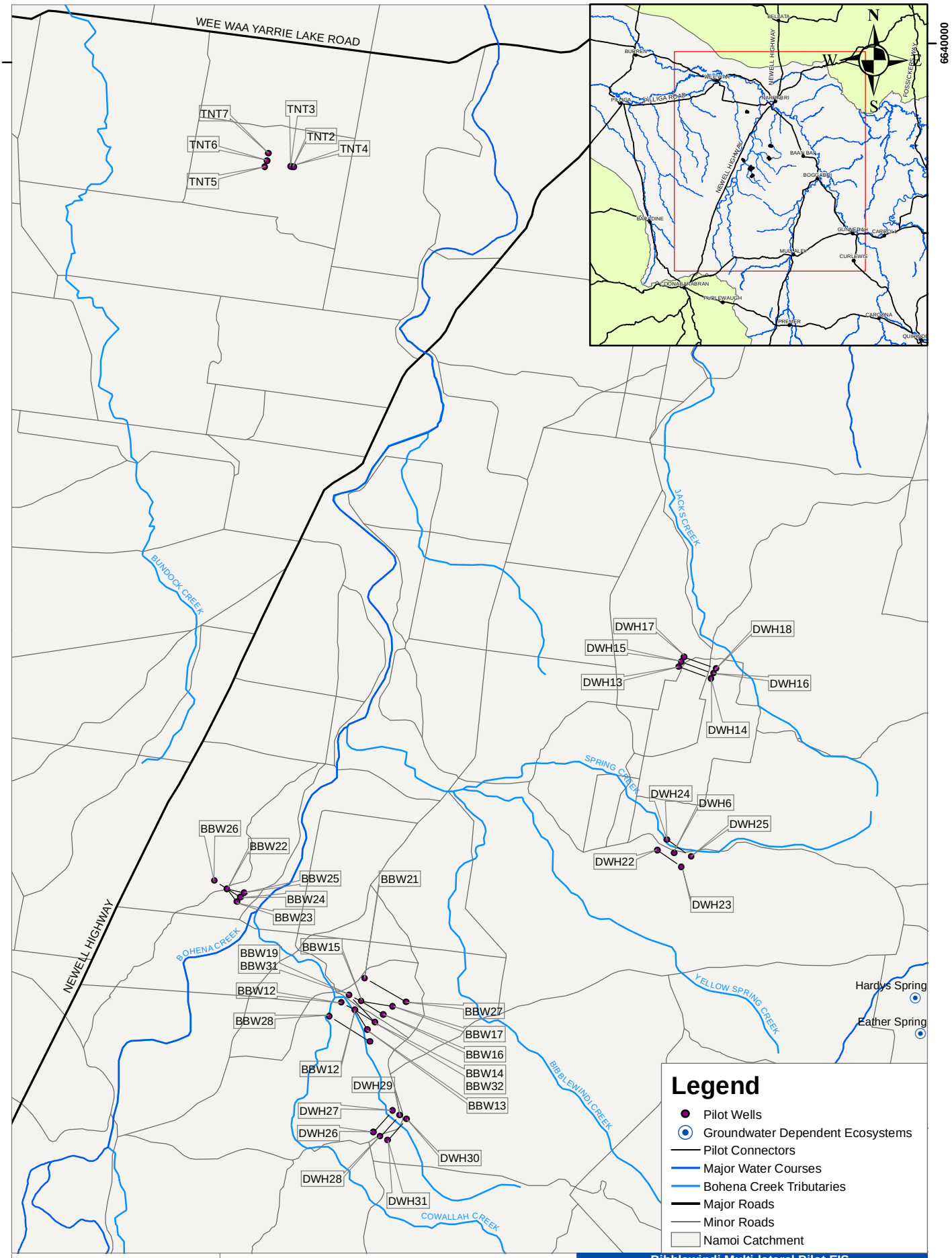
There are no plans to use the process of hydraulic stimulation (also known as hydraulic fracturing or fracking) within the program.

2.3 Historical Extraction

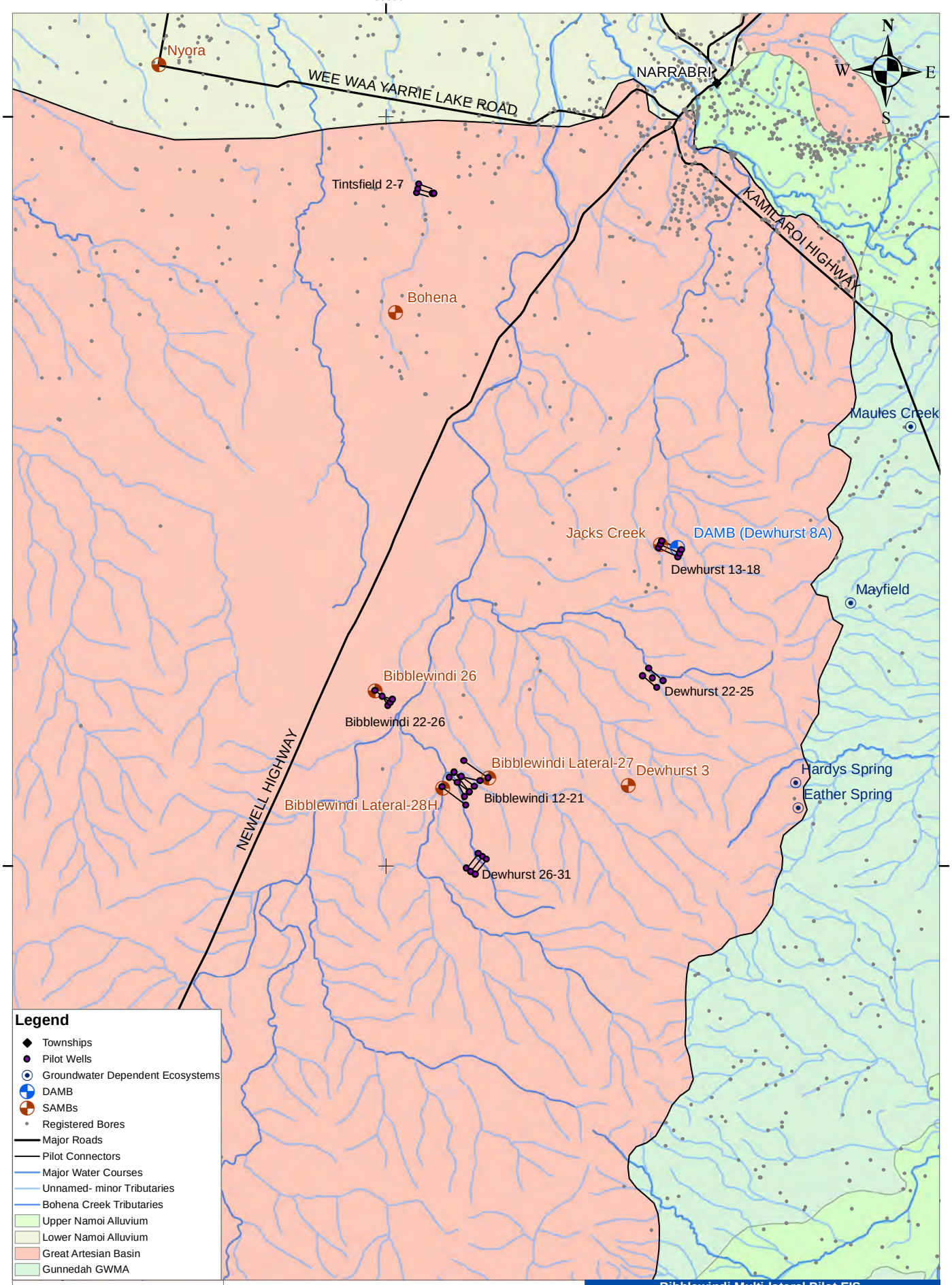
Historical water extraction has occurred at three of the pilot sites (Bibblewindi Multi-lateral, Bibblewindi West and Tintsfield 2-7) between March 2009 and February 2012, as detailed in Table 2-3 and Figure 2-3. As of February 2012, no extraction has been undertaken within the program area.

Table 2-3 Historical extraction rates

Pilot ID	Historical extraction (m^3) (Between March 2009 and Feb 2012)
Bibblewindi Multi-lateral Pilot	177,172
Bibblewindi West Pilot	94,020
Tintsfield 2-7 Pilot	19,226



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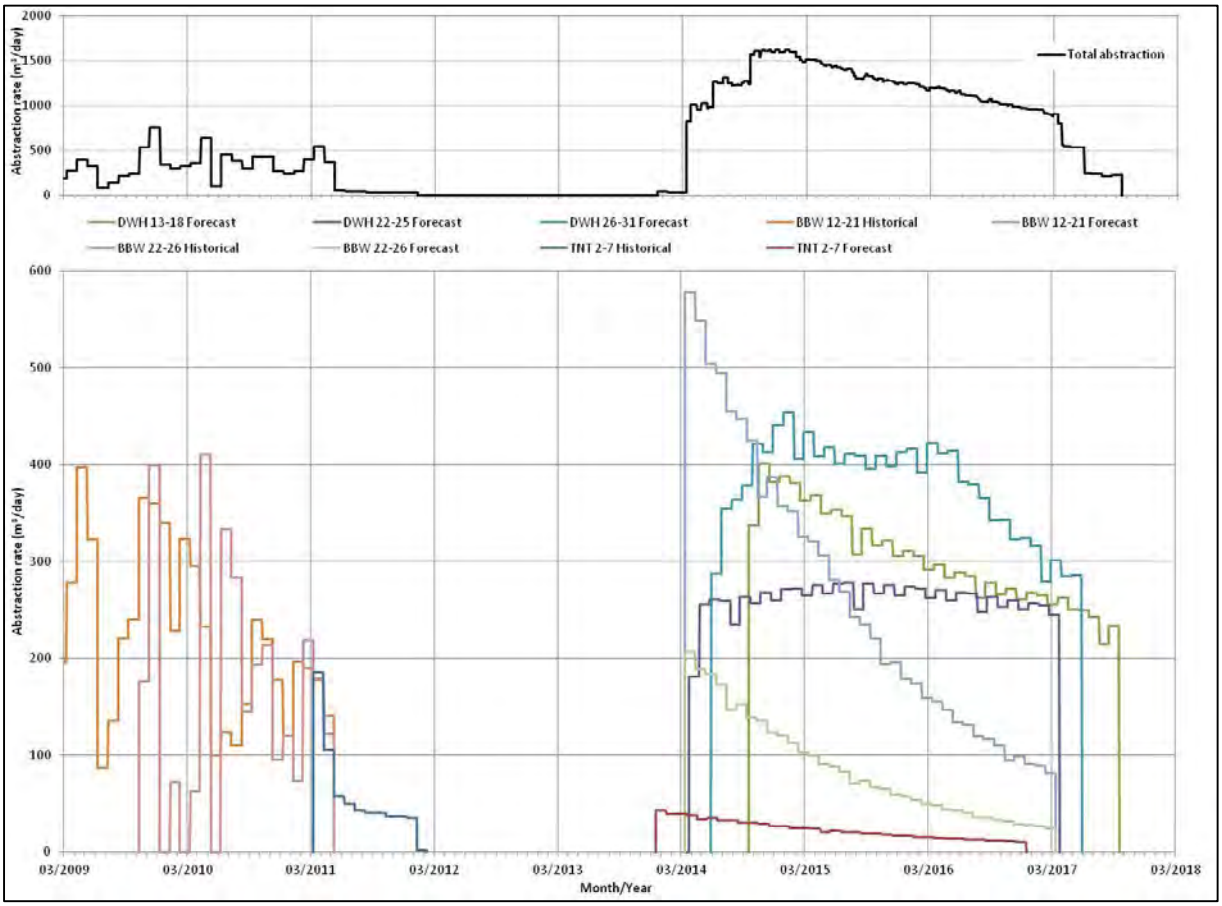
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Figure 2-2
Location of SAMBs and DAMB and WSP

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Figure 2-3 Simulated water extraction rates



3 Numerical Model

3.1 Narrabri Program Area Groundwater Model

The numerical groundwater flow model of the Narrabri program area has been utilised to simulate the potential cumulative impact on surface water and groundwater resources, and GDEs from the operation of the six pilot sites. Initial model development included:

- Data collation, literature review and gap analysis, including review of:
  - geological data;
  - existing exploration program borehole data;
  - existing well test work and formation evaluation data;
  - existing regional coal mining exploration borehole data;
  - relevant water management records;
  - groundwater quality data; and
  - regional groundwater literature and relevant coal mining-related groundwater studies;
- Characterisation of the groundwater environment, including identification of environmental values associated with groundwater resources;
- Development of the hydrogeological conceptual model (HCM); and
- Development of a groundwater flow model to facilitate the assessment of the potential impacts of CSG water extraction on water resources.

3.1.1 Model Development

The numerical groundwater flow model for the Narrabri program area was initially developed by Golder Associates (Golder Associates, 2011). The model was then developed further by Halcrow Group Ltd, a CH2M HILL Company in 2012.

The numerical groundwater model was constructed using MODFLOW-2005 and the graphical user interface (GUI) Groundwater Vistas interface V6.07 Build 18. MODFLOW is a three-dimensional finite-difference multi-layered numerical model developed by USGS. Groundwater Vistas was used to undertake pre- and post- processing of the input and output from MODFLOW. Further model refinement and development was undertaken by Halcrow using Groundwater Vistas V6.22 Build 2.

A 3D geological model of the study area was synthesised from point data provided by Santos including Department of Minerals and Energy (DME) and the Department of Mineral Resources (DMR) borehole logs. The base of the model was set within the Boggabri Volcanics/Werrie Basalts.

The model extends:

- Eastward beyond the Boggabri Ridge to the eastern side of the Namoi River;
- Southward beyond the Walla Walla Ridge into the Bando Trough;
- Westward to the Rocky Glen Ridge; and

- Northward beyond the Narrabri High and the Namoi River to the inferred location of the groundwater divide within the GAB (in accordance with groundwater level information presented in GABFLOW2000 (Welsh, 2000).

The model grid is aligned with grid north and the domain extends 123 km along a north-south axis and 107 km along an east-west axis. The south western corner of the grid is located near Yearinan at 711000, 6547000 and the north eastern corner of the grid is located near Rocky Creek at 818000, 6670000, in the GDA94 (MGA94 Zone 55) coordinate system.

The model consists of 178 columns and 176 rows. The model grid cell size is 1 km by 1 km with refinement of the cells in the vicinity of Rocky Glen Ridge, Narrabri High and Boggabri Ridge (refined to 0.5 km wide and/or 0.5 km long) to accommodate steep changes in basement topography. The model consists of 14 layers, defined in Table 3-1.

Table 3-1 Stratigraphy and model layering

Epoch	Hydrostratigraphic unit	Hydrogeological Classification	Model layer
Quaternary	Alluvium	STU	1
Jurassic	Pilliga Sandstone	STU	2 and 3
	Purlawaugh Fm	NTU	4
	Garrawilla Volcanics	LSTU	
Triassic	Deriah Fm	PNTU	5 and 6
	Napperby Fm	PNTU-NTU	
	Digby Fm	NTU	
Permian	Black Jack Group	STU to PNTU	7, 8 and 9
	Millie Group (Porcupine Fm & Watermark Fm)	NTU	10
	Upper Maules Creek Fm	NTU	11
	Target coal seams (Rutley Namoi & MCF)	STU	12
	Lower Maules Creek Fm	NTU	13
Pre-Permian	Basement	NTU	14

Notes:
STU – Significant transmissive unit
LTU – Less significant transmissive unit
PNTU – Probable negligibly transmissive unit
NTU – Negligibly transmissive unit

3.2 Approach to Cumulative Impact Modelling

The numerical groundwater flow model of the Narrabri program area was adapted and refined to model the potential cumulative impact of the operation of the six pilot sites.

The modelling was undertaken utilising MODFLOW-SURFACT™ v4 to assess the cumulative impact assessment of pilot activities. MODFLOW SURFACT™ was selected over the standard MODFLOW2005 package on account of MODFLOW SURFACT's better ability to handle the re-wetting of dry cells within the model enabling the model to recover following depressurisation. Groundwater Vistas v6.33 was utilised for pre- and post-processing of numerical outputs.

The basic model architecture has not been modified, preserving the existing vertical layer structure and parameterisation. Additional horizontal discretisation has been focused at the location of each pilot site to provide clearer spatial resolution and to model appropriate curvature of the piezometric surface.

3.2.1 Grid refinement

The minimum cell spacing of the base Narrabri groundwater flow model was 500 m by 500 m. To facilitate a more accurate representation of the curvature of the water table in the vicinity of the localised hydraulic stress imposed by the six pilots, further grid refinement was made to a minimum cell size of 100 m by 100 m, as presented in Table 3-2 below.

Table 3-2 Details of grid refinement

Model	No. Rows	No. Columns	No. Layers	No. Active cells	Row spacing (m)		Column Spacing (m)	
					Min	Max	Min	Max
Original Narrabri program area model	176	178	14	395,612	500	1125	500	1476
Refined six pilot model	309	288	14	1,184,022	100	1125	100	1476

3.2.2 Pilot configurations

Individual pilots, comprising combinations of lateral well arrays, have been modelled in greater detail with the in-seam lateral component of individual wells in each array represented as multiple WEL or DRN boundaries at which the flux or head is manipulated respectively. Hence DWH 26-31, consisting of three vertical and three lateral wells is simulated in this model as three lines of nine WEL/DRN boundary cells, 27 model cells in total. In the WEL simulation used to determine system fluxes, the prognosed water extraction rate is divided equally between the 27 cells. In the DRN simulation used to determine head impacts, the depressurisation is applied equally at all 27 cells (See Table 3-3 for details of all simulated pilot sites).

Table 3-3 Pilot site configuration

Pilot site	No. Pilot Lines	No. Pilot wells per line	Total No. DRN/Well Cells
Bibblewindi Multi-lateral	Mixed configuration	-	75
Bibblewindi West (BBW 22-26)	Mixed configuration	-	20
DWH 13-18	3	10	30
DWH 22-25	2	8	16
DWH 26-31	3	9	27
TNT 2-7	3	8	24

3.2.3 Extraction rates

Historical and predicted water rates were simulated within the model. Historical water extraction data were incorporated into the simulations due to the consequence of the magnitude of these historical extractions and the likely impacts on heads in the respective coal seam. Table 2-2 and Table 2-3 detail the proposed and historical water rates respectively. Figure 2-3 illustrates the simulated water extraction rates, periodised according to modelled timesteps.

Water extraction from WEL boundaries relating to each of the six pilots is assigned to the model layer associated with the respective target seam. Pilot sites BBW Multi Lateral, BBW West, DWH 13-18, DWH 22-25 and DWH 26-31 target seams of the Maules Creek Formation (Layer 12). The TNT 2-7 pilot site targets the Hoskissons seam of the Black Jack Group (Layer 8).

3.2.4 Model Simulation Duration

The model simulated three separate transient models, as shown in Table 3-4, representing historical extraction, proposed extraction and a recovery period. Three transient models were required in this instance to maintain model stability and optimise computational resources.

Each pilot extracts water for a duration of 3 years with different start dates. To accommodate the varying start dates the proposed extraction model was run for a total duration of 4 years. Extraction at each of the six pilot sites was represented as active well nodes within the model simulation. Well nodes were activated at the relevant start date for each pilot and deactivated after a three year period. The hydraulic heads within the model domain were then allowed to recover for a period of 1,500 years.

The duration of recovery was designed to ensure that impacts arising due to releases from aquifer storage at later times, delayed yield, induced by greater-than-negligible drawdown due to water extraction, could be captured.

Table 3-4 Details of model simulation durations

Model Run	Duration	Start date	Stress Period (SP) Set-Up	Total No. Stress Periods (SP)	Time Steps (TS) per SP
Historical	55 months	March 2009	55 monthly SPs	55	5 TS/SP
Proposed extraction "predictive model"	4 years*	October 2013	48 monthly SPs	48	5 TS/SP
Recovery	1500 years	October 2017	1 x 10 year SP 1x 40 year SP 1x450 year SP 1x 1000 year SP	4	Adaptive time stepping used
*Each pilot site is active for a duration of 3 years. Proposed extraction model duration of 4 years accommodates the different start dates of proposed extraction.					

3.2.5 Initial Conditions

Initial values of groundwater head, or 'Initial Heads' (IH), are commonly derived from monitoring data, where such data are available. Prior monitoring data to adequately describe IH are not available and therefore IH have been derived from a precursor "*steady-state model*", calibrated using the data available for the shallow alluvial groundwater sources (Namoi alluvium) and sparse head data for deeper layers obtained during historical exploratory drilling. These IH have been used as seed heads for the "*historical model*" for the simulation of the historical pilot water extraction (the first transient model). The historical model incorporates some water level/pressure recovery which will have occurred between the end of the historical water extraction and the commencement of the six pilot exploration sites presented in this report. The historical model yields "historical heads" (HH) representing the groundwater condition at the time of the start of the "*predictive model*" (the second transient model).

3.2.6 Observation Wells

The 'specific' determination deploys theoretical observation wells sited at each pilot site to capture the maximum drawdown created by the water extraction from that respective pilot array. The 'generalised' determination relies on monitoring positions located in accordance with the proposed Shallow Aquifer Monitoring Bore (SAMB) and Deep Aquifer Monitoring Bore (DAMB) arrays. The proposed SAMB and DAMB locations are shown on Figure 2-2.

3.3 Model Assumptions

There is inherent uncertainty associated with any numerical groundwater model. The uncertainty arises from the assumptions employed in the model, but also the adequacy of the input data to sufficiently calibrate a steady state model, and run transient models. Some of the assumptions include:

- The formations are assumed to be homogeneous and isotropic (with the exception of the coal seams) from the scale of each grid cell to the regional scale. In reality, the hydraulic properties of each formation will vary spatially both laterally and with depth.

- The groundwater level and extraction data from the Pineena database and from New South Wales Office of Water are assumed to be adequate to represent the long term average. However, the period of measurement is only 16 years, whereas the period of modelling is likely to be at least 500 years.
- A constant groundwater extraction rate (from private bores) and constant rainfall recharge are used in the transient (prediction) simulations. However, in reality the rates will change with season and from year to year. The inclusion of time-variable values may result in scatter of the predicted heads which is unrelated to the CSG extraction.
- Recharge to the Maules Creek and Black Jack Group is required to be able to model the observed high groundwater pressures. Recharge is likely to be via vertical infiltration through the Bogabbri Volcanics at outcrop. Recharge in the model was implemented by Golder by adding a basement flux to the bottom layer of the model. Although this has allowed a more reasonable calibration to the deeper DST pressure measurements it has also resulted in groundwater mounding where the Permo-Triassic strata of the Gunnedah Basin outcrop.

Some of the potential input data gaps include:

- Extraction returns or licensed rates are not available for all of the Namoi Alluvium/ Pilliga Sandstone extractions. Extractions for which returns/licensed rates are not available were not included into the model. This may have an effect on the extent of the calibration.
- A steady state model is designed implicitly to represent the long term conditions. However, the model was calibrated to spot groundwater level measurements within the Pilliga Sandstone and underlying formations from Santos DST pressure measurements and from work undertaken by Aquaterra at the Narrabri Coal Mine in 2009. This could potentially result in poor calibration with some of the deeper formations.
- In general, 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 calibration dataset is considered not of sufficient duration to undertake both steady state and transient calibration.

4 Impact Assessment

4.1 Potential head impact

Simulation of multiple pilot sites, including the Bibblewindi Multi-lateral Pilot, and associated historical and proposed extractions resulting in maximum head impacts varying with time and location, addresses two determinations of impact that are specific and generalised as discussed in Section 3.2.6.

Thresholds of significance of water level decline or pressure head decline of 0.5 m and 2.0 m have been considered by which to determine the significance of impact on highly productive and less productive groundwater sources respectively.

4.1.1 Specific determination of impact

Figure 4-1 shows drawdown versus time for the period covering historical and proposed extraction and the initial 40 years of recovery for all theoretical observational bores central to the pilot sites, including the Bibblewindi Multi-lateral Pilot in the Maules Creek Formation (MCF) coals (Layer 12). The graph shows the trend observed within all wells, including the after two stages of extraction and demonstrates the initial rapid recovery when extraction ceases.

Drawdown within all pilot sites reaches a maximum at the end of proposed extraction at that site (pilot sites have different start dates) and generally achieves over 80% recovery within 10 years. Maximum drawdown in the MCF coals is 995 m, observed in DWH 13-18 at the end of proposed extraction and 8.5 years after the onset of the historical model run in March 2009. DWH 13-18 shows a 93% recovery only 10 years after the cessation of extraction at that site. Thus the recovery of the Bibblewindi Multi-lateral pilot operation will show at least 80 % recovery within 10 years of cessation of pilot activities.

Figure 4-2 shows drawdown versus time data for all theoretical observational bores central to the pilot sites in the MCF coals (Layer 12) for the recovery period between 50 years and 1500 years since the onset of historical extraction in March 2009. The graph in figure 4-2 shows a slower recovery rate than that observed in the initial 10 year period. Drawdown in layer 12 at all pilot sites recovers to less than 2 m within 600 years of the cessation of proposed pilot extraction.

Figure 4-3 shows the spatial extent of drawdown up to 0.5 m within the MCF coals (Layer 12) at 8 years from March 2009. This is when the majority of pilots exhibit maximum drawdown.

Maximum drawdown in the layers overlying the MCF coals occurs at later periods and recovers more slowly due to delayed yield. Maximum drawdown in the Porcupine and Watermark formations (Layer 10) is 15 m, observed around at the Bibblewindi Multi-lateral Pilot (shown on the graph as BBW 12-21) at 34 years from March 2009. The other pilots within the cumulative assessment exhibit a maximum drawdown at an earlier time. Figure 4-4 shows the spatial extent of drawdown up to 0.5 m in the Porcupine and Watermark Formations at 28.5 years since March 2009 when the majority of pilot wells exhibit a maximum drawdown in model Layer 10.

Figure 4-5 shows drawdown versus time for the same time period as Figure 4-1 but for the theoretical observation bore at the Tintsfield site which extracts from the Hoskissons Seam (Layer 8). Similar to the extraction observed in the MCF, the graph shows the rapid response to the commencement and cessation of extraction in the target Hoskissons seam. Maximum

drawdown in the Hoskissons seam is 726 m occurring 8 years after the onset of historical extraction in March 2009. After the initial 40 years of recovery drawdown in the Hoskissons Seam (Layer 8) at the Tintsfield pilot site is reduced to less than 2 m. Figure 4-6 shows the extent of drawdown up to 0.5 m in the Hoskissons seam at 8 years from March 2009.

As with extraction from the MCF, drawdown in the strata overlying the Hoskissons seam experiences a lag due to delayed yield. Maximum drawdown in the Triassic strata (Deriah, Napperby and Digby formations, Layer 6) is represented at the Tintsfield pilot site, where the pilot targets the Hoskissons seam is predicted to be 6.5 m occurring 12 years following the onset of historical extraction in March 2009. Impacts to the MCF at the Tintsfield Pilot are negligible. There is no measurable drawdown in the overlying Pilliga Sandstone (Layer 3) or Namoi alluvium (Layer 1) at the location of the Tintsfield site. Figure 4-7 shows the extent of drawdown up to 0.5 m in the Triassic strata at 12 years from March 2009.

4.1.2 Generalised determination of impact

Table 4-1 presents the maximum drawdown predicted at proposed SAMB/DAMB monitoring bore locations within key layers at key time steps. Table 4-1 illustrates that there is negligible predicted impact (defined as less than 0.5 m) in the Namoi alluvium (Layer 1) and the Pilliga Sandstone (Layer 3).

Table 4-1 Maximum drawdown in SAMB and DAMB locations

HSU	HSU No.	Model Layer	Maximum drawdown in layer (m)*					
			Sept/Oct 2013 (End of historical extraction)	Oct 2017 (End of predictive model run)	Oct 2027 (10 years of recovery)	Oct 2117 (100 yrs of recovery)	Oct 2517 (500 yrs of recovery)	Jan 3517 (1500 yrs of recovery)
Namoi alluvium	8	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pilliga Sandstone	10	3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Triassic Strata (Deriah, Napperby and Digby Formations)	3	6	<0.5	<0.5	<0.5	<0.5	0.7	<0.5
Hoskissons seam	3	8	<0.5	<0.5	1.1	2.9	1.6	<0.5
Porcupine and Watermark Formations	5	10	2.0	4.8	9.4	9.7	3.7	0.8
Maules Creek Formation seams	11	12	179.4	995.0	116.0	7.3	2.2	0.5

*Maximum drawdown based on generalised impact at proposed monitoring locations. Specific drawdown at theoretical observation bores located centrally within pilot sites may potentially be greater.

Figure 4-8 and Figure 4-9 show drawdown versus time data for the Namoi alluvium (Layer 1), Pilliga Sandstone (Layer 3), Triassic strata (Layer 6), Hoskissons seam (Layer 8), and the Porcupine and Watermark Formations (Millie Group, Layer 10) in the location of BIBBLEWINDI 28 SAMB (proximal to several pilot sites) and JACKS CREEK SAMB (proximal to DWH 13-18 pilot) respectively. SAMB locations are shown on Figure 2-2. Figure 4-8 and Figure 4-9 confirm that the drawdown at the BIBBLEWINDI 28 SAMB and JACKS CREEK SAMB locations emulates that predicted for the theoretical wells located centrally to the individual

pilot sites and that there is no significant impact above the Triassic strata (none exceeding 0.5 m).

Figure 4-10 shows drawdown versus time data for the Namoi alluvium (Layer 1), Pilliga Sandstone (Layer 3), Triassic strata (Layer 6), Hoskissons seam (Layer 8), Porcupine and Watermark Formations (Millie Group, Layer 10) and MCF (Layer 12) in the location of an indicative monitoring bore location (distally east of the Program area). The figure shows minimal impact of extraction outside of the Program area in all layers.

4.2 Predicted Fluxes

Mass balance data has been used to identify the factors supporting the modelled CSG extraction from the MCF coals (Layer 12) and the Hoskissons Seam (Layer 8), in terms of flux between layers and change in layer storage. Previous investigation has identified a hydraulic gradient existing between deeper strata to shallower strata creating a consistent upward flux in the system naturally with or without active CSG extractions. To exclude the impacts of the naturally occurring upward flux and to identify the impacts resulting from the proposed CSG extraction only, two transient simulations were conducted; one with and one without active CSG extraction. The nett difference between the two simulations is presented below.

Figure 4-11 shows the nett change in flux between layers and in layer storage for model Layers 1-12 at 8 years from March 2009, or 36 months after the onset of proposed extraction when all six pilots are active. Figure 4-11 shows the extraction from Layer 12 (MCF coals) is accommodated by a nett increase in flux from Layer 13 (Qz bottom), a nett decrease in flux to Layer 11 (Qz top) and a nett decrease in storage in the target layer itself. The extraction from layer 8 (Hoskissons seam) is accommodated by a nett increase in flux from Layer 9 (Qz bottom) and a nett decrease in flux in to Layer 7 (Qz top). Figure 4-11 demonstrates that the fluxes originating from layers above Layer 6 (the Triassic Strata) are negligible at 36 months from the onset of the proposed pilot extraction, indicating the impacts of depressurisation of the MCF coals (Layer 12) and the Hoskissons Seam (Layer 8) are confined by the Black Jack Group (Layers 7-9) and the Triassic Strata (Layers 5 and 6).

Figure 4-12 shows the nett change in flux between layers and in layer storage for model Layers 1-12 at 28.5 years from March 2009, 20 years into the recovery phase and the time of maximum impact observed in the Porcupine and Watermark Formations (Layer 10). Figure 4-12 demonstrates that the predicted drawdown in Layer 10 is accommodated by a nett decrease in flux from underlying layers (Qz bottom), a nett increase in flux to layer 9 (Qz top) and a nett decrease in storage in the layer itself. Figure 4-12 demonstrates that the fluxes originating from layers above Layer 9 (Black Jack Group) are negligible at 20 years into the recovery phase. Negligible fluxes above Layer 9 indicate the impacts of depressurisation of the MCF coals are still confined by the Black Jack Group (Layers 7-9) and the impacts related to depressurisation of the Hoskissons Seam (Layer 8) are insignificant beyond 20 years of recovery.

Figure 4-13 illustrates the nett change in fluxes (flows) of groundwater into and out of model Layers 6 to 12 and into or from layer storage, at 8 years and 28.5 years from March 2009. The black arrows indicate the CSG produced water extraction from the respective layers. The fluxes / storage changes in each layer sum to zero, with gains or losses from overlying or underlying layers matched by extractions and changes in layer storage accordingly. The numbers have been rounded to the nearest unit for simplicity.

A total of 1.43 GL of water is required by the six pilot sites to satisfy the proposed CSG extraction. A maximum induced flux of approximately 2.0 m^3/d is predicted to occur between

the Gunnedah-Oxley Basin (GOB) and the NSW Great Artesian Basin (GAB) groundwater sources 500 years from commencement of the recovery phase. A maximum induced flux of approximately 0.5 m3/d is predicted to occur between the GOB and Upper Namoi Alluvium (UNA) groundwater sources at 1,100 years from the start of the recovery phase.

Predicted fluxes between groundwater sources are considered insignificant in terms of the aquifer interference policy.

4.3 Outcomes related to the Aquifer Interference Policy

The outcomes of the simulations have been considered in the context of the NSW Aquifer Interference Policy (AIP) 2012 minimal harm criteria. The Bibblewindi Multi-lateral project area lies within the NSW GAB groundwater sources WSP which comprises the Southern Recharge Beds; this overlies the Murray Darling Basin Porous Rock groundwater WSP (incorporating the Gunnedah-Oxley Basin).

4.3.1 NSW Upper and Lower Namoi Groundwater Source WSP

The alluvial groundwater sources of the Upper and Lower Namoi alluvium (NSW Upper and Lower Namoi groundwater source WSP) are considered within the context of the AIP to be highly productive alluvial groundwater sources. These deposits are represented in the model as Layer 1. No decline in water table level or change in flux is indicated by model outcomes (Table 4-1). Hence no aquifer interference to this groundwater source is indicated by the modelling of the pilot CSG water extraction activities.

4.3.2 NSW GAB Groundwater Source WSP

The porous rock groundwater source of the GAB Surat Pilliga Sandstone (NSW GAB groundwater source WSP) is considered within the context of the AIP to be a highly productive porous rock groundwater source. These strata are represented in the model as Layers 2 & 3. The Purlewaugh Formation (represented in the model as Layer 4, with the Garrawilla Volcanics) also forms part of the same WSP although it is considered to constitute a non-aquifer. No decline in water table level or change in flux in Layers 2, 3 or 4 is indicated by the model outcomes. Hence no aquifer interference to this groundwater source is indicated by the modelling of the pilot CSG water extraction activities.

4.3.3 NSW Murray Darling Basin Porous Rock Groundwater Source WSP

The porous rock groundwater source of the Gunnedah Basin (GMA604) (NSW MDB Porous Rock groundwater source WSP), comprising the Triassic strata of the Digby, Napperby and Deriah formations (Layers 5 and 6) and the Permian strata of the Black Jack Group (Layers 7, 8 and 9) down to and including the MCF (Layers 11, 12 and 13), is considered within the context of the AIP to be a less productive porous rock groundwater source. These combined strata are represented in the model as Layers 5 to 13, with the CSG water extraction occurring in Layers 8 and 12. A decline in head of over 2 m within Layers 8 to 12 is indicated by the model outcomes. Given that the pilot CSG water extraction will occur within this AIP-classified water source, the impact on hydraulic (pressure) head within the combined group of layers (5-13) and the fluxes developed within the groundwater source to meet the pilot CSG water demand are interpreted to comprise aquifer interference and will require licensing and approval.

Figure 4-3 and Figure 4-4 illustrate the extent of cumulative drawdown in the target MCF seams (Layer 12) and the Porcupine and Watermark Formations (Layer 10) of all six pilots

respectively. Figure 4-6 and Figure 4-7 illustrate the extent of drawdown in the target Hoskissons Seam (Layer 8) and the Triassic strata (Layer 6) of the Tintsfield pilot respectively. The zones of influence illustrated in these figures remain west of the outcrop of the Gunnedah Basin Permo-Triassic strata. Hence the registered bores illustrated in Figure 2-2 within this region of the MDB Porous Rock (Gunnedah Basin GMA604) groundwater source WSP which extract from this groundwater source will not be impacted by the pilot CSG water extraction. Those registered bores illustrated in Figure 2-2 that also lie within the zones of influence shown in Figure 4-3, Figure 4-4, Figure 4-6 and Figure 4-7 are positioned on the outcrop of the Pilliga Sandstone and are highly likely to be completed within this groundwater source only and are therefore considered very unlikely to experience any impact. Impacts to registered bores are considered further in Section 4-6.

4.4 Potential impact on high priority GDEs

Three high priority GDEs are identified in the vicinity of the Narrabri program area. Hardy's Spring, Mayfield Spring and Eather Spring, are understood to be hydrogeologically associated with the Pilliga Sandstone and located approximately 20 km to the east of the Bibblewindi Multi-lateral Pilot. As stated above, the Pilliga Sandstone forms part of the NSW GAB Groundwater Source WSP but modelling has indicated no decline in water table level or change in flux in the relevant model layers and hence no impact at any of these GDE springs is predicted to occur. It is considered that each of the GDEs can be characterised as a recharge-rejection ("water table") spring in the Pilliga Sandstone, caused by the underlying very low vertically conductive Purlewaugh Formation which effectively insulates the spring from any depressurisation occurring below.

4.5 Potential impact on GDE terrestrial vegetation

Given the findings set out in Section 4.2, the model results also indicate that there will be no significant impact on groundwater dependant terrestrial vegetation (including the Pilliga Scrub) identified within the program area.

4.6 Potential impact on registered water supply bores

The locations of registered water supply bores are shown on Figure 2-2. Based on the hydrogeological setting of the project area, and the accessibility of groundwater from the GAB Surat Pilliga Sandstone, it is considered unlikely that any registered extraction exists from bores in formations deeper than Layer 3 of the model (Pilliga Sandstone). As discussed in Section 4.2, the predicted impacts on the GAB Surat Pilliga Sandstone and Upper and Lower Namoi alluvium groundwater sources insignificant, and thus the predicted impact on registered water supply bores as a result of the cumulative pilot activities will not be significant.

With specific reference to the Bibblewindi Multi-lateral Pilot, there are 5 registered bores within 5 kilometres of the pilot. All are understood to draw water from the GAB Surat Pilliga Sandstone, and thus, the impact on these water supply bores is not predicted to be significant.

4.7 Mitigation

Given the outcomes reported in Sections 4.1 to 4.5 above, it is considered unnecessary to instigate mitigation measures, beyond standard operational environmental management

controls, in relation to impacts to groundwater or groundwater dependent features as a result of the operation of the proposed six pilot sites.

4.8 Monitoring

To demonstrate that pilot test or further development activities are unlikely to cause harm to groundwater, surface water and GDEs; Santos propose to undertake the following monitoring well installation and activities:

- Design and implementation of a deep aquifer monitoring bore (DAMB), one location has been identified as a proposed DAMB within the older Triassic and Permian strata;
- Design and implementation of a shallow aquifer monitoring bore (SAMB) network; seven potential SAMB locations have been identified for installation within the overlying substrates (including Pleistocene alluvial deposits and Cretaceous to Jurassic GAB strata).
- Baseline assessment of registered groundwater bores within the program area, which includes gathering information on the water quality, groundwater level and general condition of the bores; and
- Baseline assessment of surface water sites within the program area to provide baseline water quality conditions to enable the identification of any changes in water quality in the future.

Figure 4-1 Predicted drawdown in the MCF coals (Layer 12) at the pilot site locations (up to 50 years)

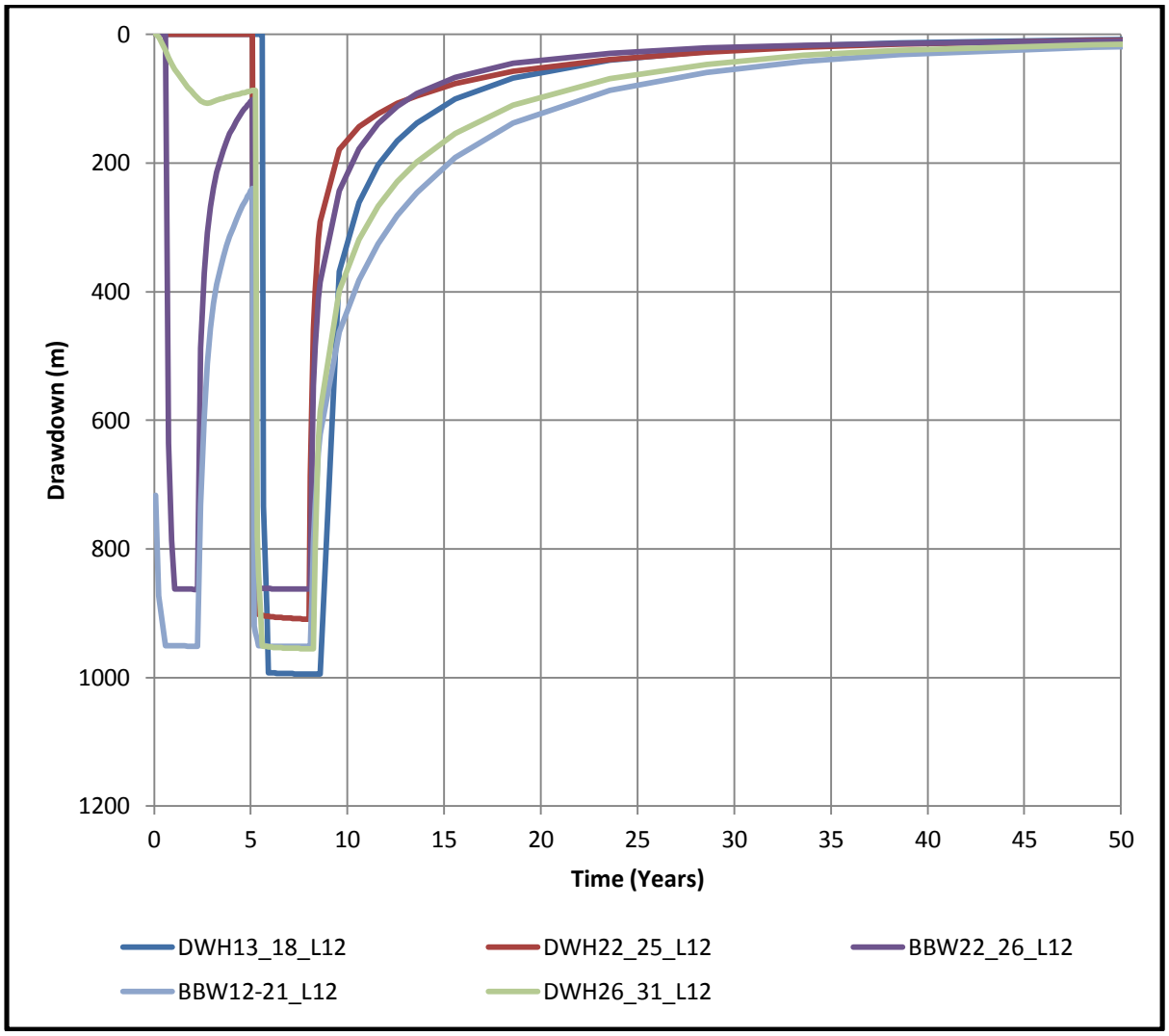
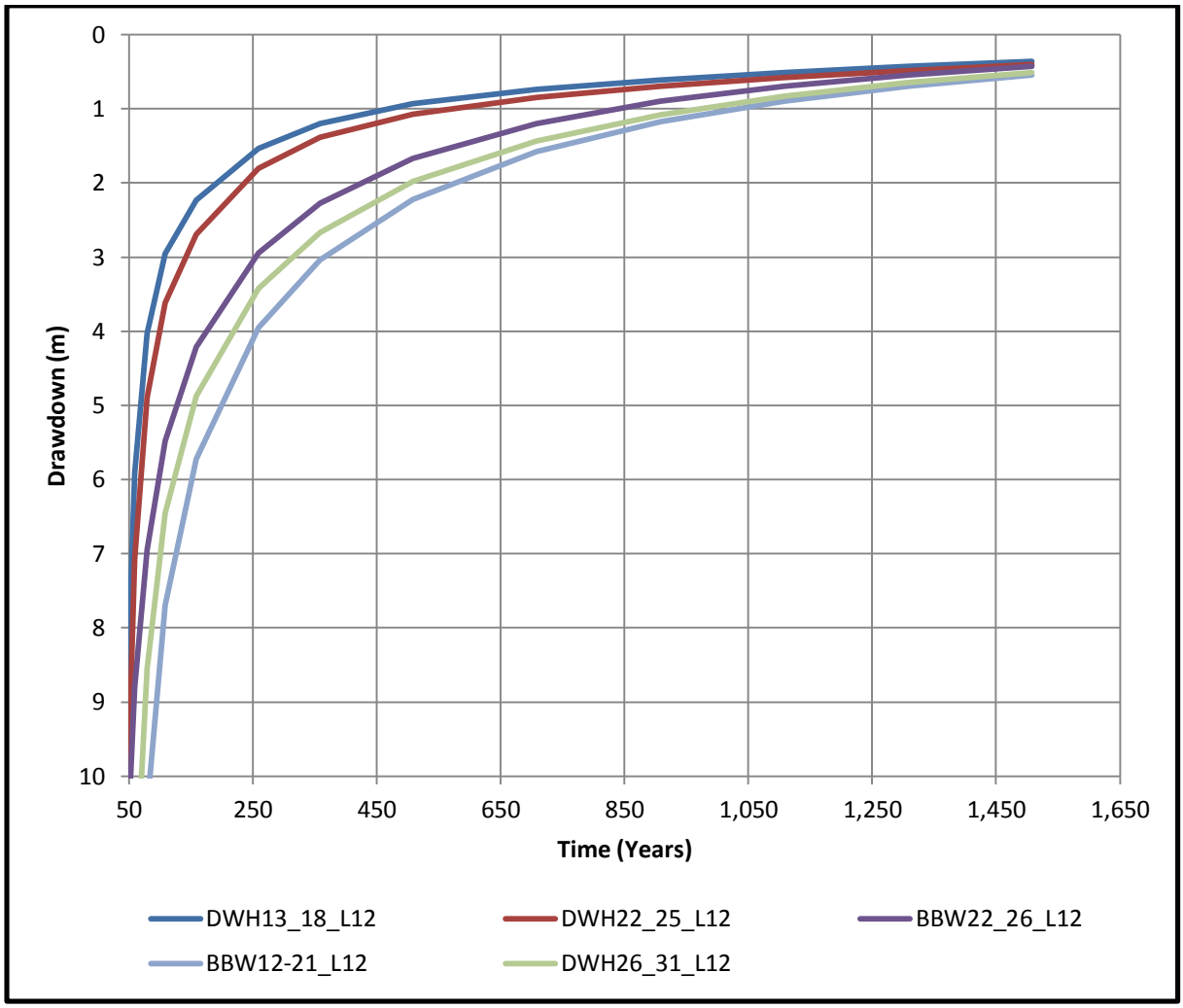
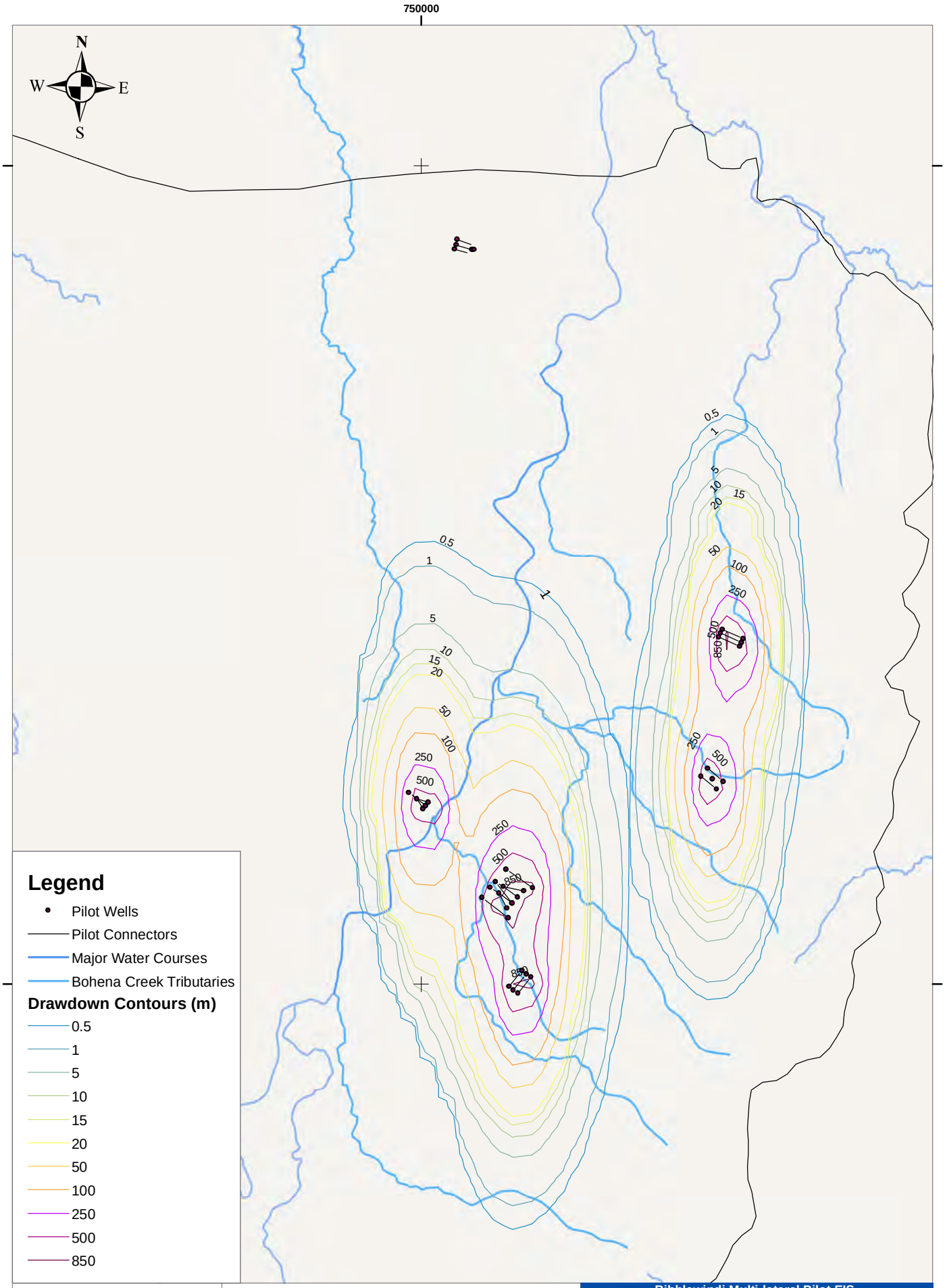


Figure 4-2 Predicted drawdown in the MCF coals (Layer 12) at the pilot site locations (from 50 to 1500 years)





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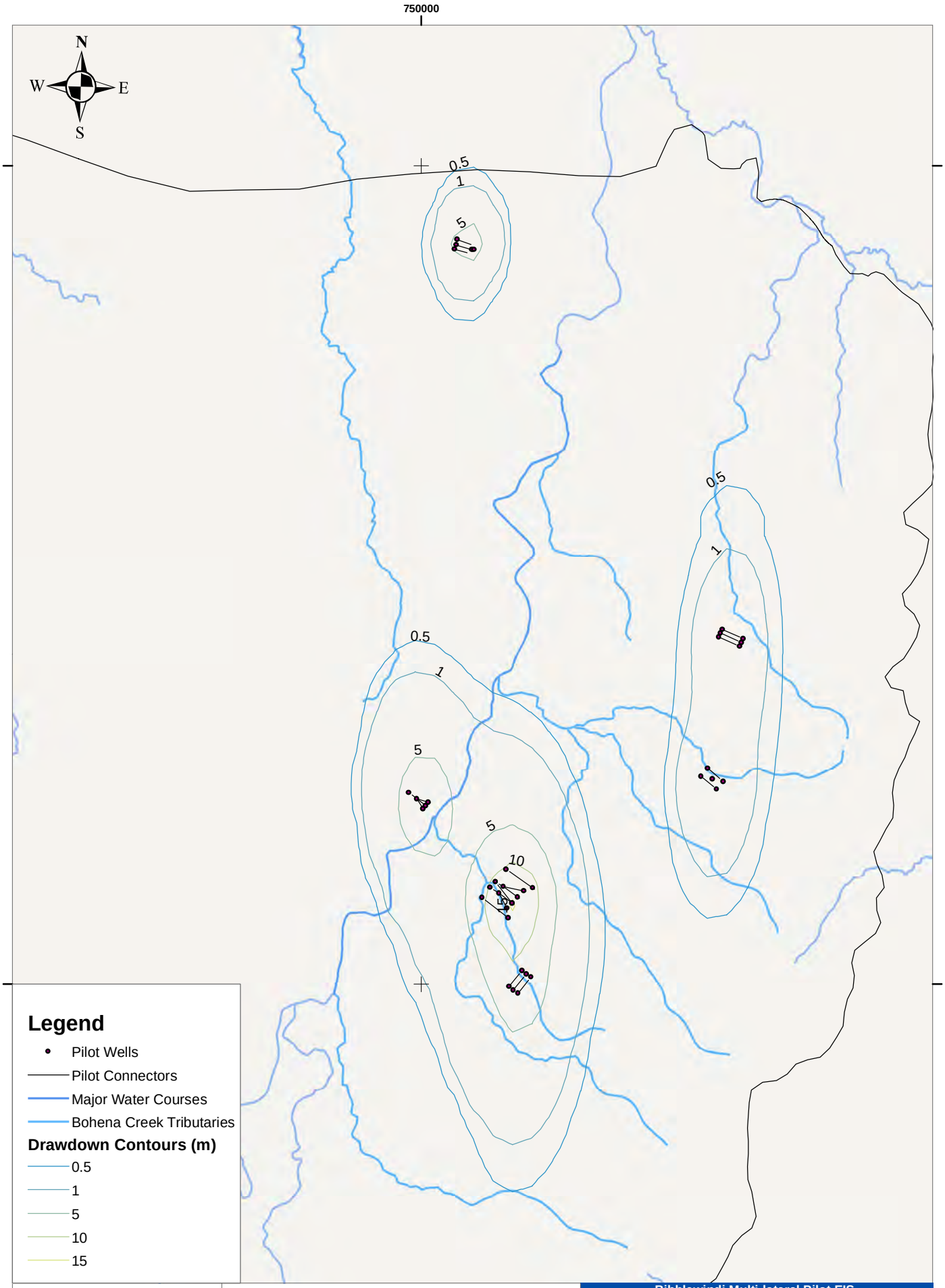
0 2.5 5 10 Km

Scale: 1:250,000 @A4
Projection: GDA94

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Figure 4-3
Predicted Drawdown Contours in HSU 11 (MCF Coals) 8 years from March 2009

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0 2.5 5 10 Km

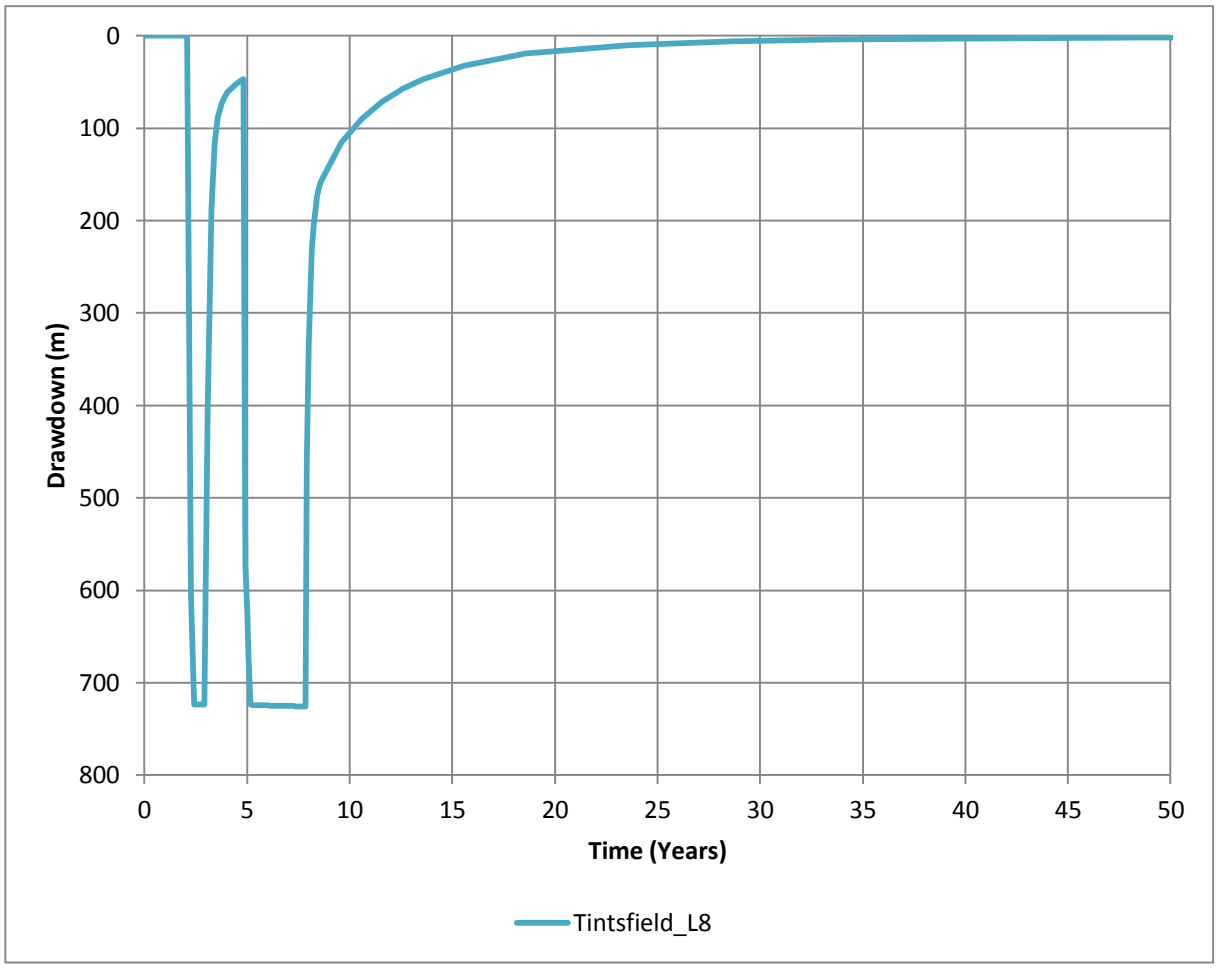
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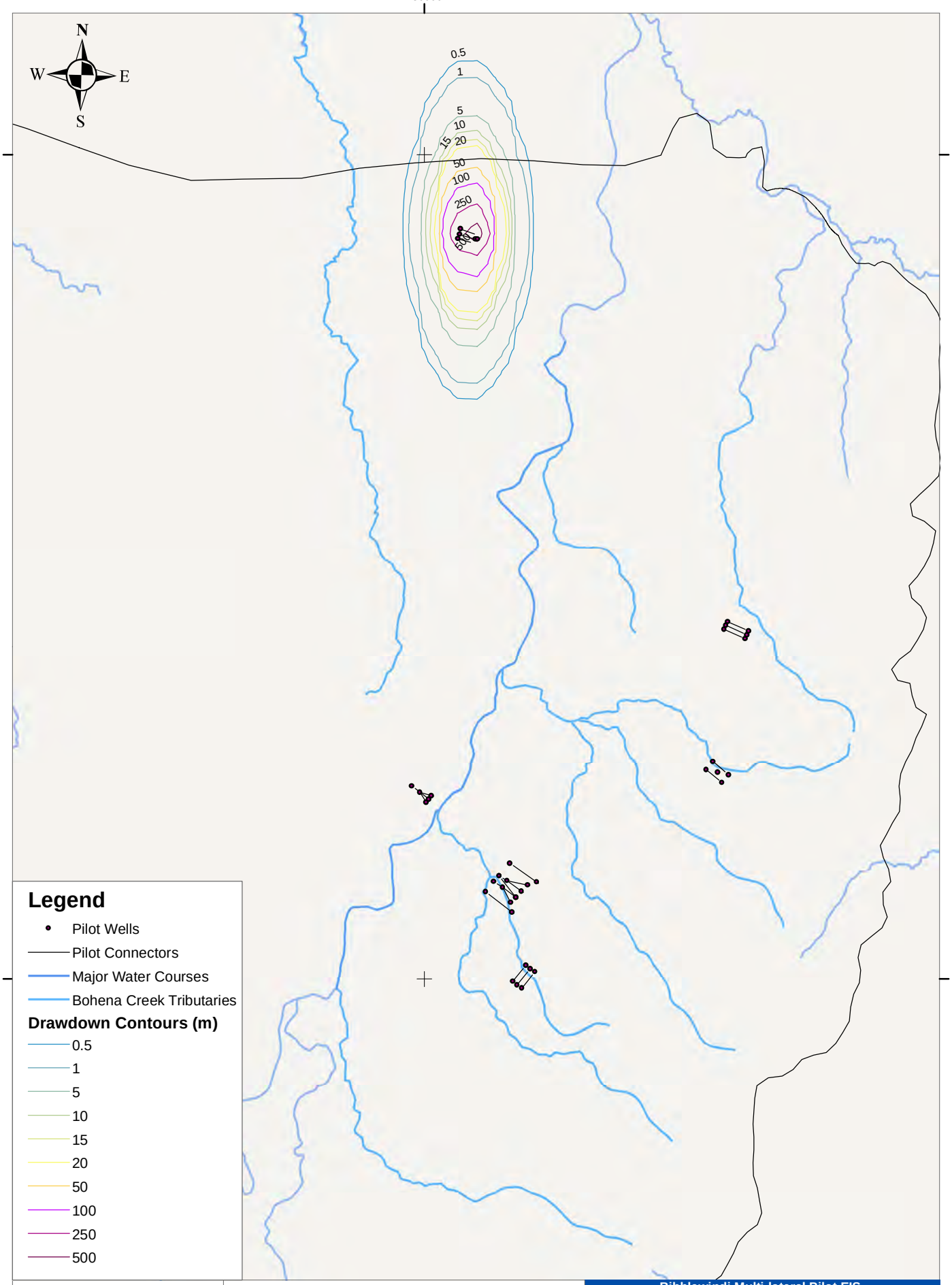
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Figure 4-4
Predicted Drawdown Contours in HSU 5 (Porcupine and Watermark Fms) 28.5 years from March 2009

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Figure 4-5 Predicted drawdown in the Hoskissons Seam (Layer 8) at the Tintsfield pilot site location (up to 50 years)





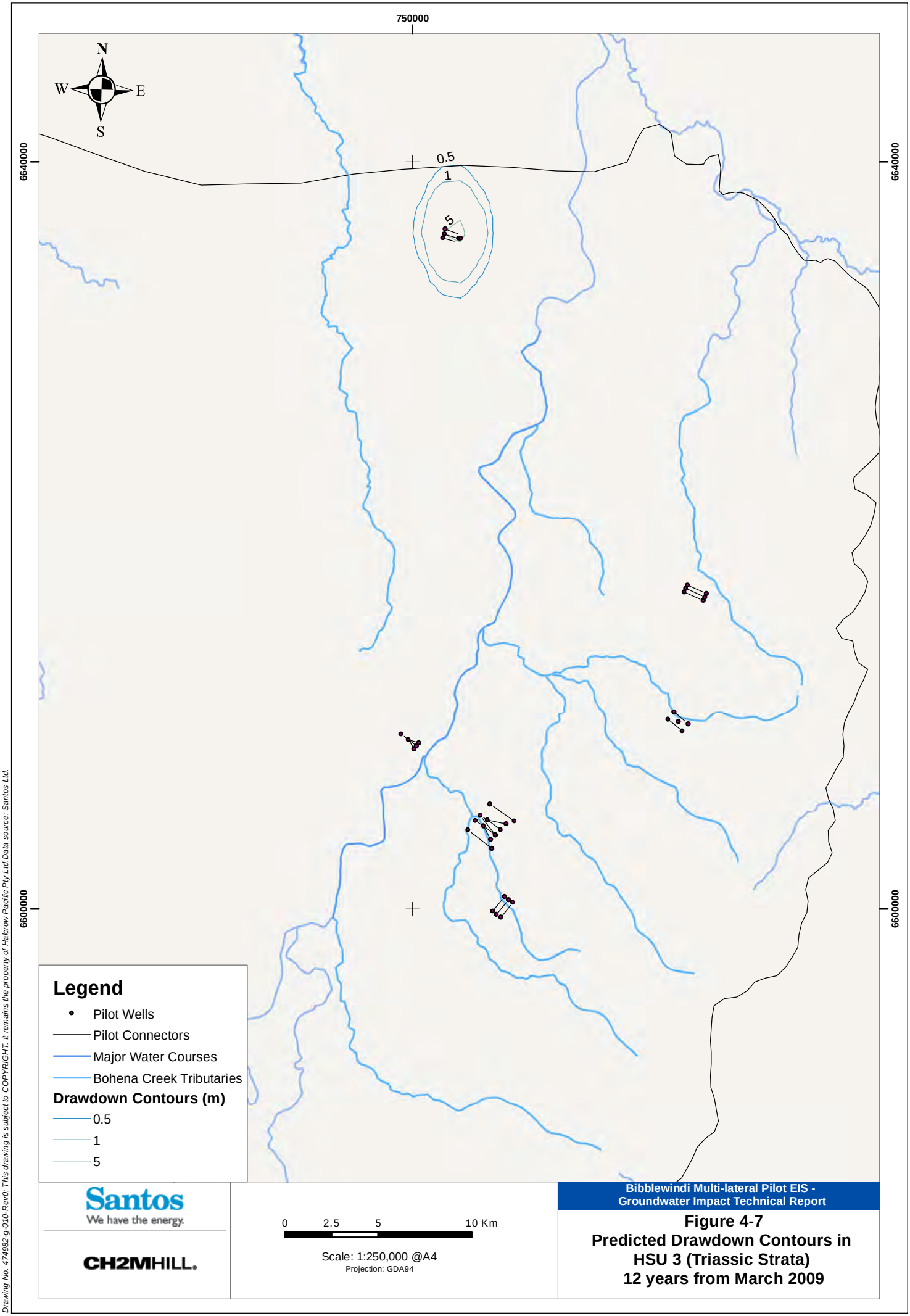
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Figure 4-6
Predicted Drawdown Contours in HSU 13 (Hoskissons Seam) 8 years from March 2009

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Figure 4-7
Predicted Drawdown Contours in HSU 3 (Triassic Strata) 12 years from March 2009

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Figure 4-8 Predicted drawdown at BIBBLEWINDI 28 SAMB (Layers 1, 3, 6, 8 and 10) (Layer 1 is masked by Layer 3)

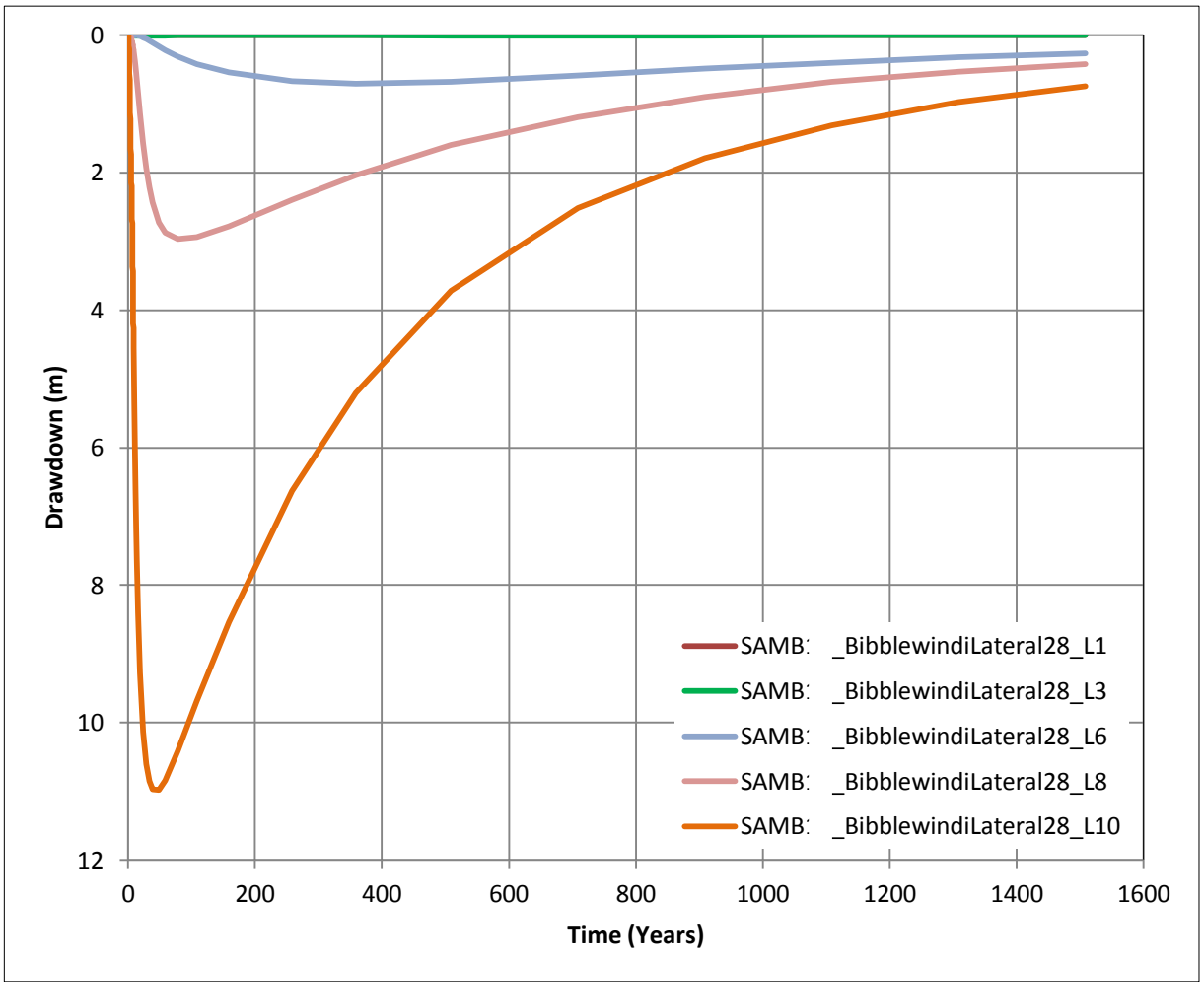


Figure 4-9 Predicted drawdown at JACKS CREEK SAMB (Layers 1, 3, 6, 8 and 10) (Layer 1 is masked by Layer 3)

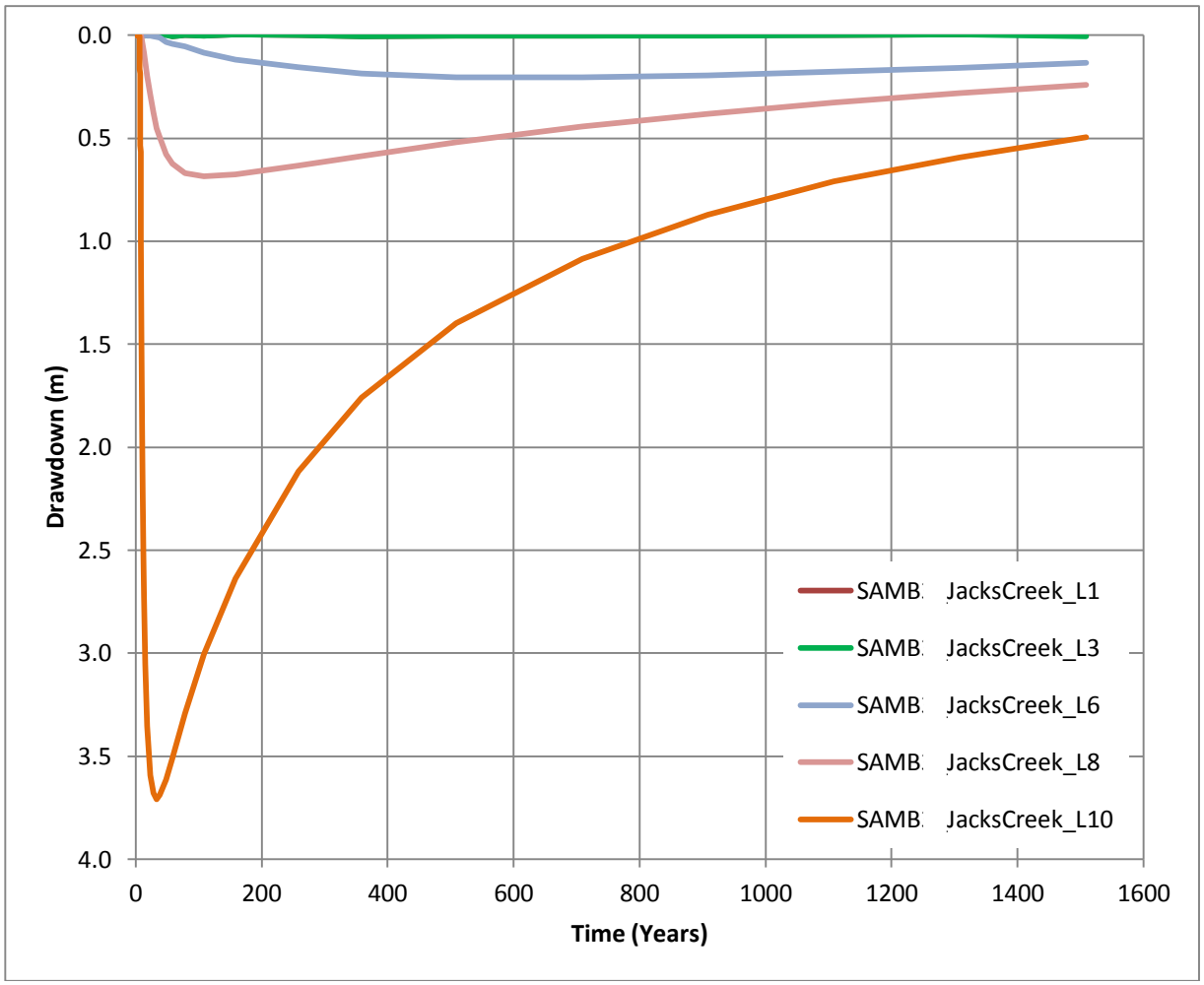


Figure 4-10 Predicted drawdown at indicative monitoring location (Layers 1, 3, 6, 8, 10 and 12) (Layer 1 is masked by Layer 3)

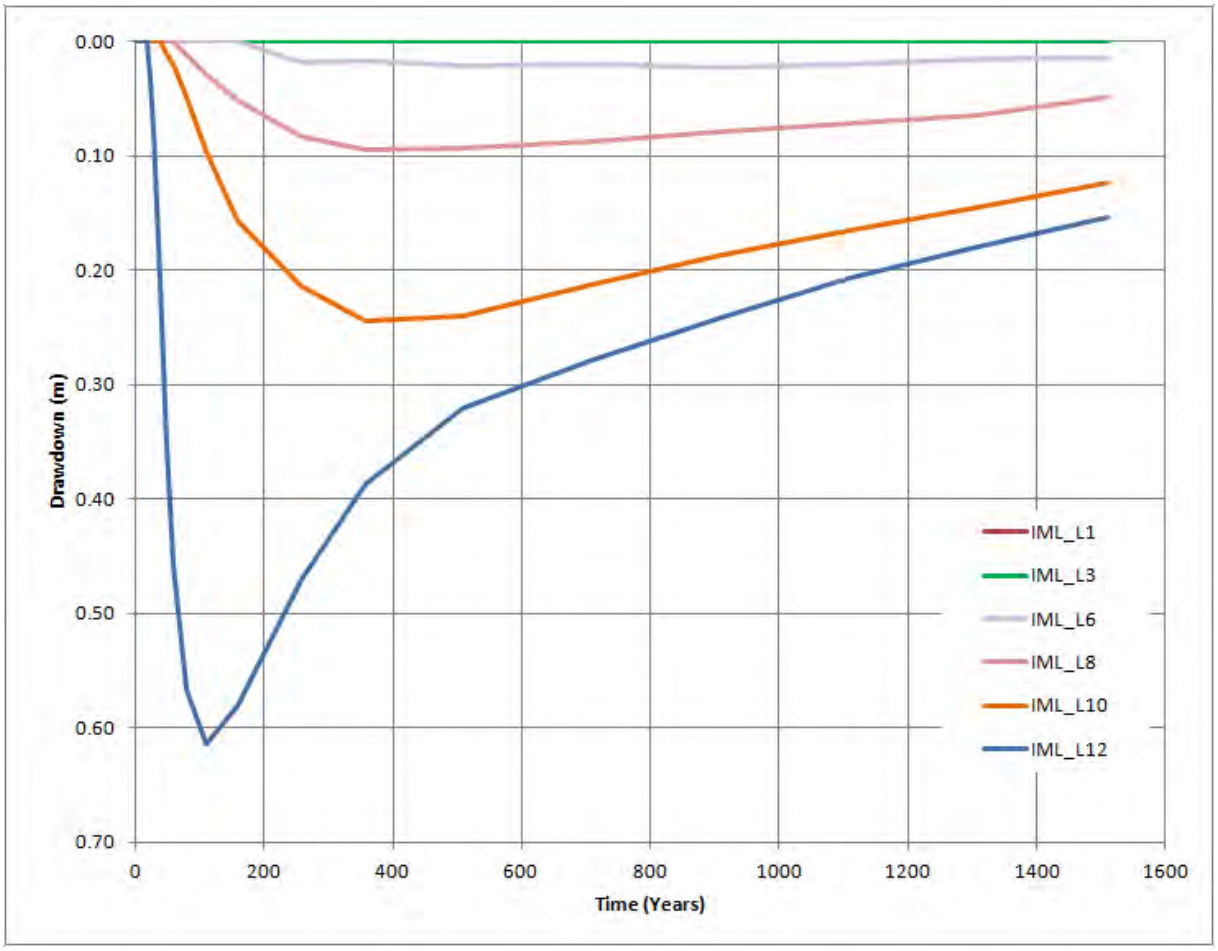
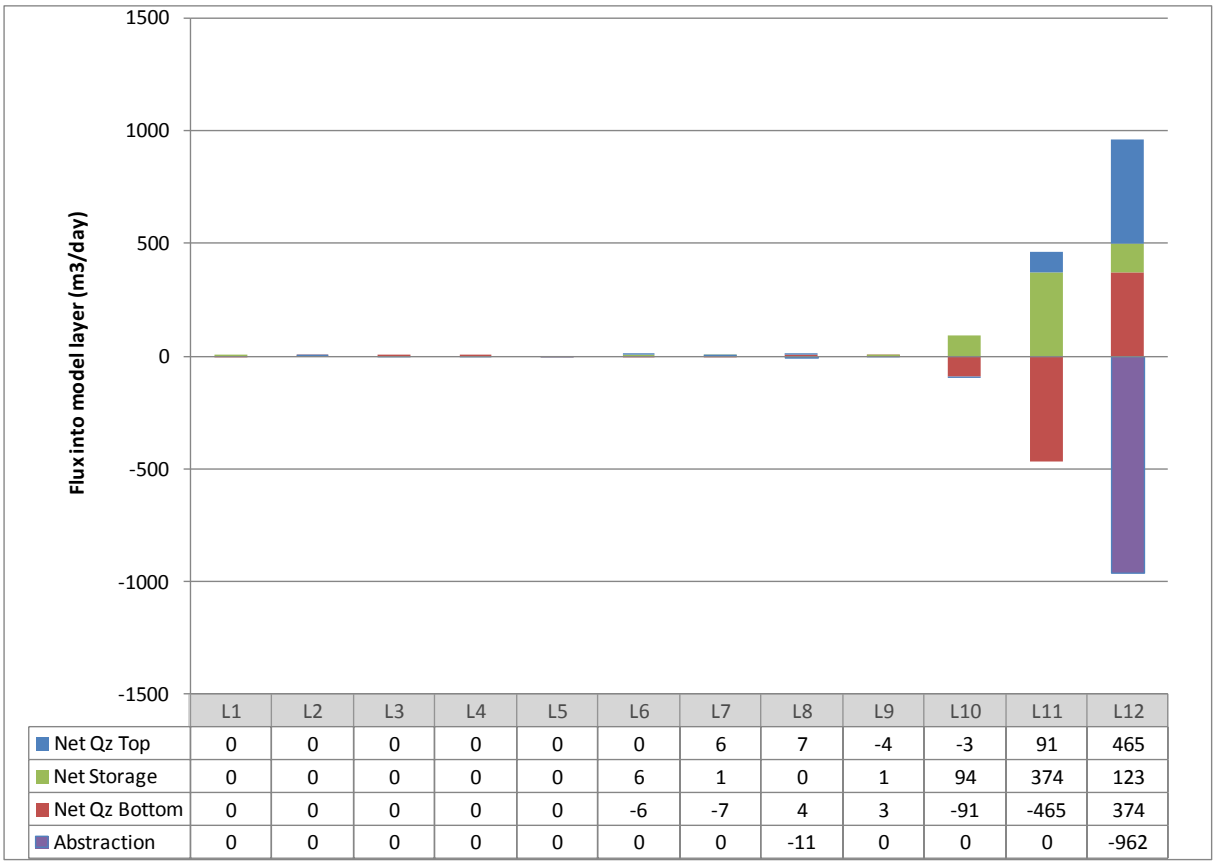
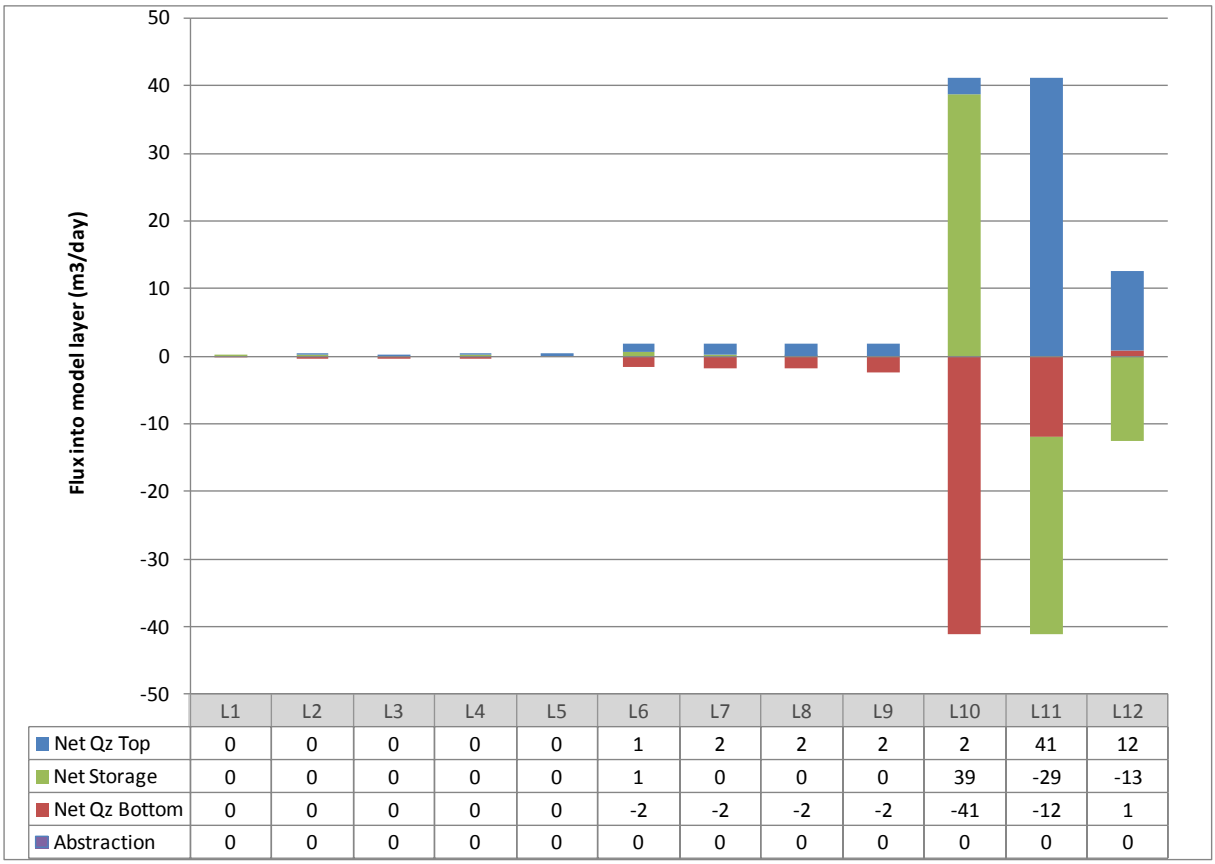


Figure 4-11 Mass balance summary by model layer, 8 years from March 2009 (36 months from onset of pilot extraction)



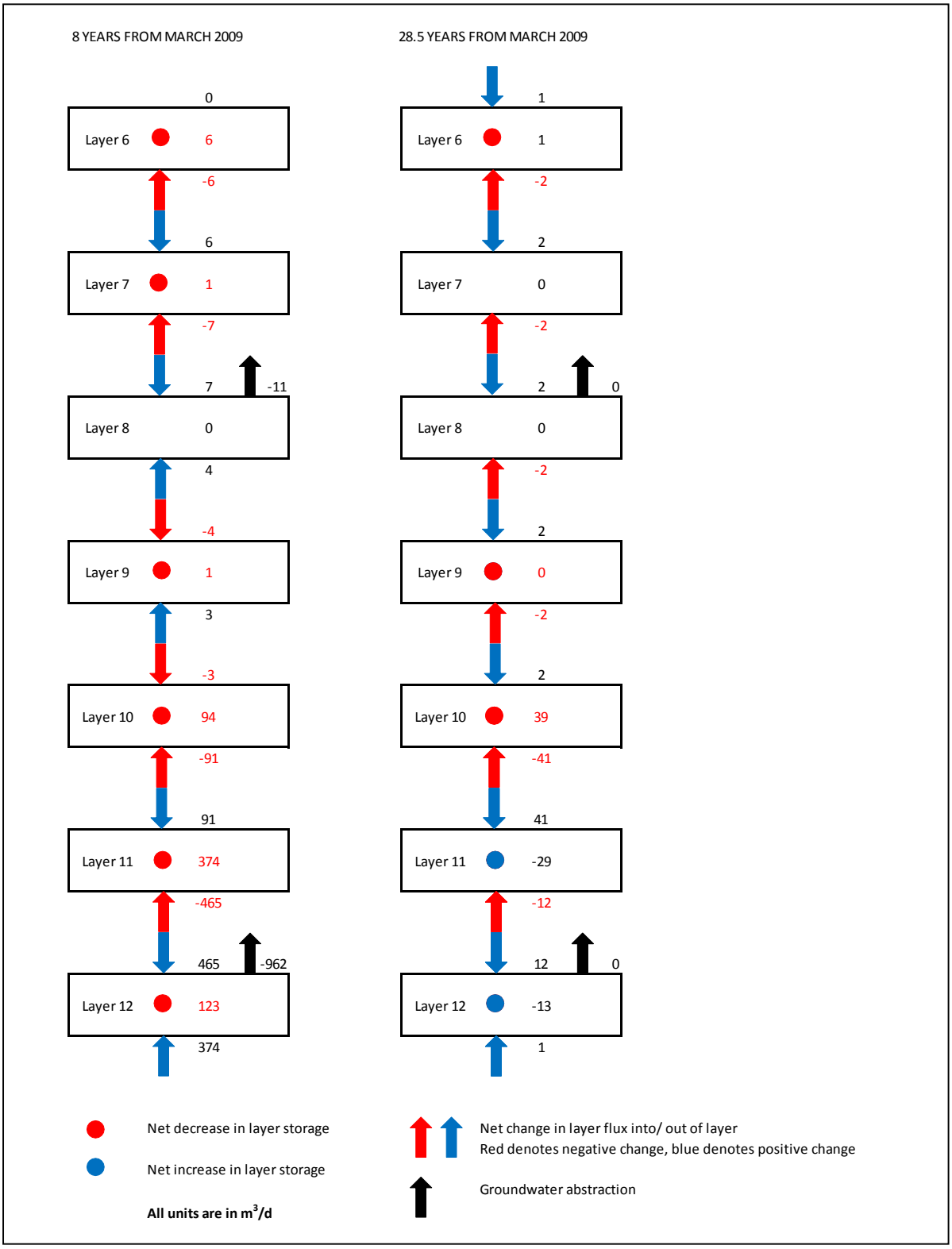
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
Net Qz Top	0	0	0	0	0	0	6	7	-4	-3	91	465
Net Storage	0	0	0	0	0	6	1	0	1	94	374	123
Net Qz Bottom	0	0	0	0	0	-6	-7	4	3	-91	-465	374
Abstraction	0	0	0	0	0	0	0	-11	0	0	0	-962

Figure 4-12 Mass balance summary by model layer, 28.5 years from March 2009 (20 years since cessation of pilot extraction)



	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
Net Qz Top	0	0	0	0	0	1	2	2	2	2	41	12
Net Storage	0	0	0	0	0	1	0	0	0	39	-29	-13
Net Qz Bottom	0	0	0	0	0	-2	-2	-2	-2	-41	-12	1
Abstraction	0	0	0	0	0	0	0	0	0	0	0	0

Figure 4-13 Mass balance comparison of model layers 6 to 12 at 8 and 28.5 years from March 2009 (units in m^3/d)



5 Summary and Conclusions

5.1 Summary

In summary, the following tasks to assess the potential impacts to groundwater and groundwater dependent resources as a result of the operation of the six concurrent CSG pilot sites have been undertaken:

1. A cumulative impact assessment of 6 concurrent CSG extraction pilot sites operating within the Narrabri Gas program area has been undertaken using an amended version of the Narrabri groundwater flow numerical model run with MODFLOW SURFACT^{TM} v4.
2. Amendments to the original regional model included grid refinement in the area surrounding the pilot sites, assigning DRN/WEL cells and extraction rates to all six pilot site locations and separation of extraction phases into three distinct transient models (historical, proposed and recovery).
3. Five pilot sites target the Maules Creek Formation coals (Layer 12), the sixth pilot site targets the Hoskissons Seam within the Black Jack Group (Layer 8). Applied extraction rates were calculated from data provided by Santos pro-rated by the number of model DRN/WEL cells.
4. Three transient model simulations were run to cover *historical* extraction (4.5 years duration), *predictive* (proposed) extraction (4 years duration to accommodate different start dates of pilot sites, all proposed extractions were run for a 3 year period) and long term *recovery* (1,500 years duration). Simulation outcomes of each were then collated and considered together.
5. Groundwater head data were used to assess the maximum drawdown in the target seams and the overlying layers, particularly focussing on the Namoi alluvium (Layer 1), Pilliga Sandstone (Layer 3), Triassic strata (Layer 6) and the Porcupine and Watermark Formations (Layer 10).
6. Mass balance data were used to assess the interlayer fluxes and change in storage resultant from the CSG extraction.

Significant impacts on highly productive and less productive groundwater sources have been defined as reductions in water level or pressure head of 0.5 m and 2.0 m respectively.

5.2 Conclusions

Based on the outcomes of the numerical groundwater modelling presented in this report, the following conclusions can be drawn:

1. All six pilots extract groundwater for a total of three years with different proposed start dates. The total volume of water to be abstracted from the Maules Creek Formation coals (five active pilot sites) is 1.41 GL. The total quantity of water to be abstracted from the Hoskissons Seam (one active pilot site, Tintsfield 2-7) is 0.03 GL.
2. No aquifer interference to either the alluvial groundwater sources of the Upper and Lower Namoi alluvium (NSW Upper and Lower Namoi groundwater source WSP) or the GAB Surat Pilliga Sandstone (NSW GAB groundwater source WSP) is indicated by the modelling of the Bibblewindi Multi-lateral pilot alone or the combined six pilot CSG water extraction activities;

3. A reduction in groundwater head of over 2 m is indicated for the lower part of the porous rock groundwater source of the Gunnedah Basin (GMA604) (NSW MDB Porous Rock groundwater source WSP). This impact on hydraulic (pressure) head combined with the fluxes developed within the lower part of the groundwater source required to meet the pilot CSG water demand are interpreted to comprise an aquifer interference within the combined groundwater source and thus may require licensing and approval;
4. No impact to any identified high priority GDEs identified in the vicinity of the Narrabri Gas program area is predicted to occur as a consequence of the Bibblewindi Multi-lateral pilot alone or the combined six pilot CSG extraction activities;
5. No impact on any registered water extraction bores identified in the vicinity of the Narrabri Gas Project area is predicted to occur as a consequence of the Bibblewindi Multi-lateral pilot alone or the combined six pilot CSG extraction activities; and
6. It is therefore considered unnecessary to instigate mitigation measures in relation to the proposed Bibblewindi Multi-lateral pilot alone or the combined six pilot CSG extraction activities beyond standard operational environmental management controls.

6 References

New South Wales Government, 2003. Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources.

New South Wales Government, 2008. Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources.

New South Wales Government, 2010. Water Sharing Plan for the Peel Valley Regulated, Unregulated, Alluvium and Fractured Rock Water Sources.

New South Wales Government, 2011. Water Sharing Plan for the NSW Great Artesian Basin Shallow Groundwater Sources.

New South Wales Government, 2011. Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources.

New South Wales Government, 2011. Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources.

New South Wales Office of Water (NOW), 2003. Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources.

New South Wales Office of Water (NOW), 2012. NSW Aquifer Interference Policy.

Abbreviations	
AIP	Aquifer Interference Policy
AMB	Aquifer Monitoring Bore
CSG	Coal Seam Gas
DAMB	Deep Aquifer Monitoring Bore
EPBC	Environmental Protection, Biodiversity and Conservation
GAB	Great Artesian Basin
GDE	Groundwater Dependent Ecosystem
GMA	Groundwater Management Area
GMZ	Groundwater Management Zone
HSU	Hydrostratigraphic Unit
MAR	Managed Aquifer Recharge
MCF	Maules Creek Formation
MDBA	Murray Darling Basin Authority
MNES	Matters of National Environmental Significance
NGP	Narrabri Gas Project
NOW	New South Wales Office of Water
NSW	New South Wales
PAL	Petroleum Assessment Lease
PEL	Petroleum Exploration Licence
PIP	Pre-drilling project initiation package
SAMB	Shallow Aquifer Monitoring Bore
SDE	Surface Water Dependent Ecosystem
WSP	Water Sharing Plan

Glossary	
Aquifer	A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs
Confined aquifer	An aquifer that lies below a low permeability material; the piezometric surface in confined aquifers is above the base of the confining material; e.g. artesian aquifers
Ecosystem	The community of a plant, animal and other organisms existing within a defined area, and their interactions within the community and their non-living environment
Groundwater Dependent Ecosystem (GDE)	Ecosystems which have their species composition and their natural ecological processes determined by groundwater
Proposed action	A project, a development, an undertaking, an activity or series of activities

Appendix 4

Ecological Assessment

Ecological Assessment

Bibblewindi Gas Exploration Pilot Expansion, Bibblewindi State Forest NSW

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Document Status

Version	Purpose of Document	Orig	Review	Review Date
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Approval for Issue

Name	Signature	Date
Sigrid Sanderson		15/08/2013

Executive Summary

RPS Australia East Pty Ltd (RPS) has been engaged by Santos Limited (Santos) to undertake an Ecological Assessment of the proposed Bibblewindi Gas Exploration Pilot Expansion (the proposed activity). The proposed activity will involve:

- construction of two pilot wells (Bibblewindi 31 & 32) which will be situated within two existing pilot well lease areas; and
- operation of the Bibblewindi 31 and 32 pilot wells and the existing 12 wells as the Bibblewindi Multi-Lateral Pilot.

The lease areas are located within the Bibblewindi State Forest within Petroleum Assessment Lease (PAL) 2, approximately 40 kilometres south south-west of Narrabri NSW.

The lease areas contain existing cleared and levelled disturbance areas of approximately one hectare per Site (0.91 and 0.83 hectares for Bibblewindi 31and 32, respectively). Access to the lease areas will be via existing unnamed tracks which adjoin Little Tighes Road.

This Ecological Assessment will inform the Environmental Impact Statement (EIS) prepared in accordance with the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) in relation to the proposed activity. For the purposes of this assessment, the Study Area has been defined as a 20 metre wide area encompassing the existing approximately 100 x 100 metre well Sites (i.e. approximately 140 x 140 metres per well) as shown in Figure 2.

Flora

Native vegetation is absent from much of the Site, due to the existing lease areas. A minimal amount of native and exotic grasses have recolonised small patches of the lease areas. No additional clearing of vegetation is required as part of the proposed activity.

Ground truthing of the vegetation within the Study Area delineated one native vegetation community, which is not commensurate with any Threatened Ecological Community (TEC) listed under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and/or the *Threatened Species Conservation Act* 1995 (TSC Act). The vegetation community present within the Study Area was mapped in accordance with Namoi CMA Vegetation Mapping and its floristic composition is commensurate with 'Ironbark Shrubby Woodlands of the Pilliga area, Brigalow Belt South'.

No threatened flora listed under the TSC Act and/or EPBC Act were recorded within the Study Area. Provided that the mitigation measures in **Section 6** are adhered to, no threatened flora species assessed as having the potential to occur within the Study Area are considered likely to be either directly or indirectly impacted upon as a result of the proposed activity.

Fauna

The existing lease areas are characterised by cleared areas, from which native vegetation has been cleared for previous exploration. These cleared areas offer potential basking habitat for reptiles and, consequently, foraging habitat for some birds. However, the areas are generally of limited value to fauna species, due to the lack of habitat resources.

The vegetation in the surrounding Study Area is in a relatively disturbed state and is consequently considered to be of low quality. Due to the history of selective logging, the stand of canopy trees is immature and lacks suitable hollows for most hollow dwelling fauna species that occur in the area. The understorey lacks shrub diversity, however it does provide foraging habitat for a range of bird and mammal species.

Other habitat attributes such as flowering eucalypts, leaf litter, fallen timber, small exposed rocks and exposed soil/sand were also present.

There are no permanent drainage lines, dams or other hydrological features that would offer aquatic habitat within the Sites, however, there is an ephemeral drainage line approximately 70 metres north west of the Proposed Bibblewindi 32 (existing 19H) lease area.

No threatened fauna or migratory species listed under the TSC Act and/or EPBC Act were recorded within the survey area during opportunistic surveys. Provided that the mitigation measures in **Section 6** are adhered to, no threatened or migratory fauna assessed as having potential to occur within the Study Area are considered likely to be either directly or indirectly impacted upon as a result of the proposed activity.

Conclusion

Those aquatic species, threatened flora, threatened populations, threatened ecological communities, threatened and migratory fauna species listed under the *TSC Act* and the *EPBC Act* (threatened and migratory entities) that have been recorded as present, or as having potential to occur within the locality have been considered in this Ecological Assessment.

Provided the mitigation measures in **Section 6** are adhered to no aquatic species, EPBC Act and/or TSC Act listed threatened or migratory entities are considered likely to be either directly or indirectly impacted upon as a result of the proposed activity.

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1.0 Introduction

RPS Australia East Pty Ltd (RPS) has been engaged by Santos Limited (Santos) to undertake an Ecological Assessment of the Bibblewindi Gas Exploration Pilot Expansion (the proposed activity). The proposed activity is located within Petroleum Assessment Lease (PAL) 2, approximately 40 kilometres south south-west of Narrabri NSW.

This Ecological Assessment will inform the Environmental Impact Statement (EIS) prepared in accordance with the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) in relation to the proposed activity. This assessment outlines the occurrence, or likely occurrence, and potential for impact upon any threatened species, populations or ecological communities listed within the *Threatened Species Conservation Act* 1995 (TSC Act) and/or the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act).

1.1 Terminology

The following definitions (**Table 1**) are used throughout this report:

Table 1 Terminology

Terms	Definition
Site	The Site is described as the existing well leases Bibblewindi 14 and 19H.
Study Area	The Site footprint and a surrounding area of approximately 20 metres which could potentially be directly or indirectly affected by the proposed activity. Notably indirect impacts, where they occur, have the potential to radiate further than this distance from Site.
Locality	Surrounds the Study Area for a distance of ten kilometres.

1.2 Description of the Proposed Activity

The proposed activity includes drilling two new wells (Bibblewindi 31 and Bibblewindi 32) on existing lease areas and operation of the existing Bibblewindi Multi-Lateral Pilot including Bibblewindi 31 and Bibblewindi 32.

The proposed activity includes:

- Site preparation and establishing necessary equipment, temporary structures and facilities on the existing well leases Bibblewindi 14 and 19H to enable drilling;
- Drilling one vertical well (Bibblewindi 31) and one lateral (Bibblewindi 32) pilot well to target the Bohena coal seam;
- Installing surface and sub-surface infrastructure within the existing lease area to connect the wells to the existing gas and water gathering system for the Bibblewindi Multi-Lateral Pilot;
- Operating the Bibblewindi 31 and Bibblewindi 32 pilot wells and the existing Bibblewindi Multi-Lateral Pilot as a combined pilot for up to 3 years;
- Management of the water and gas produced during operation;
- Occasional maintenance of Bibblewindi 31 and 32; and
- On completion of operations, pilot wells and ancillary infrastructure will be decommissioned and well leases rehabilitated or suspended.

The proposed activity does not include the assessment of the existing Site establishment and construction activities for clearing and preparation of the lease areas, the water and gas gathering system, access tracks and partial rehabilitation of the lease areas. These works were previously approved by the former NSW Department of Primary Industries (DPI), which approved drilling and operation of Bibblewindi 12, 13, 14, 15, 16, 17, 18H and 19H on 8 August 2008 and Bibblewindi 21H, 27, 28H and 29 on 20 July 2009.

1.3 Purpose and Scope

This Ecological Assessment will inform the biodiversity component of the EIS that has been prepared for the proposed activity. The scope of the assessment was to:

- Undertake a desktop review of databases, reports, aerial photographs, and vegetation and habitat mapping relevant to the Study Area;
- Describe the existing environment within the Study Area;
- Identify flora and fauna species occurring within the Study Area and verify vegetation communities occurring within the Study Area;
- Undertake targeted flora and fauna survey within and adjacent to the Study Area for threatened species likely to occur;
- Determine the presence or probability of threatened entities (species, populations and ecological communities (or their habitats)) occurring within the Study Area, as listed in New South Wales (NSW) under the TSC Act;
- Determine the presence or likely occurrence of threatened entities and other Matters of National Environmental Significance (species, migratory species, ecological communities (or their habitats)) as listed nationally under the EPBC Act;
- Identify any Key Threatening Processes (KTP) in operation within the Study Area;
- Assess the potential impacts of the proposed activity, including direct and indirect impacts;
- Identify the need for any further assessment under State or Commonwealth Legislation; and
- Identify measures to avoid or mitigate potential impacts to ecological values of the Study Area.

1.4 Environmental Setting

1.4.1 Regional Context

The proposed activity is located within the Bibblewindi State Forest within PAL 2, approximately 40 kilometres south south-west of Narrabri NSW (**Figure 1**).

The Study Area is within the Brigalow Belt South Interim Biogeographic Regionalisation for Australia (IBRA) Bioregion, Pilliga Outwash and Pilliga IBRA Subregions. The Study Area is located within the Namoi Catchment Management Area (CMA) and Narrabri Local Government Area (LGA).

1.4.2 Site Description

The proposed pilot well known as ‘Bibblewindi 31’ will be situated within the existing Bibblewindi 14 pilot well lease area, and the proposed pilot well known as ‘Bibblewindi 32’ will be situated within the existing Bibblewindi 19H pilot well lease area.

The Sites contain existing cleared and levelled disturbance areas of approximately one hectare per Site (0.91 and 0.83 hectares for Bibblewindi 31and 32, respectively). Access to the lease areas will be via existing unnamed tracks which adjoin Little Tighes Road (**Figure 2**).

Native vegetation is absent from much of the Site, due to the existing lease areas. A minimal amount of native and exotic grasses have recolonised small patches of the Sites. No additional clearing of vegetation is required as a result of the proposed activity.

1.5 Qualifications

Qualified RPS ecologists undertook the field surveys and subsequent reporting. Staff qualifications and experience are presented in **Table 2**.

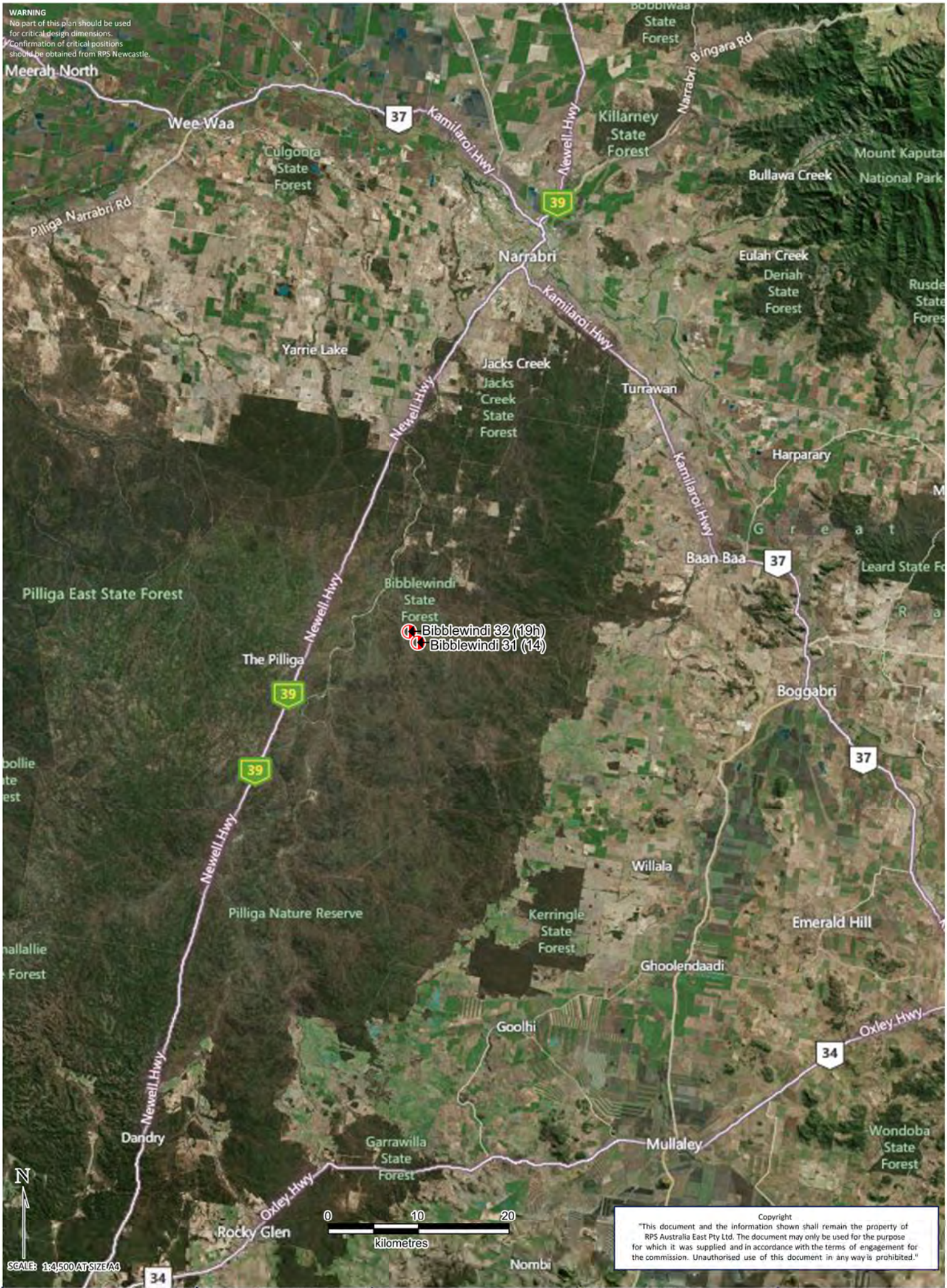
Table 2 RPS Staff and Qualifications

Name	Position/ Project Role	Qualifications	Relevant Experience
Arne Bishop	Ecologist – Field surveys and reporting	Bachelor of Environmental Science/Landscape Architecture	7 + years
Justin Cutajar	Environmental Scientist – Aquatic Assessment	Bachelor of Environmental Science (Honours First Class)	4 + years
Matt Doherty	Technical Director (Ecology) Project Manager and–peer review	Bachelor of Landscape Management and Conservation	11+ years

1.6 Licensing and Certification

Research was conducted under the following licences:

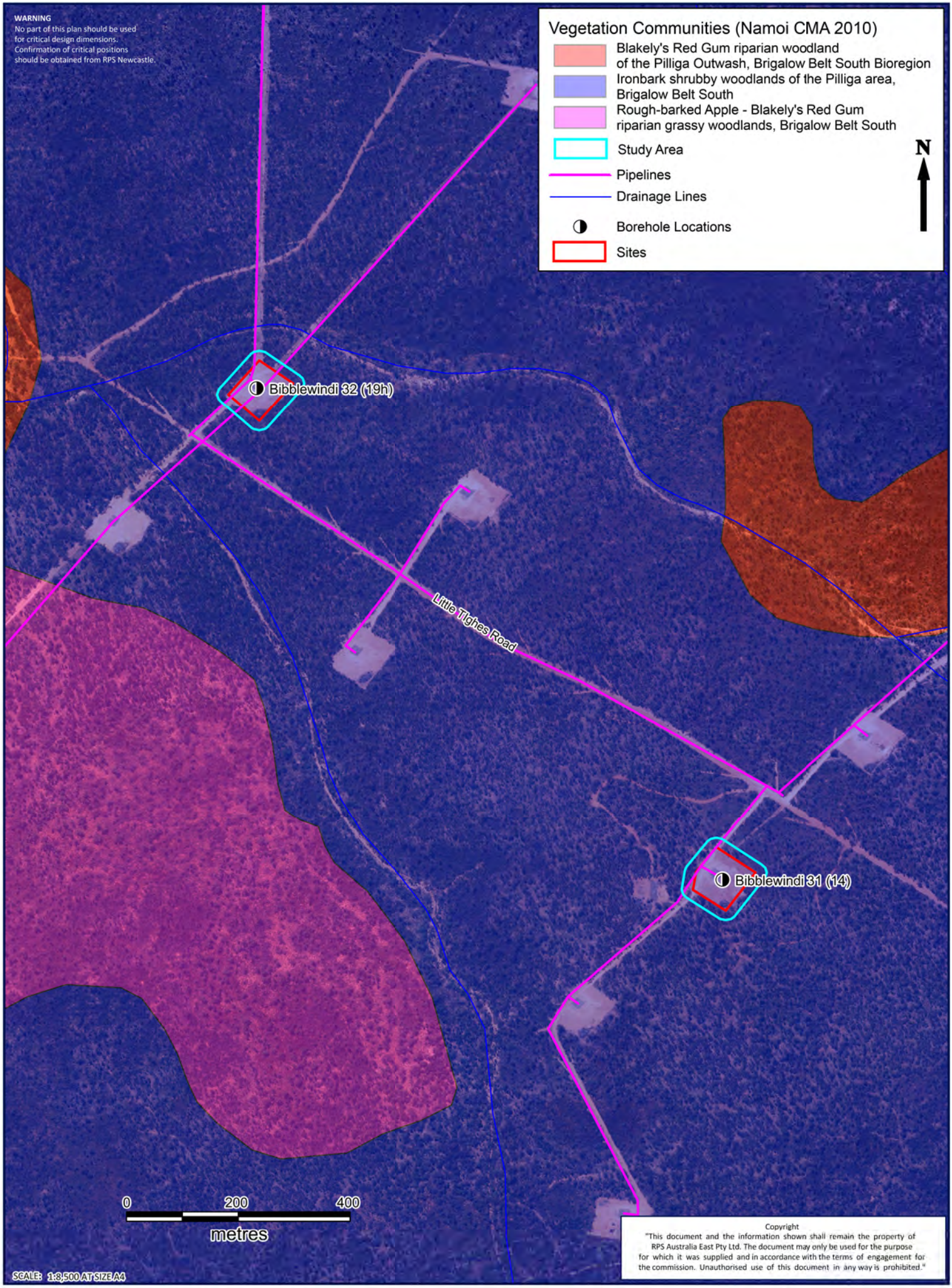
- NSW National Parks and Wildlife Service Scientific Investigation Licence S100536 (Valid 31 December 2013);
- Animal Research Authority (Trim File No: 10/1755) issued by NSW Agriculture (Valid 12 March 2014);
- Animal Care and Ethics Committee Certificate of Approval (Trim File No: 10/1755) issued by NSW Agriculture (Valid 12 March 2016); and
- Certificate of Accreditation of a Corporation as an Animal Research Establishment (Trim File No: 01/1522 & Ref No: AW2001/014) issued by NSW Agriculture (Valid 22 May 2014).



TITLE: FIGURE 1: REGIONAL LOCATION	LOCATION: BIBBLEWINDI 31 & 32	DATUM: GDA 94 PROJECTION: MGA ZONE 56	DATE: 07/02/2013 PURPOSE: ECOLOGY	LAYOUT REF: J:\JOBS\Santos\117518 Bibblewindi 31 32\10 - Drafting\MapInfo Workspaces\Eco VERSION (PLAN BY): AB (B A4)

CLIENT: SANTOS
JOB REF: 117518-3

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TITLE: FIGURE 2: VEGETATION COMMUNITIES & STUDY AREA

LOCATION: BIBBLEWINDI 31 & 32

DATUM: GDA 94
PROJECTION: MGA ZONE 56

DATE: 02/07/2013
PURPOSE: ECOLOGY

LAYOUT REF: J:\JOBS\Santos\117518 Bibblewindi 31 32\10 - Drafting\MapInfo Workspaces\Eco
VERSION (PLAN BY): AB (C A4)

CLIENT: SANTOS
JOB REF: 117518-3

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2.0 Legislative Context

The proposed activity is subject to both State and Commonwealth legislation and legislative instruments, as outlined below.

2.1 Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places, defined in the EPBC Act as Matters of National Environmental Significance (MNES). The MNES identified in the Act include:

- World heritage properties.
- National heritage places.
- Wetlands of international importance (listed under the Ramsar Convention).
- Threatened species and communities.
- Migratory species protected under international agreements.
- Commonwealth marine areas.
- The Great Barrier Reef Marine Park.
- Nuclear actions (including uranium mines).

Under the EPBC Act, actions that have, or are likely to have, a significant impact on a MNES require approval from the Australian Government Minister for Sustainability, Environment, Water, Population and Communities (the Minister).

2.2 NSW Threatened Species Conservation Act 1995

The NSW *Threatened Species Conservation Act 1995* (TSC Act) provides for the protection and management of threatened species, populations and ecological communities listed under the schedules 1, 1A and 2 of the Act. The purpose of the TSC Act is to:

- Conserve biological diversity and promote ecologically sustainable development.
- Prevent the extinction and promote the recovery of threatened species, populations and ecological communities.
- Protect the critical habitat of those species, populations and ecological communities that are endangered.
- Eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities.
- Ensure that the impact of any action affecting threatened species, populations or ecological communities is properly assessed.
- Encourage the conservation of threatened species, populations and ecological communities through co-operative management.

2.3 NSW Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act) regulates development carried out in New South Wales. As the proposed activity is State Significant Development (SSD), it will be assessed under Part 4 of the Act.

Under Part 4 of the Act, the Minister for Planning and Infrastructure is the consent authority who is required to examine fully and take into consideration all matters likely to affect the environment as a result of such activity. The Environmental Impact Statement (EIS) is prepared in accordance with Section 78A(8A) of the Act, and assists in establishing whether or not the activity is likely to significantly affect the environment.

2.4 National Parks and Wildlife Act 1974

Part 8A of the *National Parks and Wildlife Act 1974* (NPW Act) regulates the undertaking of activities which may impact on threatened species, populations and ecological communities listed under the TSC Act and their habitats. The NPW Act provides that a person must not harm any animal that is a threatened species, population or ecological community; pick any plant which is part of a threatened species, population or ecological community; damage any critical habitat; or damage any habitat of a threatened species, population or ecological community without a licence being obtained under the NPW Act or TSC Act or unless another exception applies.

2.5 State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) *2007*

State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (NSW) (the Mining SEPP) applies to the project. The Mining SEPP aims to "provide for the proper management and development of mineral, petroleum and extractive material resources for the social and economic welfare of [NSW]". Clause 6 of the Mining SEPP provides that development for the purposes of petroleum exploration may be carried out without development consent. However, under clause 7(2) of the Mining SEPP, development consent is required for the purposes of drilling or operating petroleum exploration wells, unless they consist of a set of fewer than five wells that is more than three kilometres from any other petroleum well (other than an abandoned petroleum well) in the same petroleum title. The project will result in more than five petroleum wells, other than abandoned wells, within a three kilometre radius within PAL 2 and is therefore SSD under the State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP). This has the effect that the proposed activity is required to be assessed under Part 4 of the EP&A Act.

2.6 State Environment Planning Policy 44 – Koala Habitat Protection

State Environmental Planning Policy No.44 - Koala Habitat Protection (SEPP 44) aims to protect the Koala and its habitat by incorporating prescriptions for consent authorities to consider during the assessment of development applications. SEPP 44 contains prescriptions for the consideration of "potential koala habitat" and "core koala habitat" for developments within Local Government Areas listed in Schedule 1 of the Policy. The Study Area is located within the Narrabri LGA, listed in Schedule 1 as an area to which SEPP 44 applies.

2.7 Noxious Weeds Act 1993

The *NSW Noxious Weeds Act 1993* provides for the identification and classification of noxious weeds in each New South Wales Local Government Area (LGA). The Act imposes obligations on occupiers of land to control noxious weeds declared for their LGA.

2.8 Fisheries Management Act 1994

The objectives the *Fisheries Management Act 1995* (NSW) (TSC Act) include the need to:

- Conserve fish stocks and key fish habitats.
- Conserve threatened species, populations and ecological communities of fish and marine vegetation.
- Promote ecologically sustainable development, including the conservation of biological diversity, and, consistently with those objects:
  - Promote viable commercial fishing and aquaculture industries;
  - Promote quality recreational fishing opportunities;
  - Appropriately share fisheries resources between the users of those resources; and
  - Provide social and economic benefits for the wider community of New South Wales.

To meet these objectives, Part 7 of the FM Act outlines legislative provisions to protect fish habitat and Part 7A outlines provisions to conserve threatened species of fish and marine vegetation and their habitat.

In understanding this definition it is important to note that the term 'fish' includes all aquatic invertebrates such as yabbies, shrimps, oysters, mussels, insect larvae, beach worms, sea stars, jellyfish, etc.

3.0 Methodology

3.1 Terrestrial Desktop Assessment

Relevant environmental documents, databases, maps, and legislation (Federal, State and Local) were reviewed to identify potential development constraints, as well as any significant ecosystems and/or species that may occur within the Study Area.

The following databases and maps were reviewed:

- EPBC Act Protected Matters Search Tool (Department of Sustainability, Environment, Water, Population and Community (DSEWPaC 2012, 2013) within a ten kilometre radius of the Sites (**Appendix 1**);
- Review of threatened fauna and flora records contained in the Office of Environment and Heritage (OEH 2012, 2013) Wildlife Atlas database within a ten kilometre radius of the Site.
- Review of threatened fauna and flora records contained in Eco Logical Australia's unpublished data (ELA 2013). Data within a ten kilometre radius was reviewed;
- National Vegetation Information Systems mapping for the Namoi Catchment (Namoi CMA 2010); and
- Aerial photography.

3.2 Aquatic Desktop Assessment

A desktop assessment was undertaken to identify potential development constraints as well as significant ecosystems and species that may potentially occur in the area of consideration. The following databases and maps were reviewed:

- EPBC Protected Matters Search Tool (DSEWPaC 2012, 2013), undertaken with a ten kilometre radius;
- Review of threatened fauna and flora records contained in the OEH Wildlife Atlas (OEH 2012, 2013) (data within a ten kilometre radius was reviewed);
- National Vegetation Information Systems mapping for the Namoi Catchment (Namoi CMA 2010);
- Strahler (1957) Stream Order Index;
- Key Fish Habitat (NSW Department of Primary Industries (DPI) 2007);
- NSW Wetland Mapping 2006;
- OEH waterways mapping 2013b; and
- Aerial photography.

3.3 Field Survey

A field survey was undertaken by an RPS ecologist on Thursday 27 November 2012.

3.3.1 Flora

Flora surveys and vegetation mapping works carried out for the Study Area were as follows:

- Delineation of vegetation communities using Aerial Photography Interpretation (API) and ground truthing. Vegetation communities were determined based on structure, floristic composition, topography and soil type;
- General flora surveys, including the consideration of the Study Area in line with methodology such as

'Random Meander Technique', described by Cropper (1993), were conducted across the Study Area. An inventory of flora species recorded in the Study Area was compiled (**Appendix 2**).

- Assessment of the potential for the vegetation communities to constitute Threatened Ecological Communities (TECs) as listed within the TSC Act and/or the EPBC Act. The floristic composition, geomorphologic characters, and geographic distribution were considered when determining whether a TEC was present.
- Targeted flora surveys were conducted in areas that preliminary desktop assessments identified as being potentially suitable habitats for threatened species. These surveys included quadrat (area assessment of the proposed lease area) and transect surveys.

3.3.2 Fauna

3.3.2.1 Fauna Species

The Study Area was traversed on foot and all species and evidence of fauna presence observed was recorded. An inventory of fauna species recorded in the Study Area was compiled (**Appendix 3**). Opportunistic sightings of indirect evidence of fauna presence were noted. Such indicators included:

- Scats and scents (predator scats were collected for contents analysis);
- Nests;
- Burrows;
- Feather, fur remains, skin and skeletal material of vertebrate fauna;
- Tracks, scratches and diggings;
- Whitewash, regurgitation pellets and prey remains from owls; and
- Chewed *Allocasuarina* cones, indicative of feeding by *Calyptorhynchus lathami* (Glossy Black-cockatoo).

3.3.2.2 Fauna Habitat

An assessment of the relative habitat value present on Site was undertaken. This assessment focused primarily on the identification of specific habitat types and resources on the Site favoured by known threatened species from the region. The assessment also considered the potential value of the Site (and surrounds) for all major guilds of native flora and fauna. Habitat assessment included:

- Presence, size and types of tree hollows;
- Presence of rocks, logs, caves, rocky outcrops, leaf litter, overhangs and crevices;
- Vegetation complexity, structure and quality;
- Presence of freshwater or estuarine aquatic habitats, noting permanency;
- Connectivity to adjacent areas of habitat;
- Extent and types of disturbance;
- Presence of foraging opportunities such as flowering eucalypts, fruits, seeds or other nectar bearing native plants; and
- The location of any notable fauna habitat features, such as hollow-bearing trees, was recorded using a Trimble DGPS.

3.3.3 Assessment of Likelihood of Occurrence of Threatened Flora and Fauna

The database searches identified threatened flora and fauna species that have been recorded or that are likely to occur within ten kilometres of the Study Area. The probability that each threatened species and vegetation community occurs within the Study Area was determined as being either Unlikely, Possible, Likely or Known, based on the criteria in (**Table 3**).

Table 3 Likelihood of occurrence criteria for threatened species

Likelihood of occurrence	Criteria - one or more of the following conditions applies
Unlikely	The species has not been recorded previously in the Study Area or nearby, and is beyond the current known geographic range. The species has specific habitat requirements that are not present in the Study Area. The species is considered extinct.
Possible	The species has historically been recorded in the Study Area (>20 years ago). The species has specific habitat requirements that are present in the Study Area, but in a poor or modified condition. The species is unlikely to maintain a resident population in the Study Area, however, may occasionally utilise resources within the Study Area.
Likely	The species has recently been recorded in the Study Area (i.e. within last 20 years). The species has specific habitat requirements that are present in the Study Area and are in good condition. The species is known or likely to maintain resident populations in proximity to the Study Area. The species is known or likely to regularly utilise resources in the Study Area.
Known	The species was recorded in the Study Area during the current survey.

3.3.4 Aquatic Habitat Assessment

A variety of aquatic ecology and geomorphological factors were considered when assessing the potential aquatic value of the adjacent unnamed ephemeral creek. This included:

- The potential of aquatic habitat for fauna.
- Presence and abundance of riparian and aquatic vegetation.
- Riparian condition.
- Bank and bed sediment type.

3.4 Survey Limitations

The DEC (2004) guidelines have not been considered applicable to the proposed activity due to the lack of vegetation and faunal habitats present within the Site. However, the surrounding Study Area has been considered for its likelihood to contain threatened entities and the potential for direct and indirect impacts upon them (refer to **Table 9**).

The detectability of plants, and the further ability to accurately identify plants to a species level, varies greatly with the time of year, the prevailing climatic conditions, and the presence of reproductive material (e.g. flowers, fruit, and seed capsules). Consequently, the survey conducted for the Study Area should not be regarded as conclusive evidence that certain protected plants do not occur within the Study Area.

The limitations to the fauna surveys conducted in the Study Area include:

- The survey period not coinciding with the period that some migratory or nomadic species occur in the locality;
- Species with large home ranges (e.g. owls and raptors) not present in this part of their home range during the survey period;
- The difficulty in detecting certain species during the survey period (e.g. cryptic species, species present in the Study Area at very low densities);
- Biological factors such as sex, age-class, and breeding biology, which may influence species' habitat use and detectability during different times of the year;
- The lack of suitable climatic conditions necessary for the presence and/or detectability of certain species (e.g. amphibians following heavy rainfall); and
- Due to the small size and predominantly existing nature of the proposed impacts, fauna surveys were not conducted within the Study Area. Instead, habitat assessments and opportunistic surveys were completed. The likely occurrence of species was assumed, based on habitat assessments, previous local records, seasonality, predicted faunal movements of locally occurring threatened species in combination with the local knowledge and experience of the authors.

In response to the abovementioned limitations, the precautionary approach has been adopted; as such, an 'assumed presence' of known and expected threatened species, populations, and ecological communities has been made, where relevant, to ensure a holistic assessment.

4.0 Results

4.1 Database Search Results

4.1.1 Flora

Based on database interrogation, nine threatened flora species (**Table 4**) and seven TECs (**Table 5**), listed under the EPBC and/or TSC Acts, are either known or have the potential to occur within the locality.

Table 4 Threatened flora species with potential to occur within the locality

Scientific name	Common name	Status under TSC Act	Status under EPBC Act	Source
Bertya opponens	Coolabah Bertya	V	V	OEH (2013), DSEWPaC (2013)
Diuris tricolor	Painted Diuris or Pine Donkey Orchid	V	-	EcoLogical Australia (2013)
Monotaxis macrophylla	Large-leafed Monotaxis	E	-	OEH (2013)
Philotheca ericifolia		-	V	OEH (2013), DSEWPaC (2013)
Polygala linariifolia	Native Milkwort	E	-	OEH (2013), EcoLogical Australia (2013)
Pomaderris queenslandica	Scant Pomaderris	E		OEH (2013)
Pterostylis cobarensis	Cobar Greenhood Orchid	V	V	DSEWPaC (2013), EcoLogical Australia (2013))
Pultenaea setulosa		-	V	DSEWPaC (2013)
Rulingia procumbens		V	V	OEH (2013), DSEWPaC (2013), EcoLogical Australia (2013)
Tylophora linearis		V	E	DSEWPaC (2013), EcoLogical Australia (2013)

Key: CE= Critically Endangered, E= Endangered, V= Vulnerable.

Table 5 Threatened Ecological Communities with potential to occur within the locality

Community name	Status under TSC Act	Status under EPBC Act	Source
Carex Sedgeland of the New England Tableland, Nandewar, Brigalow Belt South and NSW North Coast Bioregions.	E	-	OEH (2013)
TSC Act - White Box Yellow Box Blakely's Red Gum Woodland.	E	CE	OEH (2013), DSEWPaC (2013)

Community name	Status under TSC Act	Status under EPBC Act	Source
EPBC Act - White Box-Yellow Box-Blakely's Red Gum grassy woodland and derived native grassland.			
TSC Act - Inland Grey Box Woodland in the Riverina; NSW South Western Slopes; Cobar Peneplain; Nandewar and Brigalow Belt South Bioregions. EPBC Act - Grey Box (*Eucalyptus microcarpa*) grassy woodlands and derived native grasslands of south-eastern Australia.	E	E	OEH (2013), DSEWPaC (2013)
Fuzzy Box Woodland on alluvial soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions.	E	-	OEH (2013)
TSC Act - Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions. EPBC Act - Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions.	E	E	DSEWPaC (2013)
TSC Act - Native Vegetation on Cracking Clay Soils of the Liverpool Plains. EPBC Act – Natural Grasslands on Basalt and Fine-textured Alluvial Plains of Northern New South Wales and Southern Queensland.	E	CE	DSEWPaC (2013)
TSC Act - Myall Woodland in the Darling Riverine Plains; Brigalow Belt South; Cobar Peneplain; Murray-Darling Depression; Riverina and NSW South Western Slopes bioregions. EPBC Act - Weeping Myall Woodlands.	E	E	DSEWPaC (2013)

Key: CE= Critically Endangered, E= Endangered, V= Vulnerable.

4.1.2 Fauna

Based on database interrogation, 34 threatened and/or 11 migratory fauna species (**Table 6**), listed under the EPBC and/or TSC Acts, are either known or have the potential to occur within the locality.

Table 6 Threatened fauna and migratory species with potential to occur within the locality

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Source
Leipoa ocellata	Malleefowl	E	V, M	DSEWPaC (2013)
Lophoictinia isura	Square-tailed Kite	V		OEH (2013)
Calyptorhynchus lathami	Glossy Black-Cockatoo	V		OEH (2013), EcoLogical Australia (2013)
Glossopsitta pusilla	Little Lorikeet	V		OEH (2013)
Neophema pulchella	Turquoise Parrot	V		OEH (2013)
Ninox connivens	Barking Owl	V		OEH (2013)

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Source
Tyto novaehollandiae	Masked Owl	V		OEH (2013)
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V		OEH (2013), EcoLogical Australia (2013)
Chthonicola sagittata	Speckled Warbler	V		OEH (2013),
Anthochaera phrygia	Regent Honeyeater	CE	E, M	DSEWPaC (2013)
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V		OEH (2013), EcoLogical Australia (2013)
Daphoenositta chrysoptera	Varied Sittella	V		OEH (2013)
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V		OEH (2013)
Stagonopleura guttata	Diamond Firetail	V		OEH (2013)
Phascolarctos cinereus	Koala	V	V	OEH (2013), DSEWPaC (2013)
Cercartetus nanus	Eastern Pygmy-possum	V		OEH (2013)
Petaurus norfolcensis	Squirrel Glider	V		OEH (2013)
Miniopterus schreibersii oceanensis	Eastern Bentwing Bat	V		EcoLogical Australia (2013)
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V		OEH (2013), EcoLogical Australia (2013)
Chalinolobus picatus	Little Pied Bat	V		OEH (2013), EcoLogical Australia (2013)
Nyctophilus corbeni	Corben's or Greater Long-eared Bat	V	V	OEH (2013), DSEWPaC (2013), EcoLogical Australia (2013)
Vespadelus troughtoni	Eastern Cave Bat	V		OEH (2013), EcoLogical Australia (2013)
Pseudomys pilligaensis	Pilliga Mouse	V	V	OEH (2013), DSEWPaC (2013)
Botaurus poiciloptilus	Australasian Bittern	E	E	DSEWPaC (2013)
Geophaps scripta scripta	Squatter Pigeon (southern)	E	V	DSEWPaC (2013)
Lathamus discolor	Swift Parrot	E	E	DSEWPaC (2013)
Polytelis swainsonii	Superb Parrot	V	V	DSEWPaC (2013)
Rostratula australis	Australian Painted Snipe	E	E, M	DSEWPaC (2013)
Maccullochella peelii	Murray Cod	-	V	DSEWPaC (2013)
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	DSEWPaC (2013)
Petrogale penicillata	Brush-tailed Rock-wallaby	E	V	DSEWPaC (2013)

Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Source
Aprasia parapulchella	Pink-tailed Worm-lizard	V	V	DSEWPaC (2013)
Uvidicolus sphyrurus	Border Thick-tailed Gecko	V	V	DSEWPaC (2013)
Apus pacificus	Fork-tailed Swift	-	M	DSEWPaC (2013)
Haliaeetus leucogaster	White-bellied Sea-Eagle	-	M	DSEWPaC (2013)
Hirundapus caudacutus	White-throated Needletail	-	M	DSEWPaC (2013)
Merops ornatus	Rainbow Bee-eater	-	M	DSEWPaC (2013)
Myiagra cyanoleuca	Satin Flycatcher	-	M	DSEWPaC (2013)
Gallinago hardwickii	Latham's Snipe	-	M	DSEWPaC (2013)
Ardea ibis	Cattle Egret	-	M	DSEWPaC (2013)
Ardea alba	Great Egret	-	M	DSEWPaC (2013)

Key: CE= Critically Endangered, E= Endangered, V= Vulnerable, M= Migratory.

4.1.3 Matters of National Environmental Significance (MNES)

Matters of National Environmental Significance (MNES) are identified in the Protected Matters Report generated by the Protected Matters Search Tool (**Appendix 1**). Additional federally listed threatened or migratory species and ecological communities have been identified through interrogation of the NSW Wildlife Atlas Data (OEH 2013).

4.2 Aquatic Desktop Assessment Results

4.2.1 Namoi River Catchment

The Study Area is located within the Namoi River catchment which covers an area of approximately 42,000 square kilometres stretching from Woolbrook in the east to Walgett in the west. The catchment is bounded by the Great Dividing Range in the east, the Liverpool Ranges and Warrumbungle Ranges in the south and the Nandewar Ranges and Mount Kaputar to the north.

The Namoi River flows in a westerly direction from its headwaters in the Great Dividing Range. Its main tributary, the Peel River, joins the Namoi near Gunnedah. The Peel River originates in the southeast of the catchment near its border with the Hunter Valley, and flows in a north-west direction towards the Namoi River. The Peel is regulated by Chaffey Dam which provides water for irrigation as well as supplementing the water supply for the city of Tamworth (in addition to Dungowan Dam on Dungowan Creek).

Other major tributaries of the Namoi River include the Manilla and McDonald Rivers upstream of Keepit Dam, Coxs Creek and the Mooki River, which join the Namoi upstream of Boggabri, and Pian, Narrabri, Baradine and Bohena Creeks joining below Boggabri. The Namoi River then flows westerly across the plains and joins the Barwon River near Walgett. The Pian Creek and Gunidgera Creek system is an anabranch of the Namoi River which flows from the northern side of the river near Wee Waa in a westerly direction and rejoins the Namoi upstream of Walgett.

4.2.2 Bohena Sub-catchment

The Study Area is located within the Bohena sub-catchment of the Namoi River catchment. The Bohena Creek sub-catchment covers an area of approximately 830 square kilometres south of Narrabri and is the northern extension of the Borah sub-catchment. The major water system of the Bohena sub-catchment is Bohena Creek. Bohena Creek is considered a fifth order stream and is largely ephemeral, draining predominantly during rainfall events.

4.2.3 Watercourses

No watercourses are mapped as intersecting the Bibblewindi 31 and 32 lease areas (**Figure 3**). However, there are a number of watercourses adjacent to the proposed pilot wells including:

- Mount Pleasant Creek is approximately 520 and 230 metres west of Bibblewindi 31 and Bibblewindi 32, respectively;
- an unnamed ephemeral drainage line is 630 metres east and 70 metres north east of Bibblewindi 31 and Bibblewindi 32, respectively;
- Cowallah Creek is 1.6 and 0.5 kilometres west of Bibblewindi 31 and Bibblewindi 32, respectively; and
- Bohena Creek is 5.5 and 4.2 kilometres north-west of Bibblewindi 31 and Bibblewindi 32, respectively.

The majority of watercourses in the Bohena sub-catchment are ephemeral, including those that are mapped adjacent to Bibblewindi 31 and 32. Narrabri has recorded above average rainfall for 2013 (BOM, 2013), yet water flow and semi-permanent standing pools were not evident within the assessed watercourses during the on-ground Site assessment. This indicates that these creeks and channel systems are highly ephemeral and would only flow during times of heavy rainfall.

4.2.4 Permanent and Semi-permanent Wetlands

The OEH wetland mapping (2006) identified no wetlands within the Study Area or surrounds (ten kilometre radius).

4.2.5 Aquatic Vegetation

According to Namoi CMA (2010), four vegetation communities occur in close proximity to the riparian areas within the locality (**Figure 3**), including:

- Blakely's Red Gum riparian woodland
- Rough-barked Apple - Blakely's Red Gum riparian grassy woodlands.
- Ironbark shrubby woodlands
- Ironbark - Brown Bloodwood - Black Cypress Pine heathy woodlands, Brigalow Belt

Blakelyôs Red Gum riparian woodland

Blakely's Red Gum riparian woodland is located predominantly along Cowallah and Bohena Creek. A small patch also exists along the unnamed ephemeral drainage line, upstream of Bibblewindi 32.

Rough-barked Apple ï Blakelyôs Red Gum riparian grassy woodland

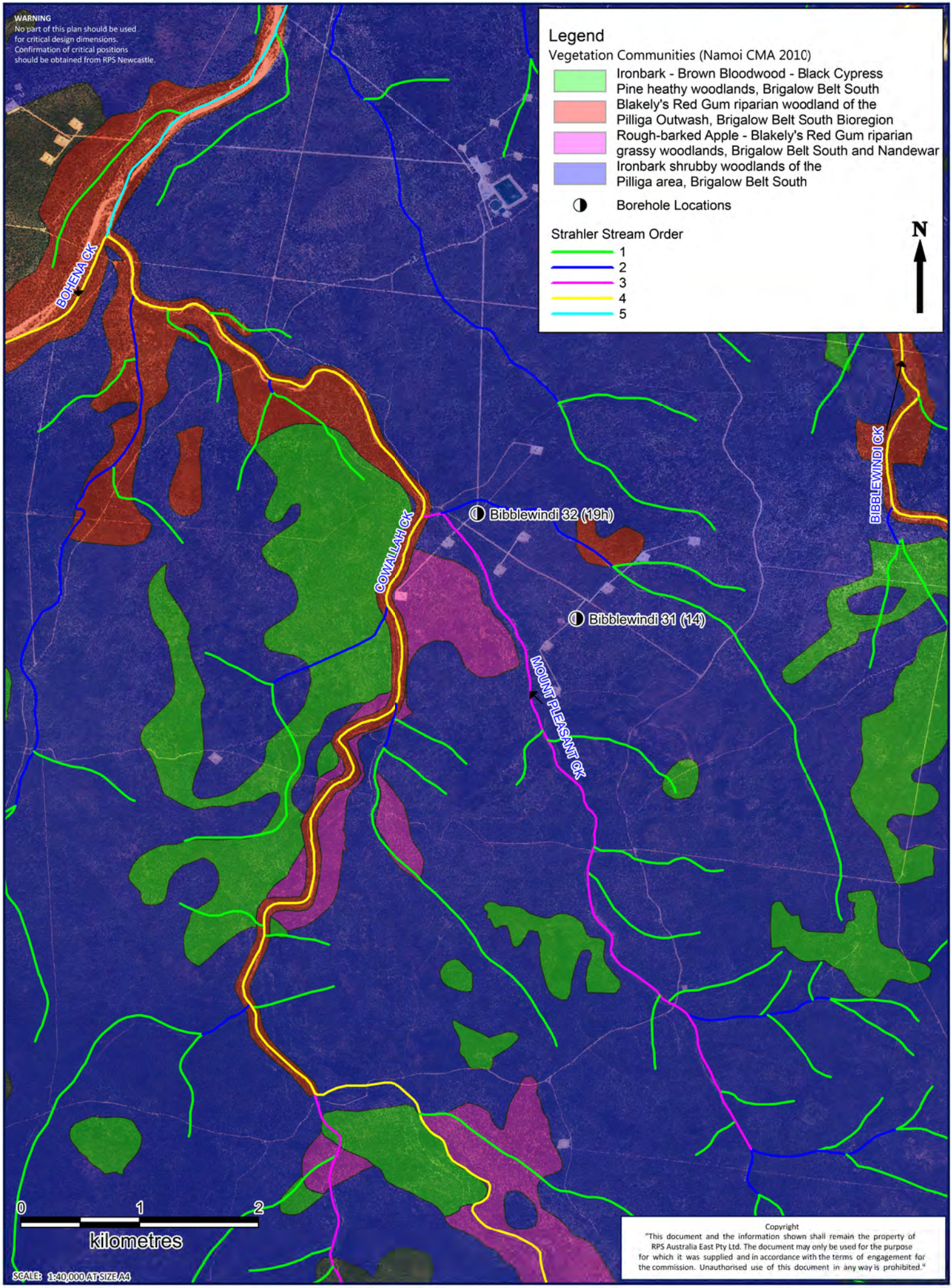
This vegetation community is associated with the ephemeral drainage lines along Cowallah Creek and extends out to the border of Mount Pleasant Creek.

Ironbark shrubby woodlands

This vegetation community is associated with the unnamed ephemeral drainage line. This community is not considered a riparian vegetation community.

Ironbark - Brown Bloodwood - Black Cypress Pine heathy woodlands, Brigalow Belt

This vegetation community is associated with the ephemeral drainage lines. This community is not considered a riparian vegetation community.



TITLE: FIGURE 3: STREAM ORDER AND RIPARIAN VEGETATION

LOCATION: BIBBLEWINDI 31 & 32

DATUM: GDA 94
PROJECTION: MGA ZONE 56

DATE: 02/07/2013
PURPOSE: ECOLOGY

LAYOUT REF: I:\JOBS\Santos\117518 Bibblewindi 31 32\10 - Drafting\MapInfo Workspaces\Eco
VERSION (PLAN BY): AB (C A4)

CLIENT: SANTOS
JOB REF: 117518-3

RPS AUSTRALIA EAST PTY LTD (ABN 44 140 292 762)
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4.2.6 Stream Order Index

NSW uses the Strahler stream classification system (Strahler 1957) where waterways are given an 'order' according to the number of additional tributaries associated with each waterway. This system provides a measure of system complexity and therefore the potential for fish habitat to be present. Third order streams and above are likely to display valuable fish habitat, and hence could support viable fish populations.

Stream Order was determined for the watercourses intersecting the proposed flowlines based on drainage lines captured from orthophotos at 1:50,000 and 1:25,000 scale.

According to the Strahler (1957) classification system, the stream order classifications for the major creek systems identified in **Figure 3** are as follows:

- Stream Order 2 - unnamed ephemeral drainage line.
- Stream Order 3 - Mount Pleasant Creek.
- Stream Order 4 - Cowallah Creek.
- Stream Order 5 - Bohena Creek.

4.2.7 Waterway Classification

Although some exceptions apply, stream order can also correspond with the waterway classification, with Class 4 waterways generally being first and second order streams (and some third order streams), while Class 3 will generally be third order streams. Class 1 and 2 will be third order or above streams.

Applying the general correlation between stream order and waterway classification, the major creek systems identified include:

- Class 4 (unlikely fish habitat) – unnamed ephemeral drainage line.
- Class 3 (minimal fish habitat) – Mount Pleasant Creek.
- Class 3 (minimal fish habitat) – Cowallah Creek.
- Class 2 (moderate fish habitat) – Bohena Creek.

The Waterway Classification system and a description of the associated waterway type characteristics are provided in **Table 7**.

Table 7 Classification of fish habitat in NSW (source: Fairfull and Witheridge 2003).

Classification	Characteristics of Waterway Type
CLASS 1 **Major fish habitat**	Major permanently or intermittently flowing waterway (e.g. river or major creek); habitat of a threatened fish species or 'critical habitat'.
CLASS 2 **Moderate fish habitat**	Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish species habitat and/or fish observed inhabiting the area.
CLASS 3 **Minimal fish habitat**	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). Semi-permanent pools from within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.
CLASS 4 **Unlikely fish habitat**	Named or unnamed waterway with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water or pools after rain events (e.g. dry gullies or shallow floodplain depressions with no permanent aquatic flora present).

According to the Waterway Classification system (**Table 7**), drainage features located within the vicinity of Bibblewindi 31 and 32 (unnamed ephemeral drainage line, Mount Pleasant Creek, Cowallah Creek) provide either unlikely or minimal fish habitat. Bohena Creek located 4.2 kilometres north-west of Bibblewindi 32 is considered to contain moderate fish habitat.

4.2.8 Key Fish Habitat Areas

The DPI (2007) Key Fish Habitat mapping considers Mount Pleasant Creek, Cowallah Creek and Bohena Creek as likely fish habitat areas.

4.3 Field Survey Results

4.3.1 Flora

4.3.1.1 Flora Species

A total of 25 flora species were identified within the Study Area.

No threatened flora species listed under the TSC Act and/or EPBC Act were identified as occurring within the Site.

4.3.1.2 Vegetation Communities

One vegetation community was observed within the Study Area, namely, *Ironbark Shrubby Woodlands of the Pilliga area, Brigalow Belt South* (**Plate 1**). However, as depicted below the community does not occur within any of the existing lease areas (**Plate 2**) and is only present within the surrounding Study Area. A detailed description of this vegetation community is provided below. The location and extent of this community is shown in **Figure 2**. A detailed flora species list is included in **Appendix 2**.

Ironbark Shrubby Woodlands of the Pilliga area, Brigalow Belt South



Plate 1 Ironbark Shrubby Woodlands of the Pilliga area, Brigalow Belt South

Description:	This vegetation community commonly occurs throughout the majority of the Bibblewindi State Forest. It is dominated by Ironbark and Allocasuarina species including *Eucalyptus crebra* (Narrow-leaved Ironbark) and *Allocasuarina luehmannii* (Bulloak). It is characterised by a shrubby mid-layer and a ground layer consisting of graminoids and grasses.
Canopy Layer:	15 to 19 metres – a patchy to moderate 15 – 50% projected foliage cover (PFC). The dominant species was *Eucalyptus crebra* (Narrow-leaved Ironbark*).*
Shrub Layer:	Variable height of 0.1 to 1.7 metres, 80 to 95% cover. Dominated by *Acacia caroleae* (Wattle) and, to a lesser extent, *Acacia spectabilis* (Mudgee Wattle), *Callistemon linearis* (Narrow-leaved Bottlebrush), and *Cassinia arcuata* (Sifton Bush).
Ground Layer:	Variable height of 0.1 to 0.8 metres, 50 to 65% cover. The ground layer was scattered and sparse and was dominated by *Dianella revoluta* (Blue Flax-lily), *Lomandra filiformis* (Wattle Mat-rush), *Aristida ramosa* (Purple Wire Grass), *Eragrostis brownii*, *Aristida vagans* (Threeawn Speargrass) and *Cheilanthes sieberi* (Mulga Fern).
Condition:	This vegetation community occupies the entirety of the vegetation which adjoins the Bibblewindi 31 and 32 Sites and has a low to moderate condition. The majority of the native vegetation within the Study Area is of a young age, which limits the resources that the community can produce and hence the fauna species it can support.
Classification:	The vegetation community surveyed within the Site was not found to be commensurate with any Threatened Ecological Community (TEC) listed under either the TSC Act or EPBC Act.

Existing Lease Areas

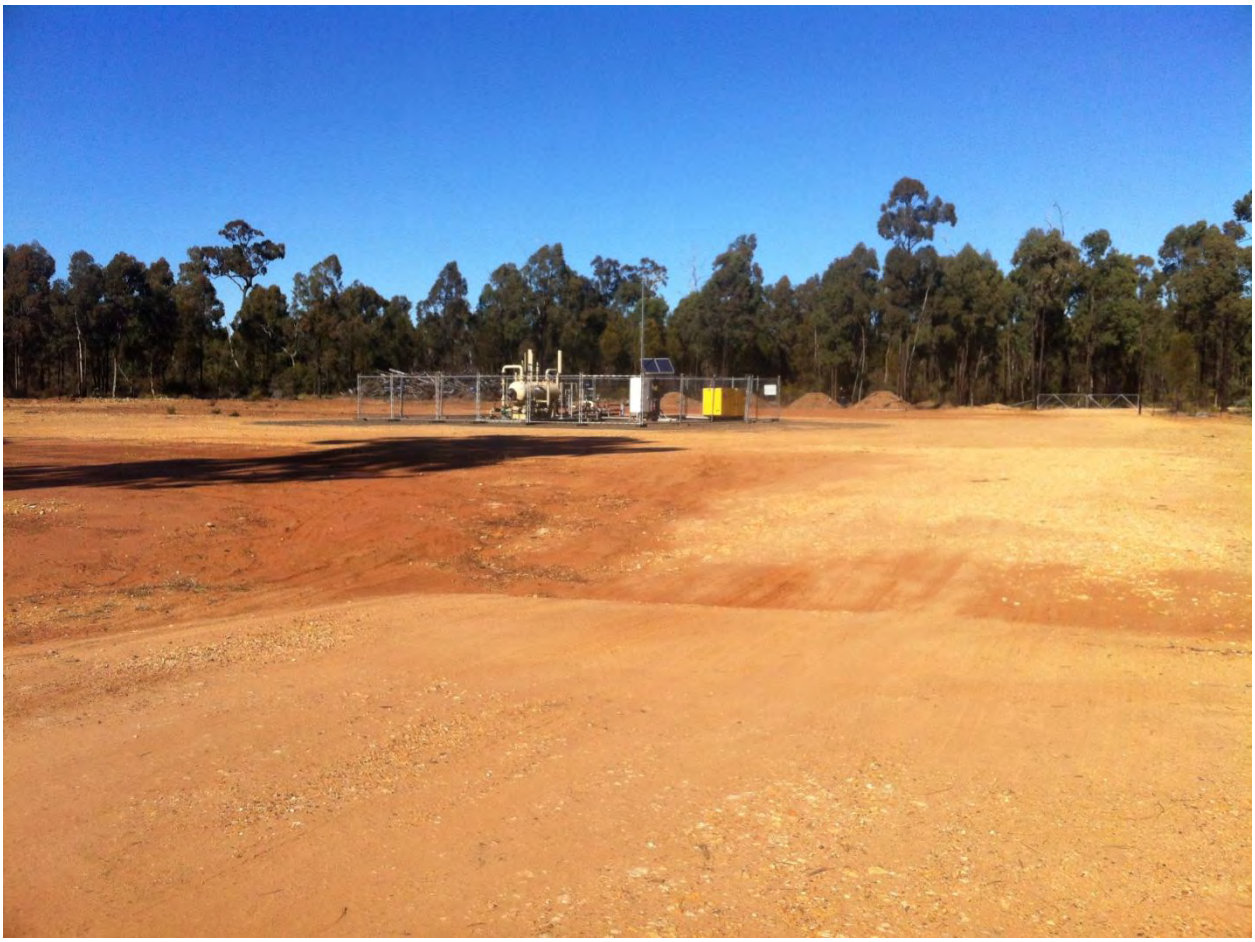


Plate 2 Existing Lease Area (Bibblewindi 14/Proposed Bibblewindi 31)

Description: The existing lease areas are largely devoid of flora species. Each Site comprises a cleared area of approximately one hectare in size, consisting of mostly imported fill. A series of stockpiles are located within the lease areas, including soil stockpiles and stockpiles of cleared vegetation. Areas of scouring exist across the lease area. The Bibblewindi 31 and 32 Sites exhibited some evidence of natural regeneration. The natural regeneration was still in its infancy and was dominated by native grasses (*Panicum effusum, Eragrostis brownii*). Some juvenile shrubs (*Dodonaea viscosa*) were beginning to encroach into the lease areas.

Classification: These areas of regenerating vegetation /cleared areas do not correspond with the definition of any TECs listed under the EPBC Act and/or the TSC Act.

4.3.1.3 Noxious and Environmental Weeds

Of the 25 flora species identified during the survey, none of them are introduced species.

4.3.2 Fauna

4.3.2.1 Fauna Species

A total of nine common native avifauna species were recorded in the Study Area (refer to **Appendix 3**). No exotic fauna species were recorded during opportunistic surveys.

4.3.2.2 Fauna Habitat

The existing lease areas are characterised by cleared areas, from which native vegetation has been cleared for previous exploration activities. These cleared areas offer potential basking habitat for reptiles and, consequently, foraging habitat for some birds. However, they are generally of limited value to fauna species, due to the lack of habitat resources.

The Study Area surrounding the existing lease areas contains open forest dominated by *Eucalyptus crebra* (Narrow-leaved Ironbark). The vegetation present on Site was primarily regrowth with many canopy trees being of a relatively young age (less than 40 millimetre Diameter at Breast Height). The canopy was fragmented, possibly as a result of selective logging practices within the region. As a result of the maturity of the canopy, no hollow-bearing trees were observed within the Study Area. Hollows are an important habitat attribute for a number of fauna guilds, including forest owls, microchiropteran bats, arboreal mammals and a number of hollow-nesting woodland bird species. The understorey also exhibited signs of regeneration after fire disturbance and some areas were almost completely dominated by *Acacia spectabilis*. However, this vegetation type still provides habitats such as high, mid and low canopy, shrub and groundlayer vegetation. Other habitat attributes such as leaf litter, fallen timber, small exposed rocks and exposed soil/sand were also present.

There are no permanent drainage lines, dams or other hydrological features that would offer aquatic habitat within the Site, however there is an ephemeral drainage line approximately 70 metres north-west of the proposed Bibblewindi 32 (existing Bibblewindi 19H) lease area (refer to **Figure 2**).

4.4 Aquatic Field Assessment

4.4.1 Aquatic and Riparian Vegetation

Riparian vegetation, dominated by Sparse grasses and graminoids such as *Juncus* sp., occurs as a narrow strip (approximately two metres wide) along the unnamed ephemeral drainage line. Trees were present, but these were generally set back from the channel and are unlikely to create a source of woody debris in the short term. The tree canopy overhangs a number of areas along the unnamed ephemeral drainage line and thus would provide a source of detritus and food for some aquatic fauna. This community is considered to be commensurate to '*Ironbark Shrubby Woodlands of the Pilliga area, Brigalow Belt South*' (Namoi CMA, 2010).

No aquatic vegetation was identified during the survey.

4.4.2 Aquatic Habitat Values

Aquatic habitat was in poor to moderate condition. The cover of instream habitat (e.g. small and large woody debris, tree roots and aquatic vegetation) was limited. There were no log-jams along the unnamed ephemeral drainage line.

Due to a lack of suitable habitat (absence of slow flowing deep waters), the unnamed ephemeral drainage line is unlikely to support listed rare and threatened species such as the Murray Cod (*Maccullochella peelii peelii*). While Mount Pleasant and Cowallah Creek were not surveyed in this scout they are also considered unlikely to harbour suitable habitat for the Murray Cod due to their ephemeral nature. No suitable habitat for turtles was identified.

Under prolonged wet conditions these creeks are likely to be characterised by shallow pools and runs with poor instream-diversity. The ephemeral nature of these creeks is more likely to support common fish species during migration and breeding and potentially provide feeding areas for some aquatic fauna (e.g. fish, macro-invertebrates).

4.4.3 Other Habitat Features

While these waterways are small, they are an important component of ecological function, potentially providing breeding and habitat resources for species such as frogs and reptiles. They also provide for fauna movement throughout the broader landscape.

4.4.4 Geomorphology

The unnamed ephemeral drainage line is characterised by a small, tightly sinuous ephemeral channel system that flows into Cowallah Creek. The tributary was two to three metres wide, with gentle banks characterised by sandy soils. Deposition was apparent upon inspection and there was little evidence of active erosion. The banks were relatively stable and despite above average rainfall in the area, there was limited erosion observed in the channel.

The tributary does not appear to interact with the local groundwater. Water levels in the tributary are more likely to be affected by water backing-up the tributary, when water levels in Cowallah and Bohena Creeks are high, then by runoff flows within the tributary catchment. Only larger catchment flows would activate erosion in this creek line and mobilise sediments.

5.0 Ecological Impact Assessment

5.1 Identification of Threatened Species, Populations and Ecological Communities

Threatened flora and Threatened and Migratory fauna species (listed under the *TSC Act* and the *EPBC Act*) that have been gazetted / recorded within the locality have been considered in this Ecological Assessment. TECs and Endangered Populations known from the broader area have also been addressed. Each species / community / population is considered for its potential to occur within the Site and for the likely level of impact as a result of the proposed activity. This Ecological Assessment deals with each species / community / population separately and identifies the ecological parameters of significance associated with the proposed activity.

ôSpeciesôor **ôTECs / Populationsô**– Lists each threatened species / TEC / population known from the vicinity of the Site. The status of each threatened species under the *TSC Act* and *EPBC Act* is also provided.

ôHabitatô– Provides a brief account of the species / community / population and the preferred habitat attributes required for the existence / survival of each species / community / population.

ôLikelihood of Occurrenceô- Assesses the likelihood of each species / community / population to occur on Site considering the aforementioned habitat description and local habitat preferences, results of recent field investigations, data gained from various sources, and previously gained knowledge via fieldwork undertaken within other ecological assessments in the locality and the Pilliga in general.

Species are assessed as being either Unlikely, Possible, Likely or Known to occur in the Study Area, based on the criteria in (**Table 8**). The analysis was undertaken using database information for point locality records against habitat preferences identified by OEH (Threatened Species Profiles), Harden (1990-1993, 2002) and DSEWPaC (Species Profile and Threats Database).

ôPotential for Impactô– Through consideration of the likely level / significance of impacts to each species / community / population that would result from the proposed activity, taking into account both short and long-term impacts, a decision has been made as to whether further assessment is required. This assessment is largely based on the chance of occurrence of each species / community, with due recognition to other parameters such as home range, habitat use, connectivity etc. It also considers the scope of the proposed activity.

Table 8 Likelihood of Occurrence of Threatened Flora and Fauna Species, Populations and Ecological Communities within the Study Area.

Species	Common Name	TSC Act Status	EPBC Act Status	Habitat	Likelihood of Occurrence	Potential for Impact
Flora						
Bertya opponens	-	V	V	This species is only known within four Sites in NSW, with the largest known population located in Jacks Creek State Forest, part of the Pilliga forests. This population grows on red sandstone in a forest consisting mainly of eucalypt and cypress spp.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain some, albeit sub-optimal, habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an Assessment of Significance (AoS) for this species is not required.
Diuris tricolor	Pine Donkey Orchid	V	-	The Pine Donkey Orchid 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. It usually flowers between early September to late October. Sporadically distributed on the western slopes of NSW, extending from south of Narrandera all the way to the north of NSW. Localities in the south include Red Hill north of Narrandera, Coolamon, and several Sites west of Wagga Wagga. Condobolin-Nymagee road, Wattamondara towards Cowra, Eugowra, Girilambone, Dubbo and Cooyal, in the Central West. Pillaga SCA, Pillaga National Park and Bibblewindi State Forest in the north and Muswellbrook in the east.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an Assessment of Significance (AoS) for this species is not required.
Monotaxis macrophylla	Large-leafed Monotaxis	E	-	This species is solely related to the occurrence of fire. Vegetation communities in which it has been recorded varies, and includes coastal heath, arid shrub land, forests and montane heath from sea level to 1300 metres altitude.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Philotheca ericifolia	-	-	V	This species has a scattered distribution covering 400 kilometres between West Wyalong and the Pilliga. It mainly grows in dry sclerophyll forests and heathlands on damp sandy flats, in gullies and on rocky ridges. Associated species include *Melaleuca uncinata*, *Acacia triptera* and *Eucalyptus crebra*.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Polygala linariifolia	Native Milkwort	E	-	This species has been recorded within the Pilliga region, where it mainly grows in dry sclerophyll and eucalypt forests on sandy soils. It is known to occur within Fuzzy Box Woodland, White Cypress Pine- Bulloak – Ironbark Woodland, Rough-barked Apple riparian forb-grass open forest and Ironbark – Brown Bloodwood Shrubby Woodland. Other associated species include *E. trachyphloia, E. sphaerocarpa, A. floribunda, A. leiocarpa, Tristina suaveolens, Allocasuarina torulosa* and *Wahlenbergia species.*	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Pomaderris queenslandica	Scant Pomaderris	E	-	Widely scattered but not common in north-east NSW and in Queensland. It is known to occur within several locations on the NSW north coast and a few locations on the New England Tablelands and North West Slopes, including near Torrington and Coolata. Found in moist eucalypt forest or sheltered woodlands with a shrubby understorey, and occasionally along creeks.	This species is unlikely to occur within the Site as a result of the existing disturbance. This species was not detected during field surveys. The vegetation community on Site does not represent suitable habitat for this species based on current records. Therefore it is considered **unlikely** to occur within the Study Area.	Considered unlikely to occur. Therefore the proposed activity is **unlikely** to impact upon this species. An AoS for this species is not required.
Pterostylis cobarensis	Cobar Greenhood Orchid	V	V	The known distribution of this species ranges from Nyngan to the Bourke district in the western plains of NSW. It grows mainly in Eucalypt woodlands, open mallee or *Callitris* shrublands with skeletal sandy-loam soils. Associated species include *E. morrisii*, *E. viridris* and *C. glaucophylla*.	No records for this species exist within ten kilometres of the Site and it was not detected during field surveys. Surveys were conducted late within this species flowering period (Sept-Nov) and, due to its cryptic nature, would be difficult to detect during the remainder of the year. Therefore it is **possible** that this species occurs	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.

Species	Common Name	TSC Act Status	EPBC Act Status	Habitat	Likelihood of Occurrence	Potential for Impact
					within the Study Area.	
Pultenaea setulosa	-	-	V	Known from Broad Sound to the Marlborough area in Queensland (Bentham, 1864) and also from the Nandewar Range in northern New South Wales (Weston, 1991). In NSW, the species grows in wet sclerophyll forest on volcanic substrates (Weston, 1991). This species occurs within the Fitzroy (Queensland) and Border Rivers–Gwydir (NSW) Natural Resource Management Regions.	This species is unlikely to occur within the Site as a result of the existing disturbance. No records for this species exist within ten kilometres of the Site and it was not detected during field surveys. The vegetation community on Site does not represent suitable habitat for this species based on current records. Therefore it is considered **unlikely** to occur within the Study Area.	Considered unlikely to occur. Therefore the proposed activity is **unlikely** to impact upon this species. An AoS for this species is not required.
Rulingia procumbens	-	V	V	This species has been recorded within the Pilliga Nature Reserve and Mt Kaputar National Park as well as the Cobar region and upper Hunter Valley. It is often found in sandy soils and disturbed habitats within communities of *E. dealbata - E.sideroxylon* woodland or *Melaleuca uncinata* shrubland.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Tylophora linearis	-	V	E	Grows in dry scrub and open forest. Recorded within low-altitude sedimentary flats in dry Eucalypt and/or Callitris woodlands. Can also be associated with *Melaleuca uncinata*, *Eucalyptus fibrosa, E. sideroxylon, E. albens, Allocasuarina luehmannii, Acacia hakeoides, A. lineata, Myoporum* sp and *Casuarina* sp.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
TSC Act and/or EPBC Act - Threatened Ecological Communities						
Carex Sedgeland of the New England Tableland, Nandewar, Brigalow Belt South and NSW North Coast Bioregions.	E	-		Carex Sedgelands are fens dominated by sedges, grasses and semi-aquatic herbs. Dominant species are *Carex appressa*, *Stellaria angustifolia*, *Scirpus polystachyus*, *Carex gaudichaudiana*, *Carex* sp. Bendemeer, *Carex tereticaulis* and *Isachne globosa*, either as single species or in combinations. Carex Sedgelands are mostly found at higher altitude on tablelands but also extend onto the slopes. The community has been recorded within the LGAs of Armidale Dumaresq, Warrumbungle, Glen Innes Severn, Guyra, Gwydir, Inverell, Liverpool Plains, Tamworth Regional, Uralla and Walcha. The community occupies an estimated extent of 5000 hectares, which is estimated to be a 50% decline in extent since European settlement. Less than 100 hectares is currently represented in conservation reserves in NSW.	This ecological community was not identified on Site or within the Study Area. Therefore it is **unlikely** that this community occurs within the Site or the Study Area.	This ecological community is considered **unlikely** to be adversely affected by the proposed activity, as this ecological community is not known to occur within the Site or the Study Area. Therefore an AoS for this community is not required.
TSC Act - Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions. EPBC Act - Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions.	EEC	E		Distribution is limited to the Darling Riverine Plains and the Brigalow Belt South Bioregions. This ecological community represents occurrences of one type of eucalypt woodland where *Eucalyptus coolabah* subsp. *coolabah* (Coolibah, Coolabah) and/or *Eucalyptus largiflorens* (Black Box) are the dominant canopy species and where the understorey tends to be grassy. This community is found on the grey, self-mulching clays of periodically waterlogged floodplains, swamp margins, ephemeral wetlands and stream levees. The main tree species in the canopy of the woodland are *Eucalyptus coolabah* subsp. *coolabah* (Coolibah) and/or *Eucalyptus largiflorens* (Black Box).	This ecological community was not identified on Site or within the Study Area. Therefore it is **unlikely** that this community occurs within the Site or the Study Area.	This ecological community is considered **unlikely** to be adversely affected by the proposed activity, as this ecological community is not known to occur within the Site or the Study Area. Therefore an AoS for this community is not required.
TSC Act - Inland Grey Box Woodland in the Riverina; NSW South Western Slopes; Cobar Peneplain; Nandewar and Brigalow Belt South Bioregions. EPBC Act - Grey Box (*Eucalyptus microcarpa*) grassy woodlands and derived native grasslands of south-eastern Australia.	EEC	E		Inland Grey Box Woodland includes those woodlands in which the most characteristic tree species, *Eucalyptus microcarpa* (Inland Grey Box), is often found in association with *E. populnea* subsp. *bimbil* (Bimble or Poplar Box), *Callitris glaucophylla* (White Cypress Pine), *Brachychiton populneus* (Kurrajong), *Allocasuarina luehmannii* (Bulloak) or *E. melliodora* (Yellow Box), and sometimes with *E. albens* (White Box). The community generally occurs as an open woodland 15–25 metres tall, but in some locations the overstorey may be absent as a result of past clearing or thinning,	This ecological community was not identified on Site or within the Study Area. Therefore it is **unlikely** that this community occurs within the Site or the Study Area.	This ecological community is considered **unlikely** to be adversely affected by the proposed activity, as this ecological community is not known to occur within the Site or the Study Area. Therefore an AoS for this community is not required.

Species	Common Name	TSC Act Status	EPBC Act Status	Habitat	Likelihood of Occurrence	Potential for Impact
				leaving only an understorey. Inland Grey Box Woodland occurs predominately within the Riverina and South West Slopes regions of NSW down to the Victorian border. This community also extends across the slopes and plains in Central and Northern NSW up to the Queensland Border.		
TSC Act - Myall Woodland in the Darling Riverine Plains; Brigalow Belt South; Cobar Peneplain; Murray-Darling Depression; Riverina and NSW South Western Slopes bioregions. EPBC Act - Weeping Myall Woodlands.		EEC	E	This ecological community is scattered across the eastern parts of the alluvial plains of the Murray-Darling river system. Typically, it occurs on red-brown earths and heavy textured grey and brown alluvial soils within a climatic belt receiving between 375 and 500 mm mean annual rainfall. The structure of the community varies from low woodland and low open woodland, to low sparse woodland or open shrubland, depending on Site quality and disturbance history. The tree layer grows to a height of about ten metres and invariably includes *Acacia pendula* (Weeping Myall or Boree) as one of the dominant, or the only, tree species present. This EEC is known to occur within the LGAs of Berrigan, Bland, Bogan, Carrathool, Conargo, Coolamon, Coonamble, Corowa, Forbes, Gilgandra, Griffith, Gwydir, Inverell, Jerilderee, Lachlan, Leeton, Lockhart, Moree Plains, Murray, Murrumbidgee, Narrabri, Narranderra, Narromine, Parkes, Urana, Wagga Wagga and Warren but may occur elsewhere in these bioregions.	This ecological community was not identified on Site or within the Study Area. Therefore it is **unlikely** that this community occurs within the Site or the Study Area.	This ecological community is considered **unlikely** to be adversely affected by the proposed activity, as this ecological community is not known to occur within the Site or the Study Area. Therefore an AoS for this community is not required.
TSC Act - Native Vegetation on Cracking Clay Soils of the Liverpool Plains. EPBC Act – Natural Grasslands on Basalt and Fine-textured Alluvial Plains of Northern New South Wales and Southern Queensland.		EEC	CE	Native Vegetation on Cracking Clay Soils of the Liverpool Plains is mainly a native grassland community, which includes a range of small forb and herb species. The main grass species include *Austrostipa aristiglumis* (Plains Grass), *Dichanthium sericeum* (Queensland Bluegrass) and *Panicum queenslandicum* (Coolibah Grass). It also contains scattered and patchy shrubs and trees, including *Acacia pendula* (Boree), *Angophora floribunda* (Rough-barked Apple), *Eucalyptus conica* (Fuzzy Box), *E. populnea* (Bimble Box) and *E. melliodora* (Yellow Box). In wetter locations, rushes and sedges are common. This community is located around Coonabarabran, Gunnedah, Murrurundi, Narrabri, Tamworth and Quirindi on the North West Slopes and Plains of NSW. Most surviving remnants of the community are on Travelling Stock Routes.	This ecological community was not identified on Site or within the Study Area. Therefore it is **unlikely** that this community occurs within the Site or the Study Area.	This ecological community is considered **unlikely** to be adversely affected by the proposed activity, as this ecological community is not known to occur within the Site or the Study Area. Therefore an AoS for this community is not required.
Fuzzy Box Woodland on alluvial soils of the South Western Slopes, Darling Riverine Plains and Brigalow Belt South Bioregions.		E	-	Tall woodland or open forest dominated by *Eucalyptus conica*, (Fuzzy Box*)*, often with *Eucalyptus microcarpa* (Grey Box*)*, *Eucalyptus melliodora* (Yellow Box*)*, or *Brachychiton populneus* (Kurrajong*)*. *Allocasuarina luehmannii* (Bulloak) is common in places. Shrubs are generally sparse and the groundcover moderately dense, although this will vary with season. Alluvial soils of the South West Slopes, Brigalow Belt South and Darling Riverine Plains Bioregions. Mainly in the Dubbo-Narromine-Parkes-Forbes area.	This ecological community was not identified on Site or within the Study Area. Therefore it is **unlikely** that this community occurs within the Site or the Study Area.	This ecological community is considered **unlikely** to be adversely affected by the proposed activity, as this ecological community is not known to occur within the Site or the Study Area. Therefore an AoS for this community is not required.
TSC Act - White Box Yellow Box Blakely's Red Gum Woodland. EPBC Act - White Box-Yellow Box-Blakely's Red Gum grassy woodland and derived native grassland.		E	CE	White Box Yellow Box Blakely's Red Gum Woodland (commonly referred to as Box-Gum Woodland) is an open woodland community (sometimes occurring as a forest formation), in which the most obvious species are one or more of the following: *Eucalyptus albens* (White Box), *E. melliodora* (Yellow Box) and *E. blakelyi* (Blakely's Red Gum). Intact Sites contain a high diversity of plant species, including the main tree species, additional tree species, some shrub species, several climbing plant species, many grasses, and a very high diversity of herbs. Box-Gum Woodland is found from the Queensland border in the north, to the Victorian border in the south. It occurs in the Tablelands and Western Slopes of NSW.	This ecological community was not identified on Site or within the Study Area. Therefore it is **unlikely** that this community occurs within the Site or the Study Area.	This ecological community is considered **unlikely** to be adversely affected by the proposed activity, as this ecological community is not known to occur within the Site or the Study Area. Therefore an AoS for this community is not required.
Fish						

Species	Common Name	TSC Act Status	EPBC Act Status	Habitat	Likelihood of Occurrence	Potential for Impact
Maccullochella peelii peelii	Murray Cod	-	V	Found in clear rocky streams, slow flowing turbid rivers and billabongs. Usually found near large rocks, snags, overhanging vegetation and other woody structures.	The Study Area does not provide suitable habitat to support this species. The closest ephemeral drainage line is ~70 metres north west of Bibblewindi 32. Therefore it is considered **unlikely** to occur within the Site or the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Reptiles						
Aprasia parapulchella	Pink-tailed Worm-lizard	V	V	This species inhabits grassy woodlands with suitably sized small to medium rocks under which it shallowly buries itself in soil.	This species is unlikely to occur within the Site as a result of the existing disturbance. No records for this species exist within ten kilometres of the Site. Habitat in the form of grassy woodlands with suitable rocks does not exist within the Study Area. Therefore it is considered **unlikely** to occur within the Site or the Study Area.	Considered unlikely to occur. Therefore the proposed activity is **unlikely** to impact upon this species. An AoS for this species is not required.
Uvidicolus sphyrurus	Border Thick-tailed Gecko	V	V	Favours forest and woodland areas on steep rocky or scree slopes, with boulders, rock slabs, fallen timber and deep leaf litter.	This species is unlikely to occur within the Site as a result of the existing disturbance. No records for this species exist within ten kilometres of the Site and it was not detected during field surveys. There is no preferred habitat features within the Study Area. Therefore it is considered **unlikely** to occur within the Site or the Study Area.	Considered unlikely to occur. Therefore the proposed activity is **unlikely** to impact upon this species. An AoS for this species is not required.
Birds						
Anthochaera phrygia	Regent Honeyeater	CE	E, M	Inhabits dry open forest and woodland, particularly Box-Ironbark woodland and open riparian forests of River She-oak.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Botaurus poiciloptilus	Australasian Bittern	E	E	This species inhabits estuarine and terrestrial wetlands with dense vegetation where it builds nests and forages on invertebrates and small vertebrates.	The Site and the Study Area do not provide suitable habitat to support this species. The closest ephemeral drainage line is ~70 metres north west of Bibblewindi 32. Therefore it is considered **unlikely** to occur within the Site or the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	-	The inland distribution of the species is restricted by the occurrence of the various *Casuarinaceae spp*. *C. lathami,* which characteristically inhabits forests on Sites with low soil-nutrients status, reflecting the distribution of key *Allocasuarina spp*.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **likely** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Chthonicola sagittata	Speckled Warbler	V	-	Occupies Eucalypt and Cypress woodlands in drier coastal areas and on the western slopes of the Great Dividing Range. Appears unable to persist in districts where no forested fragments larger than 100 hectares remain. The Speckled Warbler forages on the ground mainly in open grassy areas for seeds and insects.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **likely** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	-	Frequents drier forests and woodlands, particularly open woodland lacking a dense understorey. Also found in grasslands in proximity to wooded areas where there are sufficient logs, stumps and dead trees nearby. Occasionally found in mallee and *Eucalyptus camaldulensis* (River Red Gum) forest bordering wetlands with an open understorey of *Acacia* sp., *Muehlenbeckia* sp. (Lignum), *Typha* sp. (Cumbungi) and *Poa* sp. (grasses).	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **likely** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.

Species	Common Name	TSC Act Status	EPBC Act Status	Habitat	Likelihood of Occurrence	Potential for Impact
Daphoenositta chrysoptera	Varied Sittella	V	-	Inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland where it forages on arthropods. Varied Sittellas build cup-shaped nests of cobwebs and plant fibres in the canopy.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Geophaps scripta scripta	Squatter Pigeon (southern)	E	V	Occurs on the inland slopes of the Great Dividing Range with a distribution that extends from the Burdekin-Lynd divide in central Queensland, west to Charleville and Longreach, east to the coast from Prosperine to Port Curtis, and south to scattered Sites in south-eastern Queensland. Inhabits grassy woodlands and open forests that are dominated by eucalypts. Only nine confirmed records have been made in NSW since 1975.	This species was not recorded on Site and no records exist within ten kilometres of the Site. Due to the lack of records within the area and lack of suitable habitat, it is **unlikely** that this species occurs on Site or within the Study Area.	Considered unlikely to occur. Therefore an AoS for this species is not required.
Glossopsitta pusilla	Little Lorikeet	V	-	Forages primarily in the canopy of open Eucalypt forest and woodland. Riparian habitats are particularly used, due to higher soil fertility. Also found in isolated flowering trees in open country, e.g. paddocks and roadside remnants.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **likely** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Lathamus discolour	Swift Parrot	E	E	Migrates to south-east Australia between March and October. Occurs in areas where Eucalypts are flowering profusely or where there are abundant lerp infestations.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Leipoa Ocellata	Malleefowl	-	V, M	Occurs in semi-arid and arid zones of temperate Australia, where it occupies shrublands and low woodlands that are dominated by mallee vegetation. It also occurs in eucalypt or native pine woodlands, acacia scrublands, Broombush vegetation or coastal heathlands (SPRAT, 2010).	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Lophoictinia isura	Square-tailed Kite	V	-	This species is sparsely distributed throughout NSW mainly along the Barwon, Culgoa, Darling and Murray rivers as well as coastal forested areas. The Square-tailed Kite is usually associated with forests dominated by Eucalypt species such as *E. longifloria*, *E. maculata* and *E. elata* as well as *Angophora* and *Callitris* spp. Nests are usually located near watercourses in *Angophora* or *Eucalypt* spp.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V	-	This species is distributed across most of non-coastal NSW where it inhabits eucalypt and acacia woodlands with an open understorey and a complex ground layer including logs, dead branches and woody debris. Nests are made of plant fibres and cobweb located on branches or stumps. Diet consists of invertebrates and sometimes small vertebrates taken from logs and woody debris.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Neophema pulchella	Turquoise Parrot	V	-	In NSW, the Turquoise Parrot is distributed in the tablelands and western slopes as well as coastal areas mainly in Eucalyptus woodlands and open forests with a grassy ground cover and sparse understorey of shrubs. Associated species commonly include *Callitris* and *Eucalyptus* spp such as *E. albens* and *E. melliodora*. Diet consists of seeds from a variety of grass and thistle sp. as well as flowers, nectars, fruits and some insects. Nests are usually located in hollows, stumps or logs on the ground.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **likely** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Ninox connivens	Barking Owl	V	-	Occurs mainly in dry sclerophyll woodland. Nests in large Eucalypt hollows, and roosts in hollows or thick vegetation. Can be found roosting in dense *Acacia* sp. and *Casuarina* sp. or the dense clumps of Eucalypt trees. Hunts a range of prey species including birds and both terrestrial and arboreal mammals. The Barking Owl	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.

Species	Common Name	TSC Act Status	EPBC Act Status	Habitat	Likelihood of Occurrence	Potential for Impact
				has a widespread distribution in NSW on the coastal plains and inland slopes.	Therefore it is **likely** that this species occurs within the Study Area.	
Polytelis swainsonii	Superb Parrot	V	V	Found in Box-Gum, Box-Cypress-pine and Boree woodlands, and River Red Gum forest. Nests in small colonies in the hollows of large trees, mainly in tall riparian River Red Gum forest or woodland.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	-	Occupies open forests and woodlands, Acacia shrubland and adjoining farmland. Also Box-Gum Woodlands on the divide slopes and Box-Cypress Pine and open Box Woodlands on the plains. Generally they prefer wooded areas with an intact ground cover. Appears unable to persist in cleared and highly fragmented habitats.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **likely** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Rostratula australis	Australian Painted Snipe	E	V, M	Inhabits shallow terrestrial freshwater wetlands, including temporary and permanent lakes, swamps and claypans.	The Site and the Study Area do not provide suitable habitat to support this species. The closest ephemeral drainage line is ~70 metres north west of Bibblewindi 32. Therefore, it is considered **unlikely** to occur within the Site or the Study Area.	Considered unlikely to occur. Therefore an AoS for this species is not required.
Stagonopleura guttata	Diamond Firetail	V	-	Found in grassy eucalypt woodlands, including Box-Gum woodlands and Snow Gum woodlands. Often found in riparian areas and sometimes in lightly wooded farmland.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Tyto novaehollandiae	Masked Owl	V		Found in a range of habitats, locally within sclerophyll forests and woodlands where appropriate/preferred prey species occur (being predominantly terrestrial mammals). Requires large Eucalypt hollows for nesting and prefers to roost in these hollows as well.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Mammals						
Cercartetus nanus	Eastern Pygmy-possum	V	-	Found in a range of habitats including rainforest, sclerophyll forest, woodland and heath. Feeds on the nectar of Banksias, eucalypts and bottlebrushes.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Roosts in caves, crevices in cliffs, old mine workings, and disused Fairy Martin (*Hirundo ariel*) nests, frequenting dry open forest and woodland close to these features.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Chalinolobus picatus	Little Pied Bat	V	-	This hollow roosting species occurs mostly in dry, open woodlands throughout its range but can occupy other forms of vegetation communities such as notophyll vine forest and dry sclerophyll forest. Little Pied Bats appear to be at their highest density in the mallee woodlands of the Willandra Lakes area of NSW. They have been known to roost in trees, caves and abandoned mines and buildings.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Nyctophilus corbeni	South-eastern or Greater Long-eared Bat	V	V	Commonly roosts in crevices, hollows and under loose bark in Box / Ironbark / Cypress Pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats.

Species	Common Name	TSC Act Status	EPBC Act Status	Habitat	Likelihood of Occurrence	Potential for Impact
				Queensland.	habitat. Therefore it is **possible** that this species occurs within the Study Area.	Therefore an AoS for this species is not required.
Miniopterus schreibersii oceanensis	Eastern Bentwing Bat	V	-	Eastern Bentwing-bats occur along the east and north-west coasts of Australia. Caves are the primary roosting habitat, but they also use derelict mines, storm-water tunnels, buildings and other man-made structures. This species forms discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young. At other times of the year, populations disperse within about 300 km range of maternity caves. Hunts in forested areas, catching moths and other flying insects above the tree tops.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Petaurus norfolcensis	Squirrel Glider	V	-	Squirrel Gliders inhabit dry sclerophyll forest and woodland and are generally absent from rainforest and closed forest. Habitat types include Box-ironbark forest, River Red Gum forests and eucalypt forests.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Petrogale penicillata	Brush-tailed Rock-wallaby	E	V	Occupies rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges.	No records exist within ten kilometres of the Site for this species. No escarpments or rock outcrops required by this species exist on Site or within the Study Area. Therefore it is considered **unlikely** to occur on Site or within the Study Area.	Considered unlikely to occur. Therefore, an AoS is not required for this species.
Phascolarctos cinereus	Koala	V	V	Inhabits Eucalypt woodlands and forests, spending most of their time in trees. Feeds on the foliage of more than 70 Eucalypt and 30 non-Eucalypt species.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Pseudomys pilligaensis	Pilliga Mouse	V	V	This species is known only to occur within the Pilliga region of NSW, including the Pilliga State forest and Pilliga Nature Reserve. A defined habitat for this species is hard to characterise as the vegetation type in which this species has been found varies. Eucalypt, Callitris and Acacia woodlands are vegetation types in which this species has been found. It has been found mostly in gullies that have experienced recent fire events. Habitat features that appear to be preferential for this species include a moderate to high low-shrub cover; sparse understorey; Site moisture retention; and groundcover of plants, litter and fungi. The topography of Sites where this species is found includes rolling landscapes with low relief on sandy soil and sandstone ridges.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	-	Occurs in a range of habitats from rainforest to arid shrubland. Roosts in small colonies of up to six in tree hollows or buildings. Forages aerially between trees in the canopy.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Vespadelus troughtoni	Eastern Cave Bat	V	V	They have been found roosting in sandstone overhangs, boulder pipes, mines and occasionally buildings. They commonly utilise abandoned fairy martin nests under bridges and in culverts. All existing records are in close proximity to sandstone or volcanic escarpment. Vegetation communities in which they inhabit include tropical mixed woodland and wet and dry sclerophyll along the coast and the Great Dividing Range. This species has a relatively small foraging range of approximately 33 hectares.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.

Key: CE= Critically Endangered, E= Endangered, V= Vulnerable, M= Migratory.

Table 9 Likelihood of Occurrence of Migratory Fauna Species in the Study Area

Species	Common Name	TSC Act Status	EPBC Act Status	Habitat	Likelihood of Occurrence	Likely Level of Impact
Anthochaera phrygia	Regent Honeyeater	CE	E, M	Inhabits dry open forest and woodland, particularly Box-Ironbark woodland and open riparian forests of River She-oak.	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Apus pacificus	Fork-tailed Swift	-	M	Aerial over open country, from semi-desserts to coasts, islands and sometimes over forests and cities.	Due to the wide variety of habitats in which this species occurs, it cannot be ruled out from occurring on Site. Therefore it is **possible** that this species occurs within the Study Area.	This species is considered **unlikely** to be impacted upon due to no disturbances to potential breeding habitat resulting from the proposed activity. Therefore an AoS is not required.
Ardea alba	Great Egret	-	M	Prefer shallow water, particularly when flowing, but may be seen on any watered area, including damp grasslands.	The Site and the Study Area do not provide suitable habitat to support this species. The closest ephemeral drainage line is ~70 metres north west of Bibblewindi 32. Therefore it is considered **unlikely** to occur within the Site or the Study Area.	There is some potential for indirect impacts upon riparian areas as a result of the proposed activity. However, provided the mitigation measures in **Section 6** are adhered to, there will be no indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Ardea ibis	Cattle Egret	-	M	Found in grasslands, woodlands, wetlands, pastures and croplands, especially where drainage is poor.	The Site and the Study Area do not provide suitable habitat to support this species. The closest ephemeral drainage line is ~70 metres north west of Bibblewindi 32. Therefore it is considered **unlikely** to occur within the Site or the Study Area.	There is some, albeit minimal, potential for indirect impacts upon riparian areas as a result of the proposed activity. However, provided the mitigation measures in **Section 6** are adhered to, there will be no indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Gallinago hardwickii	Latham's Snipe	-	M	This species favours soft wet ground or shallow water with tussocks with other green or dead growth, wet parts of paddocks, seepage below dams, irrigated areas, scrub or open woodland from sea level to alpine bogs over 2000m, samphire on salt marshes and mangrove fringes.	The Site and the Study Area do not provide suitable habitat to support this species. The closest ephemeral drainage line is ~70 metres north west of Bibblewindi 32. Therefore it is considered **unlikely** to occur within the Site or the Study Area.	There is some, albeit minimal, potential for indirect impacts upon riparian areas as a result of the proposed activity. However, provided the mitigation measures in **Section 6** are adhered to, there will be no indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required
Haliaeetus leucogaster	White-bellied Sea-Eagle	-	M	Habitat characterised by the presence of large areas of open water (larger rivers, swamps, lakes, the sea). Terrestrial habitats include coastal dunes, tidal flats, grassland, heathland, woodland, forest (including rainforest) and even urban areas.	The Site and the Study Area do not provide suitable habitat to support this species. The closest ephemeral drainage line is ~70 metres north west of Bibblewindi 32. Therefore it is considered **unlikely** to occur within the Site or the Study Area.	There is some, albeit minimal, potential for indirect impacts upon riparian areas as a result of the proposed activity. However, provided the mitigation measures in **Section 6** are adhered to, there will be no indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required
Hirundapus caudacutus	White-throated Needletail	-	M	Almost exclusively aerial and most often above wooded areas, including open forest and rainforest, may also fly between trees or in clearings, below the canopy.	Due to the wide variety of habitats in which this species occurs, it cannot be ruled out from occurring on Site. Therefore it is **possible** that this species occurs within the Study Area.	This species is considered **unlikely** to be impacted upon due to no disturbances to potential breeding habitat resulting from the proposed activity. Therefore an AoS is not required.
Leipoa Ocellata	Malleefowl	E	V, M	Occurs in semi-arid and arid zones of temperate Australia, where it occupies shrublands and low woodlands that are dominated by mallee vegetation. It also occurs in eucalypt or native pine woodlands, acacia scrublands, Broombush vegetation or coastal heathlands (SPRAT, 2010).	This species is unlikely to occur within the Site as a result of the existing disturbance. However, the surrounding Study Area does contain suitable habitat. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.

Species	Common Name	TSC Act Status	EPBC Act Status	Habitat	Likelihood of Occurrence	Likely Level of Impact
Merops ornatus	Rainbow Bee-eater	-	M	Occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation.	This species may utilise the Site for foraging, however suitable roosting or breeding habitat does not occur. Therefore it is **possible** that this species occurs within the Study Area.	Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required.
Myiagra cyanoleuca	Satin Flycatcher	-	M	Found in tall forests, preferring wetter habitats, such as heavily forested gullies, but not rainforests.	The Site and the Study Area do not provide suitable habitat to support this species. The closest ephemeral drainage line is ~70 metres north west of Bibblewindi 32. Therefore, it is considered **unlikely** to occur within the Site or the Study Area.	There is some, albeit minimal, potential for indirect impacts upon riparian areas as a result of the proposed activity. However, provided the mitigation measures in **Section 6** are adhered to, there will be no indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required
Rostratula australis	Australian Painted Snipe	E	V,M	Inhabits shallow terrestrial freshwater wetlands, including temporary and permanent lakes, swamps and claypans.	The Site and the Study Area do not provide suitable habitat to support this species. The closest ephemeral drainage line is ~70 metres north west of Bibblewindi 32. Therefore, it is considered **unlikely** to occur within the Site or the Study Area.	There is some, albeit minimal, potential for indirect impacts upon riparian areas as a result of the proposed activity. However, provided the mitigation measures in **Section 6** are adhered to, there will be no indirect impacts upon this species or its habitats. Therefore an AoS for this species is not required

Key: CE= Critically Endangered, E= Endangered, V= Vulnerable, M= Migratory.

5.2 Potential Terrestrial Impacts

A range of short-term impacts are associated with the proposed activity, including impacts arising from construction and operational activities. The primary potential impacts are indirect, as the proposed activity will be carried out within the existing disturbance areas. The following sections outline the potential impacts identified, taking into consideration KTPs under the TSC and EPBC Acts.

5.2.1 Groundwater Dependent Ecosystems (GDEs)

The nearest Groundwater Dependent Ecosystems (GDEs) to the Site are:

- Eather Spring, (MGA 94, Zone 55, 771541 E and 6602247 N) approximately 19.0 kilometres east of the Bibblewindi Multi-Lateral Pilot
- Hardys Spring, approximately 18.8 kilometres east of from the Bibblewindi Multi-Lateral Pilot or approximately 1.8 km to the north of Eather Spring.

These springs are understood to comprise recharge rejection springs associated with the junction of the unconfined Pilliga Sandstone and the underlying Purlewaugh Formation. The Purlewaugh Formation acts as a barrier to further percolation of groundwater within the Pilliga Sandstone and thus groundwater discharges to surface at this interface (Appendix 6 of the EIS). As the modelling of cumulative impacts has demonstrated that there is no impact to the Upper and Lower Namoi alluvium or the Pilliga Sandstone due to the operation of the pilots, there is also no expected impact to the GDEs.

Stygofauna communities (fauna which occur in groundwater) may exist within subsurface waters and thus can also be classed as a GDE (Serov *et al.*, 2012). Slight changes in groundwater attributes (quality or quantity) may result in changes to the population assemblage. Recent investigation by Eco Logical has not identified significant stygofauna populations within groundwater sampled from monitoring wells located in similar groundwater sources. However, it is considered feasible that stygofauna populations may exist and as such, additional sampling will be undertaken to investigate presence or absence of stygofauna populations within PAL 2 and PEL 238 during operation of pilots for the program.

5.2.2 TSC Act – 7-part test considerations

Section 5A of the EP&A Act lists seven factors that must be taken into account when determining the significance of potential impacts of the proposed activity on 'threatened species, populations or ecological communities or their habitats' (threatened biota) listed under the TSC Act. The so-called '7-part test' is used to determine whether there is likely to be a significant effect on threatened species, populations or ecological communities, or their habitats.

The significance of the impacts on those threatened species, threatened populations and TECs which occur, or have the potential to occur within the locality have been assessed for their likelihood to occur within the Study Area (**Table 8**). The following sections outline the potential for impacts upon any of these threatened entities.

5.2.3 Impacts on threatened species

There is potential for indirect impacts during the construction and operational phases of the proposed activity such as; potential fauna strike associated with increased vehicle movements, increased nutrient and sediment loads as a result of sedimentation and erosion. However, provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon any TSC Act listed threatened species or their habitats as a result of the proposed activity during both construction and operation.

5.2.4 Loss of Native Vegetation

The proposed activity has been designed to avoid any works being undertaken within the remnant of Ironbark Shrubby Woodland. No vegetation clearing will occur as a result of the proposed activity.

5.2.5 Key Threatening Processes

Key Threatening Processes (KTPs) are those processes that are detrimental to the ecology of the local area that may be enacted or activated by the proposed works. These processes are listed within the NSW TSC Act. The proposed wells may include some of the following KTPs:

- **Clearing of native vegetation**

  The proposed wells will not require further clearing of native vegetation. Therefore this KTP will not be enacted or exacerbated by the proposal.

- **Competition and grazing by the feral European rabbit (*Oryctolagus cuniculus*)**

  The proposed wells are unlikely to promote the breeding or introduction of feral rabbits to the area. However, if feral rabbits are observed in the area, it is considered that this project may provide an opportunity to control them in the vicinity.

- **Competition and habitat degradation by feral goats (*Capra hircus*)**

  Feral goats have been observed in the locality. It is considered that the proposal will not enact or exacerbate this KTP.

- **High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition**

  The proposal may increase the likelihood of a fire event. However it is expected that prevention and management measures will be put into place to minimise the likelihood of a fire occurring and also to manage and extinguish a fire if one should occur.

- **Infection of native plants by *Phytophthora cinnamomi***

  It is expected that protocols will be put into place to ensure that Phytopthera is not introduced to the surrounding vegetation. This will be achieved through washdown and removal of vegetative materials from vehicles, machinery and plant equipment as described in Section 6.

- **Introduction and Establishment of Exotic Rust Fungi of the order *Pucciniales* pathogenic on plants of the family *Myrtaceae***

  It is expected that protocols will be put into place to ensure that Exotic Rust Fungi is not introduced to the surrounding vegetation. This will be achieved through washdown and removal of vegetative materials from vehicles, machinery and plant equipment as described in Section 6.

- **Invasion of native plant communities by exotic perennial grasses**

  The proposed wells and ongoing maintenance may pose a risk of importing exotic grasses to the Site. It is expected that a weed control program will be enacted to ameliorate existing weed invasion and to prevent any further potential weed invasion as described in Section 6.

- **Loss of hollow-bearing trees**

  The proposal is unlikely to require the removal of hollow bearing trees. Therefore it is considered that this KTP will not be enacted or exacerbated.

- **Predation by the European red fox (*Vulpes vulpes*)**

  Foxes are known to occur within the surrounding area. The proposal may provide an opportunity to provide information to the landholder in order to undertake a fox control program. The proposal is not

likely to exacerbate this KTP.

- **Predation by the feral cat (*Felis catus*)**

  Feral cats are known to occur within the surrounding area. The proposal may provide an opportunity to provide information to the landholder in order to undertake a cat control program. The proposal is not likely to exacerbate this KTP.

- **Predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*)**

  Feral pigs are known to occur within the surrounding area. The proposal may provide an opportunity to provide information to the landholder in order to undertake a feral pig control program. The proposal is not likely to exacerbate this KTP.

- **Removal of dead wood and dead trees**

  The proposal will not require the removal of native vegetation containing dead wood or dead trees. The proposal is not likely to exacerbate this KTP.

5.2.6 Impacts on Bibblewindi State Forest

The proposed activity has been designed to avoid any works being undertaken within the surrounding Bibblewindi State Forest. Provided the mitigation measures in **Section 6** are adhered to, there will be no direct or indirect impacts upon the Bibblewindi State Forest. Furthermore, the rehabilitation of the Site following operation will ensure that endemic native species are utilised in order to return the land back to being a productive part of the Bibblewindi State Forest.

5.2.7 Loss of Fauna Habitat

The proposed activity has been designed to avoid any works being undertaken within the remnant of Ironbark Shrubby Woodland, which offers potential habitat to a diversity of locally-occurring fauna species. No fauna habitat features located within Ironbark Shrubby Woodland, such as hollow-bearing trees, will require removal as part of the proposed activity. No 'potential' koala habitat, as defined by SEPP 44, will be removed as part of the proposed activity – nor does any occur within close proximity to the Study Area.

5.2.8 Habitat fragmentation

Habitat fragmentation occurs when a naturally occurring large and continuous area of habitat is reduced to smaller scattered remnants of habitat. Given the proposal will be carried out on an area previously cleared and will not involve any further clearing, the existing remnant of native vegetation surrounding the Site will not be fragmented by the proposed activity.

5.2.9 Introduction and spread of weeds

The proposed activity has the potential to create favourable conditions for additional introduced weed species within the Study Area, potentially leading to an increase of weed populations. This is most likely to occur in areas of soil disturbance. However, provided the mitigation measures in **Section 6** are adhered to, it is highly unlikely that there will be any introduction and/or spread of weeds as a result of the proposed activity.

5.2.10 Disruption of Breeding Cycle, Roosting and Sheltering Behaviour

Given the poor habitat values within the Site, it is considered unlikely that the proposed activity will impact upon the breeding cycle, roosting, sheltering and foraging behaviour of fauna species. However noise may have some, albeit minimal, potential for impacts (see below).

5.2.11 Noise

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. However, the paucity of intact overstorey vegetation lessens the potential impact, as few sensitive species are likely to occur within the Site or the surrounding Study Area. Large tracts of similar vegetation surround the proposed Sites, it is therefore expected that some fauna species may be displaced by noise for a short time period.

5.2.12 Dust

The proposed activity may result in short-term increased dust pollution, which has the potential to affect surrounding habitats. It is expected that amelioration measures such as damping down the soil within the roads and well Sites will be undertaken as well as mitigation measures described in Section 6.

5.2.13 Light

The proposed activity may result in short-term increased light pollution, which has the potential to affect surrounding habitats. It is expected that amelioration measures such as restricting lighting to within the impact areas where possible and switching lights off when not required will ameliorate the effects of light pollution in the locality.

5.2.14 Fauna / Vehicle Road Interactions

The proposed activity may result in fauna and vehicle interactions resulting in injury or death to the fauna and potential damage to vehicles. As described in Section 6, all construction and operational vehicles/machinery will use the designated access tracks. Speeds will be limited to 20 kilometres per hour to reduce the potential of fauna strike.

5.2.15 Cumulative Impacts

As no vegetation clearing or disturbance is to be undertaken as part of the proposed activity, ecologically-related cumulative impacts are considered unlikely. A study on the cumulative effects of the exploration and appraisal program on biodiversity within PEL 238 and PAL 2 has been undertaken and is detailed in EcoLogical (2013).

5.3 Aquatic Impact Assessment

5.3.1.1 Direct Impacts

Given that the proposed activity does not require any new creek diversions, crossings, access tracks or upgrades, there will be no direct impact on identified watercourses. In addition, it should be noted that riparian vegetation along identified watercourses will be retained, thus minimising riparian vegetation (and habitat) clearing.

Fisheries NSW Policy advocates a 50 metre riparian buffer zone of surrounding watercourses. Such a buffer zone could be implemented as the closest point to any drainage line is approximately 70 metres

(refer to **Section 4.2.3**). Accordingly, the distance of the proposed activity and infrastructure placement from surrounding waterways has been designed to minimise such impacts.

5.3.1.2 Indirect Impacts

There is the potential for indirect impacts to aquatic habitat values and aquatic habitat integrity. These largely relate to impacts to water quality resulting from contaminated and / or sediment laden runoff during construction. However, these potential impacts would be managed via the implementation of an erosion and sediment control plan in accordance with best management practices (such as the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008)). Further, sediment mobilisation is not anticipated to be significant due to the quick settlement nature of identified sediments (coarse structure).

During operation, produced water from the Bibblewindi Multi-Lateral Pilot will collect at Bibblewindi 19h and then flow through the existing flow lines. The existing flowline will transfer water to the Bibblewindi Water Transfer Tank for storage. The Leewood Water Pipeline will then transport the water to the Leewood Produced Water Facility for treatment. There are no proposed discharges to any watercourses and therefore impact to water quality, flows or increases in bank and channel erosion are not anticipated for any watercourses in the immediate vicinity, surrounding area or further downstream. The potential exists for the leakage of produced water to occur during operation and enter waterways, however the risk of this occurring will be minimised through continual monitoring of infrastructure, as outlined in the EIS.

5.4 Potential Impacts on Matters of National Environmental Significance (MNES)

An EPBC Act Protected Matters Search was undertaken using the online database to generate a list of those MNES potentially occurring within the Study Area and surrounds (DSEWPaC 2013). This data, combined with other local knowledge and records, was utilised to assess whether the proposed activity will have, or is likely to have, a significant impact on MNES.

5.4.1 World Heritage Properties

The proposed activity is not in a World Heritage Properties, and is not in close proximity to any such area.

5.4.2 National Heritage Places

The proposed activity is not in a World Heritage Places, and is not in close proximity to any such area.

5.4.3 Wetlands of International Importance

No wetlands of International Importance are located in the vicinity of the Study Area.

5.4.4 Great Barrier Reef Marine Parks

The Study Area is not part of any Great Barrier Reef Marine Park, and is not in close proximity to any such park.

5.4.5 Commonwealth Marine areas

The proposed activity will not have a significantly adverse effect on any Commonwealth Marine area, as there are no such marine areas within the region.

5.4.6 Listed Threatened Ecological Communities

No threatened Ecological Communities are present within the Study Area. Therefore no impacts to EPBC listed Ecological Communities are likely to occur as a result of the proposed activity.

5.4.7 Listed Threatened Species

Threatened species listed under the EPBC Act, which occur, or have the potential to occur within the locality, have been assessed for their potential to occur within the Study Area and likely level of impact (**Table 8**). No EPBC listed threatened species are considered likely to be directly or indirectly impacted upon as a result of the proposed activity, provided that the mitigation measures in **Section 6** are adhered to.

5.4.8 Listed Migratory Species

Migratory species listed under the EPBC Act, which occur, or have the potential to occur within the locality, have been assessed for their potential to occur within the Study Area (**Table 8**) and likely level of impact. The Study Area is surrounded by superior areas of habitat which would be suitable for migratory species. No EPBC Act listed migratory species are considered likely to be directly or indirectly impacted upon as a result of the proposed activity, provided that the mitigation measures in **Section 6** are adhered to.

6.0 Impact Mitigation and Management

6.1 Introduction

In order to minimise potential ecological impacts resulting from the proposed activity, identification of appropriate mitigation measures has been undertaken in accordance with the 'avoid – minimise – mitigate – offset' hierarchy:

- Avoiding the impact altogether by relocating the proposed activity, or parts of an activity;
- Minimising impacts by restricting the magnitude of the proposed activity and its implementation;
- Mitigating the impact of the activity by appropriately managing the proposed activity, and rehabilitating, or restoring the effected environment; and
- Offsetting any residual impacts.

6.1.1 Avoid Impacts

The proposed activity is located within existing lease areas and access tracks which are cleared of vegetation as part of previously approved works. This avoids the need to disturb areas of higher ecological significance occurring within the surrounding Bibblewindi State Forest.

6.1.2 Minimise Impacts

The lease areas will be appropriately demarcated to ensure activity and machinery stays within the existing disturbed areas. Access tracks have been located along previously disturbed and managed tracks to minimise disturbances to native vegetation and faunal habitats.

6.1.3 Mitigate Impacts

The following mitigation measures will be implemented throughout the construction and operation phases of the proposed activity:

- The lease area will be appropriately demarcated to ensure machinery is limited to the designated disturbance area. Machinery will not be stored in areas of adjacent habitat. Demarcation will also ensure that all adjacent canopy trees are appropriately protected throughout construction works;
- All contractors will be specifically advised of the designated work area. The following activities are not to occur outside of designated work areas to minimise impacts on native vegetation:
  - Vehicle movements;
  - Storage and mixing of materials;
  - Vehicle parking;
  - Liquid disposal;
  - Machinery repairs and/or refueling;
  - Construction within the Site office or shed;
  - Combustion of any material;
  - Stockpiling of soil, rubble or debris; and/or
  - Any filling or excavation including trenching, topsoil skimming and/or surface excavation.

- All construction and operational vehicles/machinery will use the designated access tracks. Speeds will be limited to 20 kilometres per hour to reduce the potential of fauna strike and to reduce dust generation;
- Plant and machinery will be cleaned of any foreign soil and propagative material prior to being transported to the Site to prevent the spread of weeds and importation of *Phytophthora*;
- If machinery is transported from an area of confirmed infection of *Phytophthora* to the Site, stringent wash down will be completed before leaving the area, removing all soil and vegetative material from cabins, trays, and under carriages;
- To minimise potential impacts on adjacent Bibblewindi State Forest, all liquids (fuel, oil, cleaning agents, drilling liquids etc.) will be stored appropriately and disposed of at suitably licensed facilities. Spill management procedures will be implemented as required. Rubbish will be collected and removed from the Site.
- Appropriate erosion and sediment control measures will be managed via the implementation of anerosion and sediment control plan in accordance with best management practices (such as the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008)). This sediment and erosion control plan is outlined further in the EIS and accompanying Agricultural Impact Statement (AIS).
- No domestic pets (including dogs or cats) will be allowed within the Site;
- In the event that the work area needs to extend outside the area investigated, further inspection will be undertaken by a qualified ecologist;
- Appropriate measures will be employed to prevent surface damage to public roads (e.g. limiting dirt track access during wet weather and protecting bitumen surfaces where tracked machinery is required to cross roads);
- Construction personnel will be trained adequately in pest management and hygiene procedures;
- Weed management procedures will be implemented to prevent the spread of weeds both on and off Site;
- Weed monitoring will to occur throughout the construction and operation phase and weed removal will be carried out as necessary. Appropriate weed removal techniques are outlined in **Table 9**.

Table 10 Weed Removal Techniques

Weed Type	Removal Technique	Method
Woody Weeds	Cut and Paint	▪ Make a horizontal cut through the stem close to the ground using secateurs, loppers or a bush saw; and ▪ Immediately apply herbicide to the exposed flat stump surface.
	Stem Injection	▪ At the base of the tree drill holes at a 45 degree angle into the sapwood; ▪ Fill each hole with herbicide immediately; and ▪ Repeat the process at 5 cm intervals around the tree.
	Frilling or Chipping	▪ At the base of the tree make a cut into the sapwood with a chisel or axe; ▪ Fill each cut with herbicide immediately; and ▪ Repeat the process at 5 cm intervals around the tree.
Small Plants	Hand removal	▪ Remove any seeds or fruits and carefully place into a bag; ▪ Grasp stem at ground level, rock plant backwards and forwards to loosen roots and pull out; and ▪ Tap the roots to dislodge any soil, replace disturbed soil and pat down.
Vines and Scramblers	Hand removal	▪ Take hold of one runner and pull towards yourself; ▪ Check points of resistance where fibrous roots grow from the nodes; ▪ Cut roots with a knife or dig out with a trowel and continue to follow the runner; ▪ The major root systems need to be removed manually or scrape/cut and painted with herbicide; and ▪ Any reproductive parts need to be bagged.
	Stem Scraping	▪ Scrape 15 to 30 cm of the stem with a knife to reach the layer below the bark/outer layer; and ▪ Immediately apply herbicide along the length of the scrape.
Weeds with Underground Reproductive Structures	Hand removal	▪ Remove and bag seeds or fruits; ▪ Push a narrow trowel or knife into the ground beside the tap root, carefully loosen the soil and repeat this step around the taproot; ▪ Grasp the stem at ground level, rock plant backwards and forwards and gently pull removing the plant; and ▪ Tap the roots to dislodge soil, replace disturbed soil and pat down.
	Crowning	▪ Remove and bag stems with seed or fruit; ▪ Grasp the leaves or stems together so the base of the plant is visible; ▪ Insert the knife or lever at an angle close to the crown; ▪ Cut through all the roots around the crown; and ▪ Remove and bag the crown.
	Stem Swiping	▪ Remove any seed or fruit and bag; and ▪ Using an herbicide applicator, swipe the stems/leaves.

6.1.4 Offset Impacts

The Site is consistent with the following Biodiversity Banking and Offsets Scheme (Biobanking) definition of cleared land '*cleared land is land on which the native over-storey has been cleared, there is no mid-storey, and less than 50% of the ground cover vegetation is indigenous species, or greater than 90% of the ground cover is clearedô*(DECC, 2009).

Therefore offsets will not be required, as the Site consists of existing cleared areas.

7.0 Conclusion

RPS has been engaged by Santos to undertake an Ecological Assessment of the proposed Bibblewindi Gas Exploration Pilot Expansion (the proposed activity). The proposed activity will involve:

- Construction of two pilot wells (Bibblewindi 31 & 32) which will be situated within two existing pilot well lease areas
- Operation of the Bibblewindi 31 and 32 pilot wells and the existing 12 wells as the Bibblewindi Multi-Lateral Pilot.

The lease areas are located within the Bibblewindi State Forest within PAL 2, approximately 40 kilometres south south-west of Narrabri NSW.

The lease areas contain existing cleared and levelled disturbance areas of approximately one hectare per Site (0.91 and 0.83 hectares for Bibblewindi 31and 32, respectively). Access to the lease areas will be via existing unnamed tracks which adjoin Little Tighes Road.

This Ecological Assessment will inform the EIS prepared in accordance with the NSW EP&A Act in relation to the proposed activity.

Flora

Native vegetation is absent from much of the Site, due to the existing lease areas and access tracks. A minimal amount of native and exotic grasses have recolonised small patches of the lease areas. No additional clearing of vegetation is required as part of the proposed activity.

Ground truthing of the vegetation surrounding the lease areas (the Study Area) delineated one native vegetation community, which is not commensurate with any Threatened Ecological Community (TEC) listed under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and/or the *Threatened Species Conservation Act* 1995 (TSC Act). The vegetation community present within the Study Area was mapped in accordance with Namoi CMA Vegetation Mapping and its floristic composition is commensurate with 'Ironbark Shrubby Woodlands of the Pilliga area, Brigalow Belt South'.

No threatened flora listed under the TSC Act and/or EPBC Act were recorded within the survey area. No threatened flora assessed as having potential to occur within the Study Area is considered likely to be directly or indirectly impacted upon as a result of the proposed activity, provided that the mitigation measures in **Section 6** are adhered to.

Fauna

The existing lease areas are characterised by cleared areas, from which native vegetation has been cleared for previous exploration. These cleared areas offer potential basking habitat for reptiles and, consequently, foraging habitat for some birds, however, they are generally of limited value to fauna species, due to the lack of habitat resources.

The vegetation in the surrounding Study Area is in a relatively disturbed state and is consequently considered to be of low quality. Due to the history of selective logging, the stand of canopy trees is immature and lacks suitable hollows for most hollow dwelling fauna species that occur in the area. The understorey lacks shrub diversity, however it does provide foraging habitat for a range of bird and mammal species. Other habitat attributes such as flowering eucalypts, leaf litter, fallen timber, small exposed rocks and exposed soil/sand were also present.

There are no permanent drainage lines, dams or other hydrological features that would offer aquatic habitat within the Sites, however, there is an ephemeral drainage line approximately 70 metres north west of the Proposed Bibblewindi 32 (existing 19H) lease area.

No threatened fauna or migratory species listed under the TSC Act and/or EPBC Act were recorded within the survey area. No threatened or migratory fauna assessed as having potential to occur within the Study Area is considered likely to be directly or indirectly impacted upon as a result of the proposed activity, provided that the mitigation measures in **Section 6** are adhered to.

Conclusion

Those aquatic species, threatened flora, threatened populations, threatened ecological communities, threatened and migratory fauna species listed under the TSC Act and the EPBC Act (threatened and migratory entities) that have been recorded, or have the potential, to occur within the locality have been considered in this Ecological Assessment.

Provided the mitigation measures in **Section 6** are adhered to no aquatic species, EPBC Act and/or TSC Act listed threatened or migratory entities are considered likely to be either directly or indirectly impacted upon as a result of the proposed activity.

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Appendix 1

EPBC Protected Matters Report

Australian Government

Department of Sustainability, Environment, Water, Population and Communities

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 18/06/13 14:14:51

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

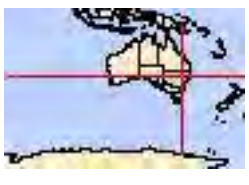
Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 10.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	4
Listed Threatened Species:	21
Listed Migratory Species:	11

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	10
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	None
State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	21
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered	Community may occur within area
Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia	Endangered	Community may occur within area
Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland	Critically Endangered	Community may occur within area
Weeping Myall Woodlands	Endangered	Community may occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Endangered	Species or species habitat likely to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat may occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat may occur within area
Lathamus discolor Swift Parrot [744]	Endangered	Species or species habitat may occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Polytelis swainsonii		
Superb Parrot [738]	Vulnerable	Species or species habitat may occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Fish		
Maccullochella peelii		
Murray Cod [66633]	Vulnerable	Species or species habitat may occur within area
Mammals		
Chalinolobus dwyeri		
Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
Nyctophilus corbeni		
South-eastern Long-eared Bat [83395]	Vulnerable	Species or species habitat may occur within area
Petrogale penicillata		
Brush-tailed Rock-wallaby [225]	Vulnerable	Species or species habitat may occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Pseudomys pilligaensis		
Pilliga Mouse, Poolkoo [99]	Vulnerable	Species or species habitat known to occur within area
Plants		
Bertya opponens		
[13792]	Vulnerable	Species or species habitat likely to occur within area
Philotheca ericifolia		
[64942]	Vulnerable	Species or species habitat likely to occur within area
Pterostylis cobarensis		
Cobar Greenhood Orchid [12993]	Vulnerable	Species or species habitat likely to occur within area
Pultenaea setulosa		
[2705]	Vulnerable	Species or species habitat likely to occur within area
Rulingia procumbens		
[12903]	Vulnerable	Species or species habitat likely to occur within area
Tylophora linearis		
[55231]	Endangered	Species or species habitat may occur within area
Reptiles		
Aprasia parapulchella		
Pink-tailed Worm-lizard, Pink-tailed Legless Lizard [1665]	Vulnerable	Species or species habitat may occur within area
Uvidicolus sphyrurus		
Border Thick-tailed Gecko, Granite Belt Thick-tailed Gecko [84578]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat likely to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat may occur within area
Xanthomyza phrygia Regent Honeyeater [430]	Endangered*	Species or species habitat likely to occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat likely to occur within area
Lathamus discolor Swift Parrot [744]	Endangered	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
Pilliga East	NSW

Invasive Species	[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Bufo marinus Cane Toad [1772]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Rhinella marina Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area

Coordinates

-30.66088 149.6472,-30.67009 149.65593

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix 2

Flora Species List

Family Name	Scientific Name	Common Name
Fabaceae/faboideae/Mimosoideae	*Acacia deanei*	Dean's Wattle
Fabaceae/faboideae/Mimosoideae	*Acacia spectabilis*	Mudgee Wattle
Casuarinaceae	*Allocasuarina luehmannii*	Bulloak
Poaceae	*Aristida ramosa*	Purple Wiregrass
Myrtaceae	*Callistemon linearis*	Narrow-leaved Bottlebrush
Cupressaceae	*Callitris glaucophylla*	White Cypress Pine
Asteraceae	*Cassinia arcuata*	Sifton Bush
Sinopteridaceae	*Cheilanthes sieberi* subsp. *sieberi*	Poison Rock Fern
Phormiaceae	*Dianella revoluta* var. *revoluta*	Spreading Flax Lily
Sapindaceae	*Dodonaea viscosa* subsp. *cuneata*	Wedge-leaf Hop-bush
Poaceae	*Eragrostis brownii*	Brown's Lovegrass
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark
Santalaceae	*Exocarpos cupressiformis*	Native Cherry
Cyperaceae	*Gahnia aspera*	Rough Saw-sedge
Goodeniaceae	*Goodenia hederacea*	Ivy Goodenia
Goodeniaceae	*Goodenia rotundifolia*	-
Cyperaceae	*Lepidosperma laterale*	Variable Saw-sedge
Myrtaceae	*Leptospermum polygalifolium* subsp. *polygalifolium*	Tantoon
Epacridaceae	*Lissanthe strigosa*	Peach Heath
Lomandraceae	*Lomandra filiformis subsp. filiformis*	Wattle Mat-rush
Myrtaceae	*Melaleuca erubescens*	-
Epacridaceae	*Melichrus urceolatus*	Urn Heath
Poaceae	*Panicum effusum*	Hairy Panic
Poaceae	*Sporobolus creber*	Slender Rat's Tail Grass
Asteraceae	*Vittadinia cuneata* var. *cuneata*	Fuzzweed

Appendix 3

Fauna Species List

Family Name	Scientific Name	Common Name
Acanthizidae	*Acanthiza reguloides*	Buff-rumped Thornbill
Acanthizidae	*Smicrornis brevirostris*	Weebill
Artamidae	*Cracticus torquatus*	Grey Butcherbird
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike
Climacteridae	*Cormobates leucophaea*	White-throated Treecreeper
Corcoracidae	*Corcorax melanorhamphos*	White-winged Chough
Corvidae	*Corvus coronoides*	Australian Raven
Meliphagidae	*Philemon corniculatus*	Noisy Friarbird
Monarchidae	*Grallina cyanoleuca*	Magpie-lark

Appendix 5

Air Quality Impact Assessment

ACOUSTICS AND AIR

BIBBLEWINDI MULTI-LATERAL PILOT EXPANSION

AIR QUALITY IMPACT ASSESSMENT

REPORT NO. 13199
VERSION E

JULY 2013

PREPARED FOR

RPS AUSTRALIA ASIA PACIFIC
LEVEL 9, 17 YORK STREET
SYDNEY NSW 2000
AUSTRALIA

WILKINSON MURRAY

DOCUMENT CONTROL

Version	Status	Date	Prepared By	Reviewed By
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C	Final	6 August 2013	John Wassermann	John Wassermann
D	Final	7 August 2013	John Wassermann	John Wassermann
E	Final	13 August 2013	John Wassermann	John Wassermann

Note

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We are committed to and have implemented AS/NZS ISO 9001:2008 "Quality Management Systems – Requirements". This management system has been externally certified and Licence No. QEC 13457 has been issued.

Celebrating 50 Years in 2012

Wilkinson Murray is an independent firm established in 1962, originally as Carr & Wilkinson. In 1976 Barry Murray joined founding partner Roger Wilkinson and the firm adopted the name which remains today. From a successful operation in Australia, Wilkinson Murray expanded its reach into Asia by opening a Hong Kong office early in 2006. 2010 saw the introduction of our Queensland office and 2011 the introduction of our Orange office to service a growing client base in these regions. From these offices, Wilkinson Murray services the entire Asia-Pacific region.

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GLOSSARY OF TERMS

Air Pollutant – Any substance in air that could, in high enough concentration, harm man, other animals, vegetation, or material. Pollutants may include almost any natural or artificial composition of airborne matter capable of being airborne.

Air Pollution – The presence of contaminants or pollutant substances in the air that interfere with human health or welfare, or produce other harmful environmental effects.

Carbon Monoxide (CO) – A colourless, odourless, poisonous gas, produced by incomplete burning of carbon-based fuels, including gasoline, oil and wood. Carbon monoxide is also produced from incomplete combustion of many natural and synthetic products. For instance, cigarette smoke contains carbon monoxide. When carbon monoxide gets into the body, the carbon monoxide combines with chemicals in the blood and prevents the blood from bringing oxygen to cells, tissues and organs. The body's parts need oxygen for energy, so high-level exposures to carbon monoxide can cause serious health effects, with death possible from massive exposures.

Concentration – The relative amount of a substance mixed with another substance. Examples are 5 ppm of carbon monoxide in air and 1 mg/l of iron in water.

Emission – Release of pollutants into the air from a source. We say sources emit pollutants.

Emission Factor – The relationship between the amount of pollution produced and the amount of raw material processed. For example, an emission factor for a blast furnace making iron would be the number of pounds of particulates per ton of raw materials.

Emission Inventory – A listing, by source, of the amount of air pollutants discharged into the atmosphere of a community; used to establish emission standards.

Flow Rate – The rate, expressed in gallons -or litres-per-hour, at which a fluid escapes from a hole or fissure in a tank. Such measurements are also made of liquid waste, effluent, and surface water movement.

Fugitive Emissions – Emissions not caught by a capture system.

Nitric Oxide (NO) – A gas formed by combustion under high temperature and high pressure in an internal combustion engine. NO is converted by sunlight and photochemical processes in ambient air to nitrogen oxide. NO is a precursor of ground-level ozone pollution, or smog.

Nitrogen Dioxide (NO_2) – The result of nitric oxide combining with oxygen in the atmosphere; major component of photochemical smog.

Nitrogen Oxides (NO_x) – A criteria air pollutant. Nitrogen oxides are produced from burning fuels, including gasoline and coal. Nitrogen oxides are smog formers, which react with volatile organic compounds to form smog. Nitrogen oxides are also major components of acid rain.

Particulates; Particulate Matter (PM10) – PM10 is a measure of particles in the atmosphere with a diameter of less than 10 or equal to a nominal 10 micrometers. A criteria air pollutant. Particulate matter includes dust, soot and other tiny bits of solid materials that are released into and move around in the air. Particulates are produced by many sources, including burning of diesel fuels by trucks and buses, incineration of garbage, mixing and application of fertilizers and pesticides, road construction, industrial processes such as steel making, mining operations, agricultural burning (field and slash burning), and operation of fireplaces and woodstoves. Particulate pollution can cause eye, nose and throat irritation and other health problems.

Parts Per Billion (ppb)/Parts Per Million (ppm) – Units commonly used to express contamination ratios, as in establishing the maximum permissible amount of a contaminant in water, land, or air.

Point Source – A stationary location or fixed facility from which pollutants are discharged; any single identifiable source of pollution; e.g. a pipe, ditch, ship, ore pit, factory smokestack.

Source – Any place or object from which pollutants are released.

Stack – A chimney, smokestack, or vertical pipe that discharges used air.

1 INTRODUCTION

Santos NSW (Eastern) Pty Ltd (a wholly owned subsidiary of Santos Limited) (Santos) is seeking consent to drill and operate two petroleum exploration (pilot) wells, known as Bibblewindi 31 and 32, within the Bibblewindi State Forest, approximately 40 kilometres south of Narrabri, NSW in Petroleum Assessment Lease (PAL) 2 (the proposed activity).

The two pilot wells are proposed to be located on existing well leases within an existing multi-lateral pilot well set (known as the Bibblewindi Multi-Lateral Pilot) which were developed by Eastern Star Gas Pty Ltd (ESG) as part of the Narrabri Gas Development Project in 2009. Santos is also seeking consent for the operation of the existing Bibblewindi Multi-Lateral Pilot and the management of the water and gas produced during operation of the 14 wells for up to 3 years.

Wilkinson Murray Pty Limited (WM) has been commissioned by RPS Australia to conduct an air quality assessment of the proposed activity.

Director General requirements have been issued for the proposed activity and required the following with regards to air quality:

"Air Quality *- including a quantitative assessment of potential:*

- *construction and operational impacts, with a particular focus on dust emissions including PM 10 emissions and the dust generation from transport;*
- *risk associated with potential discharges of fugitive and point source emissions for all stages of the proposal, including risk of environmental harm and risk to human health and amenity;*
- *cumulative impacts associated with existing emission sources as well as any currently approved developments or proposed future developments;*
- *flaring and/or venting; and*
- *monitoring and management measures, including real-time air quality monitoring;"*

2 PROJECT BACKGROUND

The proposed activity involves the drilling and operation two petroleum exploration (pilot) wells known as Bibblewindi 31 and 32 within and in conjunction with the existing multi-lateral pilot well set know as the Bibblewindi Multi-Lateral Pilot, developed as part of the exploration and appraisal program.

Gas from Bibblewindi 31 and 32 and the existing Bibblewindi Multi-Lateral Pilot will be transferred via the existing flow line to the compressor station and flare located at the Bibblewindi Water Transfer Facility. Gas would then join into the gas flowline and transfer to Wilga Park Power Station. Where gas volumes exceed demand at the Wilga Park Power Station, gas will be flared at the Bibblewindi Water Transfer Facility. It is expected that flaring would occur sporadically for short periods of time. This process would have positive environmental benefits when compared to venting the methane directly to the atmosphere.

Flaring of methane gas has potential to generate air pollutants which can result in adverse affects on nearby sensitive receptors. This report focuses on the emissions and potential impacts associated with the construction and operation of the pilot wells and the flaring.

Potential air emissions associated with works from the proposed activity would include dust generated during establishment of the well lease, emissions from vehicle movements to and from the site and emissions associated with the operation of the flare and wells on the site.

It should be noted that there may be flaring of gas during drilling which will be highly unlikely. There will be a flare and vent tank on site for emergency use only. Given the improbable nature of this occurrence this has not been assessed.

Additionally there may be fugitive emissions of gas. Fugitive emissions are likely to be very small, however to safe guard against fugitive emissions there will be sensors at transitional points across the well head and pipe network that will trigger automatic shut down of wells until the leaks are found and repaired.

Air emissions generated by the proposed development would include particulate matter, carbon monoxide, oxides of nitrogen and minor contributions of other pollutants. These pollutants generally dissipate with distance from the source and are therefore unlikely to affect nearest sensitive receptors given the separation distances to these receptors.

3 LOCAL SETTING

The proposed activity is located approximately 40km south-southwest of Narrabri and 37km west of Boggabri in the Bibblewindi State Forest of NSW (see **Figure 3-1**). The surrounding land use consists of predominately forested land with some existing infrastructure comprising of the Bibblewindi Multi-Lateral Pilot. In the wider vicinity, the land use is generally composed of rural activities.

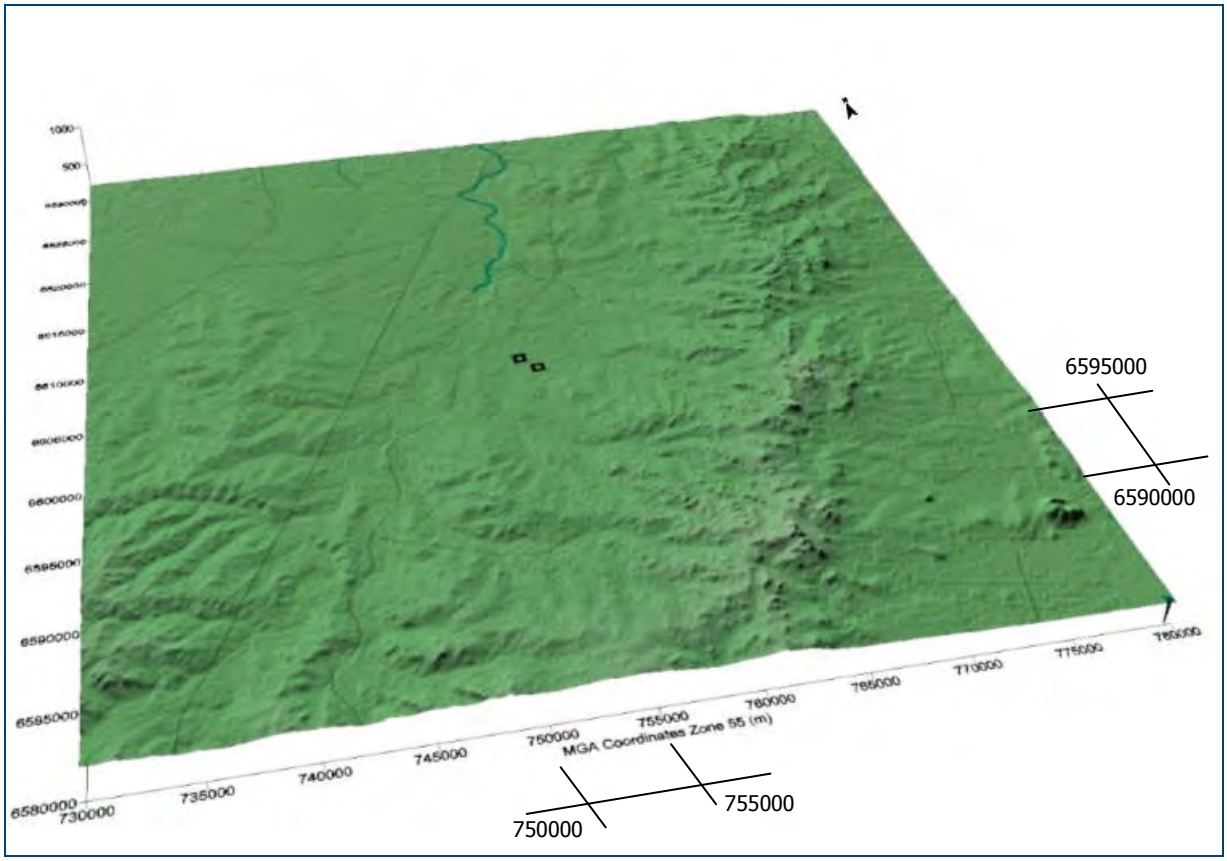
A number of residential properties have been identified located in the vicinity of the proposed pilot wells and flare location (see **Figure 3-1**). These properties have been selected to represent sensitive receptors for this assessment and are most likely to be affected by the potential impacts from the proposed activity.

Figure 3-1 Project Location



Figure 3-2 presents a three-dimensional representation of the topography in the vicinity of the proposed activity. The terrain is gently undulating to the east and south of the proposed activity, and becomes generally flatter to the northwest.

Figure 3-2 Topography surrounding Project Location (MGA Coordinates, Zone 55 m)



4 AIR QUALITY ASSESSMENT CRITERIA

Air quality criteria are benchmarks set to protect the general health and amenity of the community in relation to air quality. This section identifies the relevant air quality criteria that are applicable to the proposed activity. The air quality goals that are relevant to this study are sourced from the NSW EPA document "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (**NSW DEC, 2005**).

Emissions of carbon monoxide (CO) and nitrogen dioxide (NO_2) can be expected from the combustion and flaring of the coal seam gas.

CO enters the bloodstream and reduces oxygen delivery to the body's organs and tissues, and can impair health due to prolonged exposure at high levels. CO is an odourless gas formed from the partial oxidation of carbon-containing compounds, commonly as a result of incomplete or inefficient combustion of fuels containing carbon. CO in the atmosphere is relatively unstable and reacts with oxygen to form carbon dioxide and ozone.

NO_2 can irritate the lungs and lower resistance to respiratory infections such as influenza. NO_2 belongs to a family of reactive gases called nitrogen oxides (NOx). These gases form when fuel is burned at high temperatures, mainly from motor vehicles, power stations and industrial boilers.

The air quality goals for the relevant criteria pollutants relate to the total pollutant burden in the air and not just the pollutants from the proposed activity, as such, consideration of background pollutant levels is required when using these goals to assess potential impacts. **Table 4-1** shows the impact criteria applied in this assessment.

Table 4-1 NSW EPA Air Quality Impact Assessment Criteria

Pollutant	Averaging Period	Impact	Criterion
Total suspended particulates (TSP)	Annual	Total	90µg/m³
Particulate matter ≤10micrometers (PM10)	Annual	Total	30µg/m³
	24-hour	Incremental	50µg/m³
Deposited dust (DD)	Annual	Total	2g/m²/month
	Annual	Incremental	4g/m²/month
Nitrogen dioxide (NO_2)	1-hour	Total	246µg/m³
Carbon monoxide (CO)	15-minute	Total	100mg/m³
	1-hour	Total	30mg/m³
	8-hour	Total	10mg/m³

Source: NSW DEC, 2005

5 EXISITING ENVIRONMENT

5.1 Local Climate

Long-term climatic data from the Bureau of Meteorology (BoM) weather station at Narrabri West Post Office (Site No. 053030) is used to characterise the local climate in the area of study.

Table 5-1 and **Figure 5-1** present a summary of data from Narrabri West Post Office (Narrabri) collected approximately from 1962 to present.

The data indicate that January is the hottest month with mean maximum temperature of 33.8ºC and July is the coldest month with mean minimum temperature of 3.7ºC.

Humidity levels exhibit variability and seasonal flux across the year. Mean 9am humidity levels range from 57% in October to 84% in June at Narrabri. Mean 3pm humidity levels vary from 37% in October and December to 52% in June.

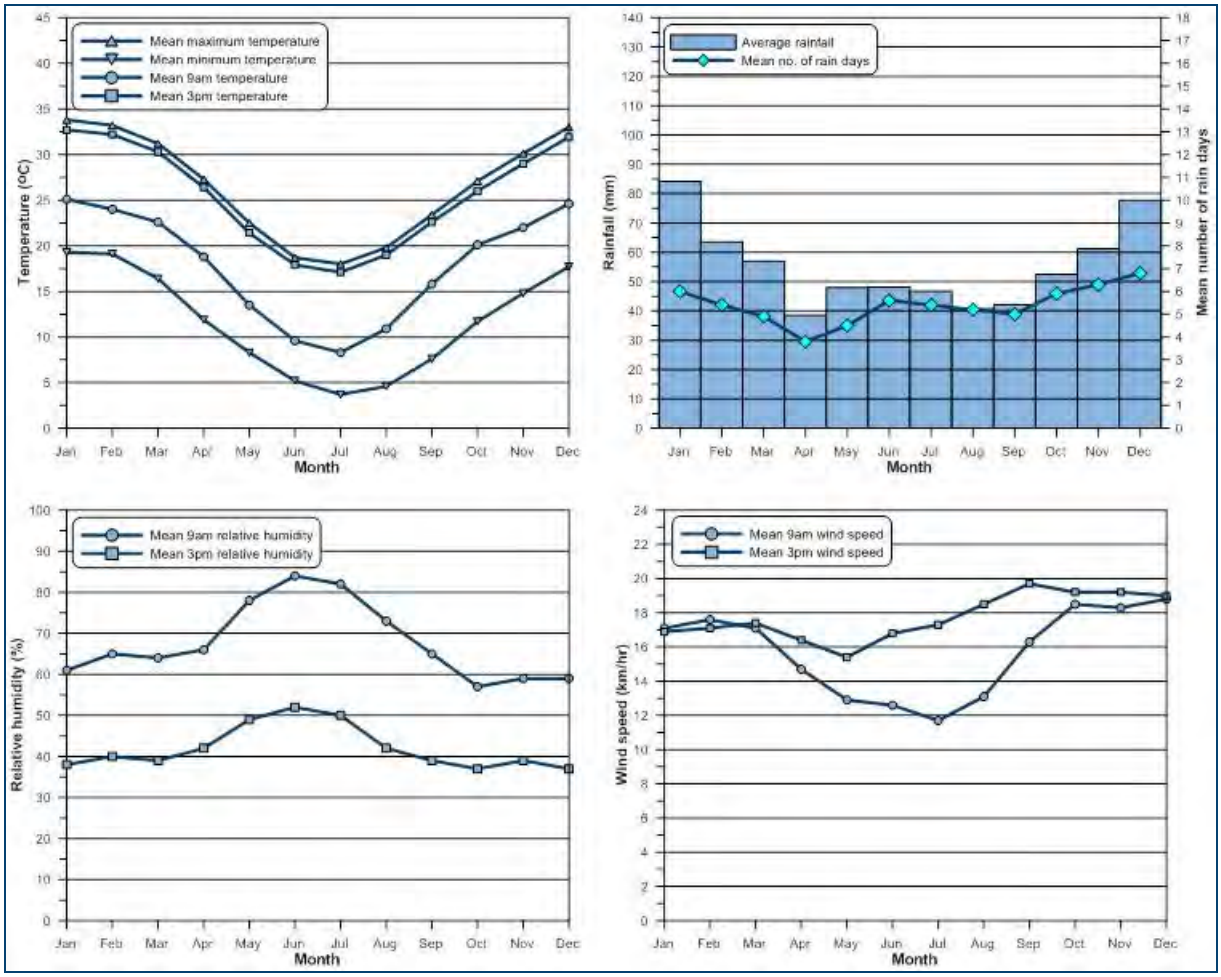
Rainfall generally peaks during the summer months and declines during winter. The data indicates that January is the wettest month with an average rainfall of 84.2mm over 3.7 days at Narrabri. April is the driest month at Narrabri with average rainfalls of 38.6mm over 2.3 days.

Wind speeds at these stations indicate that the colder months tend to have a greater spread between the 9am and 3pm conditions compared to the warmer months. At Narrabri, mean 9am wind speeds range from 11.7km/h in July to 18.8km/h in December and mean 3pm wind speeds range from 15.4km/h in May to 19.7km/h in September.

Table 5-1 Monthly Climate Statistics Summary – Narrabri West Post Office

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature												
Mean max. temperature (ºC)	33.8	33.2	31.2	27.3	22.5	18.7	18.0	19.8	23.4	27.1	30.1	33.0
Mean min. temperature (ºC)	19.3	19.1	16.4	11.9	8.3	5.2	3.7	4.6	7.6	11.7	14.8	17.7
Rainfall												
Rainfall (mm)	84.2	63.6	57.0	38.6	48.0	48.1	46.8	40.7	42.1	52.5	61.2	77.8
Mean No. of rain days (≥1mm)	6.0	5.4	4.9	3.8	4.5	5.6	5.4	5.2	5.0	5.9	6.3	6.8
9am conditions												
Mean temperature (ºC)	25.1	24.0	22.6	18.8	13.5	9.6	8.3	10.9	15.8	20.1	22.0	24.6
Mean relative humidity (%)	61	65	64	66	78	84	82	73	65	57	59	59
Mean wind speed (km/h)	17.1	17.6	17.1	14.7	12.9	12.6	11.7	13.1	16.3	18.5	18.3	18.8
3pm conditions												
Mean temperature (ºC)	32.7	32.2	30.3	26.4	21.4	17.9	17.1	19.0	22.6	26.0	29.0	31.9
Mean relative humidity (%)	38	40	39	42	49	52	50	42	39	37	39	37
Mean wind speed (km/h)	16.9	17.1	17.4	16.4	15.4	16.8	17.3	18.5	19.7	19.2	19.2	19.0

Figure 5-1 Monthly Climate Statistics Summary – Narrabri West Post Office



5.2 Local Meteorology

Suitable local site representative meteorological data for the proposed activity area and its wider surroundings were not available at the time of writing this report. To generate the representative local meteorological data required for this assessment, the meteorological component of The Air Pollution Model (TAPM) was used in accordance with the applicable EPA guidelines (**NSW DEC, 2005**).

TAPM is an incompressible, non-hydrostatic, primitive equation prognostic model with a terrain-following vertical coordinate for three-dimensional simulations. It predicts the flows important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

The TAPM modelling incorporated data assimilation of observations from the BoM weather station at Narrabri Airport (Site No. 054038) which provides the best contemporary hourly data available in the region. The 2008 calendar year was selected for dispersion modelling based on a long-term meteorological analysis for the area which indicated that conditions during 2008 most represented the long-term conditions of the area.

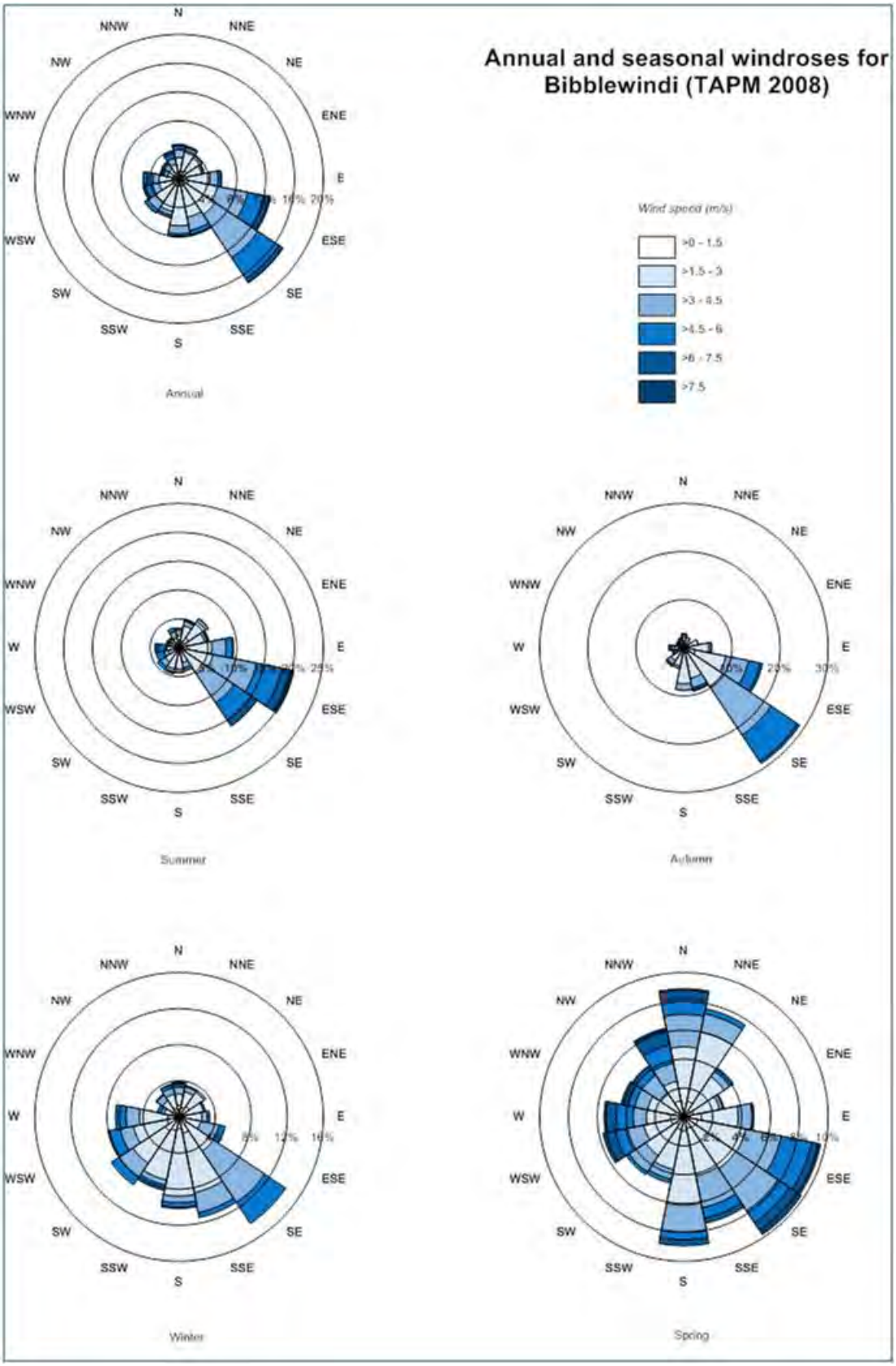
Figure 5-2 presents the annual and seasonal windroses (generated from TAPM output) for the proposed activity location. On an annual basis, winds from the southeast and east-southeast are most frequent with a spread of winds from the other directions. The seasons of summer and autumn have similar wind distribution patterns to the annual windrose with winds from the southeast quadrant most common. In winter, winds tend to mainly occur from the southeast and range to the west. During spring, winds are varied and predominantly occur from southeast and east-southeast with a lesser portion of winds from the north and south.

Table 5-2 presents a summary of the stability class distribution from the TAPM generated data. This distribution (Class A to Class F) is a measure of the turbulence of the atmosphere with Class A associated with highly unstable or turbulent conditions and Class F related to stable conditions, typically at night. The relatively high frequency of Class E and Class F combined (40.4%) suggests that emissions will disperse slowly for a fair portion of time.

Table 5-2 Stability Class Distribution (TAPM 2008)

Stability Class	Frequency of Stability Class Occurrence (%)
A	3.4
B	11.7
C	15.0
D	29.5
E	13.6
F	26.8

Figure 5-2 Annual & Seasonal Windroses for Bibblewindi (TAPM 2008)



5.3 Local Air Quality

5.3.1 Particulate Matter

Suitable site-specific air quality monitoring data are not available to quantify the existing ambient levels at the site. Background ambient monitoring data obtained from the Tamworth NSW EPA monitoring site that measures PM_{10} concentration using a Tapered Element Oscillating Microbalance (TEOM) were analysed and used to characterise the ambient air quality.

The location of this monitoring site is approximately 132km southeast of the proposed activity. Due to the presence of human activity, including residential areas, traffic, major highways and industry, the Tamworth monitoring location is likely to experience higher levels of pollutants than the areas in the vicinity of the site, which is largely rural and undeveloped. Therefore the use of the Tamworth data to represent local air quality is likely to be conservative as it may overestimate the likely levels of air pollutants.

A summary of the annual average PM_{10} monitoring data collected during 2010-2012 at the Tamworth monitoring site is presented in **Table 5-3**. The monitoring data show the annual average PM_{10} concentrations at this monitoring site are below the 30µg/m³ criterion. As a conservative measure the maximum annual average value of 15.9µg/m³ is applied to represent background levels for the proposed activity.

Table 5-3 Summary of Annual PM10 Concentrations from Tamworth NSW EPA Monitoring Site (µg/m³)

Year	PM_{10} Concentration
2010	12.0
2011	13.1
2012	15.9

There are no readily available site specific TSP and deposited dust monitoring data for the proposed activity. The NSW EPA monitoring site does not measure these components; however estimates of the background levels for the site are required to assess the impacts per the criteria presented in **Section 4**.

Estimates of the annual average background TSP concentrations can be determined from a relationship with measured PM_{10} concentrations. This relationship assumes that 40% of the TSP is PM_{10} and was developed as part of a review of ambient monitoring data collected by co-located TSP and PM_{10} monitors in Hunter Valley (**NSW Minerals Council, 2000**).

Applying this relationship with the annual average PM_{10} concentration of 15.9µg/m³ from the Tamworth monitor estimates an annual average TSP concentration of the order of 39.7µg/m³.

To estimate annual average dust deposition levels, a similar process to the method used to estimate TSP concentrations is applied. This approach assumes that a TSP concentration of 90µg/m^3 will have an equivalent dust deposition value of 4g/m²/month.

This relationship indicates a background annual average dust deposition of 1.8g/m²/month for the area surrounding the proposed activity.

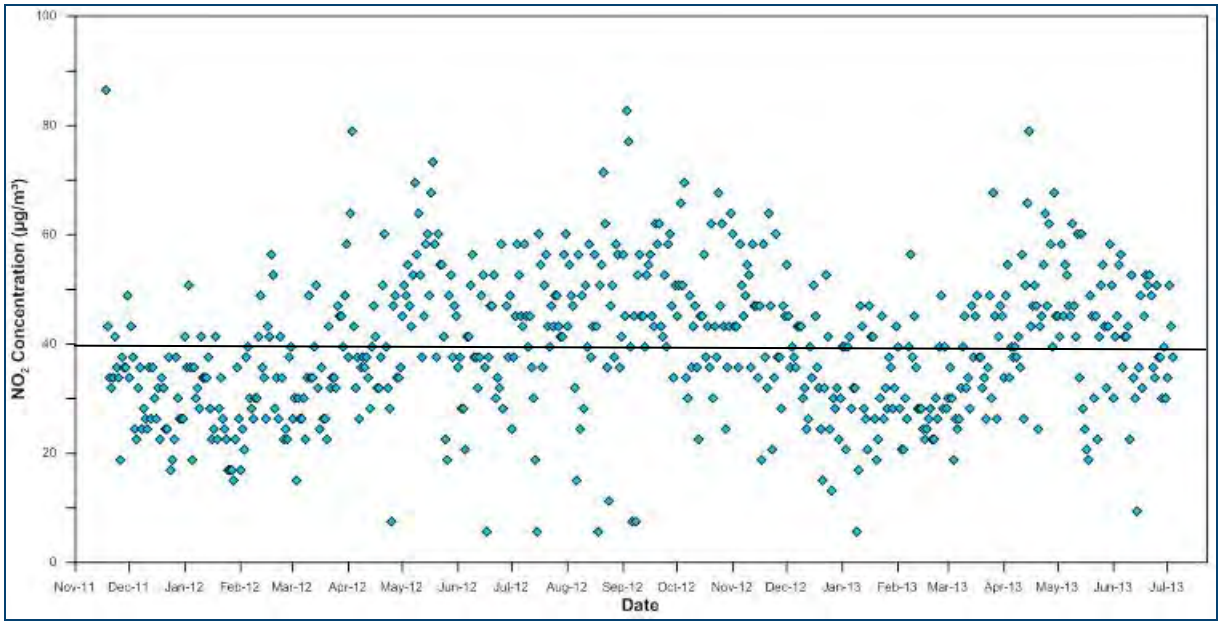
5.3.2 Nitrogen dioxide

Suitable site-specific NO_2 data was not available to quantify the existing ambient levels at the site. Background ambient NO_2 data obtained from the Muswellbrook NSW EPA monitoring site (approximately 215km from Narrabri) is the closest suitable site. 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 is likely to be conservative as it may overestimate the likely levels of air pollutants.

Figure 5-3 presents the maximum daily 1-hour average NO_2 concentrations from the Muswellbrook NSW EPA monitoring sites from November 2011 to July 2013. The monitoring data reviewed indicate that there were no exceedances of the NSW EPA 1-hour average goal of 246µg/m³ during this period at the monitor.

The data in **Figure 5-3** indicate that levels of NO_2 are relatively low compared to the criterion level and show a seasonal fluctuation.

Figure 5-3 Daily 1-hour Maximum NO_2 Concentrations – Muswellbrook



The maximum 1-hour background NO_2 levels measured at Muswellbrook during November 2011 to July 2013 is 86.48µg/m³ (1hour average); with the average being 40 µg/m³ (1hour average).

5.3.3 Carbon Monoxide

Suitable site-specific CO data was not available to quantify the existing ambient levels at the site. The NSW EPA monitoring sites at Tamworth or Muswellbrook do not record ambient concentrations of CO. 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 (ie <0.02 µg/m³ (8hour average)) which is consistent with NO_2 monitoring results.

6 APPROACH TO ASSESSMENT

6.1 Emission Estimation

6.1.1 Construction

For the construction phase of the proposed activity, minor works would be required including; the levelling of the drill pad, the installation of above ground tanks, excavation of a cellar pit and drilling.

During the construction phase of the proposed activity, air emissions generated would generally comprise of particulate matter associated with the earthworks. Other emissions would occur from the exhaust of plant equipment required for the construction phase, these emissions are generally considered to be too low to generate any significant pollutant concentrations in the vicinity of the proposed activity and have not been assessed further in this study.

The activities associated with the vehicle travel on unsealed surfaces, drilling, excavation and wind erosion are identified as the significant sources of particulate matter generation. Dust emission estimates from the construction operations have been made using emission factors developed both locally and by the US EPA.

Table 6-1 presents the estimated TSP emissions for the construction phase. Further details regarding each of the emissions estimation techniques applied to estimate the TSP emissions are provided in **Appendix A**.

Table 6-1 Estimated Emissions for Construction Operations

Activity	TSP emissions (kg/year)
Travel to site	12,774
Travel between Bibblewindi 31 and Bibblewindi 32	1,401
Excavating material	16
Drilling	5
Wind erosion of exposed areas	6,912
Total	**21,108**

This assessment considers the construction phase would be applied for the full year to provide predictions necessary to compare against criteria, whereas it is proposed to take approximately 15 weeks.

It should also be noted that as a conservative approach, no consideration of dust controls have been applied to the estimation of dust emissions during activities.

6.1.2 Operation phase

For the operation phase, air emissions associated with the flare operation were calculated based on the flare exhaust flow rate and estimated stack concentrations.

It is noted that in addition to CO and NO_2 formation, a small amount of particulate matter (<10µg diameter, referred to as PM_{10}) may be generated from the combustion operation. Considering the surrounding activities in the local area, it is unlikely that the proposed flare operation will make any significant contribution to an increase in the PM_{10} level in the surrounding areas during operation and therefore has not been investigated in this assessment.

Typically, NOx emissions emitted from flares consist for the larger part (>95%) of nitrogen monoxide (NO) and for a small part (<5%) of NO_2. After emission from the stack, NO is converted to NO_2 through oxidation with atmospheric ozone (O_3) (**Janssen et al, 1988**). The rate of this reaction is governed by the level of ozone in the air, air dispersion and other meteorological factors such as temperature. The reaction are complicated and most pronounced in urban areas with high ozone and other levels of pollution which do not generally arise in this situation.

The modelled stack parameters and emission rate of the flare unit included in the modelling is presented in **Table 6-2**.

Table 6-2 Stack Parameters & Estimated Emissions for Flare

Parameter	Value	Units
Stack height	6.1	m
Stack diameter	0.206	m
Exit velocity	5.49	m/s
Exit temperature	750	ºC
Peak gas flow rate*	20.56	Am^3/s
Peak gas flow rate**	5.49	Nm^3/s
NO_2 emission rate	0.027	g/s
CO emission rate	0.023	g/s

* A - Actual **N - Nominal 0 ºC

6.1.3 NO_x to NO_2 conversion

For this assessment, the NO_x to NO_2 was estimated using an empirical equation for estimating the oxidation rate of NO in power plant plumes as outlined in the "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (**NSW DEC, 2005**) and developed by **Janssen et al. (1988)**. This method consists of calculating the ratio of NO_2 to NO_x as determined by the atmospheric conditions and distance from the maximum recorded level to the source.

As per this method, a Level 1 assessment was carried out adding maximum prediction and maximum background concentrations to predict the total impact of NO_2. The predicted maximum impacts were recorded approximately 0.43km from the source during summer. Using this distance the ratio of NO_2 to NO_x at receptors due to the flare operations was calculated to be 3%.

6.2 Modelling methodology

The AUSPLUME dispersion model in conjunction with a TAPM generated meteorological data file (described in **Section 5.2**) provides predictions of the ground level concentrations of pollutants based on the emission estimation provided in **Section 6.1**.

Sources modelled for the construction scenario were modelled as volume sources, sources modelled for the operational scenario were modelled as point sources. **Appendix B** provides a sample of AUSPLUME output file.

7 ANALYSIS OF MODELLING RESULTS

7.1 Construction Impacts

This section presents the predicted impacts on air quality arising from dust emissions generated during the construction process for each relevant dust metric. **Figure 7-1** to **Figure 7-4** presents isopleths of the spatial distribution of predicted incremental impacts over the modelling domain for maximum 24-hour average PM_{10}, annual average PM_{10}, TSP and deposited dust levels.

Table 7-1 presents the predicted incremental and total impacts at each of the sensitive receptor locations.

Table 7-1 Predicted Incremental & Total Concentrations at Sensitive Receptors – Construction

Receptor ID	PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental Impact				Total Impact		
	24-hour Average	Annual Average	Annual Average	Annual Average	Annual Average	Annual Average	Annual Average
	Air Quality Impact Criteria						
	50	-	-	2	30	90	4
RR1	0.15	0.02	0.02	0.01	17.73	39.72	1.81
RR2	0.26	0.05	0.05	0.02	17.77	39.75	1.82
RR3	0.08	0.01	0.01	<0.01	17.71	39.71	1.80
RR4	0.08	0.01	0.01	<0.01	17.71	39.71	1.80
RR5	0.09	0.01	0.01	<0.01	17.71	39.71	1.80

The predicted results show minimal incremental impacts during the construction period at the sensitive receptors. Therefore, it is unlikely that the existing PM_{10}, TSP or dust deposition levels at any sensitive receptor will significantly change during this time.

The estimated background levels in **Section 5.3** were added to the predicted incremental levels to assess potential total impacts at the sensitive receptors. The predicted total results for PM_{10}, TSP and dust deposition are also below the relevant NSW EPA criteria at the sensitive receptors.

Additionally the impact on the nearby sensitive receptors is likely to be lower than predicted due to the vegetation between the site and receptors. Studies have shown that significant vegetation barriers can reduce dust emissions by up to 30% (**Warren, 1973**). The modelling completed for this assessment has not taken into account any mitigation from the vegetation buffer.

Figure 7-1 Predicted Maximum 24-hour Average Incremental PM_{10} Concentrations (µg/m³)

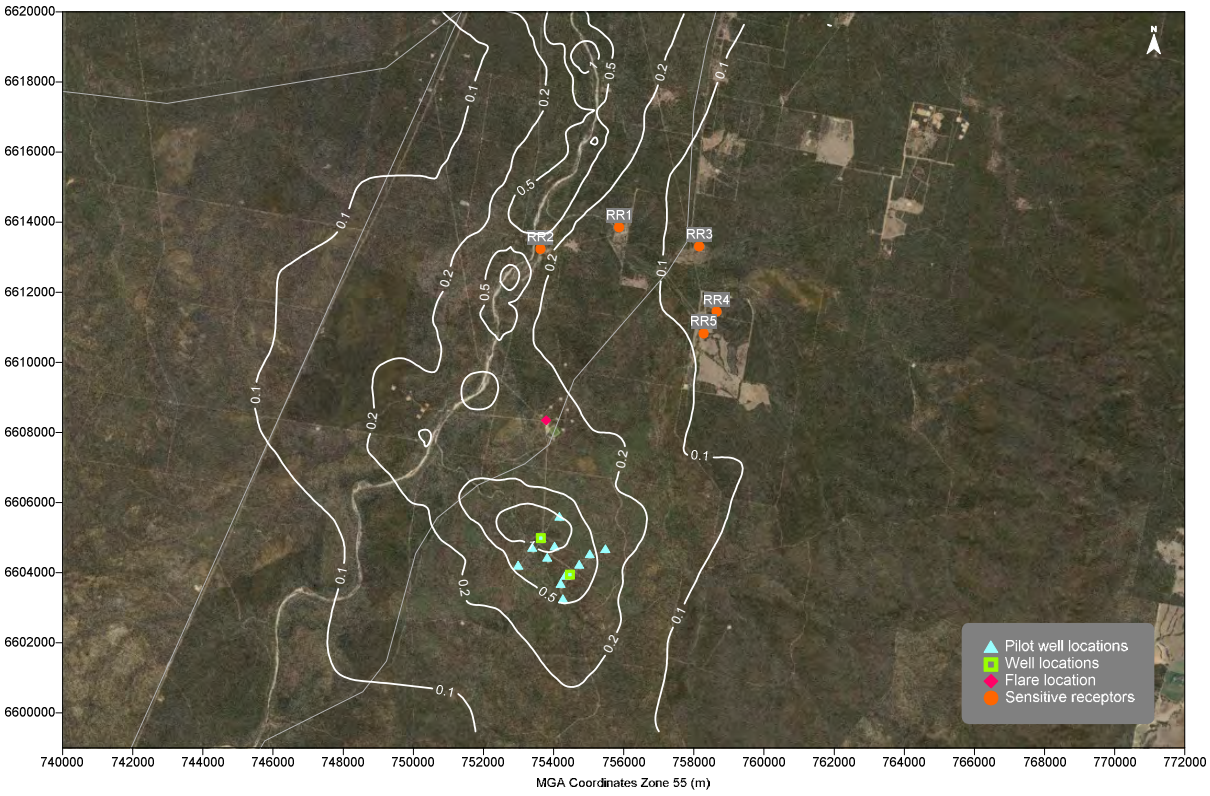


Figure 7-2 Predicted Annual Average Incremental PM_{10} Concentrations (µg/m³)

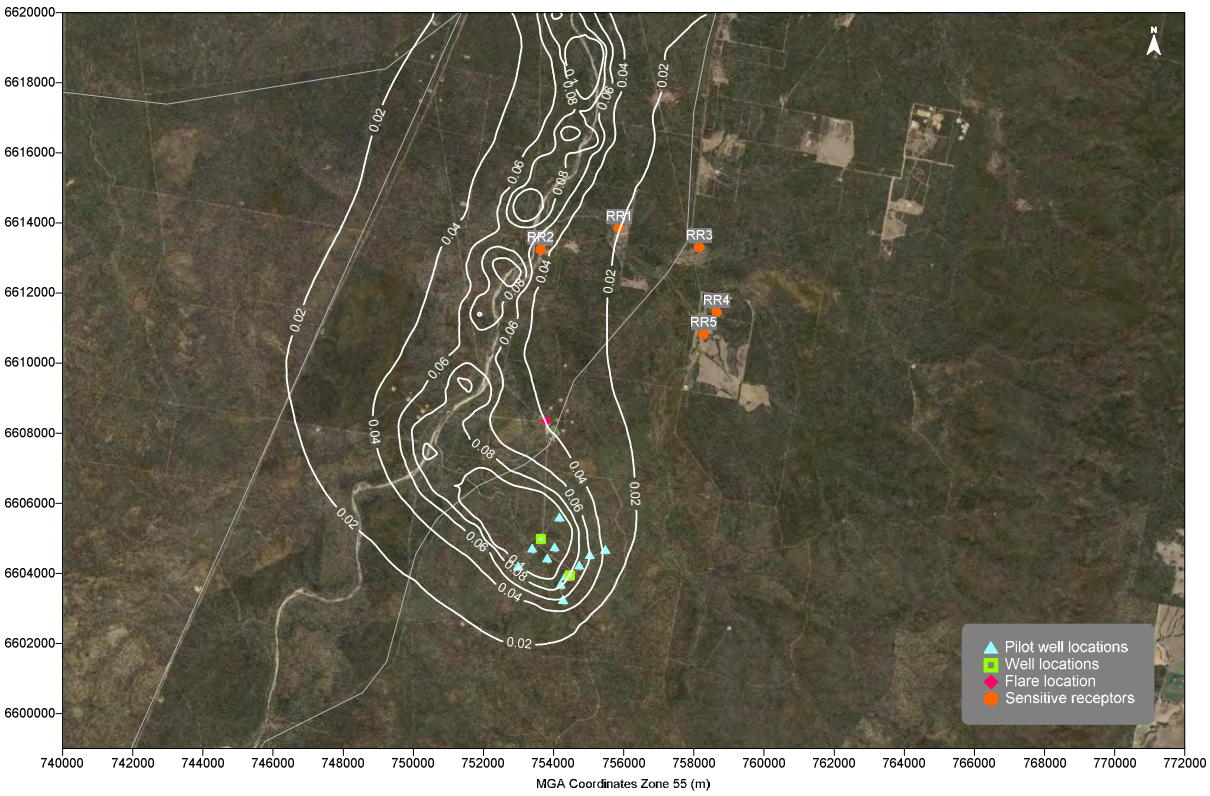


Figure 7-3 Predicted Annual Average Incremental TSP Concentrations (µg/m³)

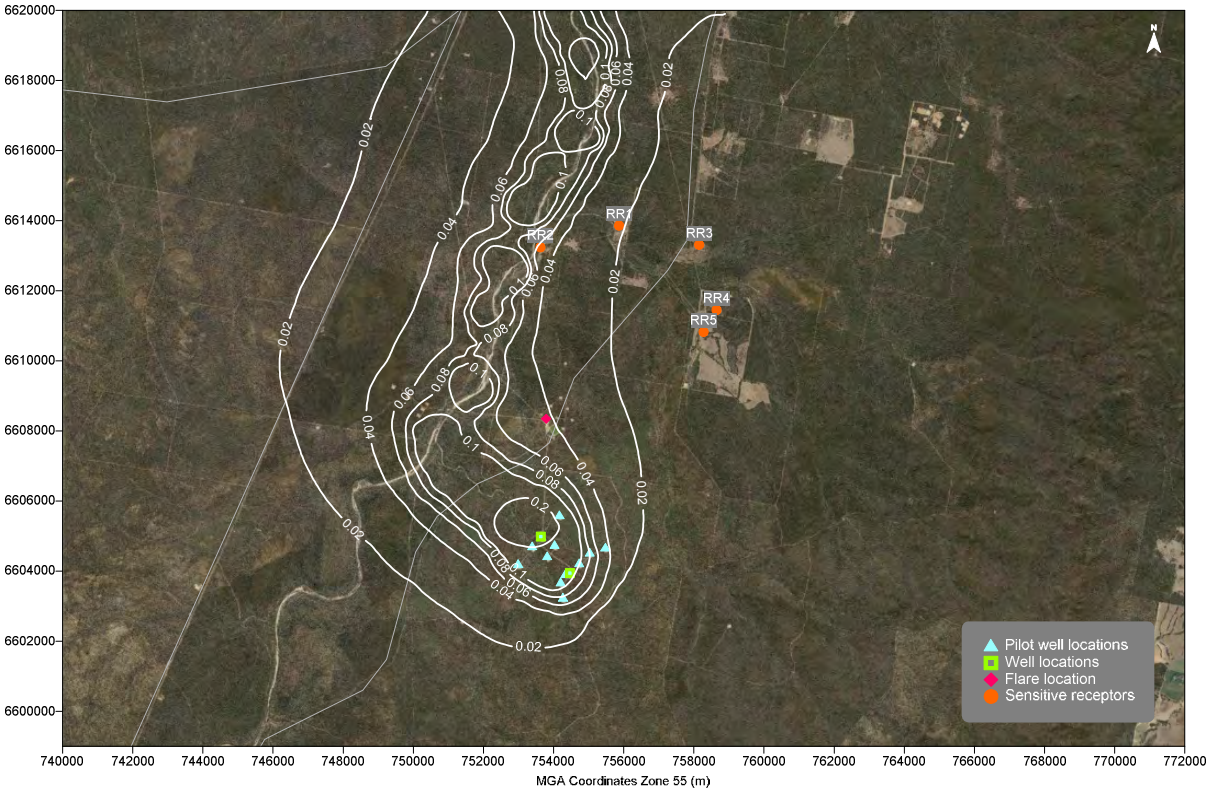


Figure 7-4 Predicted Annual Average Incremental Dust Deposition Levels (g/m²/month)



7.2 Operational impacts

The spatial distribution of the dispersion model predictions for NO_2 and CO are presented as contour plots in **Figure 7-5** to **Figure 7-9**. Each of the sensitive receptors was assessed individually as discrete receptors with the results presented in tabular form for the privately owned receptors.

Analysis of the predicted NO_2 and CO impacts presented in **Figure 7-5** to **Figure 7-8** shows minimal impact at all sensitive receptors.

Table 7-2 presents the predicted incremental NO_2 and CO impacts from the proposed flare operations at the surrounding sensitive receptors. It can be observed from **Table 7-2** that predicted incremental impacts from the proposed operation are low.

With the addition of the maximum 1-hour background NO_2 levels measured at Muswellbrook during November 2011 to July 2013 of 86.48µg/m³, the total predicted impact at the sensitive receptors would remain below the respective criterion level.

It is noted that site specific CO monitoring is not available for this assessment. However comparison of the predicted incremental CO concentrations with the NSW EPA criteria for CO shows that the proposed activity contribution would be significantly below the criteria. It is unlikely that existing background levels of CO would be approaching the criteria levels, which would result in any exceedance.

Therefore the maximum impacts due to the proposed flare operation would not exceed the NSW EPA criteria for NO_2 and CO in surrounding areas.

Table 7-2 Predicted Incremental Concentrations at Sensitive Receptors – Operation

Receptor ID	NO_2	CO		
	1-hour Average	15-minute Average	1-hour Average	8-hour Average
	Air Quality Impact Criteria (µg/m³)			
#	246	100	30	10
RR1	0.00594	0.00022	0.00017	0.00011
RR2	0.00741	0.00027	0.00021	0.00014
RR3	0.00617	0.00023	0.00017	0.00011
RR4	0.00827	0.00030	0.00023	0.00015
RR5	0.00836	0.00031	0.00023	0.00015

Figure 7-5 Predicted Incremental 1-hour Average NO_2 Concentrations (µg/m³)

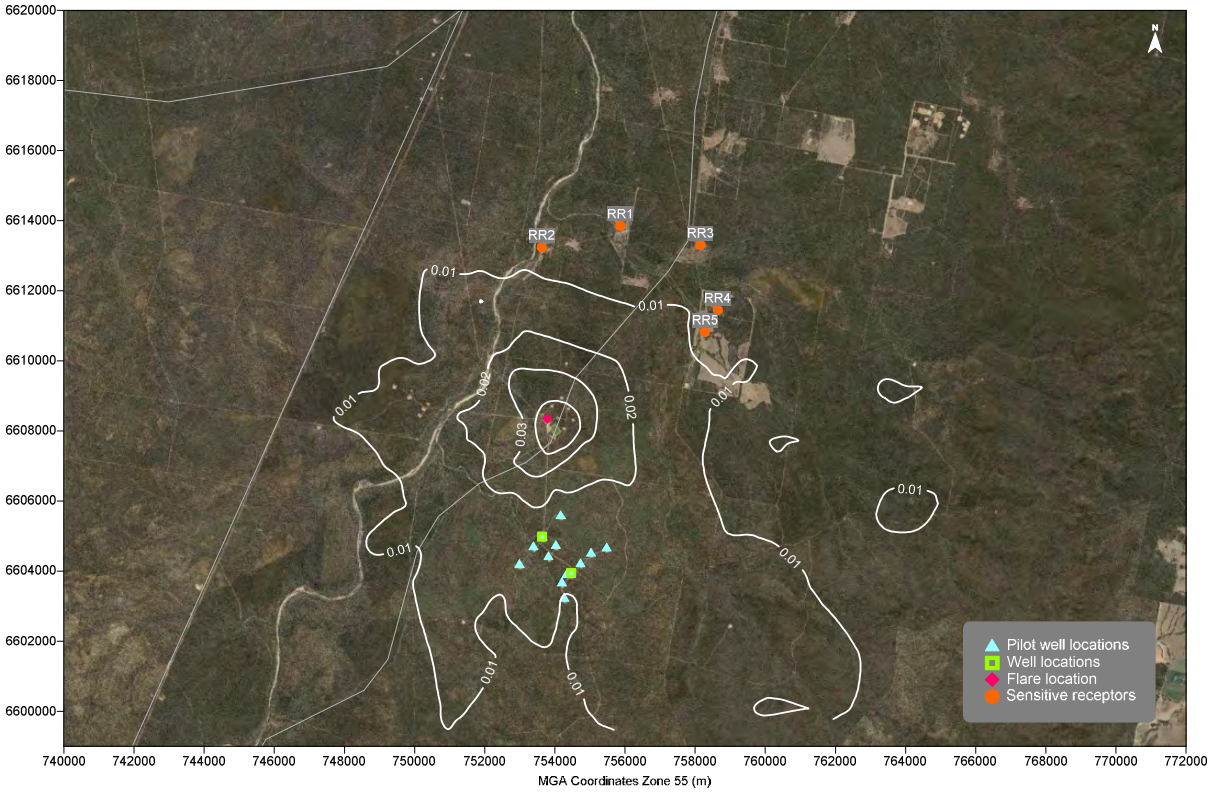


Figure 7-6 Predicted Incremental 15-minute Average CO Concentrations (mg/m³)

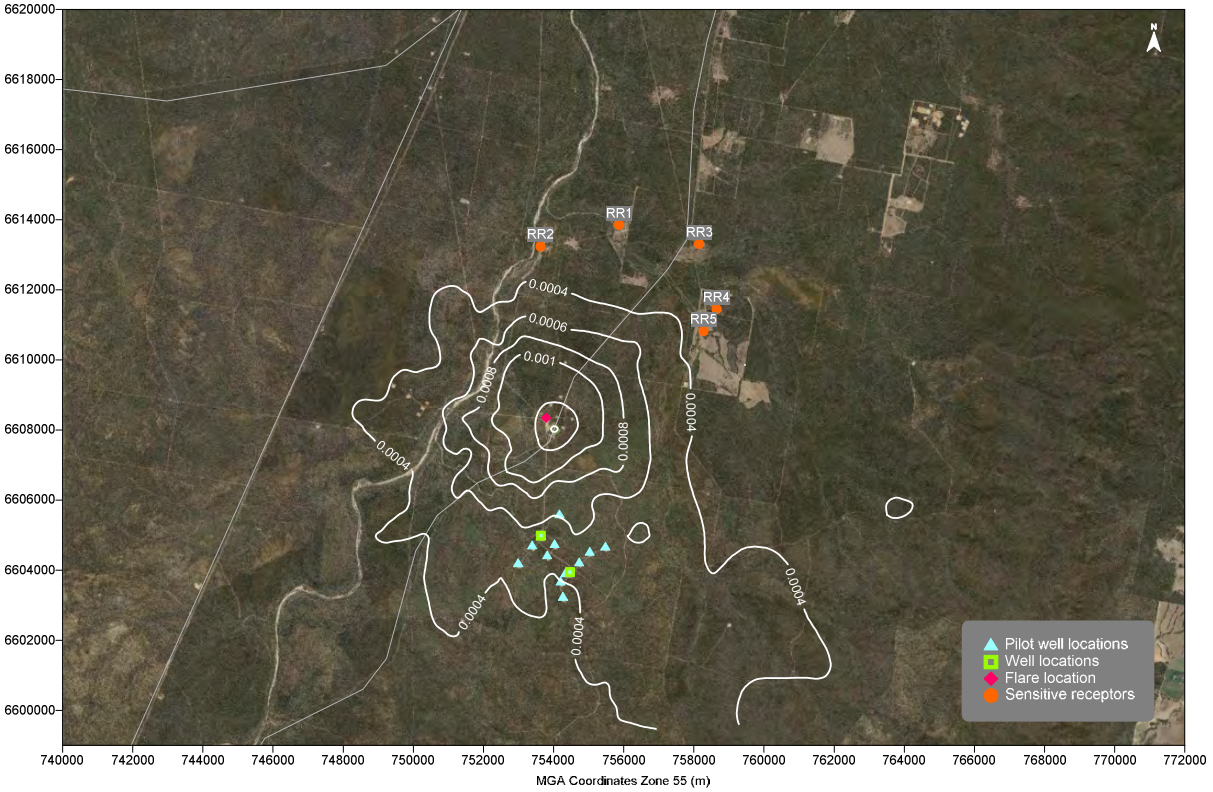


Figure 7-7 Predicted Incremental 1-hour Average CO Concentrations (mg/m³)

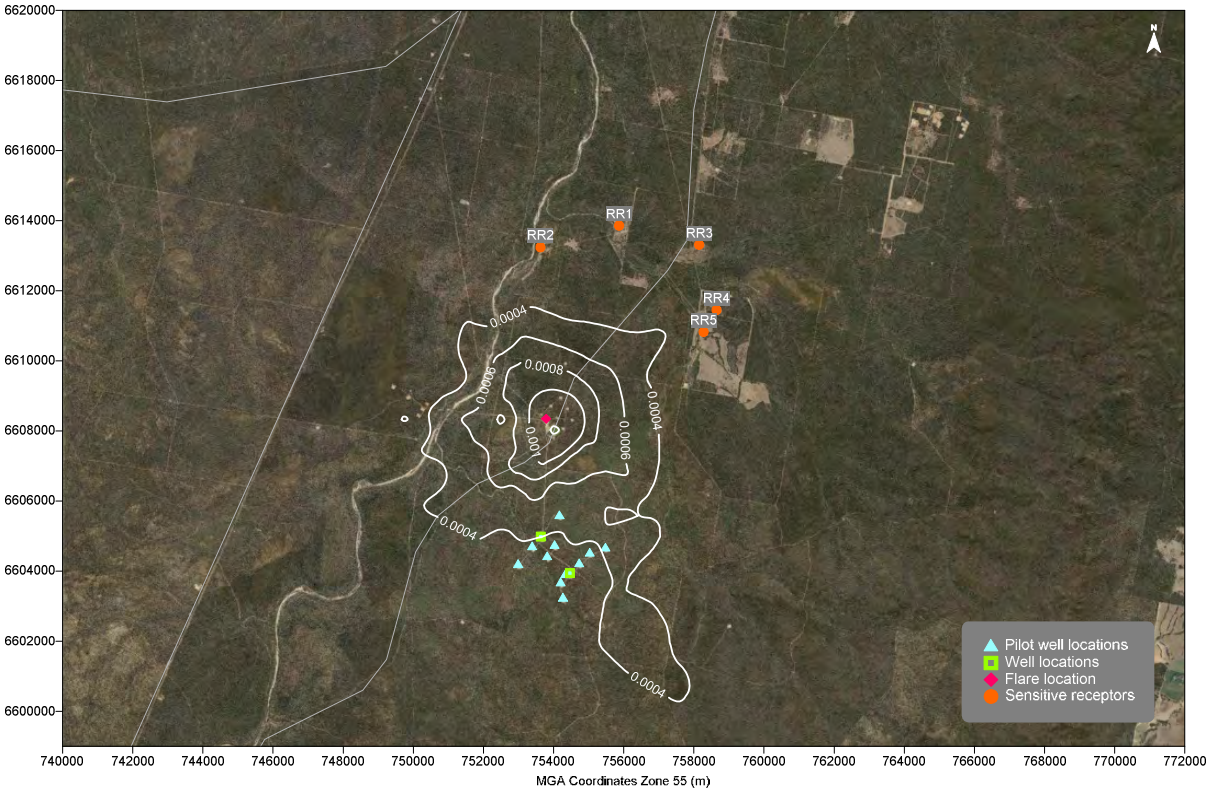
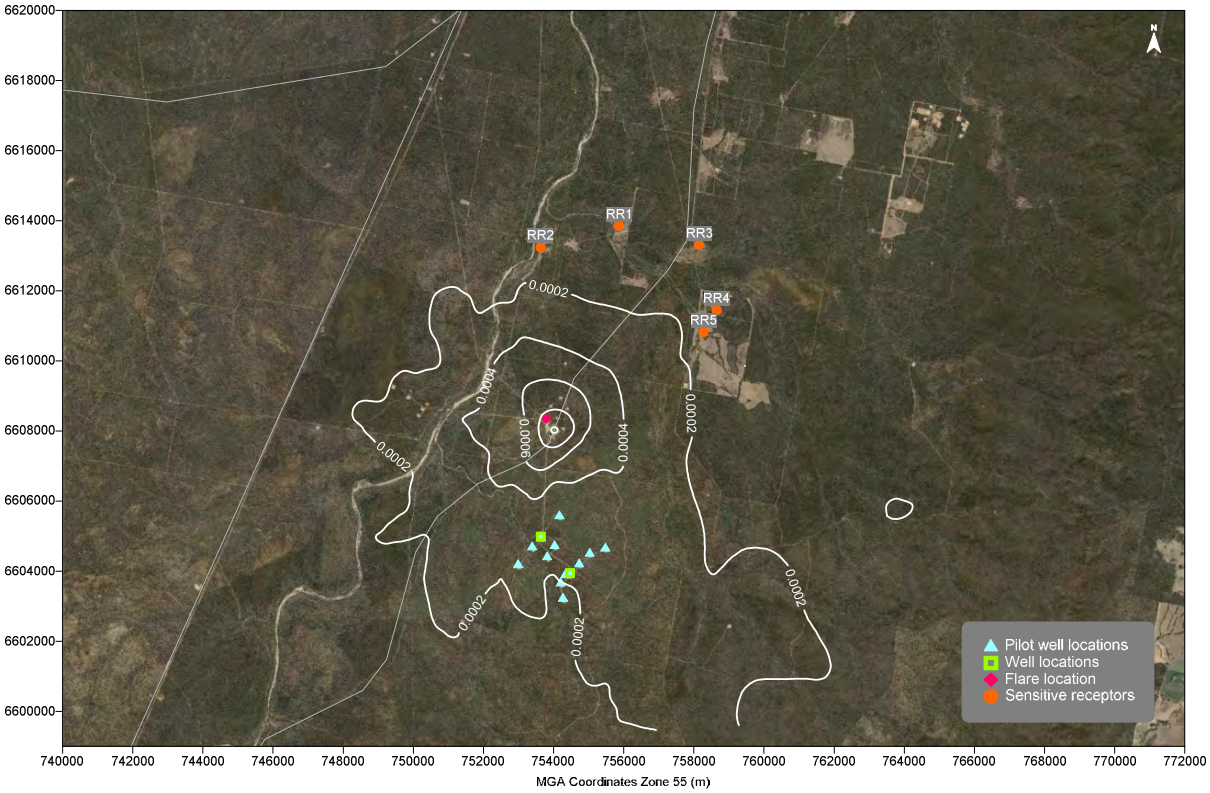


Figure 7-8 Predicted Incremental 8-hour Average CO Concentrations (mg/m³)



7.2.1 Consideration of Potential Cumulative Impacts

Analysis of the predicted incremental NO_2 and CO impacts for the proposed activity shows minimal impact at all sensitive receptors.

It is noted that in the vicinity of the proposed activity there are potentially other sources of NO_2 and CO emissions originating from on-site plant equipment, site vehicles, small generators and other flaring operations. These sources are unlikely to generate significant amounts of NO_2 and CO and would be located away from the nearby sensitive receptors to allow sufficient dilution.

The other operating flares would emit at similar rates to the proposed flare. Based on the predicted incremental levels for the proposed flare and the conservative nature of the assessment approach, it would be unlikely for any potential cumulative impacts to occur at the sensitive receptors.

8 MITIGATION MEASURES

The site activities will generate dust, therefore it is prudent to take reasonable and practicable measures to prevent or minimise dust emissions into the surrounding environment.

The primary dust sources identified from the proposed activity are:

- Wind-blown dust from exposed areas; and
- Dust generated by construction and operational activities.

Table 8-1 summarises the following procedures proposed to minimise dust emissions from the primary dust sources.

Table 8-1 Dust Mitigation Measures

Source	Control Procedure
Exposed areas	• Restrict ground disturbance to the minimum area practically possible. • Rehabilitate exposed areas as soon as practicable.
Vehicle activities	• Limit vehicle speeds. • Covering loose, dust generating material loads, travelling to and from the site.

9 CONCLUSIONS

This assessment has examined the potential air quality impacts of the proposed construction of Bibblewindi 31 and 32 and operation of the Bibblewindi Multi-Lateral Pilot and a flare located at the Bibblewindi Water Transfer Facility.

The study predicts that the additional air quality impacts arising from the proposed Project would be minor at the surrounding sensitive receptors.

The predicted change in air quality is unlikely to be detectable and the results show that levels would be well below the relevant criteria for the pollutants assessed.

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APPENDIX A

EMISSION INVENTORY

Construction Operations

Hauling on unpaved roads

Emissions from unpaved roads are dependent on the silt content of the road and the gross weight of the vehicles. TSP emissions for this activity have assumed that a no control of dust emissions from this activity as a conservative measure. The following equation developed by US EPA (**USEPA, 1985 and updates**) estimates the amount TSP emissions from the activity.

$$EF = \left(\frac{0.4536}{1.6093} \times \left(\frac{s}{12}\right)^{0.7} \times 4.9 \times \left(M \times \frac{1.1023}{3}\right)^{0.45}\right) \frac{kg}{VKT}$$

Where:

S = Silt content = 10%

M = Vehicle gross weight = 30 tonnes

Material extraction

Emissions from this activity are dependent on wind speed and the moisture content of the material. The following equation developed by US EPA (**USEPA, 1985 and updates**) estimates the amount TSP emissions from the activity.

$$EF = k \times 0.0016 \times \left(\left(\frac{U}{2.2}\right)^{1.3} \Big/ \left(\frac{M}{2}\right)^{1.4}\right) \frac{kg}{tonne}$$

Where

k = Particulate size specific factor for batch loading operations (k_{TSP} = 0.74)

U = Wind speed (m/s)

M = Moisture content of loading material = 2%

Drilling

TSP emissions from the drilling operations are estimated using emission factors developed by US EPA (**USEPA, 1985 and updates**). An emission factor of 0.59kg/hole for the drilling operation is applied. This emission factor is applicable for equipment with no dust suppression.

Wind erosion

Emissions from stockpiles and exposed areas occur due to wind erosion. The emission factor developed by State Pollution Control Commission (SPCC) (**SPCC, 1983**) allows an estimation of the total TSP generated due to wind erosion. An emission factor of 0.4 kg/ha/hour was applied in estimating the TSP emissions due to the wind erosion and has assumed that no control of dust emission from these operations would be applied.

ACTIVITY	TSP emission (kg/y)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 6	Units
Travel to site	2,839	793	trips/year	3.6	kg/VKT	40.0	km/return trip	10.0	% silt content	30	Ave GMV (tonnes)		% Control
Travel from 31 to 32	311	87	trips/year	3.6	kg/VKT	2.0	km/return trip	10.0	% silt content	30	Ave GMV (tonnes)		% Control
Excavating material	4	1,920	tonnes/year	0.002	kg/t	1.540	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %				
Drilling	1	2	holes/year	0.59	kg/hole								% Control
Wind erosion of exposed areas	1,536	2.0	ha	0.40	kg/ha/hour	1,920	hours						% Control
Total TSP emissions (kg/yr)	**4,691**												

APPENDIX B

SAMPLE OF *AUSPLUME* OUTPUT FILE

1

Dust

Concentration or deposition	Concentration
Emission rate units	grams/second
Concentration units	microgram/m3
Units conversion factor	1.00E+06
Constant background concentration	0.00E+00
Terrain effects	Egan method
Plume depletion due to dry removal mechanisms included.	
Smooth stability class changes?	No
Other stability class adjustments ("urban modes")	None
Ignore building wake effects?	Yes
Decay coefficient (unless overridden by met. file)	0.000
Anemometer height	10 m
Roughness height at the wind vane site	0.500 m

DISPERSION CURVES

Horizontal dispersion curves for sources <100m high	Pasquill-Gifford
Vertical dispersion curves for sources <100m high	Pasquill-Gifford
Horizontal dispersion curves for sources >100m high	Briggs Rural
Vertical dispersion curves for sources >100m high	Briggs Rural
Enhance horizontal plume spreads for buoyancy?	Yes
Enhance vertical plume spreads for buoyancy?	Yes
Adjust horizontal P-G formulae for roughness height?	Yes
Adjust vertical P-G formulae for roughness height?	Yes
Roughness height	0.400m
Adjustment for wind directional shear	None

PLUME RISE OPTIONS

Gradual plume rise?	Yes
Stack-tip downwash included?	Yes
Building downwash algorithm:	Schulman-Scire method.
Entrainment coeff. for neutral & stable lapse rates	0.60,0.60
Partial penetration of elevated inversions?	No
Disregard temp. gradients in the hourly met. file?	No

and in the absence of boundary-layer potential temperature gradients
given by the hourly met. file, a value from the following table
(in K/m) is used:

Wind Speed Category	Stability Class A	B	C	D	E	F
1	0.000	0.000	0.000	0.000	0.020	0.035
2	0.000	0.000	0.000	0.000	0.020	0.035
3	0.000	0.000	0.000	0.000	0.020	0.035
4	0.000	0.000	0.000	0.000	0.020	0.035
5	0.000	0.000	0.000	0.000	0.020	0.035
6	0.000	0.000	0.000	0.000	0.020	0.035

WIND SPEED CATEGORIES
Boundaries between categories (in m/s) are: 1.54, 3.09, 5.14, 8.23, 10.80

WIND PROFILE EXPONENTS: "Irwin Rural" values (unless overridden by met. file)

AVERAGING TIMES
24 hours
average over all hours

AUSPLUME Input File : Dust concentration

SOURCE GROUPS

Group No.	Members						
1	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
	15	16	17	18	19		
2	20	21	22	23	24	25	26
	27	28	29	30	31	32	33
	34	35	36	37	38		
3	39	40	41	42	43	44	45
	46	47	48	49	50	51	52
	53	54	55	56	57		

1

AUSPLUME Input File : Dust concentration

SOURCE CHARACTERISTICS

VOLUME SOURCE: 1

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
754450	6619746	256m	2m	10m	2m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
1.0000	1.0	2.50

VOLUME SOURCE: 2

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
755053	6618712	255m	2m	10m	2m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
1.0000	1.0	2.50

VOLUME SOURCE: 3

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
755196	6617708	255m	2m	10m	2m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
1.0000	1.0	2.50

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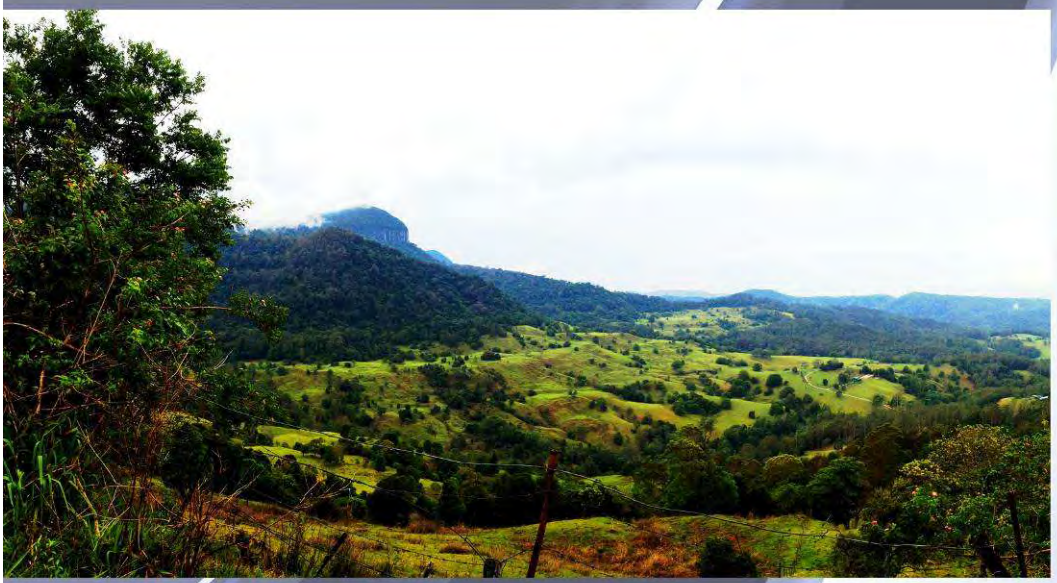
Appendix 6

Noise Assessment

NOISE MEASUREMENT SERVICES

Noise Assessment Report
Bibblewindi Gas Exploration Pilot Expansion
Santos Limited
Pilliga State Forest
Narrabri NSW

Report No 2422.R4 ***05 September 2013***





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Revision No	Issue Date	Revision Description	Checked By	Issued By
0	21/06/2013	Draft Report for Review	BT	MD
1	11/07/2013	Inclusion of other wells	MT	MD
2	27/08/2013	Inclusion of traffic assessment	MT	BT
3	04/09/2013	Inclusion of comments	MT	BT
4	05/09/2013	Minor text corrections	MT	BT

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2	4	Noise Measurement Services

REPORT FOR **RPS Australia East**

CONTACT **Greg Tallentire**

Signed



Dr Bob Thorne
(Principal)

DISCLAIMER
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Executive Summary

Noise Measurement Services Pty Ltd has been commissioned by RPS Australia East, consulting to Santos NSW (Eastern) Pty Ltd, to complete an environmental noise assessment for the Bibblewindi Gas Exploration Pilot Expansion. The Bibblewindi Gas Exploration Pilot Expansion includes the drilling and construction of Bibblewindi 31 and 32 and the operation of the Bibblewindi Multi-Lateral Pilot (Bibblewindi 12,13, 14, 15, 16, 17, 18H, 19H, 21H, 27, 28H and 29) including Bibblewindi 31 and 32 ("the proposal"). The scope of works in this Report is:

- Establishing the existing background sound levels in the vicinity of the proposed Bibblewindi multi-lateral pilot;
- Establishing the environmental noise criteria that would apply to the drilling, construction and operation of the Proposal;
- Predicting the environmental noise levels due to the construction and operation of the Proposal at noise sensitive receivers (residences), including drilling and the cumulative operation of the wells, and associated traffic noise;
- Assessing the noise related impacts, if any, at noise sensitive receivers (residences); and
- Propose measures to mitigate noise where required, reasonable and feasible.

The noise criteria to be achieved are the Intrusive noise criterion and sleep disturbance criterion under the *NSW Industrial Noise Policy*. The Rating Background Level plus 5 dB(A) and is established as LAeq 35 dB. The duration of works associated with the construction of a well is in the order of weeks. In this context the drilling is similar to short-term construction noise and the appropriate assessment guidelines are detailed in the *Interim Construction Noise Guideline.*

As demonstrated in Section 4, all levels calculated in the noise modelling process are within the noise criteria set out in the INP. The levels calculated for Bibblewindi 31 and 32 are significantly below those of the multi-lateral pilot, and do not contribute in any appreciable way to the existing levels. In turn, it is observed that the field as a whole, in drilling or in operation conditions, generates noise substantially below the criteria set out in the INP.

Conclusions

- The drilling stages will not be audible at night when the background levels drop to around 20 dB(A). If, however, unusual adverse weather conditions enhance noise propagation any audible activity would be of short duration. Noise mitigation to the mud-pump (the main source of noise) will reduce further any audible sound.
- The operation of the pilot wells should not be audible at any of the residences identified in this assessment.
- There are a minimal number of vehicle movements involved in the process, and the impact of the noise from vehicle movements will be minor.
- The construction and operation of the Proposal meet the requirements of the NSW Industrial Noise Policy, the NSW Road Noise Policy, the Interim Construction Noise Guideline and the EPA Environmental Criteria for Road Traffic Noise.

References

- Protection of the Environment Operations Act 1997 (POEO Act),
- Protection of the Environment Operations (General) Regulation 1998,
- Protection of the Environment Operations (Noise Control) Regulation 2000,
- NSW Industrial Noise Policy (INP), DEC January 2000,
- Interim Construction Noise Guideline, 2009
- Environmental Criteria for Road Traffic Noise (ECRTN), DEC, May 1999,
- NSW Environmental Noise Control Manual or ENCM (DEC Ref. 94/31),
- NSW Roads and Maritime Services Road Noise Policy (RNP) March 2011,
- Environmental Noise Management, Noise Guide for Local Government (DEC Ref.2004/59).
- *Bibblewindi Gas Exploration Pilot Expansion, Narrabri, Traffic and Transport Assessment, Issue C* - GTA Consultants 13/08/13
- *Bibblewindi Gas Exploration Pilot Expansion Environmental Impact Statement (EIS)* RPS Australia East Pty Ltd Version 0/Aug 2013

Glossary

Ambient sound

All sounds in a locality or "soundscape" from distant and nearby sources or activity including traffic, bird song, vegetation movement in the breeze, and so on.

Assessment Background Level (ABL).

The Assessment Background Level is the single figure background level representing each assessment period (day, evening and night) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (LA90) for each period.

Background sound pressure level (LA90,T), L90

Commonly called the "L90" or "background" level and is an indicator of the quietest times of day, evening or night. The L90 level is calculated as the noise level equalled and exceeded for 90% the measurement time. The level is recorded in the absence of any noise under investigation. The level is not adjusted for tonality or impulsiveness. Also known as the background "noise" level.

Character of the environment

The *character of the environment* is often assessed by third-octave or narrow band analysis of the ambient sound. Sounds may be characterised, for example, as "bangs", "hum noise", "plant sounds", and "high frequency sounds". The assessment is required to determine intrusive noise, tonality or annoying character.

Equivalent Continuous or time average sound pressure level (LAeq,T), Leq

Commonly called the "Leq" level it is the logarithmic average noise level from all sources far and near and is referenced to a specific measurement time interval; e.g. 1-hour. The level can be adjusted for tonality.

LA10.

The LA10 level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the LA10 level for 90% of the time. The LA10 is a common noise descriptor for environmental noise and road traffic noise.

INP

New South Wales Industrial Noise Policy, EPA 2000

NMS

Noise Measurement Services Pty Ltd

Rating Background Level (RBL)

The overall, single-figure, background level representing each assessment period (day/evening/night) over the whole monitoring period (as opposed to over each 24-hout period used for the assessment of background level [in NSW]). This is defined as the median value of all the day evening or night assessment background levels.

1. Introduction

1.1 Proposal Location

Noise Measurement Services Pty Ltd was commissioned by RPS Australia East consulting to Santos NSW (Eastern) Pty Ltd to complete an environmental noise assessment for the Bibblewindi Gas Exploration Pilot Expansion.

The proposed activity includes drilling two new wells (Bibblewindi 31 and Bibblewindi 32) on existing lease areas and operation of the existing Bibblewindi Multi-Lateral Pilot (including Bibblewindi 31 and Bibblewindi 32).

The proposed activity does not include the assessment of the existing site establishment and construction activities for clearing and preparation of the lease areas, the water and gas gathering system, access tracks and partial rehabilitation of the lease areas. These works were previously approved by the former NSW Department of Primary Industries (DPI), which approved drilling and operation of Bibblewindi 12, 13, 14, 15, 16, 17, 18H and 19H on 8 August 2008 and Bibblewindi 21H, 27, 28H and 29 on 20 July 2009. Bibblewindi 31 and 32 are located on existing clearings for Bibblewindi 14 and 19H respectively.

The proposed well locations are illustrated in **Plate 1.1.1**. The gathering system operational works for the wells is calculated as part of the overall noise emissions. The information of this Report is referenced to our previous reports for the Dewhurst 6, 22 - 25 and 13 – 18 pilot wells (NMS Report 2228 series). The noise level predictions, however, are referenced to Bibblewindi 31 and 32 and the Bibblewindi Multi-Lateral Pilot.

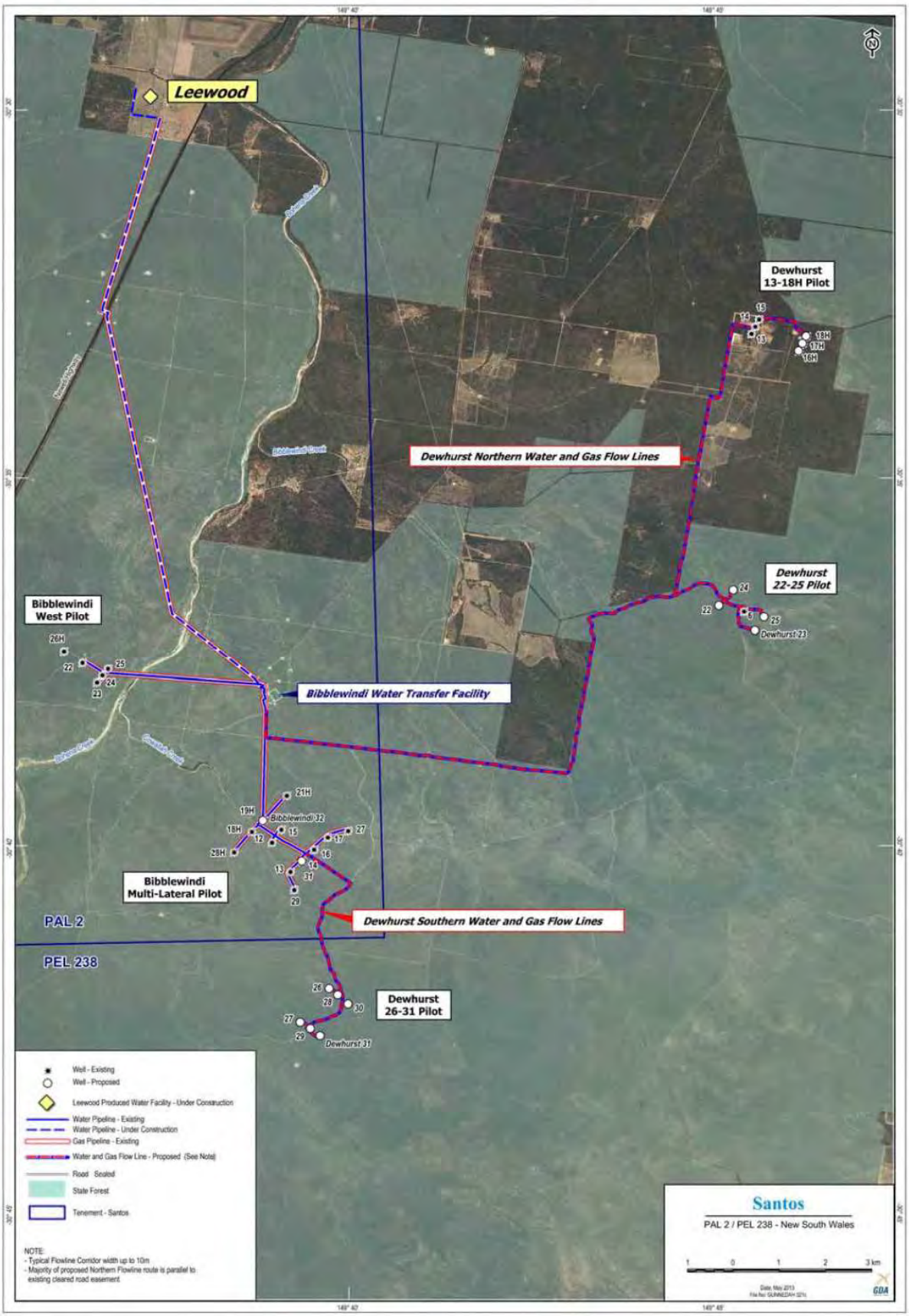


Plate 1.1.1: Location of Bibblewindi Multi-Lateral Pilot.

1.2 Proposal Description

This Report considers the noise emissions from coal seam gas (CSG) well development and operation of the pilot wells. The scope of works in this Report includes predicting the environmental noise levels due to the construction and operation of the Proposal at noise sensitive receivers (residences), from drilling and the cumulative operation of the wells, and from traffic noise related to these activities;

The proposed activity includes:

- Site preparation and establishing necessary equipment, temporary structures and facilities on the existing well leases Bibblewindi 14 and 19H to enable drilling
- Drilling one vertical well (Bibblewindi 31) and one lateral (Bibblewindi 32) pilot well to target the Bohena coal seam
- Installing surface and sub-surface infrastructure within the existing lease area to connect the wells to the existing gas and water gathering system for the Bibblewindi Multi-Lateral Pilot
- Operating the Bibblewindi 31 and Bibblewindi 32 pilot wells and the existing Bibblewindi Multi-Lateral Pilot as a combined pilot for up to 3 years
- Management of the water and gas produced during operation
- Occasional maintenance of the Bibblewindi Multi-Lateral Pilot
- On completion of operations, pilot wells and ancillary infrastructure will be decommissioned and well leases rehabilitated or suspended.

This assessment does not include flaring at the existing flare at the Wilga Park power generation facility.

1.2.1 Timing and Duration of Activities

The overall on-site activities are expected to take approximately 3 months and the main phases of work are identified in Table 1.2.5.1

Table 1.2.5.1: Duration of on-site activities

Activity	Approximate Duration	12hr or 24 hr
Site Preparation	20 days	12
Drilling* and workover	35 days	12/24
** drilling and cementing as a stand-alone process*	*3 – 7 days within the above time*	*24*
Surface facilities	50 days	24
Operation of pilot	Up to 3 years	12[1]

1 In emergencies, wells could be visited 24 hours

The maximum number of people on-site at any one time is expected to be 20 staff during drilling. Crews will be located at the Westport drillers' camp and travel to site daily. Work will be 24 hours. The maximum number of vehicle movements is expected to be approximately between 10 and 20 per day (10 during drilling and completion, and 20 for short periods when equipment is delivered to site), generally within the hours of 7:00am and 6:00pm.

1.3 Sensitive Receptors

Five noise sensitive receptors (i.e. residences R1 to R5) are within 10 km of the Bibblewindi multi-lateral pilot, as shown in **Plate 1.3.1**. **Plate 1.3.1** also shows the ambient noise monitoring locations (ML1 and ML2). There is a residence at location ML1. The location of the Bibblewindi 31 and 32 pilot wells is shown on **Plate 1.3.1**. The location of the residences and receivers in this report are given in **Table 1.3.1** by latitude and longitude.

Table 1.3.1: Residential and Measurement Locations

Location	Degrees East	Degrees South
Residence 1	149° 38' 40"	30° 35' 10"
Residence 2	149° 40' 03"	30° 34' 48"
Residence 3	149° 41' 30"	30° 35' 04"
Residence 4	149° 41' 50"	30° 36' 03"
Residence 5 and ML1	149° 41’ 38”	30° 36’ 26”
ML2	149° 41’ 59”	30° 38’ 54”

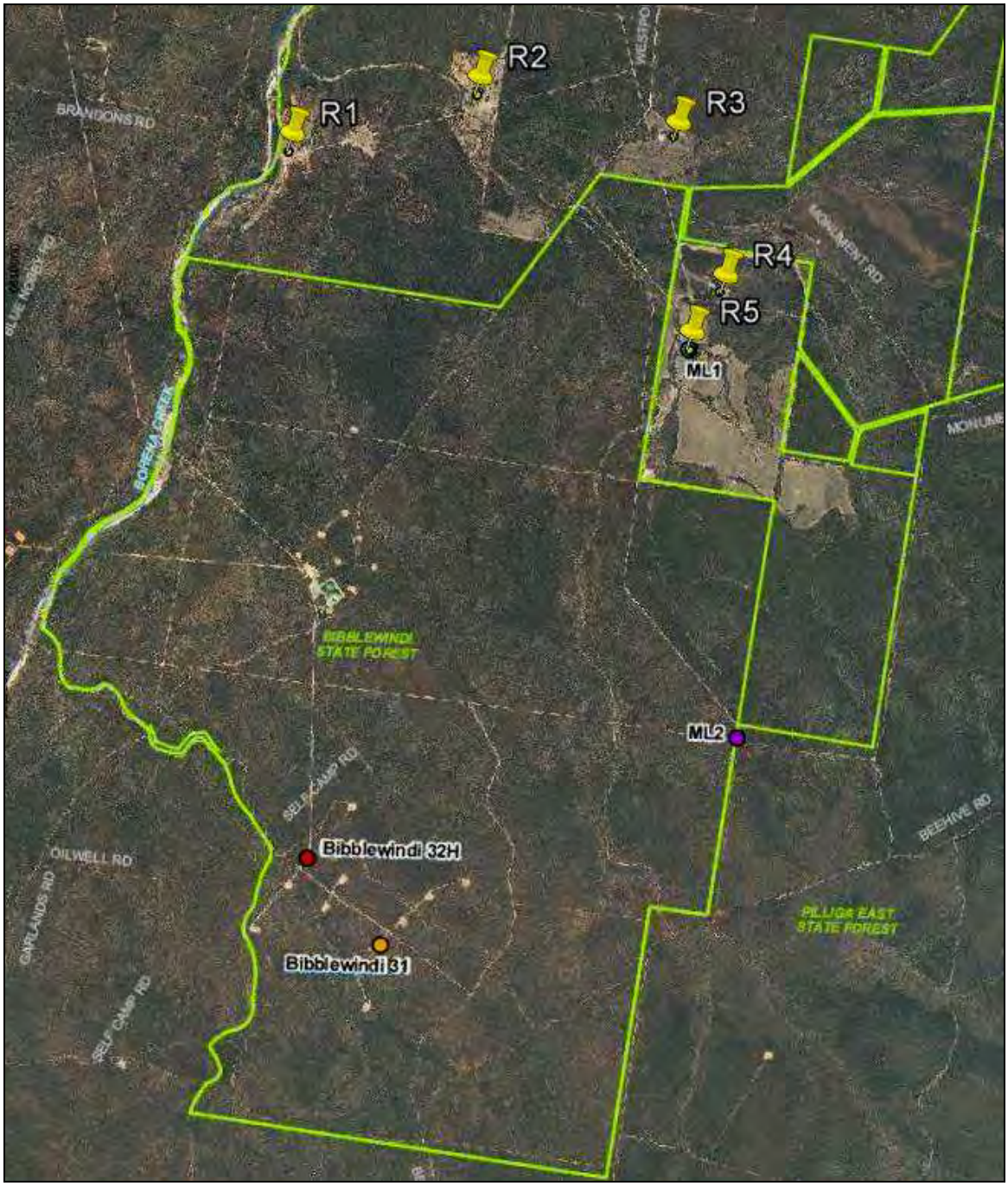


Plate 1.3.1: Residences (R1-R5), noise monitoring locations (ML1, ML2) and Bibblewindi pilot well locations

1.4 Noise Assessment Method

The basic concept of determining whether or not the noise from the construction of Bibblewindi 31 and 32 is likely to cause intrusive noise impacts is to compare the existing noise levels to the expected noise levels from the proposed activities. The operational noise assessment was conducted in accordance with the *NSW Industrial Noise Policy* (INP) published by the NSW Environmental Protection Agency (EPA) in 2000.

The determination compared the background sound levels calculated to the INP (the average of the minimum sound levels without the proposed activities) to the measured sound level at a potentially affected sensitive residence when the petroleum and gas activities are being carried out. Further operational noise levels were calculated to other residences potentially affected. Noise modelling creates different scenarios, including a scenario of worst case meteorological conditions. While different scenarios can be calculated through a noise model, it will rarely be possible to factor in all possible situations that may present themselves over time with accuracy. For this reason, assumptions must be made in applying the noise model. The calculation methods are detailed in **Annex C**.

The model identifies the proposed activities that could impact on residences. A residence may be affected by noise emissions from two or more operational wellheads. Therefore multiple noise sources are calculated.

The ambient noise level at a residence consists of the natural sound levels from wind in trees, insects, animal, rural activity, household activity noise. When the drilling occurs or the wellheads are in operation an additional sound is added to the natural environment. This is defined as the intrusive noise (or component noise) and is defined as the source noise only (i.e. without the contribution of background noise).

We conclude that, in the absence of insects and winds the background sound levels are below 30 dBA. This level constitutes the minimum Rating Background Level (RBL) considered in NSW under the INP (EPA 2000) and other policies/guidelines that refer to the determination of background noise levels detailed in the INP. The measured ambient sound levels are recorded in **Section 2**.

An RBL of 30 dBA would be expected in rural areas and so this is considered appropriate for derivation of indicative noise level criteria in this instance.

Intrusive Noise

The Intrusive Noise Criterion is determined as the Rating Background Level (RBL) plus 5 dB(A), measured as the time-average LAeq sound level over 15 minutes.

Sleep Disturbance

The Sleep Disturbance Criterion is determined as 40 dB(A) (façade-affected, being measured at 1metre from a façade) per Table 2.1 of the INP. It is measured as the time-average (LAeq) sound level over 15 minutes.

2. Ambient Noise Monitoring

2.1 Noise monitoring locations

In order to establish the existing noise environment within and adjacent to the Proposal area, ambient noise monitoring was conducted at two locations, ML1 and ML2 in November 2012. The selected locations are considered to be representative of the noise sensitive receptors within the Proposal area. In addition, two monitoring locations (ML3 and ML4) just to the north of the Proposal area are included as these give representative rural noise levels for June 2012. The measurement locations are shown graphically in **Plates 2.1.1 and 2.1.2**. The selection of noise monitoring locations was based on consideration of noise sensitive locations (residential properties) and other noise sources which may influence the noise measurements.

Plate 2.1.1: Aerial photograph showing ML1 and ML2 (November 2012). ML1 is located close to a residence.



Plate 2.1.2: Aerial photograph showing ML3 and ML4 (June 2012). ML4 is located close to a residence.



The following **photographs** illustrate the various sound measurement locations for the survey.

Photo 2.1.1: View of noise logger location ML1 including weather station and residential dwelling behind



Photo 2.1.2: View of noise logger ML2



Photo 2.1.3: View of noise logger ML3 (June 2012 Survey).



Photo 2.1.4: View of noise logger ML4 (June 2012 Survey).



2.2 Instrumentation

The two-week unattended noise logging was conducted using Larson Davis 831 sound analyser instruments, designated as Class 1 under Australian Standard *AS IEC 61672.1-2004 Electroacoustics - Sound level meters - Specifications* as having an accuracy suitable for field use. The long-term noise loggers were calibrated before and after the measurements with a drift in calibration not exceeding ±0.5 dB. Each sound level meter was calibrated before and after the measurements with a Rion NC73 calibrator and the drift in calibration not exceeding ±0.5 dB. Each sound level meter used for this assessment has a current calibration certificate.

2.3 Meteorological data

Weather data for the area was sourced from the Bureau of Meteorology's Narrabri Airport weather station (**Annex B**), which provides overall wind speed and direction over four full year periods. Additionally, during the monitoring weather data was recorded to ensure compliance with the INP. A Davis weather station was installed at one of the measurement locations in order to record ground-level meteorological data. As required by the INP guidelines, extraneous noise events and noise data adversely affected by weather, e.g. rain, were excluded. The recorded weather data was recorded every 15 minutes and the data is summarised in **Figure 2.3.1**. All the 15 minutes samples are displayed in 6-hour blocks. The noise data is unaffected by adverse weather.

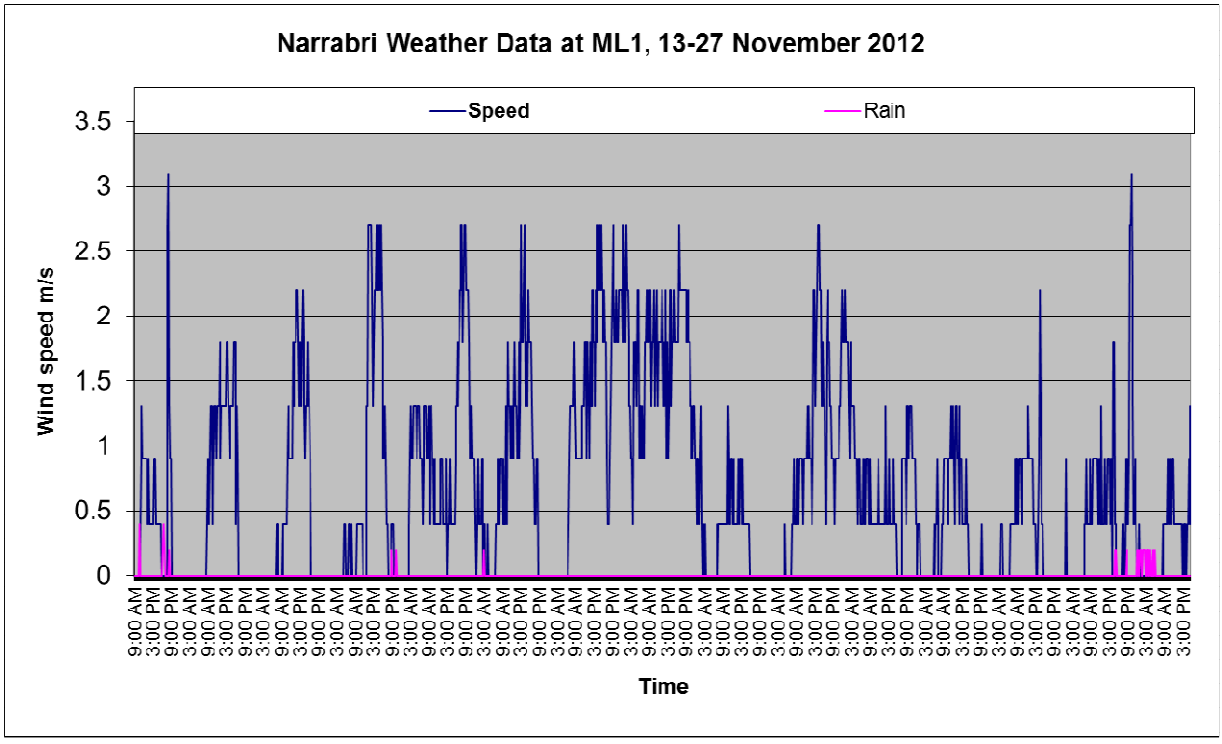


Figure 2.3.1: Weather data at Narrabri during the monitoring in November 2012

2.4 Unattended continuous noise monitoring

In order to assess the background and ambient noise levels at the site, in the absence of plant operating and in accordance with the INP, a series of surveys were taken on site, generally in accordance with Australian Standard AS1055.1:1997 - 'Acoustics-*Description and measurement of environmental noise - Part 1: General procedures'*.

The microphone at each location was 1.35m above ground level. A Davis weather station was also employed during the survey to record wind and rain information, in order that days with excessive wind or rain noise could be identified and excluded. Two loggers were used to continuously measure background noise levels between Tuesday 13 November 2012 and Tuesday 27 November 2012. The results of the noise monitoring were processed in accordance with the procedures contained in the INP. Additionally, sound levels recorded to the north of the Proposal area have been reviewed and noted as they relate to different time of year and have different background levels that will be similar to the "Bibblewindi" locale.

The noise logger measured the noise level over the sample period and the L_{A1}, L_{A10}, L_{A90}, L_{Amax} and L_{Aeq} sound levels recorded every 15 minutes. The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for 1%, 10% and 90% of the sample period respectively.

The noise logger at location ML2 failed after 3 days. This was an instrument failure.

2.5 Rating Background Noise Levels

The background sound levels calculated to the INP are presented in the following tables. The levels were measured in continuous 15 minute intervals from 14 to 26 November 2012. The data is correlated to 15-minute wind and rain data. There were no events (rain or average wind speeds above 5m/s) requiring data to be excluded. This data is available for a more precise analysis if necessary.

The L_{A90} is taken as the background noise level. The Assessment Background Level (ABL) is established by determining the lowest tenth-percentile level of the L_{A90} noise data acquired over each period of interest. The background noise level or Rating Background Level (RBL) representing the day, evening and night-time assessment periods is based on the median of individual ABLs determined over the entire monitoring duration.

The RBL is representative of the average minimum background sound level (in the absence of the source under consideration), or simply the background level. The L_{Aeq} is the average energy sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

A summary of the calculated RBLs (L_{A90}) and existing ambient noise levels (L_{Aeq}) is presented in the following tables. The calculated ABLs and existing L_{Aeq} ambient noise levels for each noise monitoring location for each assessment period (day, evening and night) are presented following.

Under the INP, where the rating background level is found to be less than 30 dB(A) the RBL is set to 30 dB(A).

Table 2.1: Ambient noise levels at Residence (ML1); RBL (Median LA90)

	Day dB(A)	Evening dB(A)	Night dB(A)
Wed 14 Nov	33.7	37.2	36.7
Thu 15 Nov	33.7	32.6	37.4
Fri 16 Nov	32.8	35.0	35.5
Sat 17 Nov	28.6	30.6	33.4
Sun 18 Nov	28.4	32.7	32.7
Mon 19 Nov	27.4	35.6	25.7
Tue 20 Nov	33.4	34.8	35.2
Wed 21 Nov	27.9	29.2	27.3
Thu 22 Nov	30.2	30.3	30.2
Fri 23 Nov	28.7	30.0	35.3
Sat 24 Nov	32.1	30.6	41.0
Sun 25 Nov	33.4	59.1	38.5
Mon 26 Nov	35.4	36.3	40.9
Time Period	7am to 6pm	6pm to 10pm	10pm to 7am
Rating Background Level (RBL)	**32**	**33**	**35**

Table 2.2: Ambient noise levels background location (ML2); RBL (Median LA90)

	Day dB(A)	Evening dB(A)	Night dB(A)
Wed 14 Nov	28.0	35.7	16.6
Thu 15 Nov	27.4	30.4	15.6
Time Period	7am to 6pm	6pm to 10pm	10pm to 7am
Rating Background Level (RBL)	**28**	**33**	**16**

Note: the measurements are truncated because the noise logger failed.

Table 2.3: Ambient (2012) noise levels in rural area to north of Proposal area (W-ML3); RBL (Median LA90)

	Day dB(A)	Evening dB(A)	Night dB(A)
Sat 23 Jun	23.6	24.8	23.7
Mon 25 Jun	21.0	24.1	21.3
Tue 26 Jun	22.2	21.3	20.8
Fri 29 Jun	22.9	29.9	21.7
Sun 8 Jul	22.1	19.3	ND
Mon 9 Jul	22.5	19.2	19.7
Tue 17 Jul	ND	ND	ND
Sun 15 Jul	ND	ND	ND
Sat 30 Jun	24.5	28.6	21.0
Mon 2 Jul	26.3	22.3	22.6
Time Period	7am to 6pm	6pm to 10pm	10pm to 7am
Rating Background Level (RBL)	**23**	**23**	**21**

Table 2.4: Ambient (2012) noise levels at residential property, rural locale north of the Proposal area (W-ML4); RBL (Median LA90)

	Day dB(A)	Evening dB(A)	Night dB(A)
Sat 23 Jun	25.7	20.0	18.7
Mon 25 Jun	21.4	18.6	20.1
Tue 26 Jun	24.3	18.9	19.1
Fri 29 Jun	23.9	26.0	22.7
Sun 8 Jul	24.5	19.9	19.9
Mon 9 Jul	23.7	19.7	19.5
Tue 17 Jul	25.1	43.0	31.2
Sun 15 Jul	30.3	36.9	33.9
Sat 30 Jun	25.6	23.1	20.5
Mon 2 Jul	27.9	19.5	19.2
Time Period	7am to 6pm	6pm to 10pm	10pm to 7am
Rating Background Level (RBL)	**25**	**20**	**20**

2.6 Ambient Leq Noise Levels

The Leq sound levels calculated to the procedure under the INP are presented in the following tables. The levels were measured in continuous 15 minute intervals from 14th to 27th November 2012. Days affected by rain or high winds (average wind gusts over 5m/s) were excluded from assessment, where possible.

Table 2.5: Ambient LAeq noise levels at residence (ML1)

	Day dB(A)	Evening dB(A)	Daytime dB(A)	Night dB(A)
Wed 14 Nov	47.2	59.8	54.7	53.4
Thu 15 Nov	46.2	51.0	48.1	53.5
Fri 16 Nov	45.9	53.8	49.7	49.3
Sat 17 Nov	46.6	51.4	48.5	51.1
Sun 18 Nov	46.7	58.8	53.7	55.0
Mon 19 Nov	44.4	48.8	46.1	45.4
Tue 20 Nov	45.6	48.1	46.4	47.4
Wed 21 Nov	44.0	54.6	49.8	56.8
Thu 22 Nov	50.7	53.5	51.6	55.9
Fri 23 Nov	45.5	53.1	49.0	55.3
Sat 24 Nov	46.2	49.2	47.2	55.6
Sun 25 Nov	47.3	61.5	56.1	55.5
Mon 26 Nov	49.6	51.1	50.0	55.1
Time Period	7am to 6pm	6pm to 10pm	7am to 10pm	10pm to 7am
Existing Leq	**47**	**56**	**51**	**54**

Table 2.6: Ambient LAeq noise levels background location (ML2)

	Day dB(A)	Evening dB(A)	Daytime dB(A)	Night dB(A)
Wed 14 Nov	43	44	44	37
Thu 15 Nov	40	45	42	36
Time Period	7am to 6pm	6pm to 10pm	7am to 10pm	10pm to 7am
Existing Leq	**42**	**44**	**43**	**36**

Note: the measurements are truncated because the noise logger failed.

This location, ML2, is in the bush and affected by insects, birds and noise in vegetation.

Supplementary Data

The levels were measured in continuous 15 minute intervals from 20 June to 20 July 2012, whilst the gas powered generators at Wilga Park were not operational. Days affected by rain or high winds (average wind gusts over 5m/s) were excluded from assessment, where possible. The data is included as it provides an assessment for mid-year (June) weather conditions; numerous days were excluded due to weather conditions being outside of tolerances for the INP.

Table 2.7: Ambient LAeq 2012 noise levels at residential property, rural locale north of the Proposal area (W-ML3)

	Day dB(A)	Evening dB(A)	Daytime dB(A)	Night dB(A)
Sat 23 Jun	45	33	44	34
Mon 25 Jun	47	29	45	43
Tue 26 Jun	45	30	44	38
Fri 29 Jun	47	36	46	36
Sun 8 Jul	48	25	47	31
Mon 9 Jul	52	30	51	37
Tue 17 Jul	51	44	50	42
Sun 15 Jul	44	43	44	42
Sat 30 Jun	46	27	45	31
Mon 2 Jul	51	28	49	38
Time Period	7am to 6pm	6pm to 10pm	7am to 10pm	10pm to 7am
Existing Leq	**48**	**37**	**47**	**39**

Table 2.8: Ambient LAeq 2012 noise levels at rural property boundary north of the Proposal area (W-ML4)

	Day dB(A)	Evening dB(A)	Daytime dB(A)	Night dB(A)
Sat 23 Jun	43	32	42	32
Mon 25 Jun	42	29	41	33
Tue 26 Jun	43	29	42	32
Fri 29 Jun	43	36	42	36
Sun 8 Jul	ND	25	ND	ND
Mon 9 Jul	43	26	41	34
Tue 17 Jul	ND	ND	ND	ND
Sun 15 Jul	ND	ND	ND	ND
Sat 30 Jun	44	32	42	34
Mon 2 Jul	43	31	42	33
Time Period	7am to 6pm	6pm to 10pm	7am to 10pm	10pm to 7am
Existing Leq	**43**	**31**	**42**	**33**

3. Noise Assessment Criteria

3.1 Operational noise criteria

Under the provisions of the *Protection of the Environment Act 1997,* any premises that has the capacity to produce more than 5 petajoules of gas per annum must hold an environmental protection licence. The licence may contain noise conditions for the Proposal. For this assessment 'best practice' has been applied to assume noise conditions may be applied to this part of the Proposal.

Potentially relevant legislation and guidelines include:

- Protection of the Environment Operations Act 1997 (POEO Act),
- Protection of the Environment Operations (General) Regulation 1998,
- Protection of the Environment Operations (Noise Control) Regulation 2000,
- NSW Industrial Noise Policy (INP), DEC January 2000,
- Interim Construction Noise Guideline, 2009
- Environmental Criteria for Road Traffic Noise (ECRTN), DEC, May 1999,
- NSW Environmental Noise Control Manual or ENCM (DEC Ref. 94/31),
- NSW Roads and Maritime Services Road Noise Policy (RNP) March 2011
- Environmental Noise Management, Noise Guide for Local Government (DEC Ref.2004/59).

Not all of the above need to be considered for this assessment. Noise generated within the Proposal area, including construction noise, noise from plant, truck movements, loading/unloading activities, mechanical services associated with site buildings, are assessed in accordance with the INP guidelines. Noise of the type that would be generated by the Proposal is classified under the INP as '*industrial noise*'. The INP assessment procedure for industrial noise sources has two components, which are:

- Controlling intrusive noise impacts in the short term for residences; and
- Protecting noise amenity for particular land uses and for residences.

3.2 Intrusive noise impacts

The INP states that the noise from any single source should not intrude greatly above the prevailing background noise level. Industrial noises are generally considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (L_{Aeq}), measured over a 15 minute period, does not exceed the background noise level (RBL), measured in the absence of the source, by more than 5 dB. This is termed the *Intrusiveness Criterion*. The RBL is the background noise level to be used for assessment purposes and is determined by the methods given in Section 3.1 of the INP. In accordance with the INP requirements, adjustments are to be applied to the level of noise produced if the noise at the receptor contains annoying characteristics such as tonality or impulsiveness.

3.3 Protecting noise amenity

To limit continuing increases in noise levels, the ambient noise level resulting from industrial type noise sources should not

normally exceed the acceptable noise levels specified in *Table 2.1* of the INP. That is, the industrial noise level contribution should not exceed the level appropriate for the particular locality and land use. This is termed the *Amenity Criterion*. Most applicable to this assessment are the amenity criteria for residential receptors in a '*Rural*' area and passive recreation areas. The recommended maximum values provide guidance on an upper limit to the level of noise from industry and industrial type facilities. In all cases, it is expected that all feasible and reasonable mitigation measures would be applied before the recommended upper limit noise levels are referenced.

3.4 Operation of Pilot

The site specific environmental noise criteria, which are derived based on existing ambient conditions, take into account the operational activities described in **section 1.2**. The predicted levels from the pilot are below the RBL of 30 dB(A).

3.5 Sleep disturbance criteria

The INP discusses sleep disturbance and its objective assessment. To reduce the risk of sleep disturbance as a result of industrial type operations during the night-time period, Table 2.1 has a recommended amenity criterion of 40 dB(A) LAeq for night-time at a residence in a rural area. *(Note – in quiet rural areas and a low background level at night an activity level of 40 dB(A) at the outdoor façade will be audible indoors).* The INP application notes recommend that the L_{A1}(1 minute) noise level outside a bedroom window should not exceed the L_{A90} background noise level by more than 15 dB(A) during the night-time period (10.00 pm to 7.00 am).

3.6 Sound character

The character of the sound emissions from the site construction, drilling, and pilot well operation is different to that the existing environment. Low frequency sound (for example, generator sound), impulsiveness (for example, the clanging of drill pipes) and possible tonal noise (for example, from generators) are the most common sounds noticed at a distance under enhanced propagation conditions. The guidelines suggest a 'penalty' or 'adjustment' based on the degree that the sound may be noticed. A value of +5dB(A) is added to the modelled sound levels to represent "tonal components that are clearly audible and their presence can be detected by one-third octave analysis". If the sound is only just detectable by the observer and is determined by narrow-band analysis an adjustment of 2 to 3 dB is more appropriate.

3.7 Interim Construction Noise Guideline

The Proposal is considered a mining project for the purpose of this noise assessment. In accordance with the recommendations in the Interim Construction Noise Guidelines (ICNG), the construction activities for mining projects are to be assessed under the INP, therefore the operational noise criteria presented previously will also apply to construction works associated with the Proposal.

The duration of works associated with a well site is in the order of weeks, with the greatest noise emissions (drilling) limited to approximately one week. In this context the drilling is akin to short-term construction noise and as such appropriate assessment guidelines are detailed in the *Interim Construction Noise Guideline* (ICNG, DECC 2009).

The Guideline presents noise management levels for use when undertaking a quantitative assessment, such as for major construction projects. The recommended standard hours are-

- Monday to Friday 7am to 6pm
- Saturdays 8am to 1pm
- No work on Sundays or public holidays

Construction Noise Criteria

The noise management level for works during the recommended standard hours is background + 10 dB(A). Above this noise level the proponent needs to implement all feasible and reasonable work practices, as defined in the Guideline, to minimise noise impacts.

For works outside the recommended standard hours, the noise management level is background + 5 dB(A).

The highly noise-affected level of LAeq 75 dB(A) represents the point above which there may be strong community reaction to noise and indicates a need to consider other feasible and reasonable ways to reduce noise, such as restricting the times of very noisy works to provide respite to affected residences.

It is noted that soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

3.8 Road Traffic Noise – Road Noise Policy

The *NSW Road Noise Policy* (RNP) came into effect on 1 July 2011 and aims to identify strategies that address the issue of road traffic noise from, inter alia, new traffic-generating developments. It also defines criteria to be used in assessing the impact of such noise, based on protecting amenity and wellbeing. Although it is not mandatory, per se, to achieve the noise assessment criteria in the RNP, proponents of a proposal will need to provide justification if it is not considered feasible or reasonable to achieve them.

The application fits the general character of the situation set out in Section 2.2.2 of the RNP – *Principal haulage routes along public roads.* In this section the noise criteria is set out for a route that is not served by an arterial route (although the highways are by definition arterial they are also subject to lower traffic flows than normal arterial routes). Table 3 of the RNP sets out the criteria to be applied; see **Table 3.8.1** following.

Table 3.8.1 – Table 3 of the RNP

Road category	Type of project/land use	Assessment criteria – dB(A)	
		Day (7 a.m.–10 p.m.)	Night (10 p.m.–7 a.m.)
Freeway/ arterial/ sub-arterial roads	1. Existing residences affected by noise from **new** freeway/arterial/sub-arterial road corridors	$L_{Aeq, (15\ hour)}$ 55 (external)	$L_{Aeq, (9\ hour)}$ 50 (external)
	2. Existing residences affected by noise from **redevelopment** of existing freeway/arterial/sub-arterial roads 3. Existing residences affected by **additional traffic** on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq, (15\ hour)}$ 60 (external)	$L_{Aeq, (9\ hour)}$ 55 (external)
Local roads	4. Existing residences affected by noise from **new** local road corridors 5. Existing residences affected by noise from **redevelopment** of existing local roads 6. Existing residences affected by **additional traffic** on existing local roads generated by land use developments	$L_{Aeq, (1\ hour)}$ 55 (external)	$L_{Aeq, (1\ hour)}$ 50 (external)

It is noted that special criteria apply under the RNP for particular uses such as schools and hospitals (internal and external).

In addition to the criteria set out in **Table 3.8.1** above, any increase in noise levels for sensitive uses of more than 12dB(A) for the day/evening or night periods will require mitigation to be considered. This is known as the "relative increase criteria", see **table 3.8.2** below.

Table 3.8.2 – Relative increase criteria for residential land uses (Table 6 of the RNP)

Road category	Type of project/development	Total traffic noise level increase – dB(A)	
		Day (7 a.m.–10 p.m.)	Night (10 p.m.– 7 a.m.)
Freeway/arterial/ sub-arterial roads and transitways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road	Existing traffic $L_{Aeq, (15\ hour)}$ + 12 dB (external)	Existing traffic $L_{Aeq, (9\ hour)}$ + 12 dB (external)

4. Noise Calculations – Impact Assessment

4.1 Environmental noise prediction method

The method of prediction is ideally suited to a combination of both ISO 9613-2 and CONCAWE methods. The calculation programs available for this purpose are (a) SoundPLAN, which has both methods as separate modules, and (b) PEN3D, an environmental noise model developed by Noise Mapping Services Pty Ltd Queensland. The PEN3D environmental model is the program used in this Report. It is a faithful representation of the Environmental calculation method described in the book by Bies & Hansen *"Environmental Noise Control"*. The program has both propagation methods and is described in **Annex C**.

The noise model is based on an assessed flat topography as the land effectively flat within the 5 km of the pilot wells to the nearest residences. Tonality is not allowed for in the models and is added into the calculation tables.

4.2 Meteorological conditions

Meteorological conditions such as the presence of a temperature inversion or light to moderate winds can have a significant effect on sound propagation. Temperature inversions (i.e. when the normal temperature profile of the atmosphere is reversed such that the air temperature increases with increasing height above ground) typically occur at night during winter periods and tend to assist the propagation of noise. Based upon information provided by Heggies (see **Annex B**), the occurrence of F class or greater temperature inversions is approximately 20% or less during the winter months. The INP suggests that the effects of temperature inversions on noise levels be assessed in locations where occurrence approaches or is in excess of 30%. Modelling, in calm conditions, with a 3m/s breeze blowing towards the nearest residences, and in inversion conditions, was conducted as part of this assessment.

4.3 Operational activities

All operational equipment was assumed to be running 24 hours per day, 7 days a week, with similar capacity during the day, evening and night-time periods. All noise sources were modelled as point sources as the distance between source and receptor is large enough to warrant this assumption. Operational activities with the potential to create a noise impact within the Proposal area are described previously and for prediction purposes consist of:

- Site clearing (not required at Bibblewindi 31 and 32 as these utilise existing sites 14 and 19H respectively) sound power level of 120 dB(Lin) or 118 dB(A), LAeq 1 hour
- Well drilling sound power level of 120 dB(Lin) or 118 dB(A), LAeq 1 hour
- Pilot well operation sound power level of 114 dB(Lin) or 97 dB(A), LAeq, 1 hour

Sound Power levels are derived from measurements previously undertaken by Noise Measurement Services and presented in **Annex A**. It may be that a specific rig, measured by Wilkinson Murray, is employed, and information from those surveys are also set out in **Annex A** (for cross reference purposes).

Well Operation

Noise predictions have been made for well operation to the nearest identified residential receptors to the Bibblewindi wells. The distances of the five nearest residential receptors to the Bibblewindi locations are shown in the predictions tables, **Table 4.3.1 and 4.3.2.** Scenarios 1 to 10 relate to noise levels from each of Bibblewindi 31 and 32 (scenarios 1 to 5 and 6 to 10 respectively). Scenarios 11 to 13 are an assessment of the two pilot wells (31 and 32) in operation at the same time and scenarios 14 to 16 are for all of the wells in the Bibblewindi Multi-lateral pilot (wells 12, 13, 14, 15, 16, 17, 18H, 19H, 21H, 28H, 31 and 32) in operation at the same time. Note that the inversion is stability 'F' and calculated as a temperature gradient of 3.0 °C/100m, 10°C ambient, 50% relative humidity. All residential receptors were modelled at a height of 1.8 m above ground level.

The noise criterion to be achieved is established as the Intrusive Noise Criterion under the INP. This is the Rating Background Level plus 5 dB(A) and is established as L_{Aeq} 35 dB.

As the exact location of the residences are not known (the locations have been estimated as closely as possible from Google Earth) the calculations are predicted in the free-field or nominally 5 metres from the assessed residence location. At the distances involved this assessment will not give rise to a significant variation in activity sound level. **Table 4.3.1** gives the predicted free-field values and **Table 4.3.2** gives the predicted time-average L_{Aeq} sound levels at the facades of the residences.

Table 4.3.1: Bibblewindi 31 and 32: Noise 'Most Likely' Predicted Levels (LAeq), Noise Criteria, and Distances to Residences. Sound levels are rounded and calculated to 5 metres from the façade ('free-field')

Residence	Distance (km) from site	Scenario 1 dB(A)	Scenario 2 dB(A)	Scenario 3 dB(A)	Scenario 4 dB(A)	Scenario 5 dB(A)
R1	8.3	<15	<15-15	<15	<15	<15
R2	9.2	<15	<15	<15	<15	<15
R3	9.5	<15	<15	<15	<15	<15
R4	8.2	<15	<15-15	<15	<15	<15
R5	7.5	<15	16-17	<15	<15	<15
Plant		Drilling	Drilling	Well	Well	Well
Weather		Calm	southerly	Calm	Southerly	inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

Table 4.3.2A: Bibblewindi 31 and 32 combined: Noise 'Most Likely' Predicted Levels (LAeq), Noise Criteria, and Distances to Residences. Sound levels are rounded and calculated at the residential façade

Residence	Distance (km) from site	Scenario 11 dB(A)	Scenario 12 dB(A)	Scenario 13 dB(A)
R1	8.3	<15	16	<15
R2	9.2	<15	<15	<15
R3	9.5	<15	<15	<15
R4	8.2	<15	16	<15
R5	7.5	<15	17	<15
Plant		Well	Well	Well
Weather		Calm	Southerly	inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

Table 4.3.2B: Bibblewindi multi lateral pilot combined: Noise 'Most Likely' Predicted Levels (LAeq), Noise Criteria, and Distances to Residences. Sound levels are rounded and calculated at the residential façade

Residence	Distance (km) from site	Scenario 14 dB(A)	Scenario 15 dB(A)	Scenario 16 dB(A)
R1	8.3	16	24	17
R2	9.2	15	23	16
R3	9.5	15	23	16
R4	8.2	17	25	18
R5	7.5	18	26	19
Plant		Well	Well	Well
Weather		Calm	Southerly	Inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

The noise emissions from the operation of the new Bibblewindi pilot wells together, under temperature inversion conditions, is calculated at approximately 18 dB(A) LAeq, at 5 km from the wells. This is significantly less than that predicted for the Bibblewindi field as a whole and the new Bibblewindi pilots (31 and 32) do not contribute significantly to the overall levels. The duration of noise from pilot well is taken as being '24/7' and is calculated on a 15-minute or 1-hour basis. This also applies to the operation of the drill rig. All other activities are taken as being 7am to 6pm daily.

Drilling

The 'worst case' assessments for noise from the drilling rig (or from similar noisy plant and machinery such as excavators) are given in **Table 4.3.3**. The weather conditions in the **Table 4.3.3** relate to 'calm' conditions where there is no breeze blowing towards a residence; and 'enhanced' conditions when there is a 3 m/s breeze blowing towards a residence.

Table 4.3.3: Predicted 'Worst Case' LAeq Sound Levels at Various Offset Distances for the drilling rig operation (or similar plant such as excavators) alone

Drill Rig and Operation	Weather Condition	Predicted LAeq Sound Level at Buffer Distances (metres) dB(A)						
		50m	100m	500m	1000m	1500m	2000m	5000m
Open Hole Drilling	Calm	70	62	45	36	30	25	<10
	Enhanced	70	64	48	39	33	29	<10
Running casing	Calm	70	62	45	36	30	25	<10
	Enhanced	72	64	47	38	32	27	<10
Cementing Casing	Calm	70	62	45	36	30	25	<10
	Enhanced	77	69	51	41	35	30	13
Core Drilling	Calm	64	58	41	33	27	23	<10
	Enhanced	68	61	43	35	29	25	<10

INP Intrusiveness Assessment (Wells)

Table 4.3.4 presents an assessment of the INP guideline values for Intrusive Noise with respect to the potential noise sources as they affect the residences. The criterion is 35 LAeq.

Table 4.3.4A: Bibblewindi 31 *or* 32: Compliance with Intrusive Noise Guideline of 35 dB(A) LAeq façade level

Residence	Distance (km) from site	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
R1	8.3	Pass	Pass	Pass	Pass	Pass
R2	9.2	Pass	Pass	Pass	Pass	Pass
R3	9.5	Pass	Pass	Pass	Pass	Pass
R4	8.2	Pass	Pass	Pass	Pass	Pass
R5	7.5	Pass	Pass	Pass	Pass	Pass
Plant		Drilling	Drilling	Well	Well	Well
Weather		calm	southerly	calm	southerly	Inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

Table 4.3.4B: Bibblewindi 31 *and* 32: Compliance with Intrusive Noise Guideline of 35 dB(A) LAeq façade level

Residence	Distance (km) from site	Scenario 11	Scenario 12	Scenario 13
R1	8.3	Pass	Pass	Pass
R2	9.2	Pass	Pass	Pass
R3	9.5	Pass	Pass	Pass
R4	8.2	Pass	Pass	Pass
R5	7.5	Pass	Pass	Pass
Plant		Well	Well	Well
Weather		calm	southerly	inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

Table 4.3.4C: Bibblewindi Multi-Lateral Pilot: Compliance with Intrusive Noise Guideline of 35 dB(A) LAeq façade level

Residence	Distance (km) from site	Scenario 12	Scenario 13	Scenario 14
R1	8.3	Pass	Pass	Pass
R2	9.2	Pass	Pass	Pass
R3	9.5	Pass	Pass	Pass
R4	8.2	Pass	Pass	Pass
R5	7.5	Pass	Pass	Pass
Plant		Well	Well	Well
Weather		calm	southerly	inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

INP Sleep Amenity (Wells)

Table 4.3.5 presents an assessment of the INP guideline values for Sleep Amenity (measured outdoors) with respect to the potential noise sources as they affect the residences. The criterion is 40 LAeq.

Table 4.3.5A: Bibblewindi 31 *or* 32: Compliance with Amenity (sleep) Guideline of 40 dB(A) LAeq façade level

Residence	Distance (km) from site	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
R1	8.3	Pass	Pass	Pass	Pass	Pass
R2	9.2	Pass	Pass	Pass	Pass	Pass
R3	9.5	Pass	Pass	Pass	Pass	Pass
R4	8.2	Pass	Pass	Pass	Pass	Pass
R5	7.5	Pass	Pass	Pass	Pass	Pass
Plant		Drilling	Drilling	Well	Well	Well
Weather		calm	southerly	calm	southerly	inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

Table 4.3.5B: Bibblewindi 31 *and* 32: Compliance with Amenity (sleep) Guideline of 40 dB(A) LAeq façade level

Residence	Distance (km) from site	Scenario 11	Scenario 12	Scenario 13
R1	8.3	Pass	Pass	Pass
R2	9.2	Pass	Pass	Pass
R3	9.5	Pass	Pass	Pass
R4	8.2	Pass	Pass	Pass
R5	7.5	Pass	Pass	Pass
Plant		Well	Well	Well
Weather		calm	southerly	inversion

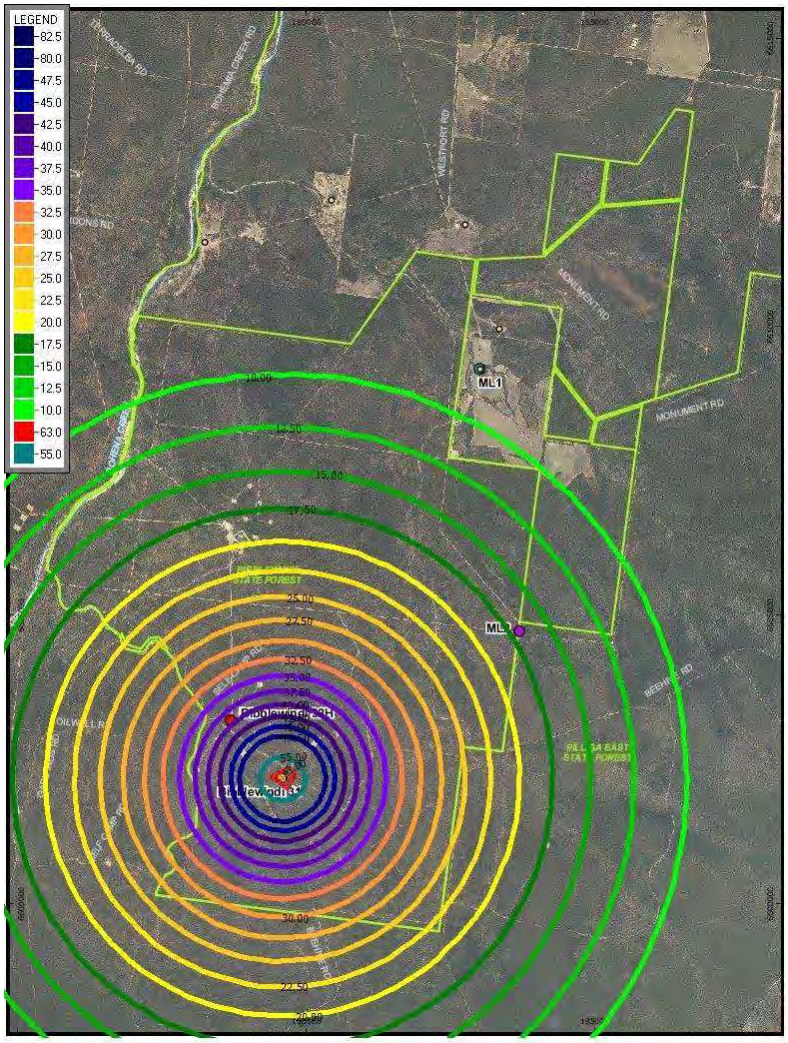
Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

Table 4.3.5C: Bibblewindi Multi-Lateral Pilot: Compliance with Amenity (sleep) Guideline of 40 dB(A) LAeq façade level

Residence	Distance (km) from site	Scenario 11	Scenario 12	Scenario 13
R1	8.3	Pass	Pass	Pass
R2	9.2	Pass	Pass	Pass
R3	9.5	Pass	Pass	Pass
R4	8.2	Pass	Pass	Pass
R5	7.5	Pass	Pass	Pass
Plant		Well	Well	Well
Weather		calm	southerly	inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

Note that measured distances from Bibblewindi 31 to the 5 receivers vary from 7800 to 10,000 metres, and from Bibblewindi 32 the distance to the receivers ranges from 7400 to 9500 metres. The distances in **Table 4.3.x** above are for the site as a whole.

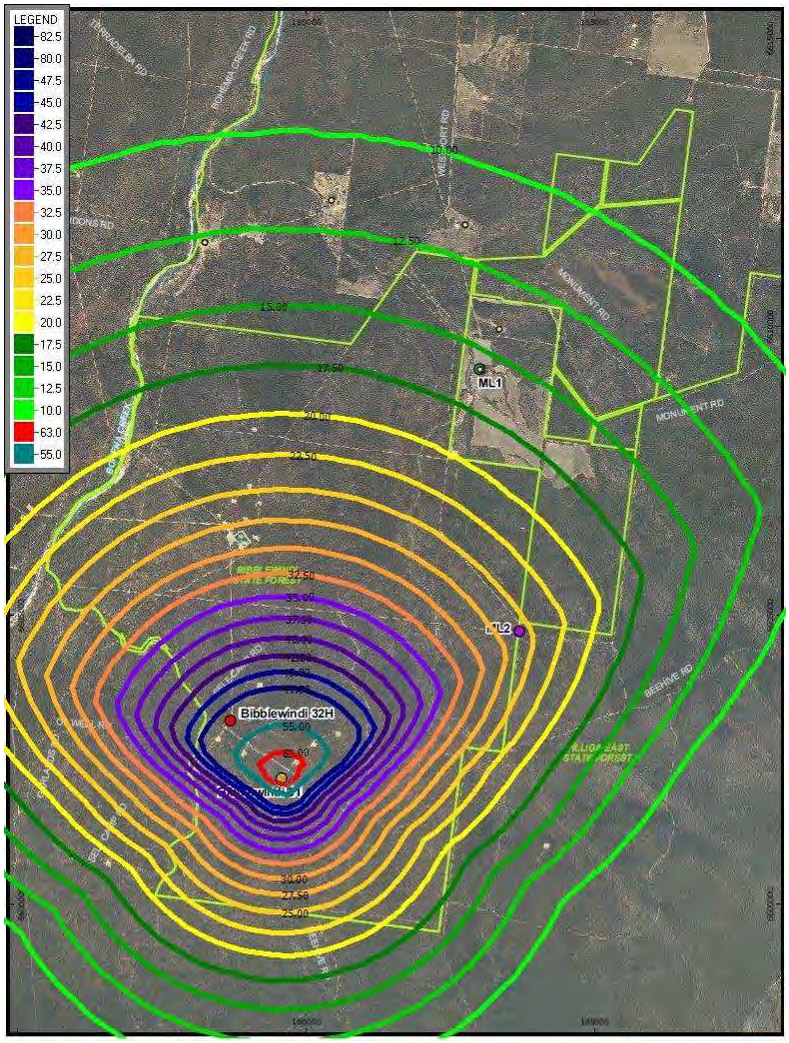


Scenario 1: Bibblewindi 31 site operations or single drilling rig, calm weather

Scenario 1: Point calculations for site operations or single drilling rig (Bibblewindi 31)

Plant Sound Power Level	dB(Lin)	dB(A)
Excavators or drill rig	120	118
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	calm	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	5.2	
R2	4.2	
R3	4.1	
R4	6.5	
R5	8.0	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

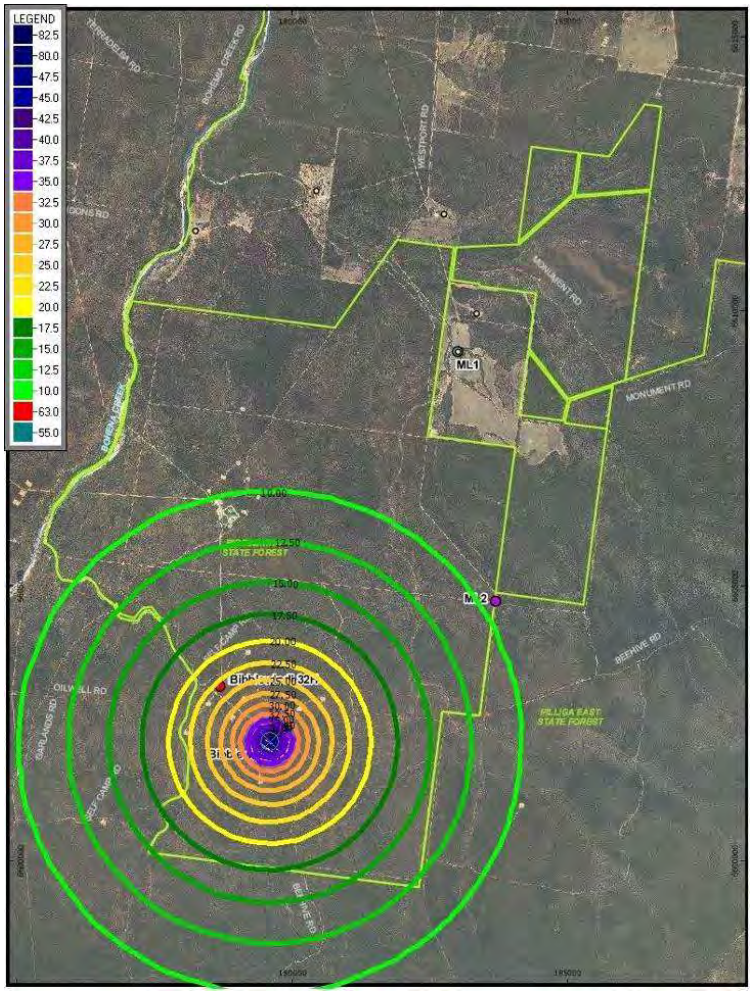


Scenario 2: Bibblewindi 31 site operations or single drilling rig, wind 3 m/s from south

Scenario 2: Point calculations for site operations or single drilling rig (Bibblewindi 31)

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Excavators or drill rig	120	118
Wind speed (modelled, m/s)	3	
Wind direction (modelled)	southerly	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	12.8	
R2	11.7	
R3	11.6	
R4	14.1	
R5	15.8	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

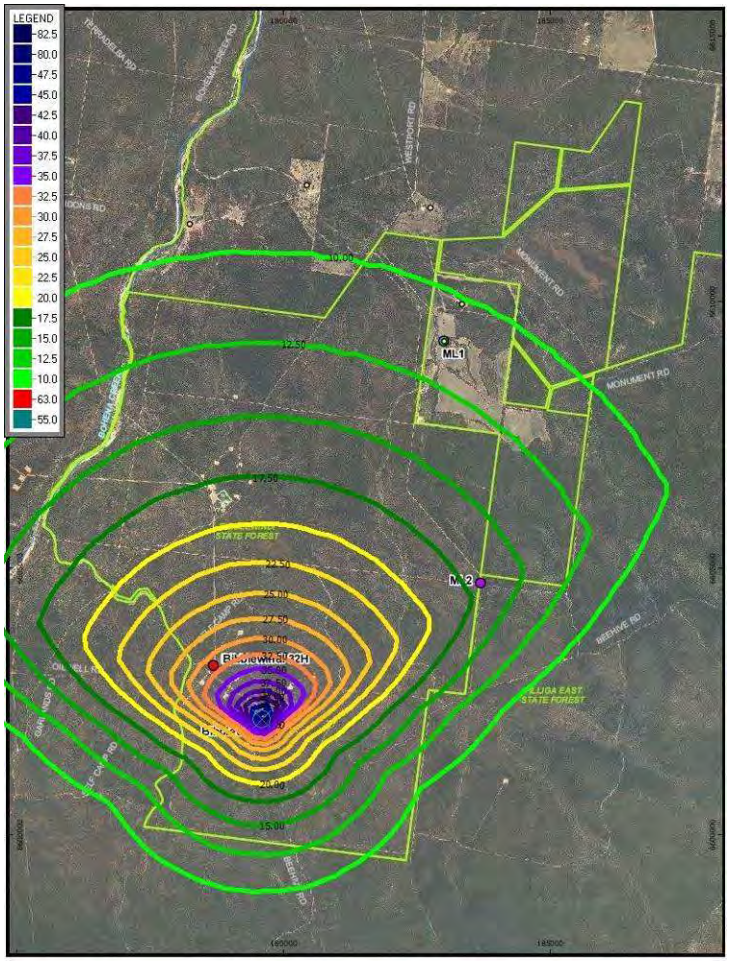


Scenario 3: single pilot well, Bibblewindi 31, calm weather

Scenario 3: Point calculations for single pilot well (Bibblewindi 31)

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Pilot well with generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	calm	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	1.7	
R2	0.9	
R3	0.9	
R4	2.7	
R5	3.8	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

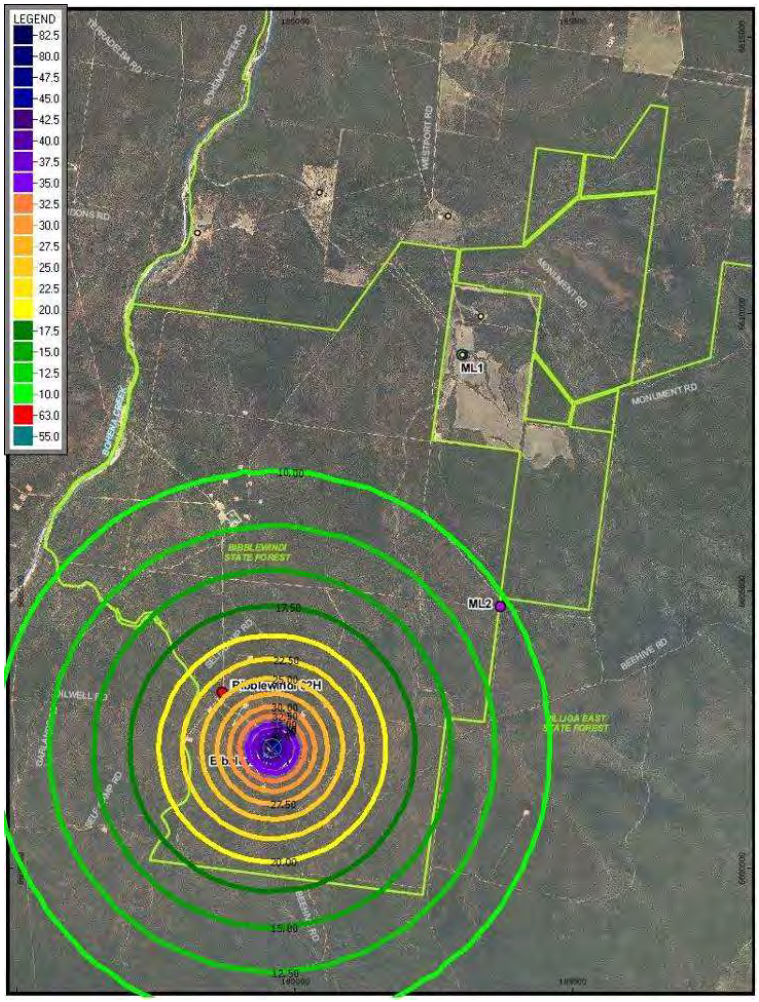


Scenario 4: single pilot well, Bibblewindi 31, wind at 3 m/s from the south

Scenario 4: Point calculations for single pilot well (Bibblewindi 31)

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Pilot well with generator	114	88
Wind speed (modelled, m/s)	3	
Wind direction (modelled)	southerly	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	9.3	
R2	8.5	
R3	8.4	
R4	10.2	
R5	11.3	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

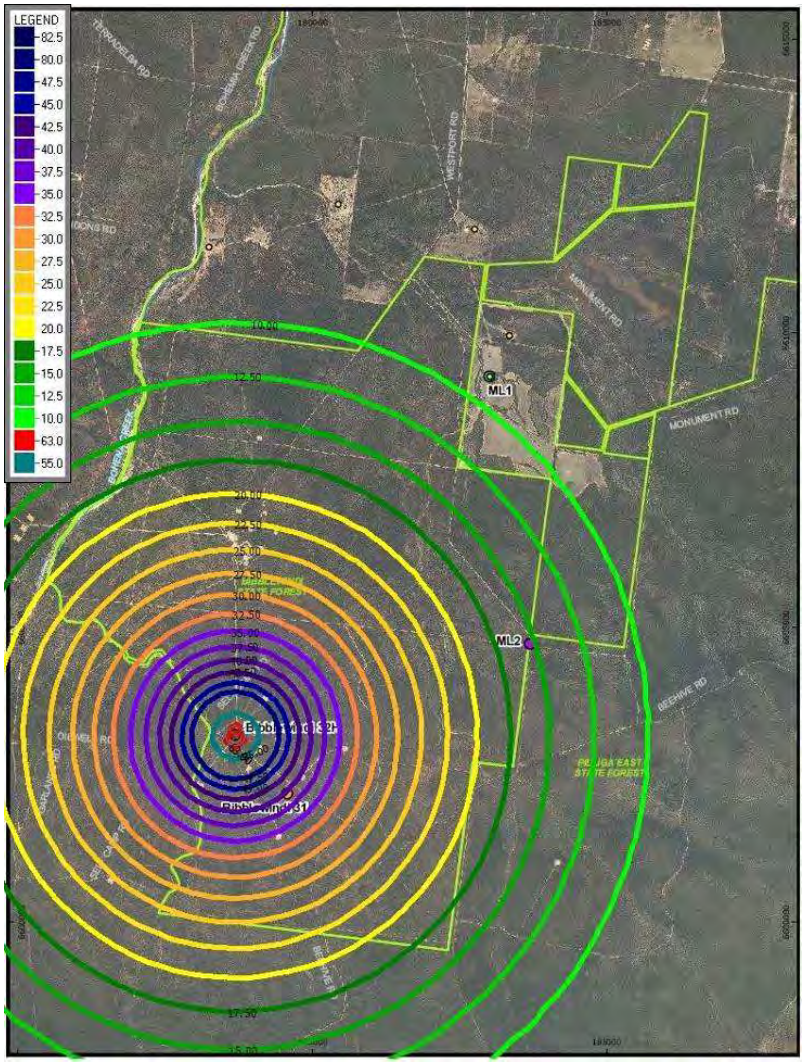


Scenario 5: single well, Bibblewindi 31, Stability factor 'F' resulting in inversion

Scenario 5: Point calculations for single pilot well (Bibblewindi 31)

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Pilot well with generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	Inversion 'F' with temperature gradient 3°C/100m	
Temperature (modelled, °C)	10	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	2.7	
R2	1.9	
R3	1.8	
R4	3.6	
R5	4.7	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

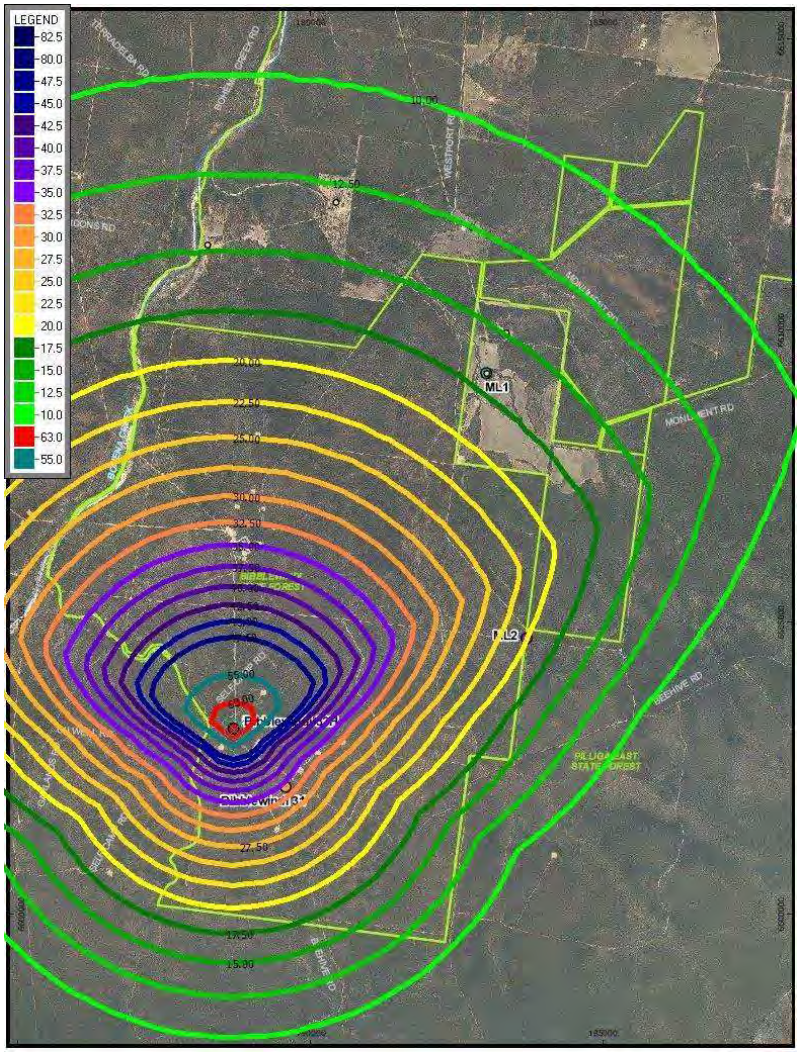


Scenario 6: Bibblewindi 32 site operations or single drilling rig, calm weather

Scenario 6: Point calculations for site operations or single drilling rig (Bibblewindi 32)

Plant Sound Power Level	dB(Lin)	dB(A)
Excavators or drill rig	120	118
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	calm	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	7.2	
R2	5.6	
R3	5.0	
R4	7.3	
R5	8.9	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

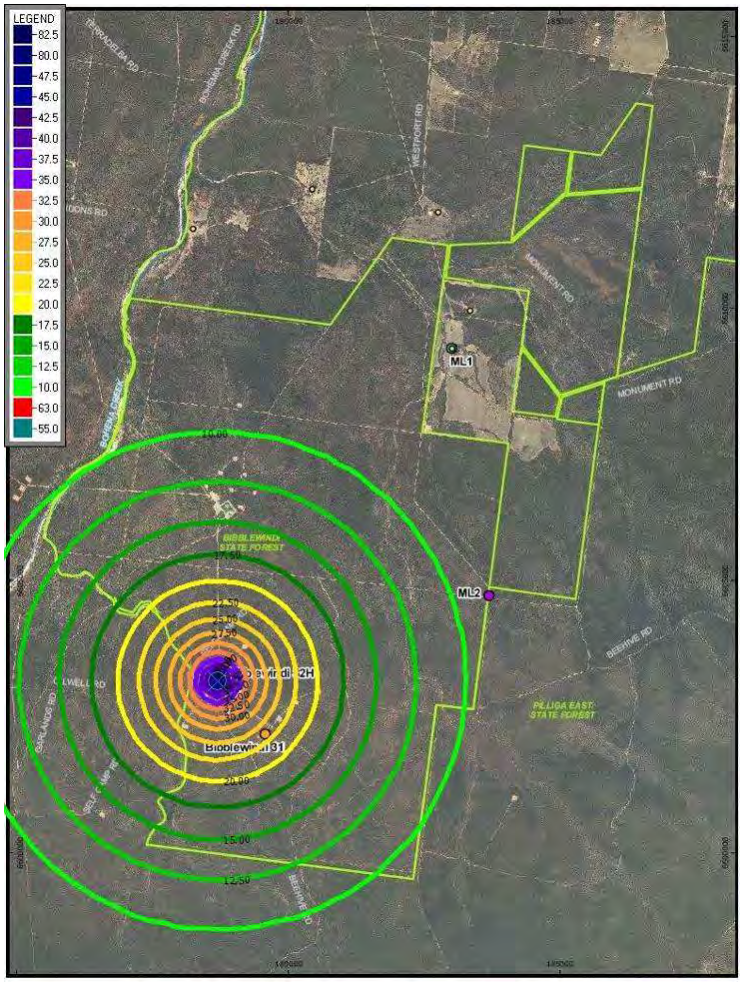


Scenario 7: Bibblewindi 32 site operations or single drilling rig, wind 3 m/s from south

Scenario 7: Point calculations for site operations or single drilling rig (Bibblewindi 32)

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Excavators or drill rig	120	118
Wind speed (modelled, m/s)	3	
Wind direction (modelled)	southerly	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	14.9	
R2	13.1	
R3	12.6	
R4	15.0	
R5	16.7	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

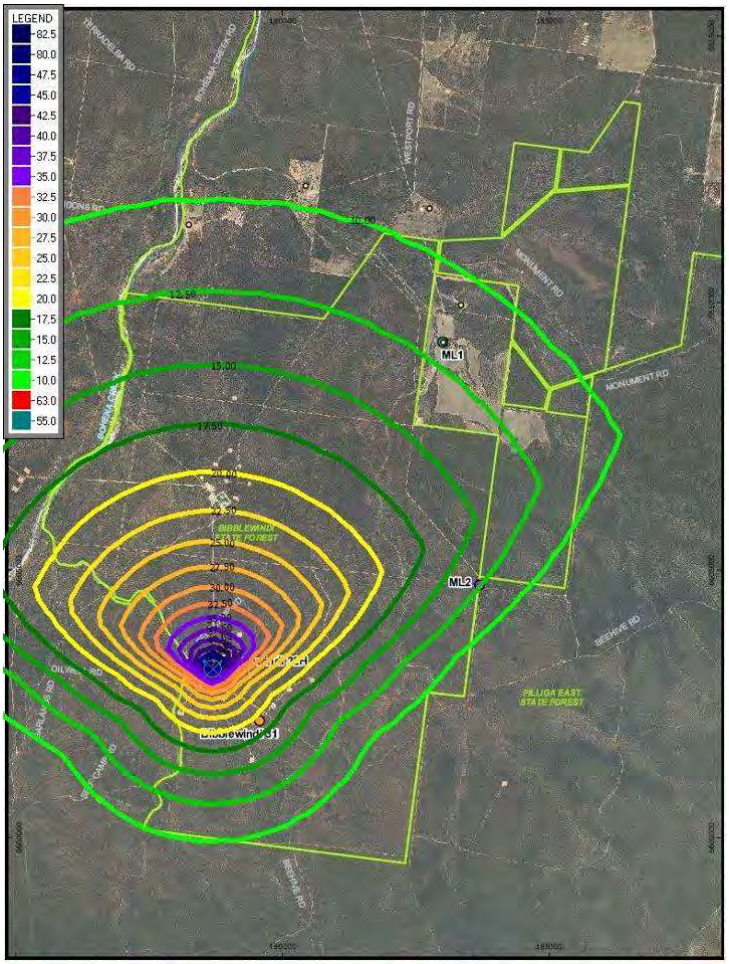


Scenario 8: Single pilot well, Bibblewindi 31, calm weather

Scenario 8: Point calculations for single pilot well (Bibblewindi 32)

Plant Sound Power Level	dB(Lin)	dB(A)
Pilot well with generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	calm	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	3.2	
R2	2.0	
R3	1.6	
R4	3.3	
R5	4.4	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

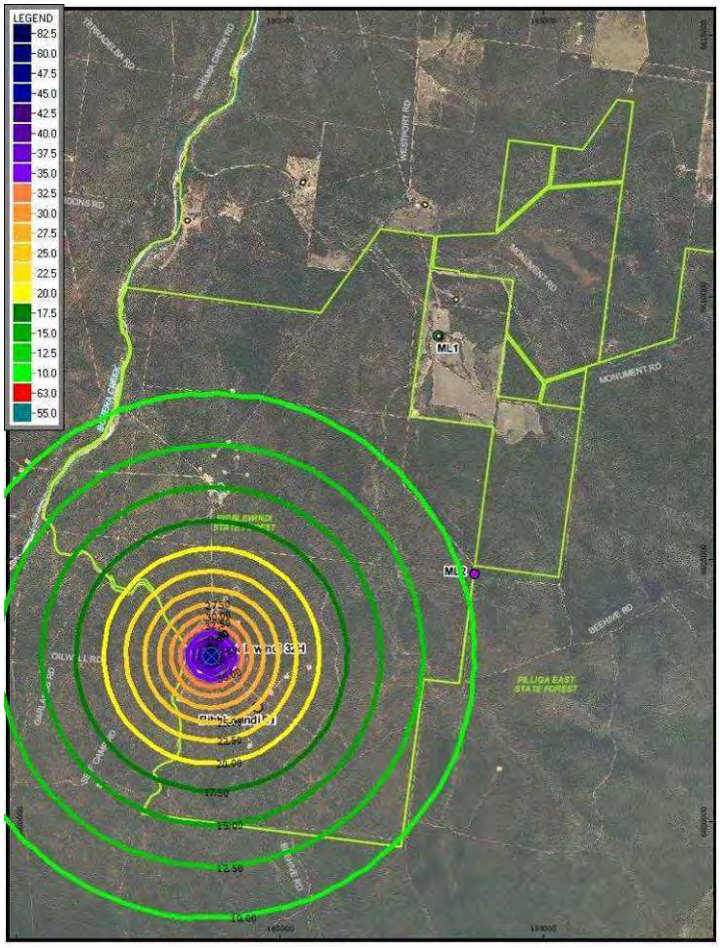


Scenario 9: single pilot well, Bibblewindi 32, wind at 3 m/s from the south

Scenario 9: Point calculations for single pilot well (Bibblewindi 32)

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Pilot well with generator	114	88
Wind speed (modelled, m/s)	3	
Wind direction (modelled)	southerly	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	10.7	
R2	9.5	
R3	9.1	
R4	10.8	
R5	11.9	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

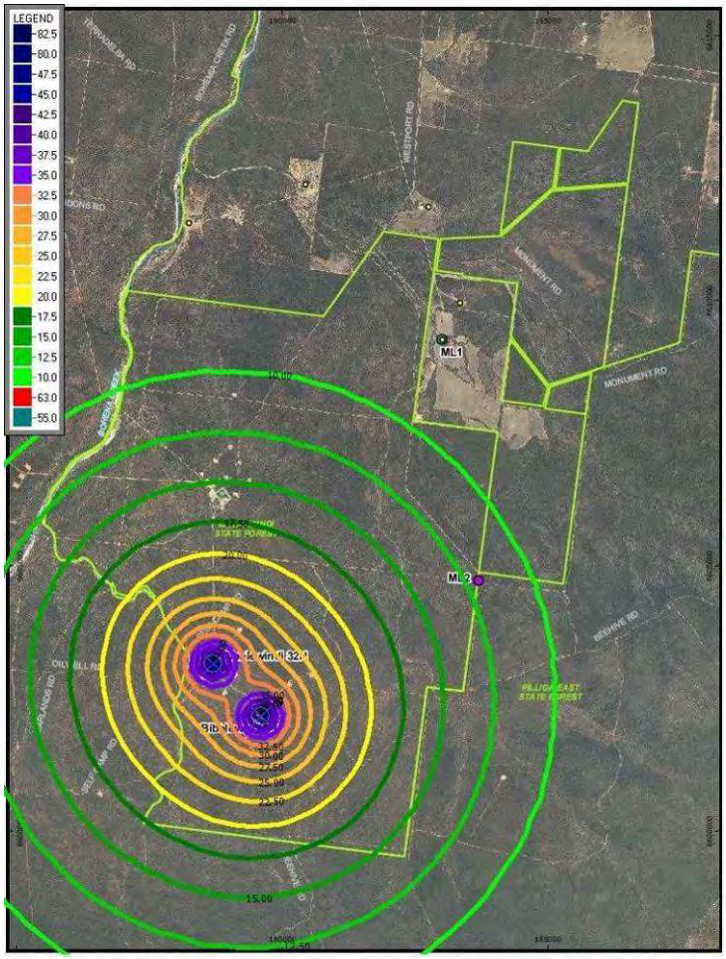


Scenario 10: single well, Bibblewindi 32, Stability factor 'F' resulting in inversion

Scenario 10: Point calculations for single pilot well (Bibblewindi 32)

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Pilot well with generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	Inversion 'F' with temperature gradient 3°C/100m	
Temperature (modelled, °C)	10	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	2.7	
R2	1.9	
R3	1.8	
R4	3.6	
R5	4.7	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

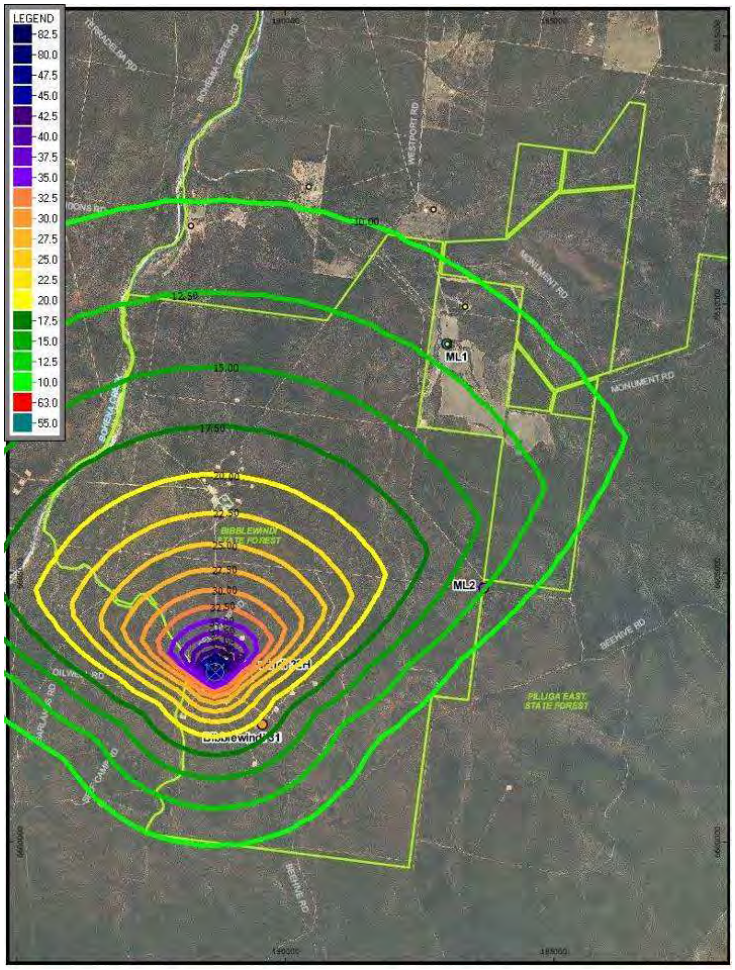


Scenario 11: Two pilot wells, Bibblewindi 31 & 32, calm weather

Scenario 11: Point calculations for two pilot wells (Bibblewindi 31 & 32)

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Pilot well with generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	calm	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	5.5	
R2	4.5	
R3	4.3	
R4	6.0	
R5	7.1	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

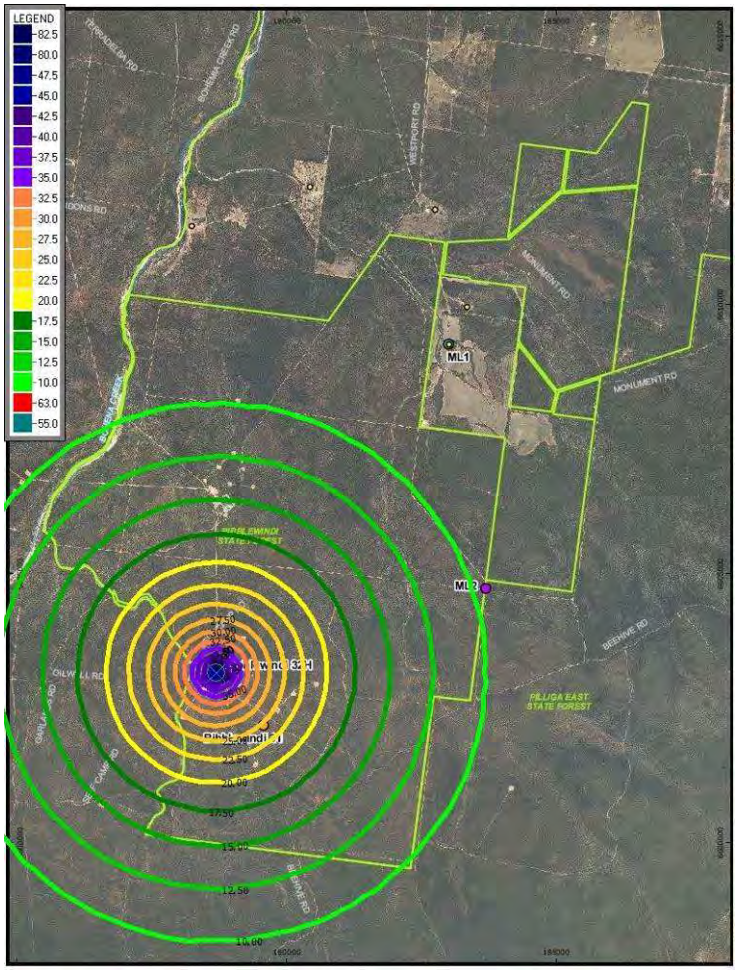


Scenario 12: Two pilot wells, Bibblewindi 31 & 32, wind at 3 m/s from the south

Scenario 12: Point calculations for two pilot wells (Bibblewindi 31 & 32)

Plant Sound Power Level	dB(Lin)	dB(A)
Pilot well with generator	114	88
Wind speed (modelled, m/s)	3	
Wind direction (modelled)	southerly	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	13.1	
R2	12.0	
R3	11.8	
R4	13.5	
R5	14.6	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

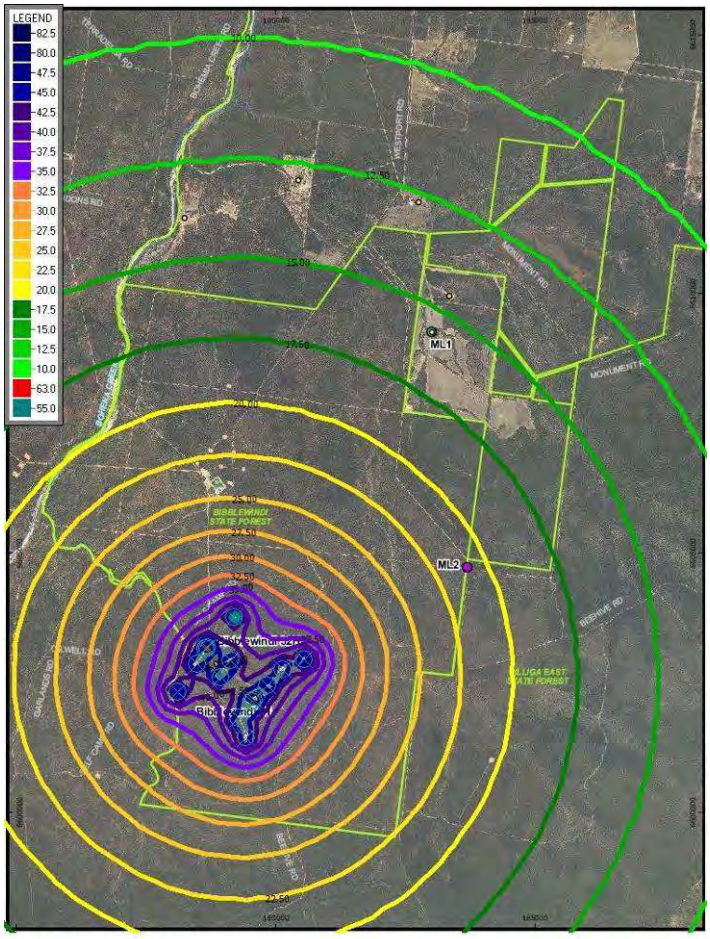


Scenario 13: Two pilot wells, Bibblewindi 31 & 32, Stability factor 'F' resulting in inversion

Scenario 13: Point calculations for two pilot wells (Bibblewindi 31 & 32)

Plant Sound Power Level	dB(Lin)	dB(A)
Pilot well with generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	Inversion 'F' with temperature gradient 3°C/100m	
Temperature (modelled, °C)	10	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	6.5	
R2	5.4	
R3	5.2	
R4	6.9	
R5	8.1	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.



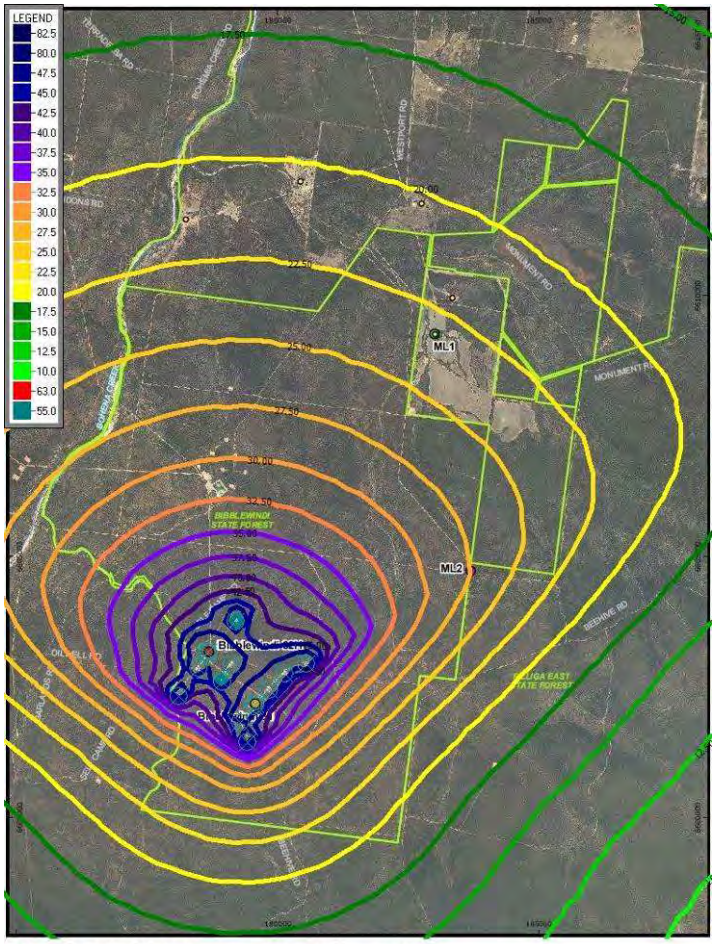
Site 12 - 32: 14 Wells operating, Calm

Scenario 14: All wells including Bibblewindi 31 & 32, calm weather conditions

Scenario 14: Point calculations for all wells including Bibblewindi 31 & 32

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Pilot well with generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	calm	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	13.9	
R2	12.9	
R3	12.7	
R4	14.5	
R5	15.7	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.



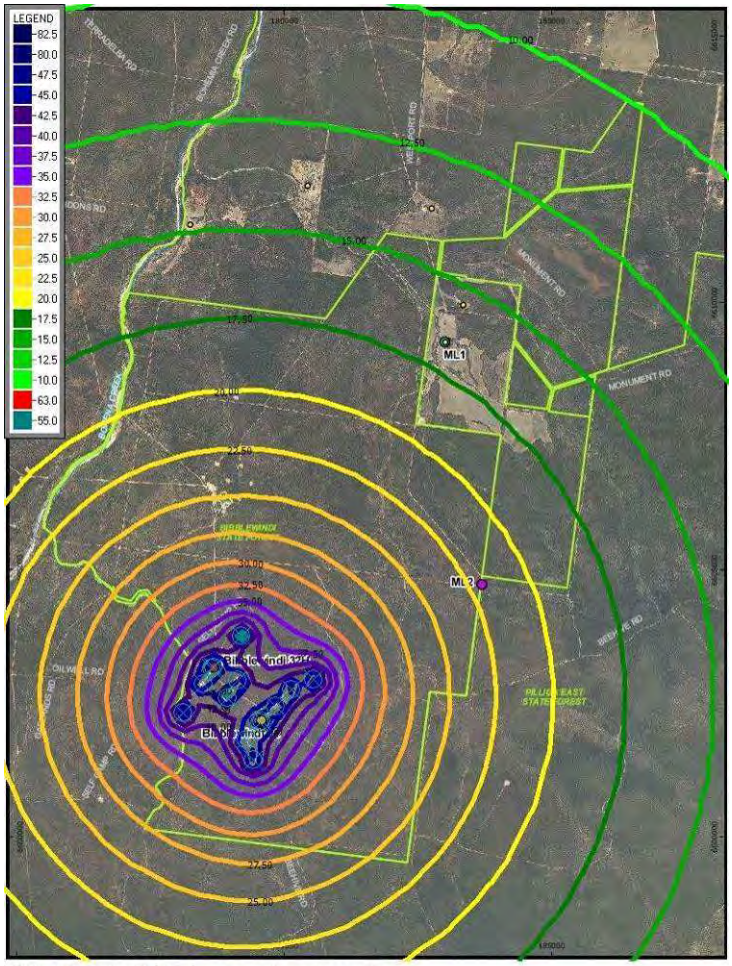
Site 12 - 32: 14 Wells operating, 3m/s southerly

Scenario 15: All wells including Bibblewindi 31 & 32, wind at 3 m/s from the south

Scenario 15: Point calculations for all wells including Bibblewindi 31 & 32

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Pilot well with generator	114	88
Wind speed (modelled, m/s)	3	
Wind direction (modelled)	southerly	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	21.4	
R2	20.5	
R3	20.3	
R4	22.1	
R5	23.2	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.



Site 12 - 32: 14 Wells operating, Inversion

Scenario 16: All wells including Bibblewindi 31 & 32, Stability factor 'F' resulting in inversion

Scenario 16: Point calculations for all wells including Bibblewindi 31 & 32

Plant Sound Power Level	dB(Lin)	dB(A)
Pilot well with generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	Inversion 'F' with temperature gradient 3°C/100m	
Temperature (modelled, °C)	10	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	14.8	
R2	13.9	
R3	13.7	
R4	15.5	
R5	16.6	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

4.4 Road Traffic Noise

4.4.1 Vehicle Volumes – Existing

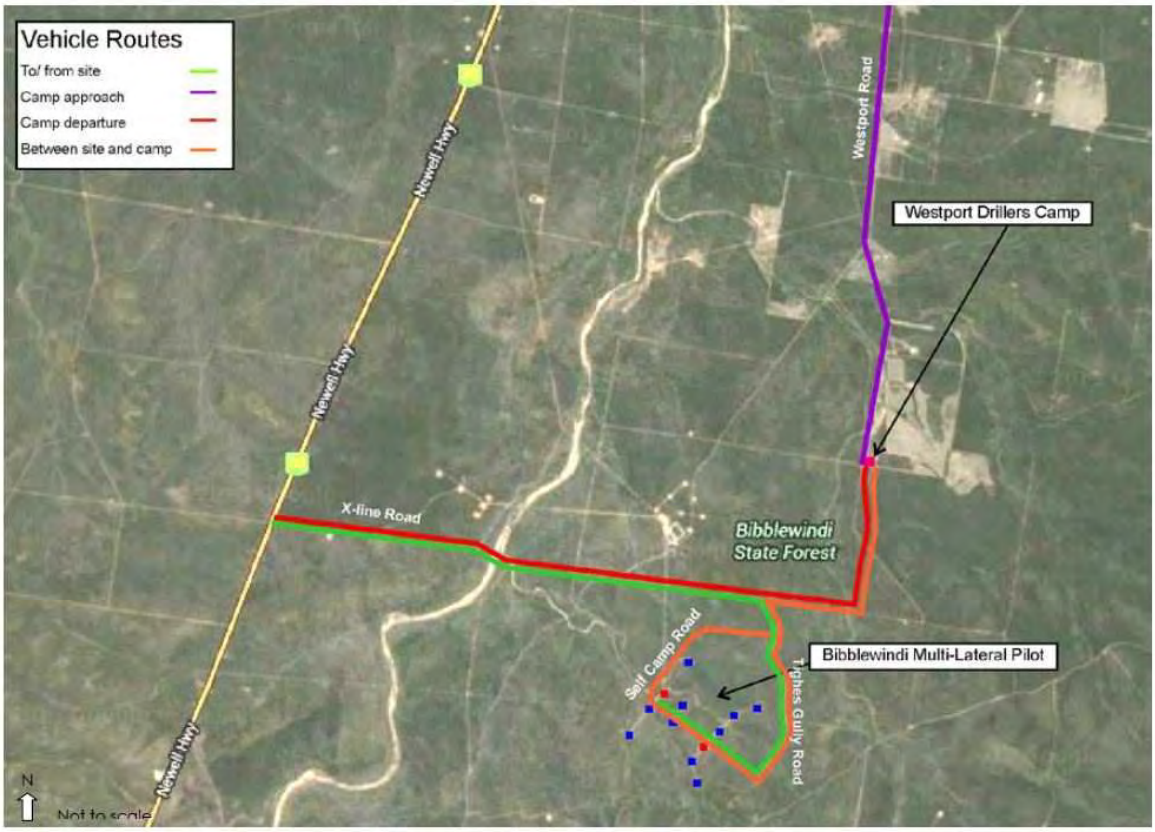
The current traffic flows on the Newell highway are given by Narrabri Council as 1860 vehicles per day with 40% of these being heavy vehicles; this is understood to be a peak period ADT. 18 hour traffic flows (from 6:00am to 12:00 midnight) are 92% of 24 hour traffic flows. State sources give an average of 1465 vehicles per day; this is understood to be a low period ADT. In absolute terms the heavy vehicle content is expected to range between 586 and 744 vehicles per day. 140 vehicles are observed per hour between 8:00am and 4:00pm.

There are currently negligible traffic volumes on X-Line Road.

4.4.2 Traffic Noise Discussion

The proposed activities contemplate the addition of traffic to the Newell Highways, along with X-Line Road from the Newell Highway to the Westport drillers' camp. See **Plate 4.4.2.1** following (GTA plate 4.1).

Plate 4.4.2.1 Vehicle paths to site



The report of GTA Consultants has summarised the impacts during the peak construction period as per **Table 4.4.2.1** following (GTA Table 4.1).

Table 4.4.2.1 Overall Estimated Construction Traffic Volumes

Table 4.1: Overall Estimated Construction Traffic Volumes

Construction Activity	Approximate Duration	Daily Construction Vehicle Generation	Estimated Vehicles per Peak Hour [1]
Site Preparation	20 days	15 [2]	<5
Drilling and Completion	35 days	10	<5
Surface Facilities	50 days	5-10 [3]	<5

[1] Peak hour defined as the maximum number of vehicles likely to be generated in any given hour by construction related vehicles
[2] Includes one vehicle generated by workers during the site preparation activity
[3] Includes three vehicles generated by workers during the surface facilities activity. It is anticipated that 3 vehicles of 4 workers would be generated over the 50 day period.

Peak traffic flows on the Newell Highway will be for a short period at the beginning and end of the process, when heavy vehicles and staff will travel along the highway from Narrabri to the site. An approximate additional traffic flow is, at its highest, 20 vehicles per day and then less than 5 in any given hour. For the balance of the time no more than 1 vehicle movement per day is expected on the Newell Highway during operation.

Newell Highway

In terms of the cumulative effects on nearby sensitive uses, a number of dwellings adjacent to the highways have been identified. It is not confirmed that these are all dwellings, or if they are permanently occupied where they are confirmed to be dwellings, but by treating them all as occupied dwellings the intent is to demonstrate the impact on sensitive uses at varying distances (up to 600m from the Highways, in accordance with the RNP). **Plate 4.4.2.2** shows the position of these dwellings.

Plate 4.4.2.2 Potentially Affected Residences (Newell Highway)



Noise levels associated with the increase in traffic due to the proposed activity are minimal with all construction vehicles and equipment to be delivered during the beginning of the construction works and collected upon completion. Between these times, equipment will remain on site.

The predicted increase in traffic noise over existing levels on the Newell Highway is calculated as at or below 0.1 dB(A) for each of receivers 1 through 13, during peak traffic flows, and will be below the *RNP relative increase* criterion of existing $L_{Aeq, 15hr}$ +12dB (external). The contribution of peak vehicle movements is negligible (i.e. makes no measureable difference, at 0.1dB(A) increase), and during operation will be below this. Noise levels are currently predicted to be at or below the *RNP Table 3 noise limits* and the addition of traffic from this activity will not affect that. Road impacts are therefore considered negligible during construction and will meet the *RNP.* During operation, traffic volumes would be less and would still be considered negligible. The nature of the additional traffic is similar to the nature of existing traffic flows on the Highways.

X-Line Road

Local traffic on X-Line road will include vehicles on shift rotations, and these will be minimal but regular during the construction (approximately 10 movements per day). Traffic flows are below those able to be employed under the CoRTN model, and accordingly an environmental model has been created using a nominal truck and in the vicinity of the Westport drillers' camp and the multilateral pilot. Levels have been compared to the RNP criteria, in **Table 4.4.2.2** following. It is unlikely that, at approximately 1000m to the nearest receiver (R5), traffic at the nearest point (Westport drillers' camp) will be audible. Predicted noise levels are below the local road criterion under the *RNP* (55dB(A) (Leq, 1hr) and are also below the *INP* criterion of 35dB(A) (Leq, 1hr).

Table 4.4.2.2 Nominal truck and car noise levels at Receivers R1 to R5, levels in dB(A) (free field); calm scenario. Sound levels are rounded and calculated at the residential façade

Residence	Distance (km) from site	Predicted levels dB(A)	RNP Criterion dB(A), 1 hr	Pass
R1	8.3	25	55	Yes
R2	9.2	24	55	Yes
R3	9.5	24	55	Yes
R4	8.2	27	55	Yes
R5	7.5	28	55	Yes

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual vehicles to residences varies

Conclusions

Accordingly it is concluded that-

- The overall noise levels produced by road traffic on the Newell Highway will not measurably increase due to the addition of construction and worker traffic.
- Increase in overall noise levels due to traffic movements is minor.
- The nature of the additional traffic is similar to the nature of existing traffic flows on the Highways.
- The increase in overall traffic noise (existing plus operational vehicles, or operation vehicles considered in isolation) is within the criteria established under the *RNP or INP*

5. Conclusions

The noise criteria to be achieved are the Intrusive noise criterion and sleep disturbance criterion under the INP. The Rating Background Level plus 5 dB(A) and is established as LAeq 35 dB. The duration of works associated with a well site is in the order of weeks, with the greatest noise emissions (drilling) limited to approximately one week. In this context the drilling is similar to short-term construction noise and the appropriate assessment guidelines are detailed in the *Interim Construction Noise Guideline.*

As demonstrated in Section 4, all levels calculated in the noise modelling process are within the noise criteria set out in the INP. The levels calculated for Bibblewindi 31 and 32 are significantly below those of the multi-lateral pilot in operation, and do not contribute in any appreciable way to the existing levels. In turn, it is observed that the field as a whole, in drilling or in operation conditions, generates noise substantially below the criteria set out in the INP.

5.1 Summary of Conclusions

It is concluded

- That the drilling stages will not be audible at night when the background levels drop to around 20 dB(A). If, however, unusual adverse weather conditions enhance noise propagation any audible activity would be of short duration. Noise mitigation to the mud-pump (the main source of noise) will reduce further any audible sound.
- That the operation of the pilot wells should not be audible at any of the residences identified in this assessment.
- There are a minimal number of vehicle movements involved in the process, and the impact of the noise from vehicle movements will be minor.

It is concluded therefore that the construction and operation of the Proposal will meet the requirements of the NSW Industrial Noise Policy, the NSW Road Noise Policy, the Interim Construction Noise Guideline and the EPA Environmental Criteria for Road Traffic Noise.

5.2 Noise Management Measures

The proposed activity will generate noise, particularly during drilling and cementing activities, which may occur up to 24 hours per day, seven days per week. The noise management approach should include:

- Consultation with potentially affected receivers
- Monitoring of noise impacts
- Implementation of feasible and reasonable work practices if required
- Complaint management and response.

Noise generated by the proposed development is unlikely to be audible at any residential receivers due to its remote location. Users of the Forest, such as bushwalkers, picnickers and Forests NSW staff, may be affected by noise and

vibration during the works. Forests NSW will be notified of the proposed activity prior to commencing works. This will include details of the timing and duration of noise generating activities.

Santos will aim to maintain noise levels at the rating background level (RBL) plus 10 dB(A) during standard working hours (7am to 6pm Monday to Friday and 8am to 1pm Saturday) and the RBL plus 5 dB(A) outside of standard working hours at the sensitive receiver. The RBL at the site has not been confirmed but is assumed to be no more than 30 dB(A). Noise monitoring will be conducted at the commencement of drilling and cementing activities to confirm actual noise levels.

In the unlikely event that noise levels exceed the RBL plus 5 dB(A) during standard working hours or the RBL plus 10 dB(A) outside of standard working hours at the sensitive receiver, feasible and reasonable work practices should be implemented to reduce noise levels. Such practices may include:

- training contractors to operate plant and equipment in ways that minimise noise generation
- scheduling deliveries to occur during day time hours where practicable
- inspecting and maintaining equipment to ensure it is in good working order
- reducing throttle setting and turning off equipment when not in use.

In the unlikely event of a noise complaint, the source of the noise will be investigated. Where necessary, it is recommended that Santos will 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.

ANNEX A: Drilling Rig Sound Power Levels

Noise Measurement Services (NMS) has surveyed the potential for noise from a drilling rig referenced as 'Brigalow 1200-1'. This Annex covers different drilling modes and assesses the potential noise impacts at various distances from the rig. Noise measurements and predictions have been taken during four different operational modes:

- Open hole drilling;
- Running casing;
- Cementing; and
- Core drilling.

The sound levels from various items of plant such as the mud pump, lighting rigs, various generators, pumps and items of mobile plant have been included in the noise assessments.

The noise criterion reported as a reference point is the time-average level of 35 dB(A) for night-time operation. It is predicted that this level is achieved at a distance of 1100 metres (open hole drilling and running casing); 1250 metres (cement casing) and 800 metres (core drilling). These distances will vary, of course, if a different noise limit is applied. Cementing is completed relatively quickly (in around 30 minutes) from the time the cement vehicles arrive onsite and until the cementing process is complete. The other processes are of a longer time period lasting for a number of days.

Noise modeling for the determination of sound power levels (as distinct from propagation of noise as detailed in **Section 4**) has been made using SoundPLAN v7.0 and the prediction methodologies *ISO 9613-2 Acoustics-Attenuation of sound during propagation outdoors-Part 2: General method of calculation* (for 'neutral' conditions) and CONCAWE (for 'worst-case' conditions) with calculated sound power levels from field measurements taken in accordance with *AS1217.7-1985 Acoustics-Determination of sound power levels of noise sources* and ISO 3744:1994 *Acoustics-Determination of sound power levels of noise sources using sound pressure-Engineering method in an essentially free field over a reflecting plane* to derive sound power values for the activities. The calculations are made with an estimated uncertainty of ±3 dB(A) at 1000 metres. The sound levels calculated in this report are cross-checked with measured levels at 50 metres and with a variation of approximately 1 dB(A) this allows confidence in the prediction methodology and assumptions.

Sound, however, is not consistent in its propagation and is affected by wind and inversion conditions, especially under cold clear nights with little or no wind movement. Under these circumstances enhanced propagation can occur and the sound of the drilling rig can be heard further than under 'optimum' conditions. As a general rule an allowance of 5 dB(A) needs to be included to allow for these effects. The allowance includes the prediction uncertainty referred to previously. The criterion level then becomes the distance at which a time-average sound level of 30 dB(A) can be reasonably predicted.

The prediction model is referenced to ISO 9613-2 for the noise contours and to ISO 9613-2 and CONCAWE for offset distances, and to AS1217.7 for the sound power calculations used in the model. Broadly, the establishing the sound power levels of the operational plant involved taking measurements at 2 metre intervals around the equipment. The distance from the microphone(s) to the plant was set at 1.0 metres. Two measurement heights were employed at each

measurement location; one at 1.35 metres above ground and one at 3.0 metres above ground. Six 10-second measurements of the A-weighted sound pressure levels were taken at each measurement location.

The sound levels were recorded in a variety of forms including A-weighted Slow response and the A-weighted time-average level, LAeq. The AS1217.7 standard refers to measurements as A-weighted Slow response. The standard, however, has been withdrawn and this Report references the time-average level, LAeq, as this is now the most common descriptor for sound power measurements and compliance assessments.

The measurements are then ascribed to the noisiest pieces of plant and the parallelepiped method employed to calculate the sound power levels. The plant noise was then cross-checked to the measurements locations in order to confirm the calculation process. A slight variation of ±1 dB(A) is expected in the calculation process as the different plant measurements are influenced by other plant, as noted in the measurement schedules. The overall level is then cross-checked to more distant measurement locations at 10 metres and 50 metres from the plant.

The following **Table A1** presents the calculated sound power levels.

Table A1: Summary sound power levels, LAeq, Brigalow 1200-1 Drilling Operation

Item of Plant	Sound Power Level LAeq SWL
Drilling Rig (truck, rig motor, drilling, mud pump) – Open hole drilling	115
Drilling Rig (truck, rig motor, drilling, mud pump) – Running casing	115
Drilling Rig (concrete truck and compressor) – Cement casing	118
Drilling Rig (truck, rig motor, drilling) – Core drilling	115
Drill engine	110
Truck engine	106
Mud Pump engine	113
Cement pump / compressor (on truck)	116
Cement pump truck	111
Lighting Generator	86
Power generator	77
Small dewatering pump	105

The predicted LAeq sound levels and distances due to the various drilling rig operations are presented in **Table A2**.

Table A2: Predicted LAeq Sound Levels at Various Offset Distances

Drill Rig and Operation	Weather Condition	Direction	Predicted LAeq Sound Level at Buffer Distances (metres)						
			50m	100m	500m	1000m	1500m	2000m	5000m
Open Hole Drilling	Neutral	Front	70	62	45	36	30	25	<10
		Left	68	61	45	36	30	25	<10
		Back	67	61	44	36	30	25	<10
		Right	69	62	45	36	30	25	<10
Open Hole Drilling	Worst	Front	72	64	47	38	32	27	<10
	case	Left	70	64	48	39	33	29	<10
		Back	69	63	47	38	33	28	<10
		Right	71	64	48	39	33	29	11
Running casing	Neutral	Front	70	62	45	36	30	25	<10
		Left	68	61	45	36	30	25	<10
		Back	67	61	44	36	30	25	<10
		Right	69	62	45	36	30	25	<10
Running casing	Worst	Front	72	64	47	38	32	27	<10
	case	Left	70	64	47	38	32	28	<10
		Back	69	63	47	38	32	28	<10
		Right	71	64	47	38	33	28	10
Cementing Casing	Neutral	Front	70	62	45	36	30	25	<10
		Left	68	61	45	36	30	25	<10
		Back	67	61	44	36	30	25	<10
		Right	68	62	45	36	30	25	<10
Cement Casing	Worst	Front	72	66	50	40	35	30	<10
	case	Left	77	69	51	41	35	30	13
		Back	76	69	50	41	35	30	13
		Right	71	66	50	40	35	30	<10
Core Drilling	Neutral	Front	60	54	39	31	26	22	<10
		Left	64	58	41	33	27	23	<10
		Back	64	58	41	33	27	23	<10
		Right	64	58	41	33	27	23	<10
Core Drilling	Worst	Front	63	57	39	31	26	22	<10
	case	Left	68	61	43	35	29	25	<10
		Back	68	61	43	35	29	25	<10
		Right	68	61	43	35	29	25	<10

Notes:

'Front' refers to the direction located by the front of the truck holding the drill rig. That is, standing at the front of the truck and looking back to the drill rig is 'front-to-back'.

'Neutral' is the predictions to the ISO 9613-2 methodology, standard assumptions

'Worst Case' is to CONCAWE methodology with a 6m/s breeze blowing from front to back.

A drilling rig that may be utilised within the Proposal is the Energy Australia Drilling Rig 1 (EDA Rig 1). The following information concerning the rig is drawn from the source noise report prepared by Wilkinson Murray: EDA Rig 1 Source Noise Level Measurements, Report No. 00574, Version A, October 2011. The Report was prepared for the RPS Group on behalf of Santos Ltd.

Figure 2-1 Indicative EDA Rig 1 Layout

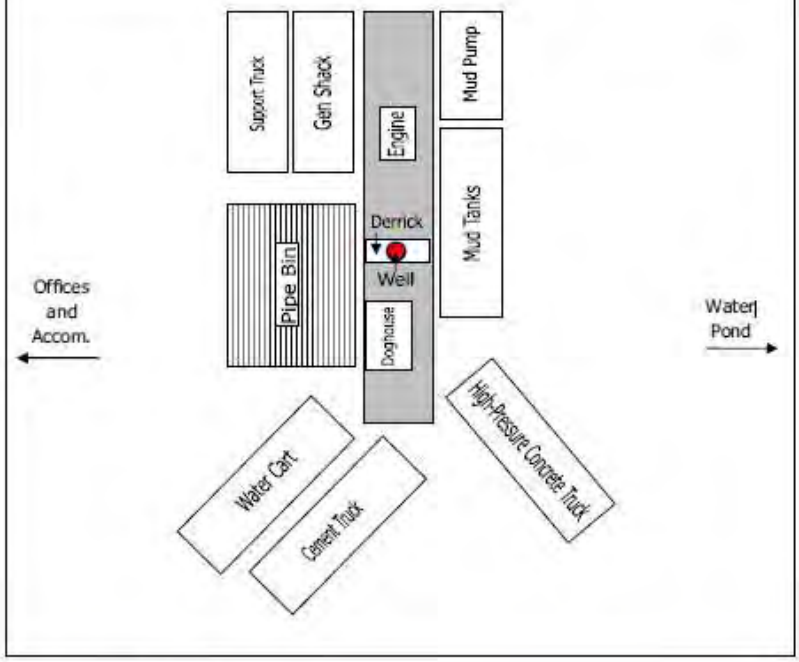


Figure 2-2 EDA Rig 1



Noise Measurement Results

Figure 3-1 presents a graphical level-history of the drilling cycle at one of the control locations. The figure shows the relative noise emissions from each activity. Drilling is reasonably consistent in noise level, with some elevation whilst drilling harder rock. Tripping produced much lower noise levels than drilling, though a worst-case 15 minute period during tripping was only approximately 5 dB below drilling noise levels. Running casing was 2-5 dB below drilling. Cementing casing was similarly 2-5 dB below drilling at the control location, though greater noise levels were measured at other locations with greater exposure to the high-pressure
concrete truck.

Figure 3-1 Noise Level History at "Control" Location

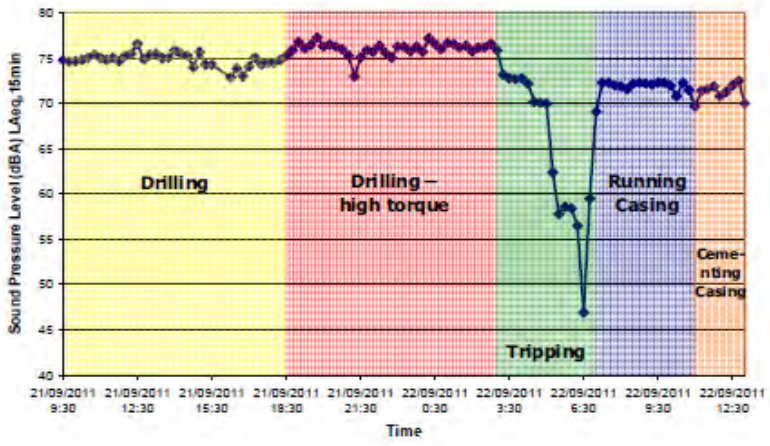


Table 3-1 presents the sound power levels for each plant item. Note that many of these sources radiate over significant areas and thus cannot be equated by point sources in the near field (less than 20m). Determination of the sound power levels has considered the radiated area of these sources. Near field measurements have been supplemented by more distant measurements (around the drill pad perimeter – approx. 50-70m from noise sources) in order to gain a greater understanding of the total noise emissions. We note that many of the sources are shielded in some directions. Furthermore, many of the sources are reflected by adjacent items. These sound power levels represent the on-axis (in this instance meaning the loudest direction in the horizontal plane surrounding the rig) equivalent sound power level including reflections (i.e. reflections are accounted for by the source level and need not be incorporated in any predictive calculations). Other noise sources were present, however the noise sources in Table 3-1 dominated the noise emissions from the site.

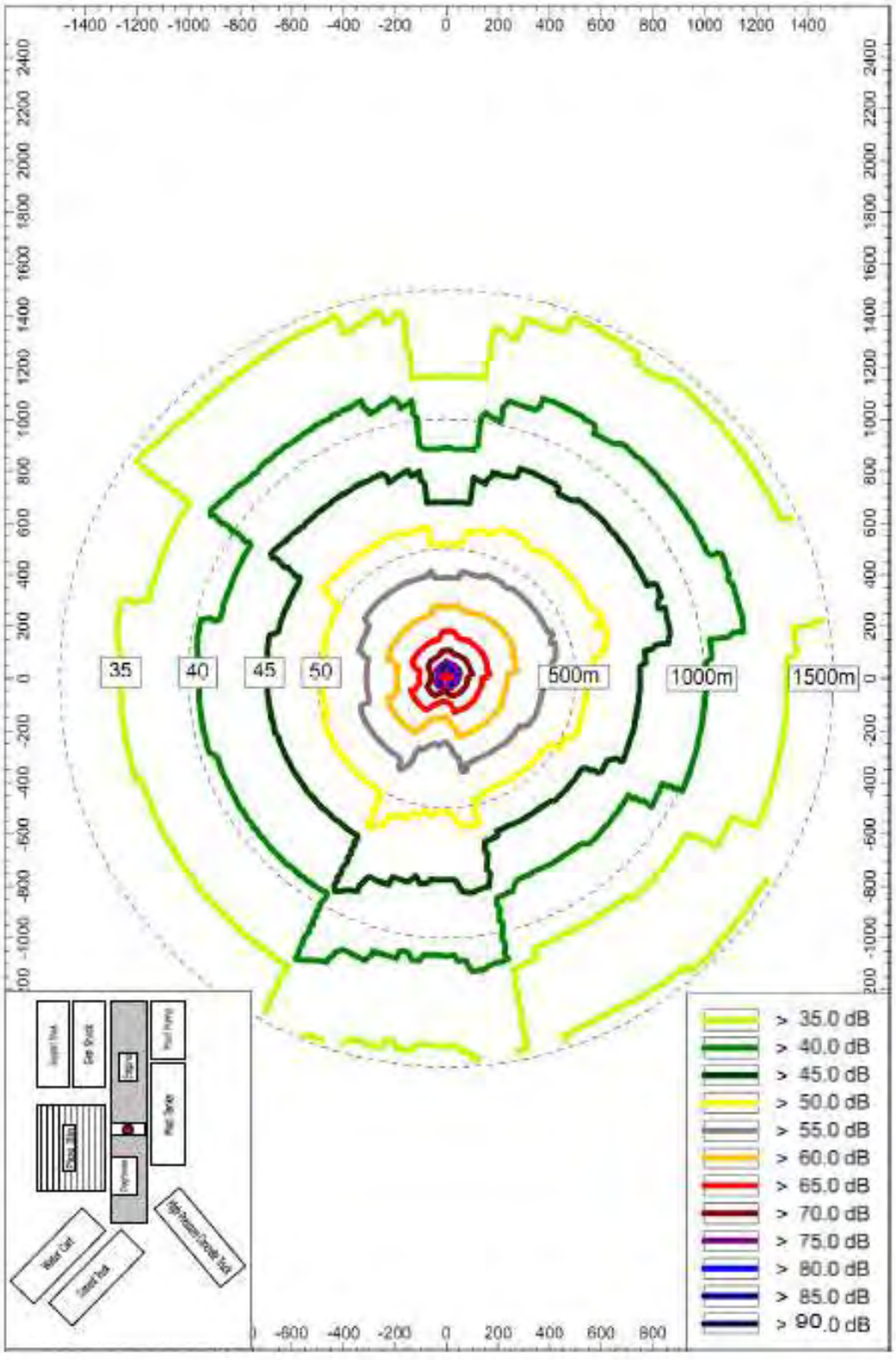
Table 3-1 Individual Source Sound Power Levels (SWL)

Plant Item	Operation	SWL dBA	Notes
Drill engine	Typical high load	120	Noise emanates from the engine casing (which is open at both ends for ventilation) and from the exhaust (which is fitted above the engine and discharges vertically).
	Typical low load/idle	116	
Mud pump	Typical high load	120	Noise emanates from the cooling fans at the rear of the pump engine, the engine casing and from the exhaust which is fitted above the engine and discharges vertically.
	Idle	112	
Drill pipe or derrick resonance	High torque drilling	117	We expect that this source could be reduced/avoided with damping and/or improved fitment of items to the derrick – primarily the aluminium cable tray that houses the hydraulic hoses.
High-pressure concrete truck	Cementing casing	122	Noise emanates from the engine, the exhausts and the radiators/fans at the front of the trailer.

Wilkinson Murray has undertaken detailed source noise level measurements of EDA Rig 1. From these measurements noise level predictions have been made for typical generic topographic and meteorological conditions. The noise level predictions show the variation in noise level and required offset distances due to site specific features, most notably those associated with topography, i.e. shielding and ground attenuation. The noise level contours suggest that for worst-case topographic conditions, i.e. a line of sight between source and receiver and a valley or similar between the

two, offset distances exceeding 1500m would be required to comply with the Interim Construction Noise Guideline noise affected level of 35 dBA. A representative noise emission contour is provided in **Figure A-1**, following.

Figure A-1 Scenario A – Drilling, Flat Ground, Still-isothermal – dBA



ANNEX B: Narrabri Meteorological Data

The following meteorological data for the Narrabri area has been sourced from the report *Narrabri Coal Seam Gas Utilisation Project Part 1 – Air Quality Impact Assessment Report No. 585/06* Part 1 November 2007 prepared by Heggies Pty Ltd.

The 2002-2006 annual wind rose from the Narrabri Weather Station is presented following as **Figure C1** from the Heggies Report. The wind rose is representative of the meteorological input file used in the assessment, and displays occurrences of winds from all quadrants. The annual wind rose indicates that winds tend to be experienced from the southeast, west and north and are typically mild to moderate, having an average wind speed of between 1.5m/s and 8m/s.

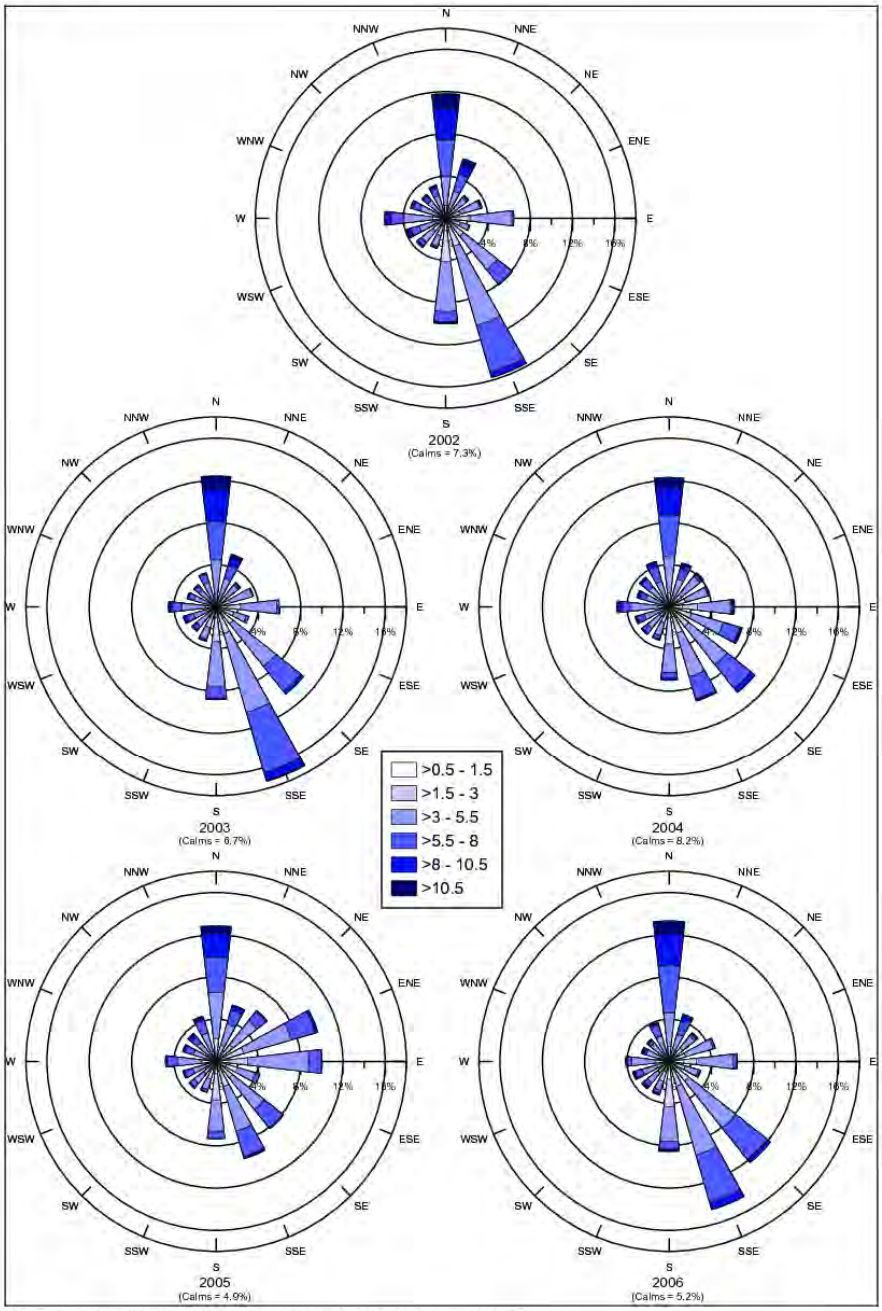
The seasonal variation in wind behaviour at the Narrabri Airport AWS is also presented following as **Figure C2** from the Heggies Report. The seasonal wind roses indicate the following:

- In winter, mild to moderate south-southeast winds are experienced 13% of the time, and mild to fresh (1.5 m/s to 10.5 m/s) north winds occur 12% of the time.
- In spring, mild to moderate winds are present from the south-southeast to southeast approximately 13% of the time, while mild to fresh winds occur from the north approximately 17% of the time.
- In summer, moderate to fresh winds occur from the north approximately 15% of the time, while moderate east winds occur 13% of the time.
- In autumn, mild to moderate winds are prevalent from the east to northeast quadrant approximately 45% of the time.

The frequency of occurrence of stability class at the Narrabri AWS site for 2005 is presented in the third chart, following, from the Heggies Report. The results indicate a high frequency of conditions typical of Stability Class "D" throughout the year. Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Turner assignment scheme (see the EPA INP) identifies six Stability Classes, "A" to "F", to categorise the degree of atmospheric stability. These classes indicate the characteristics of the prevailing meteorological conditions.

- Stability Class "A" represents highly unstable conditions that are typically found during summer, and are categorised by strong winds and convective conditions.
- Conversely, stability class "F" relates to highly stable conditions, typically associated with clear skies, light winds and the presence of a temperature inversion.
- Classes "B" through to "E" represent conditions intermediate to these extremes.

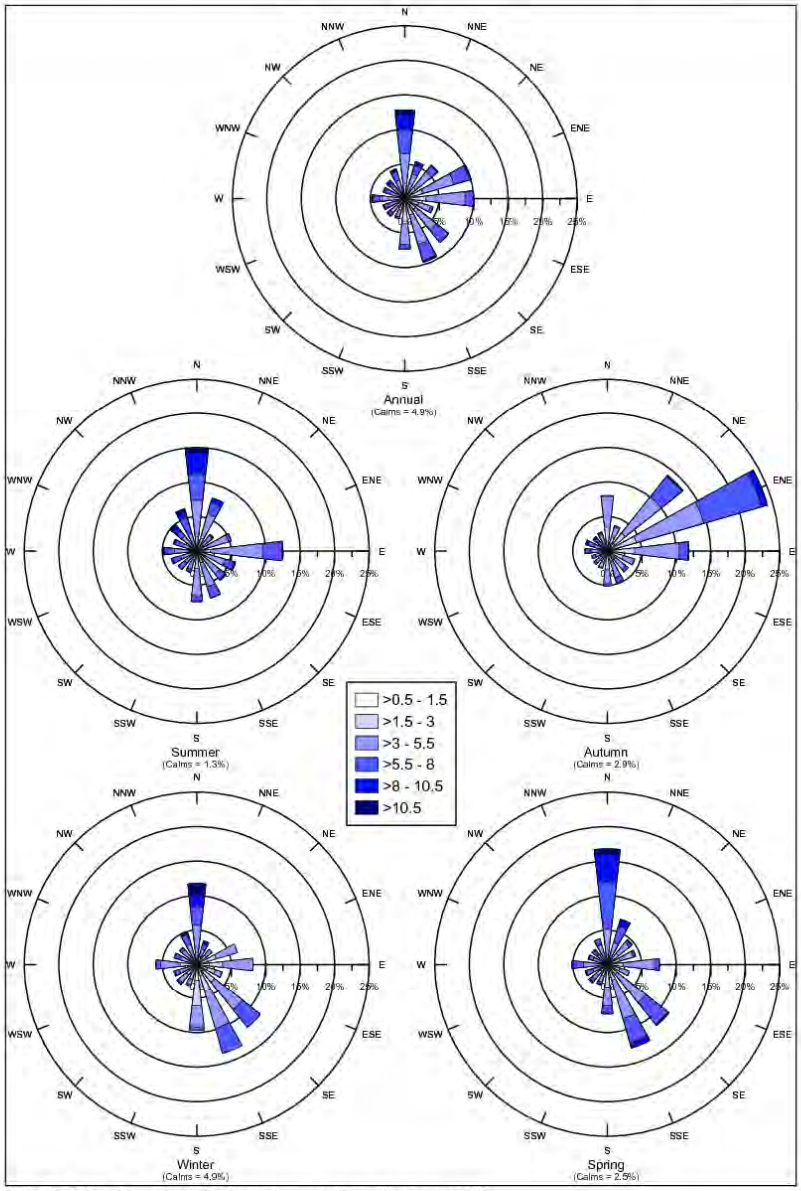
'Normal' or 'Neutral' conditions occur where the temperature slowly increases with height such as overcast conditions and / or when the wind is high enough to cause mixing of any atmospheric layers. These conditions can occur day or night; they will always prevail when it is fairly windy, overcast or at the beginning or end of the day. Category D should be used, regardless of wind speed, for overcast conditions during the day or night and for any sky condition during the hour preceding or following night. Class F conditions occur mainly at night when a layer of cold air is trapped close to the ground, under warmer air. Unusually high noise levels can be experienced.



Note: A Colour Version of this figure is available on the project CD

Figure C1 Annual Wind Roses for Narrabri Airport AWS, 2002-2006

Heggies Pty Ltd



Note: A Colour Version of this figure is available on the project CD

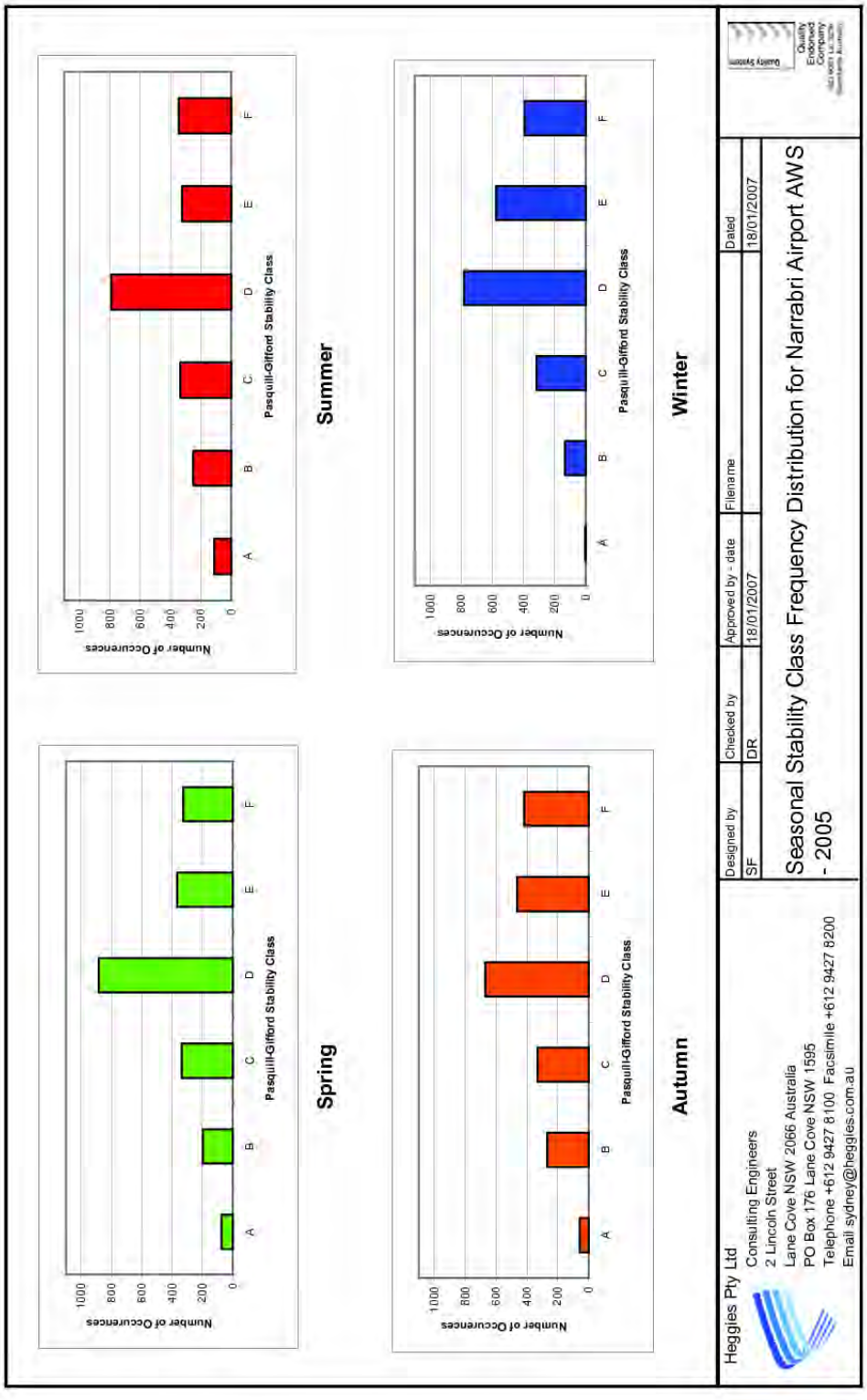
Figure C2 Seasonal Wind Roses for Narrabri Airport AWS, 2005

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Narrabri Coal Seam Gas Utilisation Project *Part 1 – Air Quality Impact Assessment*

Report No. 585/06



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ANNEX C: Noise Prediction Methods

Two different prediction methods are applied, ISO 9613-2 and CONCAWE.

ISO 9613-2

The calculations for the plant, equipment and haulage predictions are based on standard sound propagation theory described in ISO 9613-2 Acoustics – *Attenuation of sound during propagation outdoors – Part 2, General Method of Calculation.*

Equation of the Method

$Lp = Lw + Dc - A$

where

Lp is the sound pressure level at the receiver location

Lw is the sound power level of the source

Dc is the directivity correction of the source; and

A is the excess attenuation due to:

- A div geometric divergence
- A atm atmospheric absorption
- A gr ground cover
- A bar barrier effect
- A misc miscellaneous other effects

The calculation is in A-weighted equivalent continuous (LAeq) octave band values for the bands 63Hz to 8000Hz. The standard calculates the average downwind propagation with the wind blowing from source to receiver and a wind speed of 1 to 5 m/s.

The predictions are based on 'most-likely' placement of plant and equipment to give a representative assessment for different plant and activities operating in different locations and for varying times of day or night. Both single point and noise contour calculations are used to determine the noise level at noise sensitive premises. Noise contours show the range of noise levels in the locality due to the operation of the mine and plant. The single point calculations give the predicted noise at a specific location. Refinement may be made this model through collection of reliable sound power level data, modelling for variable source locations, topographic (barrier) effects and meteorological conditions. Night-time levels can be higher due to atmospheric conditions of temperature inversion, so detailed weather data would be of great assistance in modelling different weather based scenarios.

The general order of prediction uncertainty is ±3 dB at 100 - 1000 metres for an unverified model and less where measured data is used to refine the prediction scheme at distances up to 100 metres. The model is also limited to wind speeds of less than 5 m/s. Verification means that the model has been established with reference to measured sound levels at a receiver, known source levels and tightly defined propagation variables (wind speed and direction, for example). Alternatively a series of predictions with different programs but the same assumption variables can be used for verification purposes. Under light downwind conditions or temperature inversion conditions, it is likely that the noise levels at the nearest residence will be slightly higher than the predicted level. Conversely, under upwind propagation conditions, lower noise levels would be expected to be encountered. Best practice means that the highest level in the uncertainty range is referenced for assessment of impact, rather than the predicted level.

CONCAWE

The CONCAWE method is based upon the CONCAWE research paper (1). Different implementations of the method have applied modifications e.g. in SoundPLAN, PEN3D. The CONCAWE noise propagation model deals specifically with the influence of wind and the stability of the atmosphere.

Equation of the Method

The sound pressure level at a receiver is calculated as:

$$L_p = L_w + D - \sum K$$

where L_w = sound power of the source
D = directivity of the source
$\sum K$ = correction factors K1...K7

The model takes account of the following attenuation mechanisms (K factors):

- Geometrical spreading (the attenuation of a source with distance);
- Atmospheric absorption (the attenuation due to the atmosphere, varying with temperature and humidity and affecting mainly the higher frequencies);
- Ground attenuation (the additional attenuation that occurs due to complex interference effects over acoustically absorptive (soft) ground);
- Meteorological correction (the correction that accounts for refraction of sound by wind and temperature gradients);
- Source / receptor height correction (validated at a receiver height of 1.2 metres)
- Barrier attenuation (Maekawa method)

The two principal variables are wind and vertical temperature gradient. (A positive gradient is called temperature inversion, zero gradient is neutral, and a negative gradient is termed lapse). The variable K_4 is the meteorological correction due to refractions by wind and temperature gradients based on the meteorological category of the atmosphere assessed in accordance with Pasquill stability factor (2), cloud cover and wind speeds. The meteorological category affects the prediction values, as discussed following.

Accuracy of the CONCAWE Noise Prediction Method

The CONCAWE method was originally developed to predict noise levels at long distances (validated at 100 metres to 2000 metres and for wind speeds up to 7 m/s) from petrochemical plants. With the exception of the geometrical spreading the method is primarily empirically based. The 95% confidence limits for the model were derived from independently measured data and vary with meteorological category. The predictions of the CONCAWE model are less accurate in upwind conditions, when measured noise levels would have been lower and the signal (i.e. the plant noise) to background noise (i.e. overall noise from all sources) ratio would have been lower as well. The 95% confidence limits were found to be:

- Met category 2: ± 6.8 dB(A) e.g. upwind, moderate wind speed vector and zero temperature gradient, or upwind, light wind vector with temperature lapse;

- Met category 3: ± 6.9 dB(A) e.g. upwind, light wind speed vector, zero temperature gradient, or calm with temperature lapse;
- **Met category 4: ± 5.7 dB(A) calm and zero temperature gradient conditions);**
- Met category 5: ± 4.7 dB(A) e.g. light downwind with zero temperature gradient, or calm with temperature

inversion;

- Met category 6: ± 4.5 dB(A) e.g. moderate downwind with zero temperature gradient, or light downwind with temperature inversion.

The 95% confidence limit is interpreted to mean that the "true" sound level at any location will be, with 95% certainty, the predicted level +/- the confidence limit (4.5 dB(A) - 6.8 dB(A)). In practice a mid-point value of ±6dB(A) is a reasonable approach.

1. CONCAWE, The propagation of noise from petroleum and petrochemical complexes to neighbouring communities, Report 4/81.
2. NSW EPA 'Industrial Noise Policy' January 2000

IMPLEMENTATION

The method of prediction is ideally suited to a combination of both ISO 9613-2 and CONCAWE methods. The calculation programs available for this purpose are (a) SoundPLAN, which has both methods as separate modules, and (b) PEN3D, an environmental noise model developed by Noise Mapping Pty Ltd Queensland. The PEN3D environmental model is the program used in this Report. It is a faithful representation of the Environmental calculation method described in the book by Bies & Hansen *"Environmental Noise Control"*. The program has both propagation and stability analysis functions. The approach incorporates an incoherent reflection from the ground as recommended by Bies & Hansen as appropriate for calculating noise levels at distances more than 100 m from the source. NOTE: Source levels are entered as dB Lin sound power in the environmental model. Output is in dB Lin and dB(A).

Both single point and noise contour calculations are used to determine the noise level at noise sensitive premises. SoundPlan and PEN3D uses calculated sound power levels determined from measured sound pressure levels to calculate the noise level received at a specific location. Noise contours (isobars) show the range of noise levels in the locality due to the operation of the plant. The single point calculations give the predicted noise at a specific location. Best practice means that the uncertainty range of values is referenced for assessment of impact, rather than the (lower) single-number predicted level. Refinement may be made through collection of reliable sound power level data, modelling for variable source locations, topographic (barrier) effects and meteorological conditions. Night-time levels can be higher due to atmospheric conditions of temperature inversion, so detailed weather data is needed for modelling different "most-likely" scenarios. The tolerance in the Sound Power Levels quoted for various items of plant and equipment is typically ± 1 dB(A) under the refinement/verification process. The sound power levels for the assessment are given in Table D1.

Table D1: Modelled sound power levels

Plant Item	SWL	Sum	63	125	250	500	1000	2000	4000	8000
Drilling Rig	Lin	120	114	108	107	111	114	113	105	95
	A	118	88	92	98	108	114	114	106	94
Wellhead	Lin	114	113	105	99	93	89	84	80	86
	A	97	87	89	90	89	89	85	81	84

Appendix 7

Traffic and Transport Assessment



Bibblewindi Gas Exploration Pilot Expansion, Narrabri

Traffic and Transport Assessment

transportation planning, design and delivery

GTAconsultants

Bibblewindi Gas Exploration Pilot Expansion, Narrabri

Traffic and Transport Assessment

Issue: C 13/08/13

Client: RPS Australia East Pty Ltd
Reference: 13S1503000
GTA Consultants Office: NSW

Quality Record

Issue	Date	Description	Prepared By	Checked By	Approved By	Signed
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B	01/08/13	Final – Santos amendments	Brigette Humphrey-Robinson	Rhys Hazell	Brett Maynard	Brett Maynard
C	13/08/13	Final – Santos amendments	Brigette Humphrey-Robinson	Rhys Hazell	Jason Rudd	

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1. Introduction

1.1 Background

It is understood that an Environmental Impact Statement (EIS) is to be lodged with the Department of Planning and Infrastructure on behalf of Santos NSW (Eastern) Pty Ltd (Santos) for the proposed upgrade to the existing Bibblewindi Multi-Lateral Pilot located within Bibblewindi State Forest, approximately 40km south of the Narrabri Township.

Santos is proposing to drill two new wells (Bibblewindi 31 and Bibblewindi 32) on existing lease areas and operating the two new wells as part of the existing Bibblewindi Multi-Lateral Pilot well set (the proposed activity).

GTA Consultants was commissioned by RPS Australia East Pty Ltd in June 2013 to prepare a traffic and transport assessment for inclusion in the EIS. The assessment as detailed in this report identifies the anticipated traffic and transport impacts of the proposed activity.

1.2 Purpose of this Report

This report sets out an assessment of the anticipated traffic and transport implications of the project, as they relate to the proposed activity, including consideration of the following:

i existing traffic conditions surrounding the site
ii construction activities and associated traffic management
iii construction vehicle requirements
iv site accesses and truck routes to and from the site
v the traffic and transport impact of the construction works and site operation on the surrounding road network.

This report has also been prepared to address the relevant traffic and transport issues outlined within the Director General's Requirements (DGRs) for the proposal dated 20 May 2013 (reference number: SSD 5934).

1.3 References

In preparing this Traffic and Transport Assessment, reference has been made to the following:

- Leewood Project, Newell Highway, Narrabri, Transport Assessment, Revision D, GTA Consultants, 26 November 2012
- Guide to Traffic Management, Part 2: Traffic Theory, Austroads, 2008
- Procedures for use in the Preparation of a Traffic Management Plan (TMP), Roads and Maritime Services, December 2001 (Version 2.0)
- Traffic Control at Work Sites manual, Roads and Maritime Services, June 2010
- Australian Standard, Manual of Uniform Traffic Control Devices – Part 3: Traffic Control for Works on Roads, AS1742.3:2009
- Guide to Traffic Generating Developments, Roads and Maritime Services, Version 2.2, October 2002
- Director General's Requirements, 20 May 2013 (SSD 5934)
- Class Speed Matrix, MetroCount Traffic Executive, 29 September 2011-21 November 2011, Narrabri Shire Council
- Roads and Maritime Services, Traffic Counts, January 2012-March 2012, Roads and Maritime Services
- other documents and data as referenced in this report.

2. Existing Conditions

Bibblewindi Multi-Lateral Pilot (site) encompasses existing well leases including the 12 operational pilot wells and the proposed Bibblewindi 31 and Bibblewindi 32 well locations. The site is located adjacent to the Newell Highway and within Bibblewindi State Forest.

The surrounding land use is dominated by Bibblewindi State Forest, Pilliga State Forest and rural land predominantly used for farming. It is understood that the nearest dwellings are located more than 7km from the site, outside the State forest area, with Narrabri being the closest accessible town.

A number of unsealed roads are currently used to access Bibblewindi Multi-Lateral Pilot with X-Line Road providing truck access to/ from the Newell Highway.

The location of the subject site and its surrounding environs is shown in Figure 2.1.

Figure 2.1: Subject Site and Its Environs



Basemap Source: Google Maps

2.1 Road Network

The road network, particularly relating to the site access via the Newell Highway and X-line Road is shown in Figure 2.2. Detailed descriptions of the roads that make up this network are provided within the sub sections below.

Figure 2.2: Road Network



Basemap Source: Google Maps

2.1.1 Adjoining Roads

Newell Highway

The Newell Highway is a classified State Road and is a major north-south inland transport corridor linking NSW with Victoria and Queensland. West of the site, it is a two-way, sealed rural highway configured with a 2-lane, 7 metre wide carriageway, with approximately 0.5m sealed shoulders on both sides.

It is understood that the posted speed limit has recently been increased from 100km/h to 110km/h.

Newell Highway is shown in Figure 2.3 and carries approximately 1,900 vehicles per day[1].

X-line Road

X-line Road is an unsealed forestry road travelling in an east-west direction; east of the Newell Highway for approximately 4 km. North of the site, it connects with the Newell Highway at a priority controlled T-intersection and links with a number of unsealed roads within Bibblewindi State Forest.

1 Based on the tube counts undertaken by Narrabri Shire Council in September to November 2011

The intersection of Newell Highway and X-line Road is shown in Figure 2.4.

Figure 2.3: Newell Highway



Image Source: GTA Consultants

Figure 2.4: X-line Road at Intersection with Newell Highway



Image Source: Google Street View

Little Tighes Road

Little Tighes Road is an unsealed forestry road travelling in a north-south direction through the centre of the site. The locations of the existing and proposed pilot wells are accessible via a series of access tracks which branch from Little Tighes Road.

Little Tighes Road links to Self Camp Road, north of the site and Tighes Gully Road, south of the site.

2.2 Traffic Volumes

Narrabri Shire Council has provided GTA Consultants with recent traffic volume data for the Newell Highway. The tube count data was collected between September 2011 and November 2011, approximately 20km south of Narrabri and 20km north of X-line Road. The data results are summarised in Figure 2.5 and Figure 2.6 with the following key data gathered:

- Average Daily Traffic: 1,860 vehicles
- proportion heavy vehicles: 40%
- 7 day average peak hour: 134
- highest average peak hour: 156.

In addition, the survey data illustrates that the traffic flows are relatively consistent across the day time period of 8:00am to 4:00pm and are in the order of 140 vehicles per hour. Such observations are consistent with the intended use of the Newell Highway.

Figure 2.5: Newell Highway – 24 Hour Traffic Profile

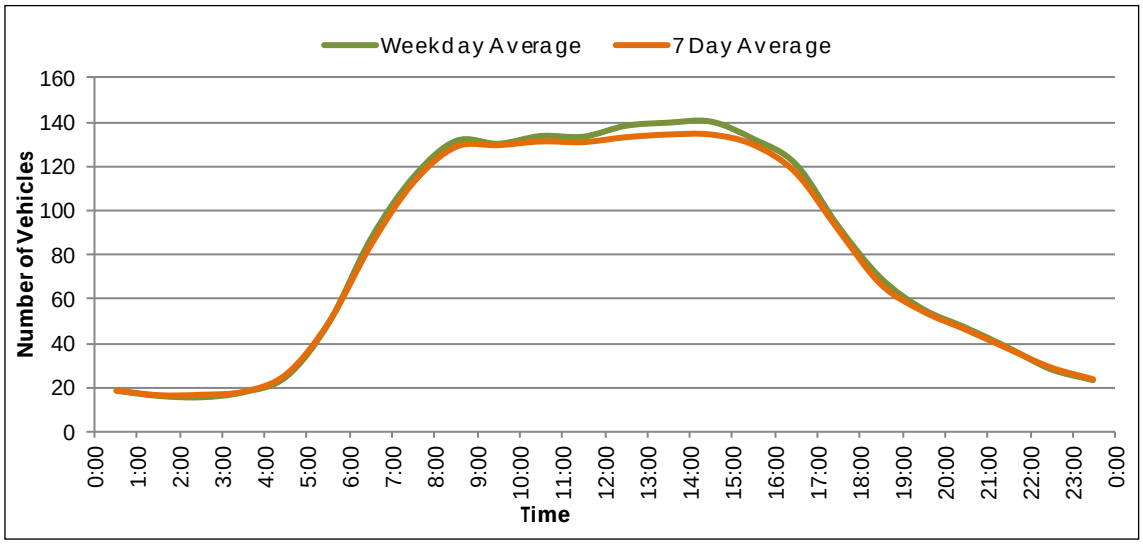


Figure 2.6 illustrates that the Newell Highway carries a high percentage of heavy vehicles, in particular articulated vehicles (Class 10) and B-doubles (Class 11). These two classes account for 32 percent of all traffic along the Newell Highway with light vehicles (cars, cars with trailers, motorbikes, etc.) accounting for 60 percent (Class 1-3). The analysis is based on the complete data set (two months) and is representative of the average percentage of vehicle types which would typically use the Newell Highway.

Figure 2.6: Newell Highway – Percentage of Vehicle Type

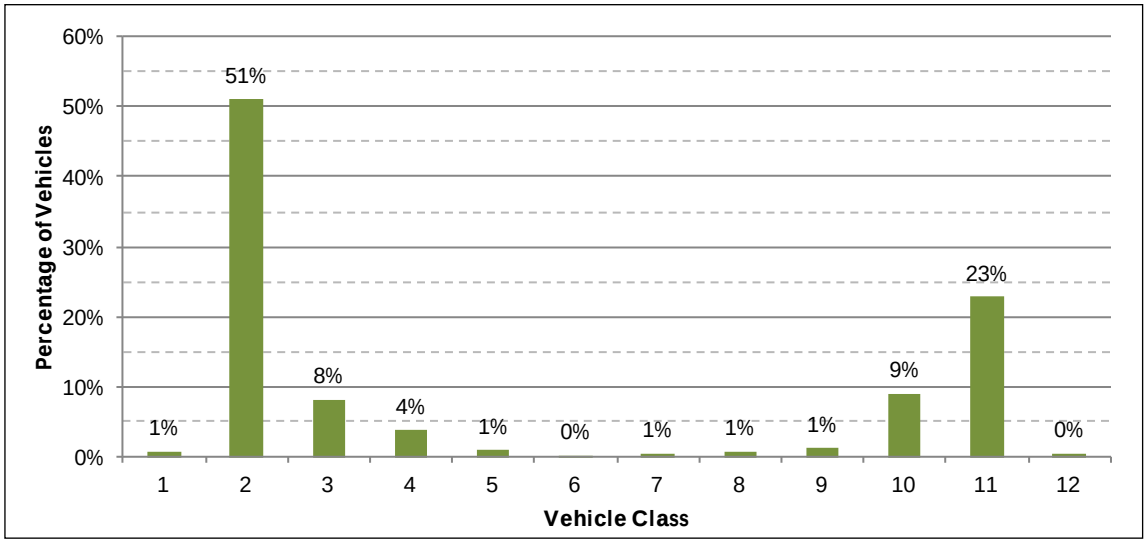


Figure 2.6 references the ARX classification system which is detailed as follows:

- Class 1: bicycle or motorcycle
- Class 2: car
- Class 3: car with trailer
- Class 4-6: two to four axle rigid vehicle
- Class 7-10: three to six axle articulated vehicle
- Class 11: B-double
- Class 12: double or triple road train.

Roads and Maritime Services (RMS) has also provided GTA Consultants with traffic volume data collected from a location near Delwood Road, approximately 18km south of X-line Road between January 2012 and March 2012. The data indicates that the average daily traffic along the Newell Highway is 1,465 vehicles.

Given that cotton farming generally peaks throughout April and wheat farming throughout September and October, it is evident that farming activity can cause traffic volume fluctuations of up to 25% along the Newell Highway. As such, the data provided by Council could be considered representative of a peak season period and that provided by RMS a low season period.

The full traffic volume data is provided in Appendix A.

2.2.1 Level of Service

Reference has been made to the Guide to Traffic Generating Developments (RMS, 2002) to estimate the existing Newell Highway Level of Service (LOS). LOS is a performance standard which describes the efficiency of traffic travelling along a stretch of road or at an intersection. It considers various factors for rural roads, including terrain (level, rolling, mountainous), speed and proportion of heavy vehicles.

The Guide indicates that in order to achieve a LOS B, traffic volumes are required to be less than 530 vehicles per hour with a 15% heavy vehicle proportion. Assuming a 40% heavy vehicle proportion along this section of the Newell Highway, this equates to 350-400 vehicles per hour. Given that the traffic volumes are approximately 150 vehicles in any peak hour along the Newell Highway this represents a LOS A or LOS B depending upon the seasonal factors.

3. Proposed Project Works

The proposed activity includes drilling two new wells (Bibblewindi 31 and Bibblewindi 32) on existing lease areas and operation of the existing Bibblewindi Multi-Lateral Pilot including Bibblewindi 31 and Bibblewindi 32.

The proposed activity includes:

- site preparation and establishing necessary equipment, temporary structures and facilities on the existing well leases Bibblewindi 14 and 19H to enable drilling
- drilling one vertical well (Bibblewindi 31) and one lateral (Bibblewindi 32) pilot well to target the Bohena coal seam
- installing surface and sub-surface infrastructure within the existing lease area to connect the wells to the existing gas and water gathering system for the Bibblewindi Multi-Lateral Pilot
- operating the Bibblewindi 31 and Bibblewindi 32 pilot wells and the existing Bibblewindi Multi-Lateral Pilot as a combined pilot for up to 3 years
- management of the water and gas produced during operation
- occasional maintenance of Bibblewindi 31 and 32
- on completion of operations, pilot wells and ancillary infrastructure will be decommissioned and well leases rehabilitated or suspended.

The proposed activity does not include the existing site establishment and construction activities for clearing and preparation of the lease areas, the water and gas gathering system, access tracks and partial rehabilitation of the lease areas. These works were previously approved by the former NSW Department of Primary Industries (DPI), which approved drilling and operation of Bibblewindi 12, 13, 14, 15, 16, 17, 18H and 19H on 8 August 2008 and Bibblewindi 21H, 27, 28H and 29 on 20 July 2009.

This assessment does however consider the cumulative impacts associated with this work and other Santos related activity in the vicinity. This includes the operational phases of several pilot wells including Bibblewindi West Pilot (and associated water flow lines), Tintsfield and Dewhurst Pilot, together with the construction, drilling and operation of various Dewhurst Pilots (and associated water and gas flow lines). It is understood that the staging of each pilot is yet to be confirmed, however each are thought to be scheduled, where possible to avoid overlap of construction activity.

4. Construction Traffic Management

Construction traffic management considerations for the duration of the construction works have been developed on the basis of the following which are described in more detail below.

- overall principles of construction traffic management
- overview of construction works
- site access
- hours of construction
- construction traffic generation
- truck routes
- traffic effects
- traffic control plan
- decommissioning works.

4.1 Overall Principles of Construction Traffic Management

The overall principles of traffic management during the construction activity include:

- restrict construction vehicle movements to designated routes to/ from the site via the Newell Highway
- manage and control construction vehicle activity in the vicinity of the site
- construction activity to be carried out in accordance with the approved hours of works as determined by the relevant authorities.

4.2 Overview of Construction Activities

It is understood that the proposed construction of the two pilot wells are anticipated to commence in April 2014 with completion by the end of August 2014, a period of approximately 3-4 months The construction activities required for operation of the two proposed pilot wells include:

- Site preparation 20 days
- Drilling and Workover 35 days
- Surface facilities 50 days.

Each construction activity will occur consecutively with no anticipated overlap.

Given that the proposed locations for Bibblewindi 31 and Bibblewindi 32 are on existing pilot well leases and have existing gatherings to the pipelines, it is understood that minimal site preparation works are required. There will also be a small amount of sub surface infrastructure within the existing lease area to connect Bibblewindi 31 and 32 well heads with the existing water and gas gathering system.

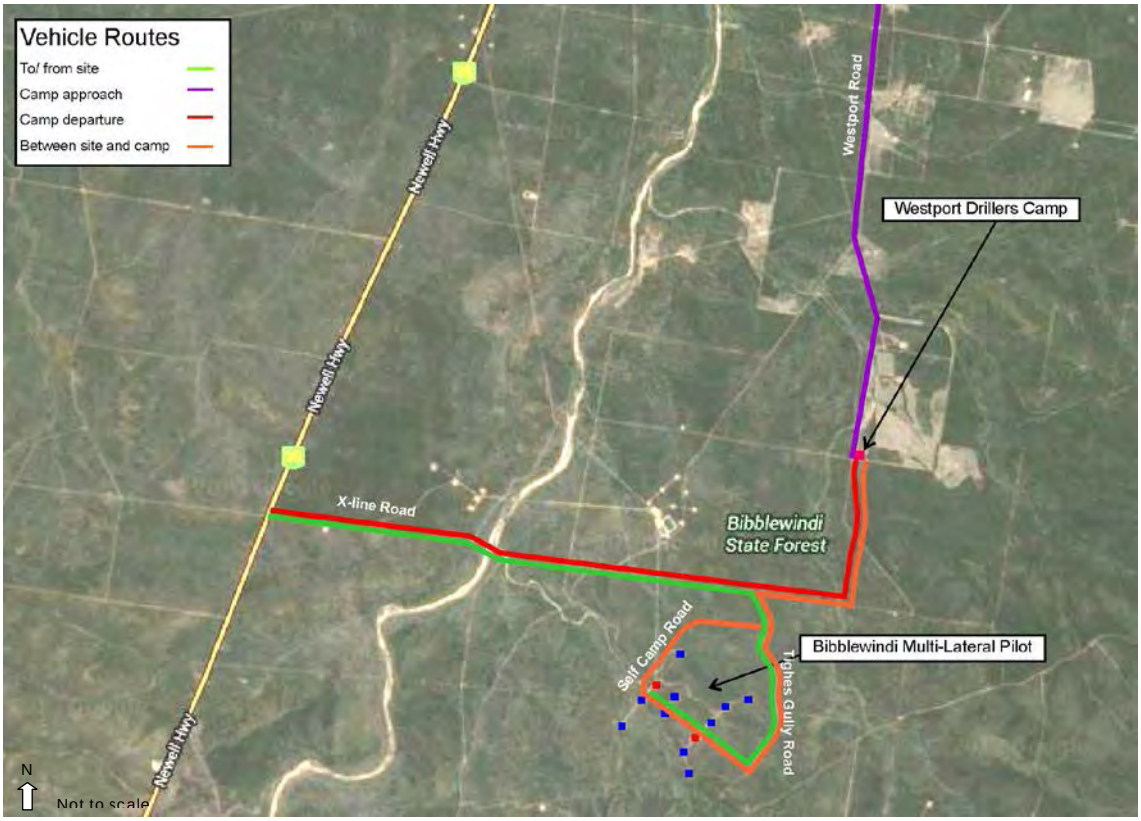
4.3 Site Access

Access to the site for all construction vehicles would be from the Newell Highway via X-line Road and a number of other unsealed forestry roads including Tighes Gully Road and Little Tighes Road which lead to the site and other related services. This access is currently used for the operation of the existing 12 pilot wells and it is understood that it was also used for construction activity relating to the other pilot wells.

It is understood that the Westport Drillers Camp would accommodate the majority of construction workers for the duration of works to significantly reduce the number of daily trips made to and from the site. The camp is located within Bibblewindi State Forest approximately 7km north of the site as shown in Figure 4.1.

It is understood that access to the camp will have separate entry and exit roads to limit conflict. As such, the preferred entry route is via Westport Road which intersects with the Newell Highway approximately 25 km north of X-line Road. The exit route will be via Middle Road, X-line Road, and X-line Road to the south. In addition, access to/ from the site for workers would be via Tighes Gully Road and Little Tighes Road.

Figure 4.1: Westport Drillers Camp



Basemap Source: Google Maps

It is noted that access to and from the site via X-line Road requires trucks to travel over Bohena Creek via an existing waterway crossing. At this location, gravel has been placed and given the temporary nature of the construction works it is not anticipated that any upgrade works would be required.

4.4 Hours of Construction

The hours of construction work will be determined by the appointed construction contractor. However, it is anticipated that construction would occur across 24 hours, 7 days per week to maximise efficiencies and the use of remote workers.

Given the rural environment these work hours are not expected to negatively impact the surrounding area. However, any associated heavy vehicle activity that passes through residential areas (including Narrabri Town Centre) should be confined to typical construction hours (7:00am-6:00pm, Monday to Friday, 8:00am-1:00pm Saturdays).

The contractor will be responsible for instructing and managing all subcontractors with respect to the hours of work.

4.5 Construction Traffic Generation

The *Guide to Traffic Generating Developments* (RMS, 2002) provides traffic generation estimates for different land uses. However, 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.

4.5.1 Construction Worker Traffic

It has been assumed that up to 40 workers would be accommodated at the Westport Drillers Camp at any one time during drilling activities, with minimal worker arrivals/ departures occurring during other activities. Based on a 12 hour working day and to accommodate 24 hour construction, there would likely be the need for workforce rotations across the construction period and two daily shift changes (i.e. 20 workers per daily shift). Given this, the construction worker traffic profile is broken into two components.

Shuttle Bus

A shuttle bus would transport up to 10 workers between the Westport Drillers Camp and the work site at the start and end of each shift. Assuming the transport of workers would be two-way to accommodate workers starting and ending their shifts, there would be up to eight bus movements per day, or four movements per shift. These movements are unlikely to need to access the Newell Highway, thus having no impact on the surrounding arterial road network.

Private Vehicles

It is assumed that workers would arrive and depart Westport Drillers Camp via private vehicles prior to and after completion of each workforce rotation. Assuming an average occupancy of 1.2 to 1.5 workers in each vehicle and the possibility of two such rotations in a 24 hour period, a maximum of 50-70 vehicle movements would be generated at these times.

This represents a theoretical peak hour; that is 40 workers arrive and 40 workers depart the Westport Drillers Camp in the one peak hour and is unlikely to occur. This workforce rotation would be infrequent throughout the whole construction period. Other days throughout the construction period would generate minimal (if any) vehicle trips.

The proposal to have construction workers access to the Camp via the north and depart via the south would distribute vehicle movements evenly thus minimising the impact where X-line Road and Westport Road intersect with the Newell Highway.

In addition, it is envisaged that the majority of worker arrivals and departures would be from the north, to/ from Narrabri with minimal vehicles expected to approach/ depart via the south.

It is understood that sufficient space for worker parking will be provided at the camp site throughout the construction period.

4.5.2 Construction Traffic Vehicle Type

Construction vehicles likely to be generated by the proposed construction activities include:

- 15m drill rig for drilling works at both sites
- 12m articulated flatbed trucks for the transportation of the excavator, piping and wellhead equipment
- standard operation vehicles including small rigid vehicles, utes, four wheel drives for smaller deliveries and some worker arrival and departures.

4.5.3 Construction Traffic Volumes

Anticipated construction vehicle volumes per construction activity for the site are outlined in Table 4.1 with key considerations detailed as follows:

- Each construction activity would occur consecutively with no anticipated overlap.
- Drilling and associated activities for each pilot well would occur consecutively with the drilling rig travelling to Bibblewindi 32 once drilling at Bibblewindi 31 is complete. At this time there would be no impact on the external road network.
- All heavy construction vehicles and equipment (plant) would be delivered to Bibblewindi 31 at the beginning of the site preparation works and would be collected upon completion of Bibblewindi 32.
- The largest vehicle to access the site during construction would be the 15m drill rig.
- Deliveries of construction materials and equipment would occur regularly throughout a typical working day (10-11 hours), therefore deliveries of construction equipment and vehicles have been distributed evenly throughout the day.
- One vehicle would generate two vehicle movements (in and out) unless otherwise stated.
- Construction materials required for construction would be delivered continuously throughout the construction period as opposed to all deliveries at the start of the construction period.
- Water may be required for dust suppression during construction. This does not form part of this assessment and will be addressed as required.

Table 4.1: Overall Estimated Construction Traffic Volumes

Construction Activity	Approximate Duration	Daily Construction Vehicle Generation	Estimated Vehicles per Peak Hour [1]
Site Preparation	20 days	15 [2]	<5
Drilling and Completion	35 days	10	<5
Surface Facilities	50 days	5-10 [3]	<5

[1] Peak hour defined as the maximum number of vehicles likely to be generated in any given hour by construction related vehicles
[2] Includes one vehicle generated by workers during the site preparation activity
[3] Includes three vehicles generated by workers during the surface facilities activity. It is anticipated that 3 vehicles of 4 workers would be generated over the 50 day period.

Given the above, it is estimated that truck volumes could peak at up to 15 vehicles (30 movements) per day throughout all construction stages. Such volumes would likely occur only at the commencement and completion of construction, where the delivery of plant is required and for a period of less than 3 days, thus having minimal impact on the surrounding road network.

The existing intersection configuration at the Newell Highway and X-line Road is capable of accommodating vehicle sizes up to 19m, noting that X-line Road was previously used by construction vehicles during the construction of the existing 12 wells. As such, access to the site via X-line Road would be adequate to accommodate the proposed construction activity and an intersection upgrade at this location would not be required.

4.6 Truck Routes

All heavy vehicles would be accommodated within the site throughout the construction period. Construction traffic would not be permitted to queue or park within X-Line Road, surrounding unsealed tracks or along the Newell Highway.

It is anticipated that the majority of truck arrivals and departures would be via the north, to/ from Narrabri with minor interstate deliveries expected to approach/ depart via the south. All truck movements would be restricted to the direct route via the Newell Highway with the aim of minimising the impact of construction traffic on local forestry roads. Truck drivers will be advised of the designated truck routes to/ from the site.

4.7 Traffic Effects

4.7.1 Traffic Generation

Based above, there would be a theoretical maximum of 110 vehicle movements on a peak day associated with all construction activity, including all worker vehicles, shuttle buses and trucks. This is however unlikely to occur as it assumes the changeover of all 40 workers during the same day and would be infrequent.

As such, it is anticipated that up to 75 vehicle movements would be more likely during the peak day. This is based on the following:

- 35 worker vehicle movements assuming changeover of half of the workforce
- 30 construction vehicle movements
- 8 shuttle bus movements.

It is also worth noting that on typical days (during drilling) where there are no worker rotations or plant deliveries, there would be approximately 20-30 vehicle movements. This includes construction vehicles and shuttle buses.

Given the existing traffic volumes on the Newell Highway and the distribution of vehicles over the day, the anticipated traffic generation (typical and maximum) would have a minimal impact on the surrounding road network and the Newell Highway would continue to operate at or near a Level of Service B.

4.7.2 Intersection Operation

Austroads *Guide to Traffic Management Part 2: Traffic Theory* provides further guidance when assessing the impacts associated with increased traffic volumes. This is particularly appropriate when considering the anticipated increase in truck volumes on X-line Road and their intersections with the Newell Highway. Gap acceptance is the point at which a minor traffic stream can enter the major traffic stream when a suitable gap presents itself.

The critical gap acceptance and follow-up headways for right turning and left turning vehicles from a minor road onto a major road are 7-8 seconds and 3.5 seconds respectively[2]. These thresholds have been determined based on a scenario where the traffic volumes are more than double those on the Newell Highway, including truck volumes.

Based on a worst case scenario, during a weekday peak period, a vehicle will pass X-line Road along the Newell Highway every 20-30 seconds. Given this and with consideration for the known critical gaps, the intersections would be capable of safely accommodating the anticipated increase in vehicles associated with the construction works. In addition, the implementation of the mitigation measures detailed in this report, including the site access plans to provide approaching vehicles with greater awareness of the X-line Road intersections and associated site vehicle activity mean that the Newell Highway would continue to operate in a safe manner throughout the works program.

4.7.3 Emergency Vehicles and Heavy Vehicles

No special provisions are required or proposed for emergency vehicles and there will be no adverse impact on emergency services.

There will be a 5-10% increase in two-way daily traffic flows and less than a 5% increase in truck movements on a peak day during construction. This increase in total traffic is considered low and will have a negligible impact on the operation of the Newell Highway.

As discussed, the increase in heavy vehicles represents a low increase in truck proportions and overall the intersection of the Newell Highway and X-line Road will continue to operate at similar level of service as under existing conditions, therefore having minimal impact on existing truck/ traffic volumes.

4.7.4 Existing and Future Developments

It is understood that there are currently no existing or proposed land use developments within the vicinity of the site that would be adversely impacted by the construction works.

Santos has other planned exploration works and pond/ flow line construction in and around Bibblewindi and Dewhurst (located east of Bibblewindi), however it is understood that the construction schedule for all Santos works considers staggered start and finish times. Therefore there will be minimal cumulative construction traffic impacts associated with these works. In addition and as discussed earlier, the Newell Highway has considerable spare capacity and

[2] Austroads Guide to Traffic Management Part 2: Traffic Theory, Section 5.5, Table 5.2, 2008

therefore would also be capable of accommodating the low traffic volumes generated by the exploration and flow line works at Bibblewindi and Dewhurst.

4.7.5 Traffic Movements in Adjoining Council Areas

No adverse affects are expected from the movement of heavy vehicles through adjacent council areas.

4.8 Traffic Control Plan

It is recommended that the appointed contractor develop a Traffic Control Plan (TCP) in accordance with the *Traffic Control at Work Sites* manual (RMS, 2010). The TCP should relate to that of Standard TCP 195 which is illustrated in Appendix B.

As part of the Leewood Ponds Project and associated works at Bibblewindi Water Management Facility, a site access plan was prepared by GTA Consultants, with signage implemented at the intersection of the Newell Highway and X-line Road. In accordance with the proposed works schedule, the construction works associated with the Leewood Ponds Project will be complete prior to the commencement of works at Bibblewindi 31 and 32. As such, it is recommended that the signage be either maintained or re-instated for the construction works to warn Newell Highway drivers of entering and exiting trucks.

The site access plan presents the principles of construction traffic management, while also considering permanent directional signage as shown in Appendix C.

4.9 Decommissioning Works

It is understood that the proposed Bibblewindi pilot wells are likely to have a lifespan of up to three years, with decommissioning works likely to occur in early 2017.

Assuming a conservative approach, with consideration of the broad RMS policy of applying an annual traffic linear growth rate of 2%, the peak traffic volumes along the Newell Highway could increase by up to 10 vehicles per hour. Given this, it is anticipated that similar traffic volumes would be generated during decommissioning, and similarly X-line Road would be used as the primary access road. As such, decommissioning of the pilot wells is likely to have a similar impact to that anticipated during construction.

5. Operational Traffic Management

5.1 Overview

Bibblewindi Multi-Lateral is anticipated to operate over a period of up to three years, with a similar number of staff to current operations once works are complete. 1-2 staff members would visit the site every 1-2 days for monitoring and maintenance purposes for the whole site encompassing the 14 pilot wells. For the purposes of this assessment, it is estimated that the Bibblewindi Multi-Lateral will be visited by one vehicle per day during operation. Vehicle movements to the site may occasionally increase for short periods for the purposes of well maintenance and work-over activities.

The operational workforce would function on a typical daytime shift basis and staff would typically travel to and from Bibblewindi by car. The shift times are assumed to be between 7:00am and 5:00pm weekdays with administration personnel comprising the vast majority of site personnel.

The workforce would be primarily drawn from the local area around Narrabri with arrival/ departures to/ from the north. As such, the operational traffic impact would be minimal, with up to five vehicles arriving/ departing during each of the weekday AM and PM peak hours. These anticipated traffic volumes would present a negligible impact to the operation of the Newell Highway at X-line Road.

It is noted that commissioning works would be undertaken prior to operation works commencing. As such, traffic volumes generated by commissioning are anticipated to be similar to that during operation.

As discussed above, Santos has other planned exploration works and pond/ flow line construction in and around Bibblewindi and Dewhurst, with an overlap of operational activities. These sites are also anticipated to generate similar operational traffic to Bibblewindi 31 and 32 (less than 5 vehicles per day), as outlined in this report. Therefore, cumulative traffic associated with these sites is anticipated to have a relatively minor impact on the Newell Highway during operations.

6. Conclusion

Based on the analysis and discussions presented within this report, the following conclusions are made:

i Santos is proposing to construct and operate an additional two petroleum exploration wells at the existing Bibblewindi Multi-Lateral Pilot.

ii The Newell Highway in the vicinity of the site currently carries approximately 1,860 vehicles per day with relatively consistent hourly flows in the order of 140 vehicles per hour between 8:00am and 4:00pm.

iii The proposed construction works are scheduled to be carried out over a period of up to 3-4 months, with works planned to commence in April 2014 and continue through to August 2014.

iv The construction works are anticipated to generate up to 40 workers at any one time with up to 20 workers on-site during each shift.

v It is anticipated that up to 75 vehicle movements would be likely during the peak day.

vi On typical days where there are no worker rotations or plant deliveries, there would be approximately 20-30 vehicle movements.

vii The Westport Drillers Camp would minimise traffic generation by reducing the frequency of workers accessing the site and would generate up to 8 bus movements per day. This is the intended transport profile for workers to arrive and depart the site.

viii Up to 30 truck movements per day including less than 10 truck movements per peak hour would be generated by construction activities.

ix X-line Road would accommodate all truck movements to/ from the Newell Highway.

x The operational workforce at each site is expected to be 1-2 staff every 1-2 days, with deliveries and visitors anticipated to be minor, equating to a vehicle generation of less than five vehicles per day.

xi Standard Traffic Control Plan 195 from the *Traffic Control at Work Sites* manual (RMS, 2010) or similar should be implemented during construction.

xii The existing layout of the intersection of the Newell Highway with X-line Road is adequate for the proposed traffic volumes.

xiii No upgrades works at the intersection of the Newell Highway with X-line Road would be required for the construction or operation of the Bibblewindi pilot wells.

Appendix A

Survey Data

Traffic Volumes

Station ID: 92742**, Prescribed Direction:** NORTH**, Road Loc Reference :** 0000017~3120~A **(Road Number~Road Link~Carriageway), Report Values Based On:** Vehicle Count**,**
Station Name: , Station Description: SH17 (Newell Hwy), at Wiggans Ck Br**, RMS Region:** WESTERN**, Local Government Area:** NARRABRI**, Suburb:** THE PILLIGA**, Date Range:** 20120101 to 20121231**, Days Available:** 86**,**
4-Bin Classifications: ALL**, 12-Bin Classifications:** ALL**, Days of Week:** ALL**, Hours of Day:** ALL**, Public Holiday:** ALL Days (including public holidays)**, School Holiday:** ALL Days (including school holidays)
For information relating to this report, you can contact us via email at RISS.Info

92742: Traffic Volume - Vehicle Count - Date and Hours by Station

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	TOTAL
Sun, 01/01/2012	8	9	7	12	8	6	20	30	67	93	131	118	141	126	127	149	130	97	88	62	50	33	30	31	**1,573**
Mon, 02/01/2012	19	13	9	12	16	19	52	76	131	153	178	202	178	165	224	206	215	168	137	74	61	50	22	32	**2,412**
Tue, 03/01/2012	31	17	22	9	8	37	50	90	145	143	162	156	175	161	169	182	158	149	96	86	56	54	43	44	**2,243**
Wed, 04/01/2012	33	23	16	23	24	32	58	113	140	169	172	197	182	194	166	179	162	142	127	93	51	57	46	39	**2,438**
Thu, 05/01/2012	43	36	26	23	25	34	62	106	141	180	191	188	208	161	184	164	187	168	111	76	81	61	36	27	**2,519**
Fri, 06/01/2012	19	18	19	14	16	29	58	100	127	175	213	191	169	159	188	205	164	163	102	59	65	53	41	29	**2,376**
Sat, 07/01/2012	27	23	26	19	23	21	43	111	100	169	143	183	138	160	174	160	126	133	99	67	73	61	30	30	**2,139**
Sun, 08/01/2012	22	18	22	14	14	27	46	84	101	121	150	147	157	157	160	173	138	135	94	52	45	38	27	19	**1,961**
Mon, 09/01/2012	19	10	12	10	14	15	52	78	91	115	111	118	139	144	113	152	161	132	99	91	68	43	50	35	**1,872**
Tue, 10/01/2012	27	21	24	12	21	30	60	81	111	156	152	148	177	156	157	140	170	136	109	73	55	45	42	42	**2,145**
Wed, 11/01/2012	20	21	25	22	22	28	52	84	119	134	176	165	136	126	135	150	157	156	101	74	70	52	41	26	**2,092**
Thu, 12/01/2012	36	16	25	15	24	21	60	93	105	145	142	166	169	159	135	137	156	131	112	83	56	49	34	31	**2,100**
Fri, 13/01/2012	26	10	15	15	17	17	49	83	98	141	146	143	125	108	139	125	151	129	89	57	44	49	42	35	**1,853**
Sat, 14/01/2012	31	21	15	27	12	24	52	81	105	121	133	129	124	136	142	156	137	131	82	64	60	42	38	32	**1,895**
Sun, 15/01/2012	20	13	20	11	16	17	41	76	104	123	150	151	144	135	147	180	124	96	75	53	43	30	28	13	**1,810**
Mon, 16/01/2012	9	10	10	5	7	16	37	55	66	90	103	105	104	115	97	104	116	120	69	72	38	47	47	29	**1,471**
Tue, 17/01/2012	27	20	16	15	21	35	54	74	100	113	147	121	114	126	130	143	123	124	73	82	49	48	35	36	**1,826**
Wed, 18/01/2012	12	16	26	14	13	22	61	82	111	112	122	99	137	119	108	136	125	109	100	79	76	41	37	39	**1,796**
Thu, 19/01/2012	26	28	23	20	18	20	43	79	117	133	135	112	108	137	144	130	129	111	90	93	50	44	33	31	**1,854**
Fri, 20/01/2012	20	20	15	16	21	26	46	64	91	124	105	110	108	122	120	126	99	111	76	69	51	52	42	20	**1,654**
Sat, 21/01/2012	23	23	21	16	18	22	35	71	87	100	106	103	123	126	141	114	112	82	83	56	53	40	39	28	**1,622**
Sun, 22/01/2012	28	20	8	9	9	8	28	73	97	109	124	101	121	110	119	129	126	101	66	67	40	21	26	20	**1,560**
Mon, 23/01/2012	11	11	12	12	17	17	36	49	70	95	77	72	87	94	99	101	121	80	84	50	60	49	44	29	**1,377**
Tue, 24/01/2012	36	18	21	16	22	30	45	72	95	118	120	123	137	147	120	118	142	139	93	68	58	47	37	25	**1,847**
Wed, 25/01/2012	13	24	11	15	17	14	42	56	82	108	120	115	105	103	123	103	92	94	72	73	68	50	46	42	**1,588**
Thu, 26/01/2012	34	14	25	25	22	24	37	64	87	119	113	141	131	123	115	125	127	84	102	68	39	37	25	26	**1,707**
Fri, 27/01/2012	12	14	7	12	17	14	20	34	61	77	65	60	75	67	75	79	72	74	60	60	44	45	24	24	**1,092**
Sat, 28/01/2012	24	12	15	19	10	24	36	64	68	99	112	122	96	100	109	99	118	122	70	34	47	38	15	28	**1,481**
Sun, 29/01/2012	19	22	14	9	12	16	35	59	75	102	115	105	114	119	114	109	102	100	64	46	38	20	20	13	**1,442**
Mon, 30/01/2012	7	13	8	8	8	7	28	53	67	73	83	84	81	75	77	90	79	84	72	47	47	56	34	34	**1,215**
Tue, 31/01/2012	33	25	12	23	19	21	39	71	91	102	118	120	134	120	101	108	113	127	71	69	47	48	28	27	**1,667**
Wed, 01/02/2012	24	14	24	18	6	22	28	54	95	90	92	112	93	97	89	99	68	74	51	31	9	3	2	1	**1,196**
Thu, 02/02/2012			1	1	1		8	17	30	31	23	18	19	7	11	12	9	8	1	4	4	2		1	**208**
Fri, 03/02/2012							7	6	11	10	19	12	8	16	13	8	15	13	5	8	4	10	5	5	**175**
Sat, 04/02/2012	3	1	2	1		3	6	14	17	20	21	47	25	21	17	32	25	24	17	11	15	3	4	3	**332**
Sun, 05/02/2012	3	3		1		6	6	14	23	21	39	37	20	22	28	29	39	15	16	15	9	8	8	4	**366**
Mon, 06/02/2012		1	1	1	2	8	15	12	31	22	30	37	31	47	51	44	44	57	54	45	30	35	32	40	**670**
Tue, 07/02/2012	22	10	12	10	16	17	22	48	80	66	79	77	80	85	95	92	96	81	60	46	61	53	53	33	**1,294**
Wed, 08/02/2012	21	20	17	17	11	31	38	46	61	97	88	72	104	75	94	91	96	104	72	54	44	48	41	31	**1,373**
Thu, 09/02/2012	34	21	19	20	21	15	35	45	81	87	87	71	87	104	128	96	101	80	72	69	46	44	45	44	**1,452**
Fri, 10/02/2012	23	22	18	11	15	17	30	39	88	63	80	79	70	74	64	88	90	76	59	44	47	47	33	37	**1,214**
Sat, 11/02/2012	23	21	19	15	13	18	24	49	55	68	65	82	91	82	82	94	112	76	67	69	45	52	45	27	**1,294**
Sun, 12/02/2012	31	26	23	20	16	7	23	41	65	83	84	98	100	122	99	121	94	71	75	51	43	41	33	17	**1,384**
Mon, 13/02/2012	12	11	18	2	9	20	28	39	63	71	74	66	73	87	79	81	82	78	76	63	44	51	39	46	**1,212**
Tue, 14/02/2012	26	26	17	19	36	18	39	59	84	98	100	95	101	133	108	111	101	94	89	69	56	53	37	25	**1,594**
Wed, 15/02/2012	26	19	12	15	24	23	36	71	99	115	111	110	115	100	111	110	99	101	102	76	64	55	47	42	**1,683**
Thu, 16/02/2012	25	18	36	14	21	25	50	73	93	129	100	112	107	128	102	140	126	106	90	83	46	42	49	36	**1,751**

Fri, 17/02/2012	32	12	26	12	17	24	50	79	67	90	103	98	87	118	88	119	107	94	71	39	41	49	38	38	**1,499**
Sat, 18/02/2012	33	29	20	18	10	21	39	56	82	104	118	89	88	97	103	95	105	106	86	66	36	55	47	27	**1,530**
Sun, 19/02/2012	26	22	20	15	19	15	27	44	72	90	93	110	104	100	109	99	102	75	58	61	39	27	27	15	**1,369**
Mon, 20/02/2012	21	14	5	5	8	20	44	45	74	91	64	77	85	91	115	107	118	78	68	56	56	49	52	34	**1,377**
Tue, 21/02/2012	24	16	13	13	18	29	43	60	91	105	101	121	124	122	114	117	97	110	79	77	49	53	37	36	**1,649**
Wed, 22/02/2012	31	14	19	18	20	24	56	68	77	87	108	123	110	130	123	115	116	106	88	83	66	52	38	48	**1,720**
Thu, 23/02/2012	27	25	23	13	18	22	55	75	98	115	130	108	119	140	134	104	126	106	76	61	49	56	40	23	**1,743**
Fri, 24/02/2012	28	22	21	21	17	10	43	66	110	109	84	103	103	104	114	111	103	79	83	56	57	37	35	24	**1,540**
Sat, 25/02/2012	31	22	15	23	19	16	35	45	65	97	87	99	110	100	95	118	95	90	82	38	59	43	38	32	**1,454**
Sun, 26/02/2012	23	21	11	16	13	13	31	55	69	79	69	150	141	114	124	117	123	63	68	54	40	46	31	27	**1,498**
Mon, 27/02/2012	16	5	5	6	5	22	30	58	70	70	88	94	83	86	96	77	92	86	68	54	47	44	49	37	**1,288**
Tue, 28/02/2012	23	16	17	17	25	40	38	75	84	100	104	124	138	125	118	128	101	113	80	68	59	61	37	23	**1,714**
Wed, 29/02/2012	14	12	13	19	18	33	32	81	81	103	93	109	95	108	110	98	102	109	79	70	55	50	48	28	**1,560**
Thu, 01/03/2012	30	17	20	17	21	26	40	75	83	98	121	113	109	102	129	127	123	113	85	61	58	53	23	26	**1,670**
Fri, 02/03/2012	17	14	16	11	21	21	32	61	87	95	111	92	93	103	98	100	102	80	107	43	36	38	19	30	**1,427**
Sat, 03/03/2012	19	17	17	8	18	18	36	46	52	86	96	85	80	120	91	65	81	69	67	52	54	37	31	21	**1,266**
Sun, 04/03/2012	21	18	8	6	10	13	18	45	63	59	96	69	88	81	73	82	90	67	52	46	33	31	23	14	**1,106**
Mon, 05/03/2012	8	4	4	2	6	15	30	43	53	72	52	57	83	57	59	76	69	57	62	37	42	29	18	18	**953**
Tue, 06/03/2012	13	8	13	5	5	13	31	53	56	76	83	62	69	81	56	62	89	63	45	40	22	30	14	14	**1,003**
Wed, 07/03/2012	13	10	10	3	17	13	29	55	66	74	66	78	62	72	73	83	88	67	45	42	42	20	27	28	**1,083**
Thu, 08/03/2012	12	8	8	6	15	16	44	36	57	53	75	76	66	80	78	65	66	71	70	41	41	35	36	19	**1,074**
Fri, 09/03/2012	10	8	14	10	8	14	35	34	65	77	63	82	82	68	88	70	75	72	61	30	31	22	21	25	**1,065**
Sat, 10/03/2012	11	13	10	12	11	23	22	36	59	58	80	61	73	72	74	75	83	53	54	37	41	40	16	24	**1,038**
Sun, 11/03/2012	5	8	8	11	6	11	19	29	47	66	70	67	77	89	97	78	96	76	60	43	35	27	23	17	**1,065**
Mon, 12/03/2012	6	10	6	6	3	16	26	43	49	58	63	79	61	75	66	83	63	89	49	34	33	45	35	28	**1,026**
Tue, 13/03/2012	30	17	12	9	19	16	45	49	81	75	97	88	96	75	72	68	76	68	55	45	42	28	20	20	**1,203**
Wed, 14/03/2012	15	10	12	7	19	21	43	51	77	73	83	76	79	89	83	104	101	73	68	64	37	40	46	29	**1,300**
Thu, 15/03/2012	19	13	12	14	19	13	30	49	70	93	65	93	86	116	100	115	87	76	78	52	37	42	43	18	**1,340**
Fri, 16/03/2012	25	21	11	9	12	15	40	70	69	85	111	113	80	91	101	89	81	82	72	58	32	30	24	22	**1,343**
Sat, 17/03/2012	20	19	9	12	13	9	20	44	50	75	103	75	77	82	70	86	72	62	62	39	32	31	30	15	**1,107**
Sun, 18/03/2012	23	13	8	5	11	17	24	23	52	50	89	76	79	94	96	83	87	99	59	45	41	34	35	14	**1,157**
Mon, 19/03/2012	5	7	6	6	6	18	28	41	70	69	50	77	60	72	94	81	84	74	64	40	28	37	38	26	**1,081**
Tue, 20/03/2012	29	12	15	25	12	21	31	50	70	61	111	93	104	101	112	128	102	109	87	57	54	40	33	22	**1,479**
Wed, 21/03/2012	19	20	7	16	12	26	34	60	61	114	112	94	109	111	137	112	98	98	75	60	51	53	35	40	**1,554**
Thu, 22/03/2012	22	17	22	15	15	20	37	65	88	95	115	117	126	119	123	116	104	100	94	72	53	36	47	26	**1,644**
Fri, 23/03/2012	20	17	16	20	22	20	30	60	83	90	113	99	79	86	111	88	89	108	90	54	43	40	29	29	**1,436**
Sat, 24/03/2012	18	15	22	19	20	24	46	65	82	114	107	117	92	107	83	103	113	80	75	56	56	42	30	25	**1,511**
Sun, 25/03/2012	19	17	13	9	14	17	27	49	100	85	87	126	98	139	168	147	89	93	68	56	30	33	26	16	**1,526**
Mon, 26/03/2012	15	9	6	9	11	20	26	49	55	74	72	79	91	85	94										**695**
TOTAL	**1,761**	**1,344**	**1,259**	**1,105**	**1,255**	**1,648**	**3,118**	**5,021**	**6,811**	**8,148**	**8,740**	**8,869**	**8,847**	**9,052**	**9,192**	**9,211**	**8,924**	**8,000**	**6,362**	**4,822**	**3,907**	**3,462**	**2,794**	**2,266**	**125,918**

92742: Traffic Volume - Vehicle Count - Date and Hours by Direction

NORTH

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	TOTAL
Sun, 01/01/2012	5	1	4	7	7	3	14	13	30	60	80	77	86	74	56	84	71	47	44	28	18	17	16	14	**856**
Mon, 02/01/2012	11	9	3	7	11	8	26	50	81	95	108	116	94	80	104	103	104	93	73	43	34	29	11	17	**1,310**
Tue, 03/01/2012	19	13	11	6	6	22	31	51	87	88	103	98	117	75	81	88	89	86	44	38	29	28	17	17	**1,244**
Wed, 04/01/2012	19	8	6	5	11	16	27	64	89	96	102	113	104	105	77	87	91	69	74	57	32	38	25	21	**1,336**
Thu, 05/01/2012	22	19	11	5	12	9	29	56	73	112	107	110	119	80	101	78	97	81	65	45	39	25	15	14	**1,324**
Fri, 06/01/2012	10	6	5	4	5	8	24	49	67	95	123	105	103	79	92	91	76	77	54	25	36	22	16	14	**1,186**
Sat, 07/01/2012	9	4	10	5	10	11	20	60	64	105	87	111	82	75	79	81	62	80	58	33	33	27	13	16	**1,135**
Sun, 08/01/2012	9	8	13	7	9	13	28	50	65	68	91	83	89	84	80	95	89	82	53	34	31	26	16	13	**1,136**
Mon, 09/01/2012	12	7	7	6	9	7	30	42	45	62	67	61	79	78	57	76	75	59	46	47	20	17	20	12	**941**
Tue, 10/01/2012	12	6	10	3	7	9	23	46	45	88	77	90	97	88	71	73	103	71	68	46	34	22	21	18	**1,128**
Wed, 11/01/2012	9	11	13	8	14	14	19	49	66	69	108	102	82	69	65	78	88	93	44	41	32	20	14	7	**1,115**
Thu, 12/01/2012	12	9	10	4	9	8	22	40	53	71	74	88	106	85	72	63	92	71	60	55	37	30	23	14	**1,108**

Fri, 13/01/2012	8	2	7	5	6	5	19	36	52	74	80	73	74	59	61	54	83	65	49	28	19	23	18	16	**916**
Sat, 14/01/2012	12	13	3	7	3	9	19	28	51	77	77	82	67	65	70	85	71	66	51	33	31	20	21	20	**981**
Sun, 15/01/2012	5	7	10	6	10	10	24	38	48	67	92	95	96	77	93	106	90	60	56	29	25	13	16	7	**1,080**
Mon, 16/01/2012	5	7	8	3	2	5	17	25	25	59	61	68	61	70	55	58	54	61	25	22	18	9	15	5	**738**
Tue, 17/01/2012	12	7	7	3	5	10	22	32	46	57	86	72	73	77	88	86	71	77	48	62	38	22	16	15	**1,032**
Wed, 18/01/2012	3	6	11	5	7	12	25	42	44	60	65	53	65	72	67	78	69	67	50	50	41	16	20	9	**937**
Thu, 19/01/2012	11	12	4	9	5	9	18	32	54	70	69	64	61	82	91	81	75	63	58	60	31	16	16	13	**1,004**
Fri, 20/01/2012	10	11	9	7	10	12	20	24	34	61	54	59	51	65	62	60	56	65	42	35	32	25	19	10	**833**
Sat, 21/01/2012	6	9	7	5	8	6	13	40	52	44	70	58	71	70	63	63	53	37	40	28	23	14	23	8	**811**
Sun, 22/01/2012	13	11	6	6	5	4	8	37	43	57	64	49	67	70	60	71	71	69	43	48	24	7	12	11	**856**
Mon, 23/01/2012	5	8	8	4	10	10	21	25	34	50	40	39	45	51	50	43	57	40	25	18	21	18	14	13	**649**
Tue, 24/01/2012	13	4	4	2	7	8	17	35	40	39	52	59	64	81	74	62	80	81	51	37	32	29	23	11	**905**
Wed, 25/01/2012	4	9	5	6	12	5	13	25	44	51	52	56	50	46	66	58	46	39	29	31	27	16	15	10	**715**
Thu, 26/01/2012	10	6	4	9	6	7	13	21	32	49	60	92	77	79	68	64	74	57	60	47	27	25	13	16	**916**
Fri, 27/01/2012	5	11	4	4	7	6	7	20	33	40	29	33	36	27	30	36	28	28	25	18	11	16	3	11	**468**
Sat, 28/01/2012	5	5	4	6	1	5	8	20	28	41	48	53	48	54	58	41	59	59	43	9	28	14	1	13	**651**
Sun, 29/01/2012	9	11	7	5	6	8	23	27	37	56	62	69	64	66	63	71	61	58	35	32	20	7	7	7	**811**
Mon, 30/01/2012	3	9	6	2	5	2	15	25	34	42	45	50	55	38	39	40	38	38	36	14	17	18	15	12	**598**
Tue, 31/01/2012	17	13	5	6	5	4	19	32	42	51	69	63	74	68	61	70	75	66	49	40	23	23	14	13	**902**
Wed, 01/02/2012	6	8	7	4	2	10	12	28	40	43	52	61	47	43	47	44	34	30	17	8	4	1	2		**550**
Thu, 02/02/2012			1				4	7	7	12	9	7	5	3	6	6	3	8		1	1	1			**81**
Fri, 03/02/2012							4		6	4	3	8	5	5	4	6	5	1	3	5	3	10	5	3	**80**
Sat, 04/02/2012	2	1	2			2	2	3	6	3	6	9	5	5	8	14	19	17	11	8	9	1	2	3	**138**
Sun, 05/02/2012	2	3		1		3	2	1	2	2	13	13	9	11	18	14	28	11	12	14	6	6	5	2	**178**
Mon, 06/02/2012		1				2	10	3	12	11	18	23	16	25	29	26	23	26	27	21	13	9	11	10	**316**
Tue, 07/02/2012	7	6	4	1	1	4	10	12	44	29	45	45	45	35	61	64	58	63	35	28	35	17	30	16	**695**
Wed, 08/02/2012	12	10	2	2	4	16	18	18	27	44	38	46	69	51	54	63	48	62	49	35	23	16	11	14	**732**
Thu, 09/02/2012	15	3	7	4	11	5	18	13	36	39	47	42	37	59	83	60	61	50	43	37	29	19	26	15	**759**
Fri, 10/02/2012	9	9	9	2	7	4	14	17	40	29	40	37	33	39	30	39	48	34	34	25	26	22	13	18	**578**
Sat, 11/02/2012	6	9	2	4	3	8	9	23	29	29	27	47	47	52	40	52	50	55	35	39	22	27	18	17	**650**
Sun, 12/02/2012	13	17	7	12	9	4	6	20	48	47	55	55	65	83	64	85	56	47	51	38	27	26	20	12	**867**
Mon, 13/02/2012	6	7	10	2	5	12	16	27	32	42	31	42	38	58	46	40	34	32	23	19	15	18	7	11	**573**
Tue, 14/02/2012	5	7	4	2	13	6	11	28	34	43	49	50	62	83	73	71	59	59	54	39	30	30	17	6	**835**
Wed, 15/02/2012	8	6	3	4	8	7	13	29	36	53	50	68	71	57	75	64	41	63	64	45	35	17	19	13	**849**
Thu, 16/02/2012	8	7	8	6	6	8	18	24	40	58	59	52	66	79	64	77	69	59	53	51	22	21	23	16	**894**
Fri, 17/02/2012	17	6	8	6	5	11	17	28	33	38	55	48	51	45	41	63	58	46	39	19	18	23	18	10	**703**
Sat, 18/02/2012	8	9	3	3	3	5	14	21	32	57	57	49	49	44	45	51	57	62	51	30	18	24	17	12	**721**
Sun, 19/02/2012	16	9	11	5	10	10	12	21	39	51	59	66	64	78	76	59	66	49	33	38	27	12	12	4	**827**
Mon, 20/02/2012	11	9	3	3	3	7	22	26	36	41	34	43	47	45	60	51	61	38	35	23	18	11	21	11	**659**
Tue, 21/02/2012	6	2	6	2	6	4	16	28	40	51	45	72	68	78	70	75	58	68	49	44	30	30	14	17	**879**
Wed, 22/02/2012	16	3	8	6	8	10	22	17	33	45	71	57	56	72	70	65	78	64	54	42	22	17	12	12	**860**
Thu, 23/02/2012	10	6	7	4	7	9	17	29	37	62	79	54	69	67	72	63	73	63	52	38	29	27	24	14	**912**
Fri, 24/02/2012	16	10	9	7	8	2	14	20	44	46	45	54	48	50	51	55	60	36	42	30	30	12	11	7	**707**
Sat, 25/02/2012	14	8	4	11	7	7	8	18	33	40	52	51	69	54	51	65	53	58	38	20	27	18	14	13	**733**
Sun, 26/02/2012	14	8	9	7	7	4	21	24	33	47	34	99	94	65	68	62	77	42	41	41	20	27	21	13	**878**
Mon, 27/02/2012	11	3	2	1	4	13	13	28	36	45	56	52	49	41	49	29	50	47	45	19	18	14	11	13	**649**
Tue, 28/02/2012	10	8	6	3	12	19	17	28	44	50	45	83	90	74	84	81	63	67	47	41	43	26	16	10	**967**
Wed, 29/02/2012	5	5	5	7	9	10	12	37	34	55	43	53	65	58	59	59	62	70	50	39	31	21	11	10	**810**
Thu, 01/03/2012	12	3	10	6	12	8	16	33	42	41	64	68	61	54	72	72	71	73	59	40	36	29	12	7	**901**
Fri, 02/03/2012	6	8	5	5	7	4	13	21	31	46	63	48	48	38	56	64	57	45	52	19	19	20	8	6	**689**
Sat, 03/03/2012	10	7	5	2	5	5	10	23	25	34	54	47	43	72	41	31	38	38	35	31	25	12	17	6	**616**
Sun, 04/03/2012	11	9	4	1	8	5	9	19	25	26	60	36	69	38	40	50	57	42	30	35	21	16	13	7	**631**
Mon, 05/03/2012	5	2	3	1	3	4	12	20	29	36	24	31	51	23	28	39	26	24	36	22	20	11		6	**456**
Tue, 06/03/2012	9	4	7	3	2	2	11	20	33	30	39	27	37	40	37	27	57	34	27	26	13	13	9	5	**512**
Wed, 07/03/2012	8	6	4		9	4	10	27	34	30	38	44	35	44	26	46	40	40	24	25	25	13	10	16	**558**
Thu, 08/03/2012	5	5	1	2	6	3	10	13	23	22	31	28	42	39	39	35	35	42	40	21	32	19	23	10	**526**
Fri, 09/03/2012	3	5	7	5	5	6	16	17	26	23	27	32	39	28	37	34	35	39	30	11	18	9	11	9	**472**

Sat, 10/03/2012	4	4	3	3	3	8	5	12	22	26	40	33	44	29	43	36	40	27	34	27	21	26	5	13	**508**
Sun, 11/03/2012	2	5	3	10	2	8	11	15	26	34	41	45	49	47	61	47	58	48	29	28	23	10	9	6	**617**
Mon, 12/03/2012	2	5	4	4	1	7	10	25	27	30	32	34	29	41	24	41	36	47	23	17	10	12	8	6	**475**
Tue, 13/03/2012	12	5	3	1	5	8	13	17	37	22	36	42	47	39	29	37	47	38	25	16	24	14	5	8	**530**
Wed, 14/03/2012	3	5	4	2	4	5	17	18	38	35	29	38	31	45	50	57	61	53	49	39	24	24	22	11	**664**
Thu, 15/03/2012	10	8	2	9	9	2	11	19	32	47	32	50	36	56	47	62	57	43	50	33	17	23	15	5	**675**
Fri, 16/03/2012	16	10	5	4	6	5	13	25	35	36	53	47	37	36	54	41	30	49	43	36	19	10	9	10	**629**
Sat, 17/03/2012	4	6	3	6	4	6	6	14	26	35	52	44	42	43	37	43	31	37	34	26	14	14	11	6	**544**
Sun, 18/03/2012	11	6	3	2	5	8	14	12	24	32	46	46	52	47	56	44	47	76	35	27	25	19	14	9	**660**
Mon, 19/03/2012	5	4	3	5	3	11	10	20	30	38	36	42	29	31	51	49	45	38	31	14	15	16	13	11	**550**
Tue, 20/03/2012	8	4	2	6	4	8	11	19	28	26	62	58	64	52	59	83	60	66	60	34	29	28	15	9	**795**
Wed, 21/03/2012	9	10	2	4	7	13	15	25	32	47	59	52	63	59	74	60	55	47	47	39	23	20	15	16	**793**
Thu, 22/03/2012	6	8	4	6	7	6	18	27	36	45	47	68	74	57	67	63	66	59	46	54	26	16	23	18	**847**
Fri, 23/03/2012	10	7	5	7	7	5	16	26	37	46	52	52	43	41	72	50	42	62	51	32	21	16	14	8	**722**
Sat, 24/03/2012	7	8	6	10	7	9	18	19	41	55	63	72	48	47	41	59	58	47	47	23	28	18	10	12	**753**
Sun, 25/03/2012	7	11	6	4	6	10	12	25	38	42	40	74	52	79	107	100	60	61	43	32	23	20	15	9	**876**
Mon, 26/03/2012	8	5	3	3	4	4	17	20	27	33	41	47	52	46	57										**367**
TOTAL	**751**	**602**	**476**	**387**	**529**	**631**	**1,310**	**2,243**	**3,255**	**4,087**	**4,680**	**4,932**	**5,013**	**4,819**	**4,957**	**4,997**	**4,909**	**4,507**	**3,565**	**2,677**	**2,045**	**1,563**	**1,205**	**928**	**65,068**

92742: Traffic Volume - Vehicle Count - Date and Hours by Direction

SOUTH

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	TOTAL
Sun, 01/01/2012	3	8	3	5	1	3	6	17	37	33	51	41	55	52	71	65	59	50	44	34	32	16	14	17	**717**
Mon, 02/01/2012	8	4	6	5	5	11	26	26	50	58	70	86	84	85	120	103	111	75	64	31	27	21	11	15	**1,102**
Tue, 03/01/2012	12	4	11	3	2	15	19	39	58	55	59	58	58	86	88	94	69	63	52	48	27	26	26	27	**999**
Wed, 04/01/2012	14	15	10	18	13	16	31	49	51	73	70	84	78	89	89	92	71	73	53	36	19	19	21	18	**1,102**
Thu, 05/01/2012	21	17	15	18	13	25	33	50	68	68	84	78	89	81	83	86	90	87	46	31	42	36	21	13	**1,195**
Fri, 06/01/2012	9	12	14	10	11	21	34	51	60	80	90	86	66	80	96	114	88	86	48	34	29	31	25	15	**1,190**
Sat, 07/01/2012	18	19	16	14	13	10	23	51	36	64	56	72	56	85	95	79	64	53	41	34	40	34	17	14	**1,004**
Sun, 08/01/2012	13	10	9	7	5	14	18	34	36	53	59	64	68	73	80	78	49	53	41	18	14	12	11	6	**825**
Mon, 09/01/2012	7	3	5	4	5	8	22	36	46	53	44	57	60	66	56	76	86	73	53	44	48	26	30	23	**931**
Tue, 10/01/2012	15	15	14	9	14	21	37	35	66	68	75	58	80	68	86	67	67	65	41	27	21	23	21	24	**1,017**
Wed, 11/01/2012	11	10	12	14	8	14	33	35	53	65	68	63	54	57	70	72	69	63	57	33	38	32	27	19	**977**
Thu, 12/01/2012	24	7	15	11	15	13	38	53	52	74	68	78	63	74	63	74	64	60	52	28	19	19	11	17	**992**
Fri, 13/01/2012	18	8	8	10	11	12	30	47	46	67	66	70	51	49	78	71	68	64	40	29	25	26	24	19	**937**
Sat, 14/01/2012	19	8	12	20	9	15	33	53	54	44	56	47	57	71	72	71	66	65	31	31	29	22	17	12	**914**
Sun, 15/01/2012	15	6	10	5	6	7	17	38	56	56	58	56	48	58	54	74	34	36	19	24	18	17	12	6	**730**
Mon, 16/01/2012	4	3	2	2	5	11	20	30	41	31	42	37	43	45	42	46	62	59	44	50	20	38	32	24	**733**
Tue, 17/01/2012	15	13	9	12	16	25	32	42	54	56	61	49	41	49	42	57	52	47	25	20	11	26	19	21	**794**
Wed, 18/01/2012	9	10	15	9	6	10	36	40	67	52	57	46	72	47	41	58	56	42	50	29	35	25	17	30	**859**
Thu, 19/01/2012	15	16	19	11	13	11	25	47	63	63	66	48	47	55	53	49	54	48	32	33	19	28	17	18	**850**
Fri, 20/01/2012	10	9	6	9	11	14	26	40	57	63	51	51	57	57	58	66	43	46	34	34	19	27	23	10	**821**
Sat, 21/01/2012	17	14	14	11	10	16	22	31	35	56	36	45	52	56	78	51	59	45	43	28	30	26	16	20	**811**
Sun, 22/01/2012	15	9	2	3	4	4	20	36	54	52	60	52	54	40	59	58	55	32	23	19	16	14	14	9	**704**
Mon, 23/01/2012	6	3	4	8	7	7	15	24	36	45	37	33	42	43	49	58	64	40	59	32	39	31	30	16	**728**
Tue, 24/01/2012	23	14	17	14	15	22	28	37	55	79	68	64	73	66	46	56	62	58	42	31	26	18	14	14	**942**
Wed, 25/01/2012	9	15	6	9	5	9	29	31	38	57	68	59	55	57	57	45	46	55	43	42	41	34	31	32	**873**
Thu, 26/01/2012	24	8	21	16	16	17	24	43	55	70	53	49	54	44	47	61	53	27	42	21	12	12	12	10	**791**
Fri, 27/01/2012	7	3	3	8	10	8	13	14	28	37	36	27	39	40	45	43	44	46	35	42	33	29	21	13	**624**
Sat, 28/01/2012	19	7	11	13	9	19	28	44	40	58	64	69	48	46	51	58	59	63	27	25	19	24	14	15	**830**
Sun, 29/01/2012	10	11	7	4	6	8	12	32	38	46	53	36	50	53	51	38	41	42	29	14	18	13	13	6	**631**
Mon, 30/01/2012	4	4	2	6	3	5	13	28	33	31	38	34	26	37	38	50	41	46	36	33	30	38	19	22	**617**
Tue, 31/01/2012	16	12	7	17	14	17	20	39	49	51	49	57	60	52	40	38	38	61	22	29	24	25	14	14	**765**
Wed, 01/02/2012	18	6	17	14	4	12	16	26	55	47	40	51	46	54	42	55	34	44	34	23	5	2		1	**646**
Thu, 02/02/2012				1	1		4	10	23	19	14	11	14	4	5	6	6		1	3	3	1		1	**127**
Fri, 03/02/2012							3	6	5	6	16	4	3	11	9	2	10	12	2	3	1			2	**95**

Sat, 04/02/2012	1			1		1	4	11	11	17	15	38	20	16	9	18	6	7	6	3	6	2	2		**194**
Sun, 05/02/2012	1					3	4	13	21	19	26	24	11	11	10	15	11	4	4	1	3	2	3	2	**188**
Mon, 06/02/2012			1	1	2	6	5	9	19	11	12	14	15	22	22	18	21	31	27	24	17	26	21	30	**354**
Tue, 07/02/2012	15	4	8	9	15	13	12	36	36	37	34	32	35	50	34	28	38	18	25	18	26	36	23	17	**599**
Wed, 08/02/2012	9	10	15	15	7	15	20	28	34	53	50	26	35	24	40	28	48	42	23	19	21	32	30	17	**641**
Thu, 09/02/2012	19	18	12	16	10	10	17	32	45	48	40	29	50	45	45	36	40	30	29	32	17	25	19	29	**693**
Fri, 10/02/2012	14	13	9	9	8	13	16	22	48	34	40	42	37	35	34	49	42	42	25	19	21	25	20	19	**636**
Sat, 11/02/2012	17	12	17	11	10	10	15	26	26	39	38	35	44	30	42	42	62	21	32	30	23	25	27	10	**644**
Sun, 12/02/2012	18	9	16	8	7	3	17	21	17	36	29	43	35	39	35	36	38	24	24	13	16	15	13	5	**517**
Mon, 13/02/2012	6	4	8		4	8	12	12	31	29	43	24	35	29	33	41	48	46	53	44	29	33	32	35	**639**
Tue, 14/02/2012	21	19	13	17	23	12	28	31	50	55	51	45	39	50	35	40	42	35	35	30	26	23	20	19	**759**
Wed, 15/02/2012	18	13	9	11	16	16	23	42	63	62	61	42	44	43	36	46	58	38	38	31	29	38	28	29	**834**
Thu, 16/02/2012	17	11	28	8	15	17	32	49	53	71	41	60	41	49	38	63	57	47	37	32	24	21	26	20	**857**
Fri, 17/02/2012	15	6	18	6	12	13	33	51	34	52	48	50	36	73	47	56	49	48	32	20	23	26	20	28	**796**
Sat, 18/02/2012	25	20	17	15	7	16	25	35	50	47	61	40	39	53	58	44	48	44	35	36	18	31	30	15	**809**
Sun, 19/02/2012	10	13	9	10	9	5	15	23	33	39	34	44	40	22	33	40	36	26	25	23	12	15	15	11	**542**
Mon, 20/02/2012	10	5	2	2	5	13	22	19	38	50	30	34	38	46	55	56	57	40	33	33	38	38	31	23	**718**
Tue, 21/02/2012	18	14	7	11	12	25	27	32	51	54	56	49	56	44	44	42	39	42	30	33	19	23	23	19	**770**
Wed, 22/02/2012	15	11	11	12	12	14	34	51	44	42	37	66	54	58	53	50	38	42	34	41	44	35	26	36	**860**
Thu, 23/02/2012	17	19	16	9	11	13	38	46	61	53	51	54	50	73	62	41	53	43	24	23	20	29	16	9	**831**
Fri, 24/02/2012	12	12	12	14	9	8	29	46	66	63	39	49	55	54	63	56	43	43	41	26	27	25	24	17	**833**
Sat, 25/02/2012	17	14	11	12	12	9	27	27	32	57	35	48	41	46	44	53	42	32	44	18	32	25	24	19	**721**
Sun, 26/02/2012	9	13	2	9	6	9	10	31	36	32	35	51	47	49	56	55	46	21	27	13	20	19	10	14	**620**
Mon, 27/02/2012	5	2	3	5	1	9	17	30	34	25	32	42	34	45	47	48	42	39	23	35	29	30	38	24	**639**
Tue, 28/02/2012	13	8	11	14	13	21	21	47	40	50	59	41	48	51	34	47	38	46	33	27	16	35	21	13	**747**
Wed, 29/02/2012	9	7	8	12	9	23	20	44	47	48	50	56	30	50	51	39	40	39	29	31	24	29	37	18	**750**
Thu, 01/03/2012	18	14	10	11	9	18	24	42	41	57	57	45	48	48	57	55	52	40	26	21	22	24	11	19	**769**
Fri, 02/03/2012	11	6	11	6	14	17	19	40	56	49	48	44	45	65	42	36	45	35	55	24	17	18	11	24	**738**
Sat, 03/03/2012	9	10	12	6	13	13	26	23	27	52	42	38	37	48	50	34	43	31	32	21	29	25	14	15	**650**
Sun, 04/03/2012	10	9	4	5	2	8	9	26	38	33	36	33	19	43	33	32	33	25	22	11	12	15	10	7	**475**
Mon, 05/03/2012	3	2	1	1	3	11	18	23	24	36	28	26	32	34	31	37	43	33	26	15	22	18	18	12	**497**
Tue, 06/03/2012	4	4	6	2	3	11	20	33	23	46	44	35	32	41	19	35	32	29	18	14	9	17	5	9	**491**
Wed, 07/03/2012	5	4	6	3	8	9	19	28	32	44	28	34	27	28	47	37	48	27	21	17	17	7	17	12	**525**
Thu, 08/03/2012	7	3	7	4	9	13	34	23	34	31	44	48	24	41	39	30	31	29	30	20	9	16	13	9	**548**
Fri, 09/03/2012	7	3	7	5	3	8	19	17	39	54	36	50	43	40	51	36	40	33	31	19	13	13	10	16	**593**
Sat, 10/03/2012	7	9	7	9	8	15	17	24	37	32	40	28	29	43	31	39	43	26	20	10	20	14	11	11	**530**
Sun, 11/03/2012	3	3	5	1	4	3	8	14	21	32	29	22	28	42	36	31	38	28	31	15	12	17	14	11	**448**
Mon, 12/03/2012	4	5	2	2	2	9	16	18	22	28	31	45	32	34	42	42	27	42	26	17	23	33	27	22	**551**
Tue, 13/03/2012	18	12	9	8	14	8	32	32	44	53	61	46	49	36	43	31	29	30	30	29	18	14	15	12	**673**
Wed, 14/03/2012	12	5	8	5	15	16	26	33	39	38	54	38	48	44	33	47	40	20	19	25	13	16	24	18	**636**
Thu, 15/03/2012	9	5	10	5	10	11	19	30	38	46	33	43	50	60	53	53	30	33	28	19	20	19	28	13	**665**
Fri, 16/03/2012	9	11	6	5	6	10	27	45	34	49	58	66	43	55	47	48	51	33	29	22	13	20	15	12	**714**
Sat, 17/03/2012	16	13	6	6	9	3	14	30	24	40	51	31	35	39	33	43	41	25	28	13	18	17	19	9	**563**
Sun, 18/03/2012	12	7	5	3	6	9	10	11	28	18	43	30	27	47	40	39	40	23	24	18	16	15	21	5	**497**
Mon, 19/03/2012		3	3	1	3	7	18	21	40	31	14	35	31	41	43	32	39	36	33	26	13	21	25	15	**531**
Tue, 20/03/2012	21	8	13	19	8	13	20	31	42	35	49	35	40	49	53	45	42	43	27	23	25	12	18	13	**684**
Wed, 21/03/2012	10	10	5	12	5	13	19	35	29	67	53	42	46	52	63	52	43	51	28	21	28	33	20	24	**761**
Thu, 22/03/2012	16	9	18	9	8	14	19	38	52	50	68	49	52	62	56	53	38	41	48	18	27	20	24	8	**797**
Fri, 23/03/2012	10	10	11	13	15	15	14	34	46	44	61	47	36	45	39	38	47	46	39	22	22	24	15	21	**714**
Sat, 24/03/2012	11	7	16	9	13	15	28	46	41	59	44	45	44	60	42	44	55	33	28	33	28	24	20	13	**758**
Sun, 25/03/2012	12	6	7	5	8	7	15	24	62	43	47	52	46	60	61	47	29	32	25	24	7	13	11	7	**650**
Mon, 26/03/2012	7	4	3	6	7	16	9	29	28	41	31	32	39	39	37										**328**
TOTAL	**1,010**	**742**	**783**	**718**	**726**	**1,017**	**1,808**	**2,778**	**3,556**	**4,061**	**4,060**	**3,937**	**3,834**	**4,233**	**4,235**	**4,214**	**4,015**	**3,493**	**2,797**	**2,145**	**1,862**	**1,899**	**1,589**	**1,338**	**60,850**

MetroCount Traffic Executive
Class Speed Matrix

ClassMatrix-180 -- English (ENA)

Datasets:

Site: **[SH17] 200m north of SR59**
Direction: 3 - South bound, A hit first., **Lane:** 0
Survey Duration: 9:07 Thursday, 20 October 2011 => 20:36 Monday, 21 November 2011
File: G:\Eng\Design\MetroCount v315\User\Data\SH17\2011\SH1710Dec2011.EC0 (Plus)
Identifier: CG48BDKS MC56-L5 [MC55] (c)Microcom 19Oct04
Algorithm: Factory default
Data type: Axle sensors - Paired (Class/Speed/Count)

Site: **[SH17] 200m north of SR59**
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Identifier: CG48BDKS MC56-L5 [MC55] (c)Microcom 19Oct04
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Site: **[SH17] 200m north of SR59**
Direction: 3 - South bound, A hit first., **Lane:** 0
Survey Duration: 13:06 Thursday, 29 September 2011 => 13:30 Wednesday, 5 October 2011
File: G:\Eng\Design\MetroCount v315\User\Data\SH17\2011\SH1705Oct2011.EC0 (Plus)
Identifier: CG48BDKS MC56-L5 [MC55] (c)Microcom 19Oct04
Algorithm: Factory default
Data type: Axle sensors - Paired (Class/Speed/Count)

Profile:

Filter time: **13:04 Thursday, 29 September 2011 => 20:36 Monday, 21 November 2011**
Included classes: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
Speed range: 10 - 160 km/h.
Direction: North, East, South, West (bound)
Separation: All - (Headway)
Name: Factory default profile

Scheme: Vehicle classification (ARX)
Units: Metric (meter, kilometer, m/s, km/h, kg, tonne)
In profile: Vehicles = 99331 / 99402 (99.93%)

Class Speed Matrix

ClassMatrix-180
Site: SH17.0S SH17.0S SH17.0S SH17.0S
Description: **Multiple sites - See Header sheet for site descriptions.**
Filter time: **13:04 Thursday, 29 September 2011 => 20:36 Monday, 21 November 2011**
Scheme: Vehicle classification (ARX)
Filter: Cls(1 2 3 4 5 6 7 8 9 10 11 12) Dir(NESW) Sp(10,160) Headway(>0)

Speed (km/h)	Class 1	2	3	4	5	6	7	8	9	10	11	12	Speed Totals	
10 - 20	.	1	.	.	.	.	.	.	.	.	.	.	**1**	**0.0%**
20 - 30	.	21	1	.	2	.	.	.	2	1	.	.	**27**	**0.0%**
30 - 40	1	19	1	4	1	.	.	.	1	2	4	.	**33**	**0.0%**
40 - 50	1	14	4	6	2	1	.	2	1	1	2	.	**34**	**0.0%**
50 - 60	1	40	12	27	2	.	.	2	.	5	3	1	**93**	**0.1%**
60 - 70	1	220	36	63	5	.	2	6	.	7	8	2	**350**	**0.4%**
70 - 80	4	717	256	173	17	7	11	16	10	32	50	16	**1309**	**1.3%**
80 - 90	24	2385	1610	427	58	13	53	126	50	218	386	62	**5412**	**5.4%**
90 - 100	130	10248	2971	1468	585	116	218	450	885	5779	13879	261	**36990**	**37.2%**
100 - 110	312	25357	2585	1199	240	47	192	178	217	2917	8246	108	**41598**	**41.9%**
110 - 120	262	10323	629	357	13	14	58	13	4	39	129	11	**11852**	**11.9%**
120 - 130	54	1131	43	42	.	5	5	.	.	6	8	7	**1301**	**1.3%**
130 - 140	13	230	6	9	1	2	.	1	.	.	1	.	**263**	**0.3%**
140 - 150	.	45	2	3	.	1	.	.	.	.	.	.	**51**	**0.1%**
150 - 160	.	17	.	.	.	.	.	.	.	.	.	.	**17**	**0.0%**
	803	**50768**	**8156**	**3778**	**926**	**206**	**539**	**794**	**1170**	**9007**	**22716**	**468**	**99331**	
Class Totals	**0.8%**	**51.1%**	**8.2%**	**3.8%**	**0.9%**	**0.2%**	**0.5%**	**0.8%**	**1.2%**	**9.1%**	**22.9%**	**0.5%**		

MetroCount Traffic Executive
Weekly Vehicle Counts (Virtual Week)

VirtWeeklyVehicle-178 -- English (ENA)

Datasets:

Site:	**[SH17] 200m north of SR59**
Direction:	3 - South bound, A hit first., **Lane:** 0
Survey Duration:	9:07 Thursday, 20 October 2011 => 20:36 Monday, 21 November 2011
File:	G:\Eng\Design\MetroCount v315\User\Data\SH17\2011\SH1710Dec2011.EC0 (Plus)
Identifier:	CG48BDKS MC56-L5 [MC55] (c)Microcom 19Oct04
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Site:	**[SH17] 200m north of SR59**
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Site:	**[SH17] 200m north of SR59**
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Identifier:	CG48BDKS MC56-L5 [MC55] (c)Microcom 19Oct04
Algorithm:	Factory default
Data type:	Axle sensors - Paired (Class/Speed/Count)

Profile:

Filter time:	**13:04 Thursday, 29 September 2011 => 20:36 Monday, 21 November 2011**
Included classes:	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
Speed range:	10 - 160 km/h.
Direction:	North, East, South, West (bound)
Separation:	All - (Headway)
Name:	Factory default profile
Scheme:	Vehicle classification (ARX)
Units:	Metric (meter, kilometer, m/s, km/h, kg, tonne)
In profile:	Vehicles = 99331 / 99402 (99.93%)

Weekly Vehicle Counts (Virtual Week)

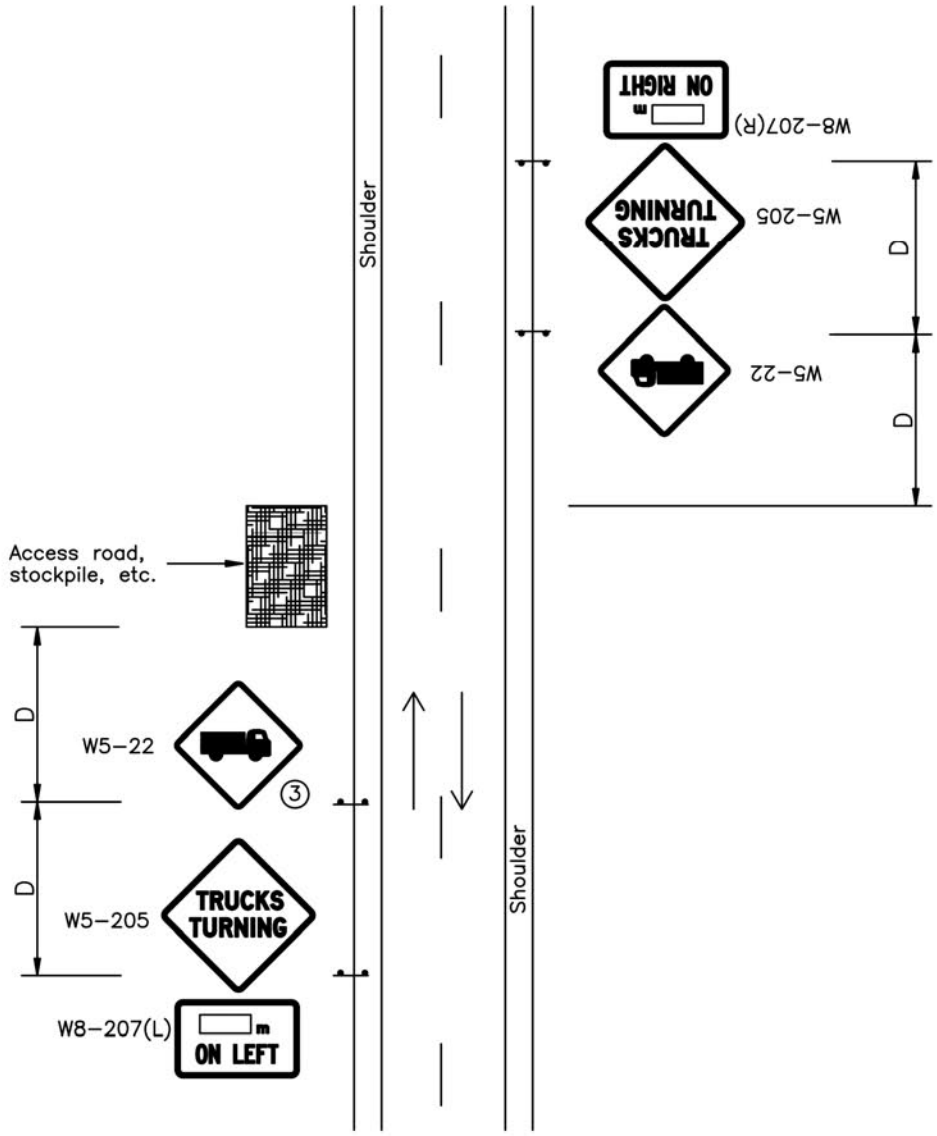
VirtWeeklyVehicle-178
Site: SH17.0S SH17.0S SH17.0S SH17.0S
Description: **Multiple sites - See Header sheet for site descriptions.**
Filter time: **13:04 Thursday, 29 September 2011 => 20:36 Monday, 21 November 2011**
Scheme: Vehicle classification (ARX)
Filter: Cls(1 2 3 4 5 6 7 8 9 10 11 12) Dir(NESW) Sp(10,160) Headway(>0)

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Averages 1 - 5	Averages 1 - 7
Hour									
0000-0100	17.4	11.3	21.9	19.3	23.6	17.5	20.6	18.8	18.9
0100-0200	11.9	8.3	20.3	21.7	20.6	15.3	19.3	16.5	16.8
0200-0300	11.0	8.1	20.9	17.0	22.1	18.0	21.0	15.9	17.0
0300-0400	15.0	11.7	19.0	21.7	23.3	17.6	19.9	18.2	18.4
0400-0500	18.3	20.6	30.3	29.0	28.3	30.9	26.6	25.2	26.2
0500-0600	36.5	40.3	59.7	58.9	53.0	51.0	48.4	49.4	49.5
0600-0700	68.8	73.7	100.6	97.0	98.9	83.6	71.9	87.6	84.6
0700-0800	88.6	108.0	135.7	119.4	126.9	115.3	97.8	115.3	112.6
0800-0900	125.6	112.6	**151.6<**	124.9	142.0	**130.3<**	113.1	131.5	128.5
0900-1000	118.1	117.3	136.0	**132.6<**	146.4	129.4	124.8	130.2	129.2
1000-1100	**128.1<**	121.4	139.9	127.9	**149.8<**	121.0	**128.1<**	**133.7<**	**130.9<**
1100-1200	124.0	**132.0<**	140.6	124.3	145.6	125.9	122.3	133.4	130.6
1200-1300	134.3	120.7	**148.6<**	136.3	150.4	**124.8<**	115.3	138.3	132.8
1300-1400	**146.4<**	122.7	143.6	**138.8<**	145.3	119.1	122.0	139.7	**134.0<**
1400-1500	138.9	**129.6<**	141.6	134.3	**155.6<**	120.8	117.6	**140.2<**	134.0
1500-1600	125.0	124.9	139.4	133.5	139.4	122.4	**122.0<**	132.4	129.4
1600-1700	99.1	117.9	128.6	122.8	137.1	114.1	99.4	121.0	116.8
1700-1800	69.5	92.9	98.9	95.4	109.1	90.3	83.9	93.0	91.2
1800-1900	55.0	68.0	78.0	72.6	75.5	63.4	55.9	69.7	66.7
1900-2000	43.1	57.7	54.3	57.0	66.1	51.9	50.8	55.6	54.4
2000-2100	30.4	47.7	52.0	56.8	50.3	47.1	40.8	47.3	46.3
2100-2200	28.4	40.0	35.7	45.4	40.5	34.6	37.9	38.3	37.7
2200-2300	20.6	33.1	24.9	33.5	29.9	26.6	35.3	28.6	29.3
2300-2400	14.4	24.9	27.7	28.4	22.3	23.8	25.9	23.6	24.0
Totals									
0700-1900	1352.6	1367.9	1582.3	1462.5	1623.0	1376.5	1302.0	1478.2	1436.7
0600-2200	1523.3	1587.0	1824.9	1718.7	1878.8	1593.8	1503.3	1707.0	1659.6
0600-0000	1558.3	1645.0	1877.4	1780.5	1930.9	1644.1	1564.4	1759.2	1712.9
0000-0000	1668.3	1745.3	2049.4	1948.1	2101.8	1794.4	1720.1	1903.1	1859.6
AM Peak	1000	1100	0800	0900	1000	0800	1000		
	128.1	132.0	151.6	132.6	149.8	130.3	128.1		
PM Peak	1300	1400	1200	1300	1400	1200	1500		
	146.4	129.6	148.6	138.8	155.6	124.8	122.0		

*** - No data.**

Appendix B

Standard Traffic Control Plan



NOTE:

① For use where roadside is generally undeveloped, ADT is more than 1,500 vehicles per day, sight distance is restricted and there are more than 20 truck movements per shift.

② See ***Traffic control at work sites,*** Section 7.7, ***Signs for depots, stockpiles, quarries, gravel pits etc.***

③ For short term works use T2–25.

ACCESS TO DEPOT, STOCKPILE, QUARRY, GRAVEL PIT ETC.
ALL ROADS
LONG TERM USE

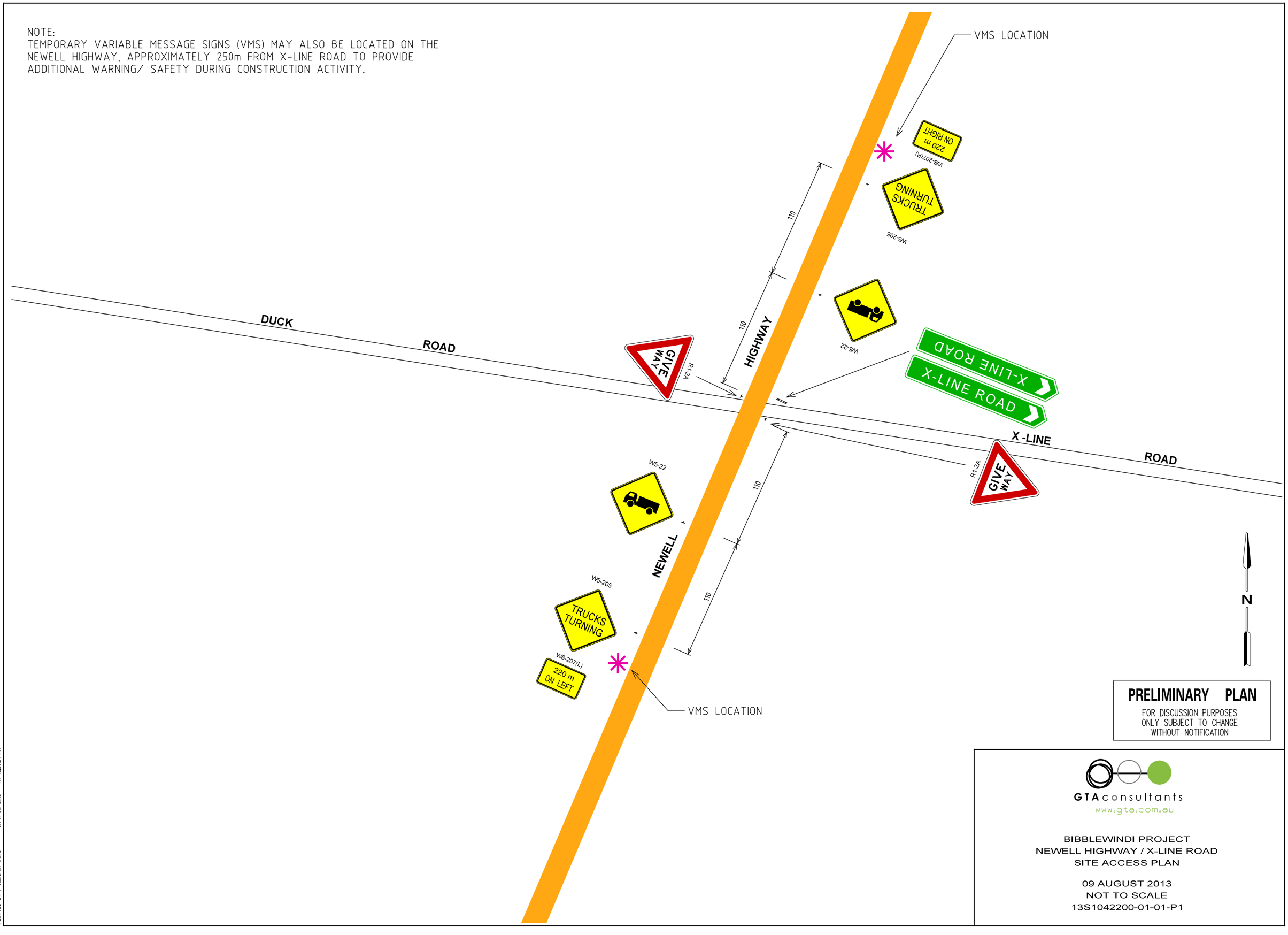
T000195

TCP 195

Appendix C

Site Access Plan

NOTE:
TEMPORARY VARIABLE MESSAGE SIGNS (VMS) MAY ALSO BE LOCATED ON THE NEWELL HIGHWAY, APPROXIMATELY 250m FROM X-LINE ROAD TO provide ADDITIONAL WARNING/ SAFETY DURING CONSTRUCTION ACTIVITY.



PRELIMINARY PLAN

FOR DISCUSSION PURPOSES
ONLY SUBJECT TO CHANGE
WITHOUT NOTIFICATION

GTAconsultants
www.gta.com.au

BIBBLEWINDI PROJECT
NEWELL HIGHWAY / X-LINE ROAD
SITE ACCESS PLAN

09 AUGUST 2013
NOT TO SCALE
13S1042200-01-01-P1

PLOTTED BY : Cameron Ward ON 9/08/2013 AT 12:30:31 PM



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GTAconsultants

Bibblewindi Gas Exploration Pilot Expansion PAL 2, Gunnedah Basin, NSW

BSAL Site Verification Report

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Version / Date: Rev B/August 2013

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Document Status

Version	Purpose of Document	Orig	Review	Review Date
A	Draft report for client review	SD	LMT KB Santos	08/08/2013 08/08/2013 28/08/2013
B	Final report	SK	LMT	28/08/2013

Approval for Issue

Signature	Date
LM Talbot	28/08/2013

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1.0 Introduction

RPS Australia East Pty Ltd (RPS) was engaged by Santos NSW (Eastern) Pty Ltd (Santos) to prepare a Biophysical Strategic Agricultural Land (BSAL) site verification report for the Bibblewindi Gas Exploration Pilot Expansion (proposed activity), located within the Bibblewindi State Forest, approximately 40 km south of Narrabri in north western NSW and within Petroleum Assessment Lease (PAL) 2 (**Figure 1**).

1.1 Assessment Area

The Bibblewindi Gas Exploration Pilot Expansion 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. No new land disturbance or vegetation clearing outside the existing well leases is required for the project.

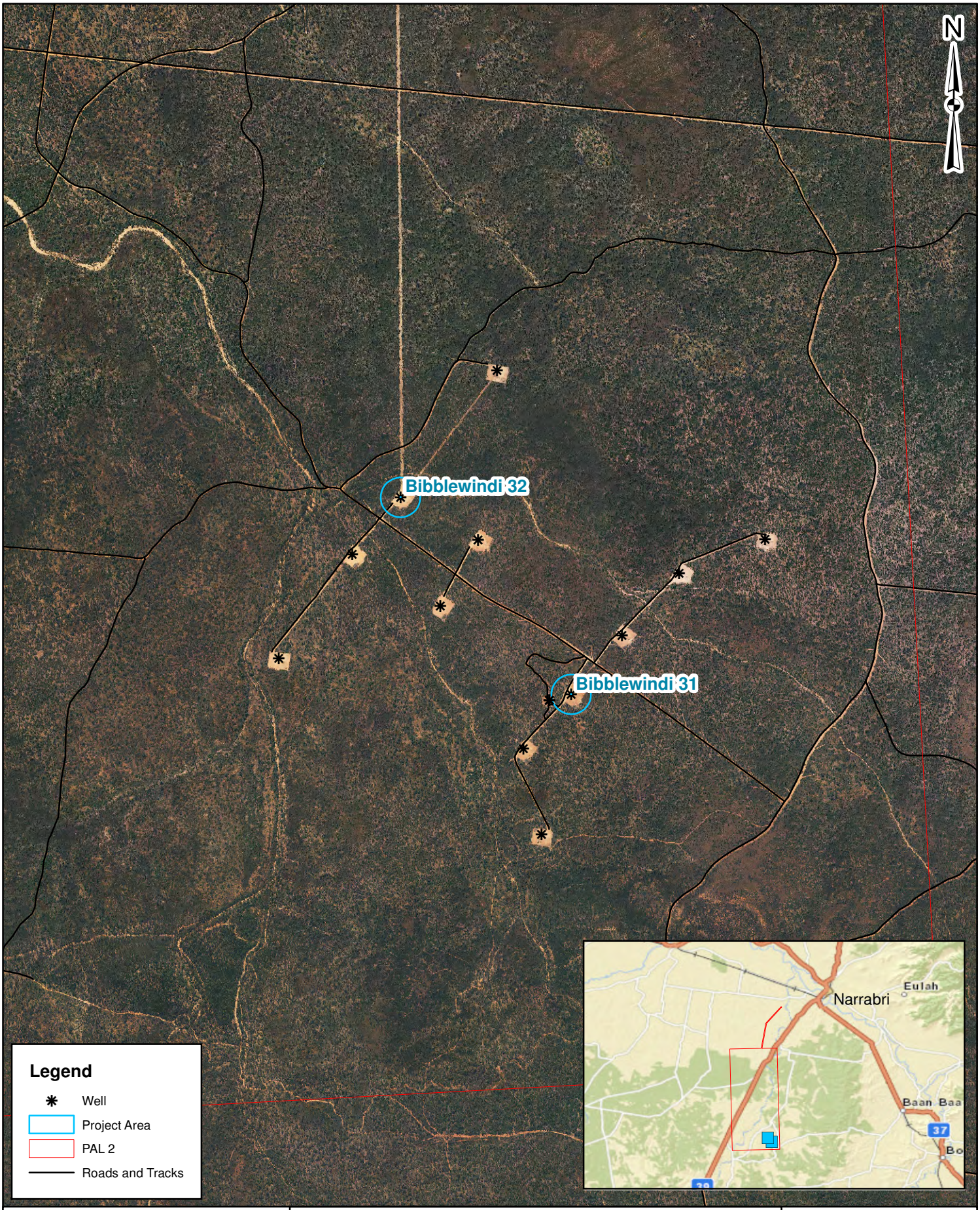
The proposed application development area includes the Bibblewindi 14 and Bibblewindi 19H well leases. As per the *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (hereafter the' interim protocol') (OEH & OASFS, 2013), the assessment area was expanded to include a 100 m buffer area to account for possible changes in design, surrounding disturbance and minor expansion (hereafter referred to as the 'project area'). The approximate location and description of the project area is provided in **Table 1** below.

Table 1 : Project Area Description

Well	Easting	Northing	Tenure description
Bibblewindi 31	754466.68	6603944.41	Crown Land State Forest
Bibblewindi 32	753647.23	6604983.47	Crown Land State Forest

1.2 BSAL Classification

The project area is located on land that is not mapped as BSAL by regional scale BSAL mapping (**Figure 2**).



Client:	Santos		
Compiled by:	SW	Date:	6/8/2013
Approved by:	LT	Date:	6/8/2013

RPS

Site Locality

Figure 1

Project: Bibblewindi 31 & 32 BSAL Assessment

Disclaimer: While all reasonable care has been taken to ensure the informationcontained on this map is up to date and accurate, no guarantee is given that theinformation portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

Source : OEH (2013), Google Earth Pro (2012).

0 0.25 0.5 1 1.5 Kilometers

Datum: GDA94





Client: Santos

Compiled by: SW | Date: 6/8/2013

Approved by: LT | Date: 6/8/2013

RPS

BSAL Classification

Figure 2

Project: Bibblewindi 31 & 32 BSAL Assessment

Disclaimer: While all reasonable care has been taken to ensure the informationcontained on this map is up to date and accurate, no guarantee is given that theinformation portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

Source : OEH (2013), Google Earth Pro (2012).

0 1.25 2.5 5 7.5 10 12.5 15 Kilometers

Datum: GDA94



2.0 Approach

The BSAL site verification assessment was undertaken in accordance with the provisions of the interim protocol for BSAL verification. To determine if the project area contained BSAL, the soils and landscape characteristics of the project area were compared against the 10 BSAL soils and landscape verification criteria provided by OEH & OASFS (2013) and summarised in **Table 2** below.

Table 2 : Soils and Landscape BSAL Verification Criteria

Criteria	Description
1. Slope	≤ 10 %
2. Rock outcrop	< 30 %
3. Surface rock fragments	≤ 20 % of area have unattached rock fragments > 60 mm diameter
4. Gilgai	≤ 50 % of the area have an average gilgai depth > 500 mm
5. Soil type (fertility)	Naturally moderate, moderately high or high fertility
6. Effective rooting depth to a physical barrier	≥ 750 mm
7. Drainage	Better than poorly drained
8. pH	Range from 5-8.9 if measured in water or 4.5-8.1 if measured in calcium chloride, within the uppermost 600 mm of the soil profile
9. Salinity	ECe ≤4 dS/m or chlorides <800 mg/kg (when gypsum is present), within the uppermost 600 mm of the soil profile
10. Effective rooting depth to a chemical barrier	≥ 750 mm

For land to be classified as BSAL it must meet all of the criteria outlined in **Table 2** and have a contiguous area greater than or equal to 20 hectares. If any criteria are not met, the land is not BSAL and there is no requirement under the interim protocol to continue the verification assessment.

The project area is located within the heavily forested Bibblewindi State Forest (**Figure 1).** Therefore the approach to the verification assessment included a desktop analysis of remotely sensed and modelled information, review of previous soil survey data from survey points in the Pilliga and Bibblewindi State Forests within close proximity to the project area and a site inspection. Section 5, Step 3 of the interim protocol identifies this as a suitable approach for BSAL verification assessment for sites that are not located in agricultural areas.

3.0 Results

3.1 Access to a Reliable Water Supply

The project area is within the *New England North West Strategic Regional Land Use Plan* (SRLUP) (DPI, 2012) and therefore has access to a "reliable water supply". No further assessment of this criterion is required.

3.2 Soils and Landscape Verification Criteria Assessment

For land to be classified as BSAL it must meet all of the 10 soils and landscape verification criteria described in **Section 2.0** and have a contiguous area greater than or equal to 20 hectares. An assessment against the criteria in the following order provided by the interim protocol was undertaken (**Figure 3**).

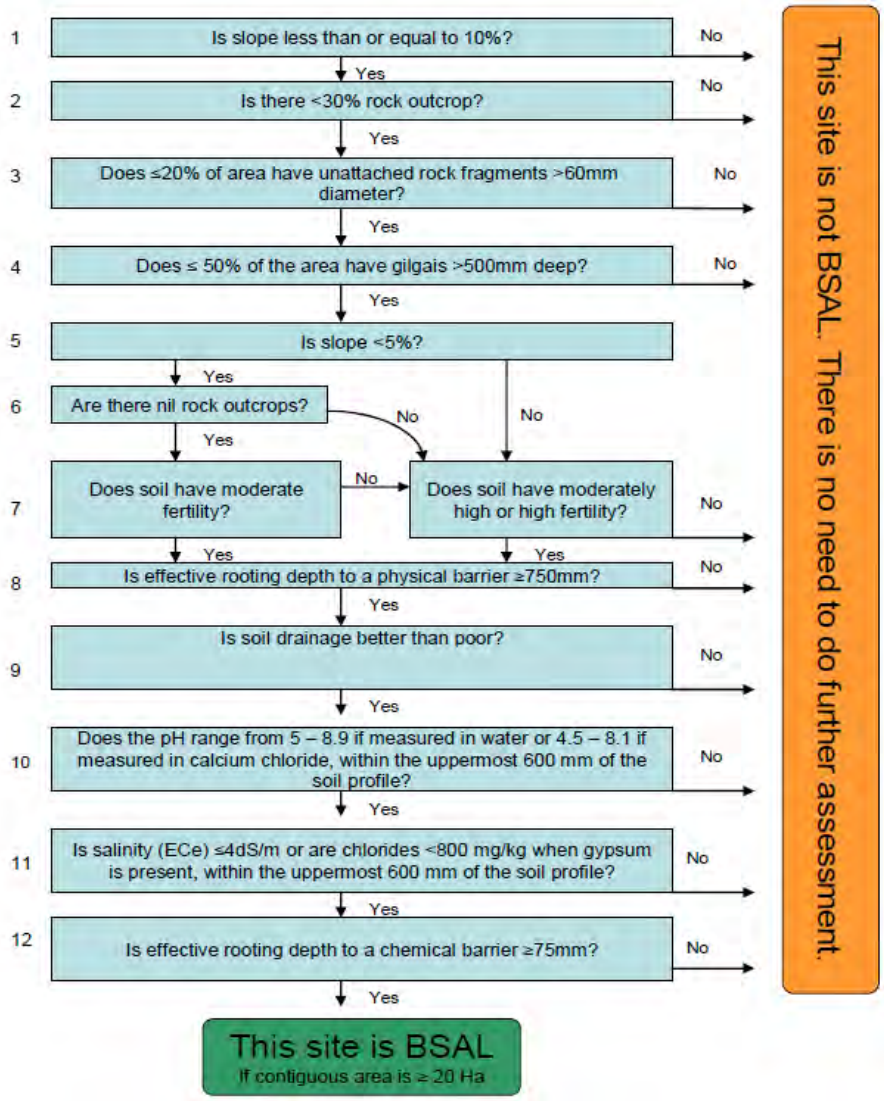


Figure 3: Flow chart for site assessment of BSAL (OEH & OASFS, 2013)

3.2.1 Criterion 1 - Slope

A slope assessment was undertaken across the project area utilising Light Detection and Ranging Radar LiDAR Data (one point per square metre). A regular grid Digital Elevation Model (DEM) was derived from ground classified points with a cell spacing of one metre using TNTmips geospatial software. For the purposes of landscape level slope analysis the DEM was resampled to 20 metres to reduce surface roughness effects and satisfy the minimum slope assessment distance provided in the interim protocol.

The generated slope layer identified that the project area and surrounds do not contain slopes greater than 10 per cent. This was verified during a site inspection conducted by RPS on 3 July 2013 in which a clinometer was used to report a slope value of one percent.

Using LiDAR data and a hand held clinometer it was determined that the slope of the project areas was less than or equal to 10 percent, thus satisfying the BSAL verification criteria for slope.

3.2.2 Criterion 2 - Rock outcrop

Field observations of the landscape of the project area made by RPS on 3 July 2013 did not identify any rock outcrops (i.e. less than 30% rock outcrop). Therefore the BSAL verification criterion for rock outcrop was met for the project area landscape.

3.2.3 Criterion 3 – Surface rockiness

Field observations of the landscape of the project area made by RPS on 3 July 2013 did not identify any unattached coarse rock fragments on the soil surface (i.e. less than or equal to 20 % of area with unattached rock fragments greater than 60 millimetre diameter) (**Plate 1**). Therefore the BSAL verification criterion for surface rockiness was met for the project area landscape.



Plate 1: Typical soil surface condition of project area landscape

3.2.4 Criterion 4 - Gilgai microrelief

LiDAR derived terrain data and field observations made by RPS on 3 July 2013 did not identify any gilgai microrelief within the vicinity of the project area (i.e. less than 50 % of the area had an average gilgai depth greater than 500 millimetres). Therefore the BSAL verification criterion for gilgai microrelief was met for the project area landscape.

3.2.5 Criterion 5 - Soil type (fertility)

The interim protocol identifies that a soil must be a type that has at least a moderate level of natural fertility to satisfy the BSAL verification criterion for soil fertility. Appendix 2, Table 6 of the interim protocol provides relative fertility classes for soil types based on the Australian Soil Classification (ASC).

The soil type of the project area was determined by desktop assessment of broadscale soils, geology and landscape data, remotely sensed radiometric data and review of findings from earlier field surveys in the local area.

3.2.5.1 Australian Soils Classification

ASC soil order mapping (1:100,000) prepared by the OEH (2012a) shows that the project area and the surrounding landscape is characterised by a single ASC soil order (Sodosols) (**Figure 4**). Rudosols and Tenosols are also described approximately 1.5 kilometres south-east of the project area. These soil orders are briefly described in **Table 3.**

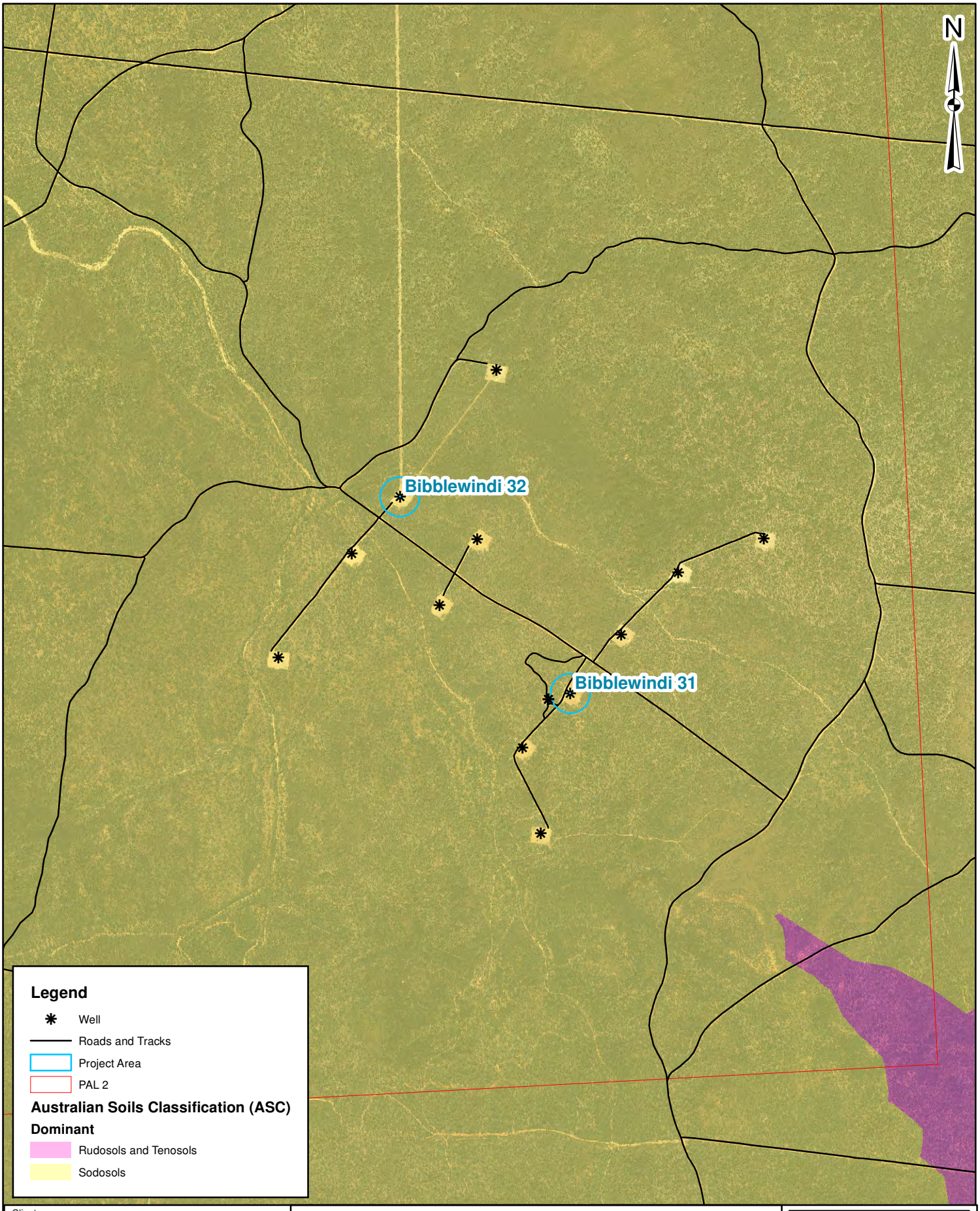
Table 3 : Australian Soils Classification

ASC Soil Order	Description
Rudosols and Tenosols	These soils have weak (Tenosol) to negligible (Rudosol) pedological organisation.
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.

3.2.5.2 Surface Geology

Detailed surface geology mapping indicated that the project area is underlain by a single geological formation described as the Keelindi beds (Qrxs/JKlk) (**Figure 5**) (Geosciences Australia, 2011). The Mesozoic – Cretaceous age Keelindi beds (Qrxs/JKlk) consist of colluvial polymictic gravel, sand, silt and clay and may include some eluvial in-situ regolith deposits overlying off-white, fine to coarse grained, poorly to well sorted, quartzose sandstone, pebbly sandstone and conglomerate interbedded with minor shale.

Sodosol soils are commonly formed from siliceous parent materials such as sandstone. The coarse textured nature of the sedimentary parent rock is reflected in the field texture grades of the soils described by previous soil surveys in the local area.



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Approved by: LT	Date: 6/8/2013

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Australian Soils Classification (ASC)

Figure 4

Project: Bibblewindi 31 & 32 BSAL Assessment

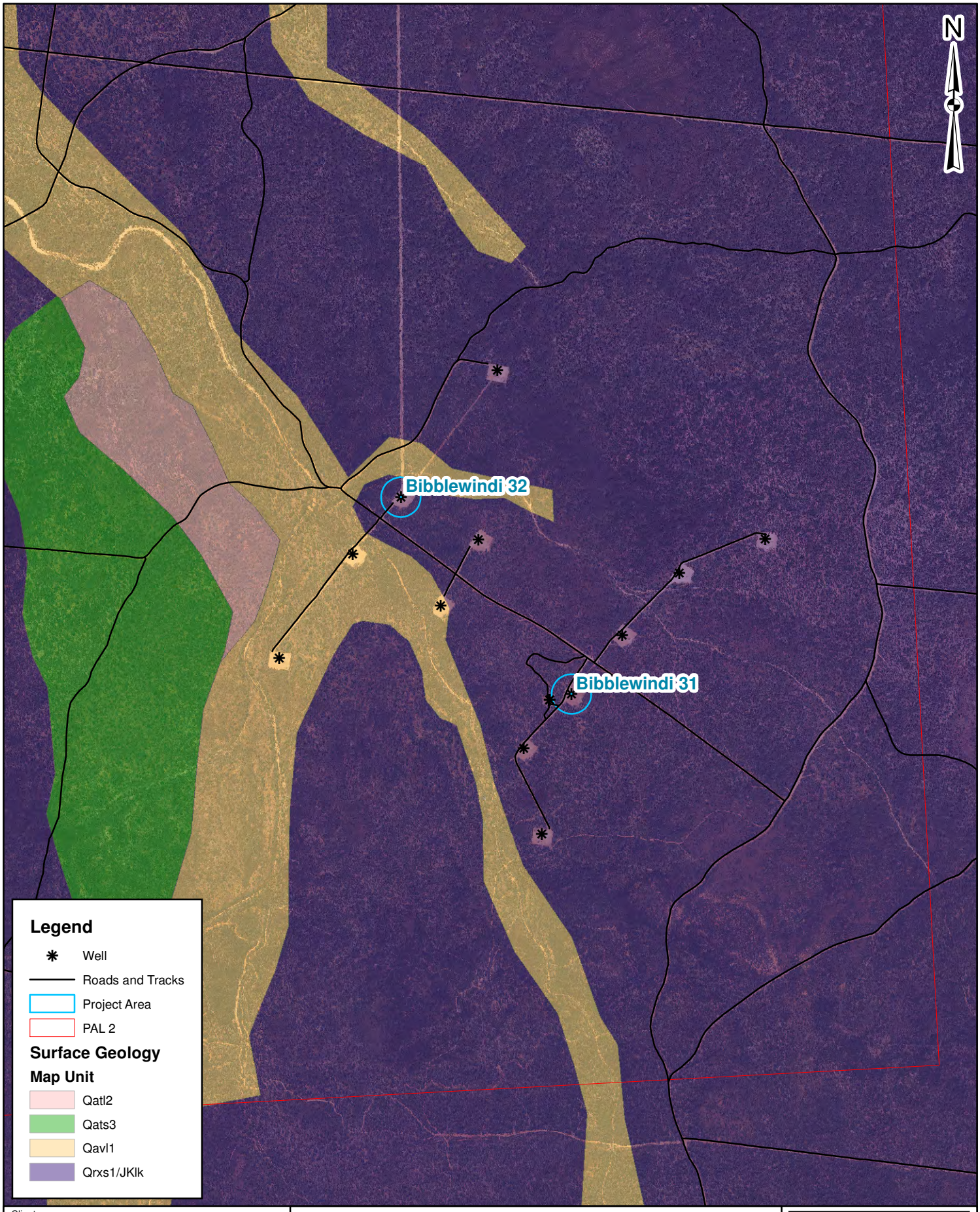
Disclaimer: While all reasonable care has been taken to ensure the informationcontained on this map is up to date and accurate, no guarantee is given that theinformation portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

Source : OEH (2013), Google Earth Pro (2012).

0 0.25 0.5 1 1.5 Kilometers

Datum: GDA94





Client:	Santos		
Compiled by:	SW	Date:	6/8/2013
Approved by:	LT	Date:	6/8/2013

RPS

Surface Geology

Figure 5

Project: Bibblewindi 31 & 32 BSAL Assessment

Disclaimer: While all reasonable care has been taken to ensure the informationcontained on this map is up to date and accurate, no guarantee is given that theinformation portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

Source : Geosciences Australian 2013

0 0.25 0.5 1 1.5 Kilometers

Datum: GDA94



3.2.5.3 Landscape Units

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 (**Figure 6**), which is described in **Table 4**.

Table 4 : Soil Landscape Units

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

The occurrence of deep texture contrast soils with harsh clay subsoils (i.e. Sodosols) within this landscape unit is consistent with the broadscale soil mapping and the findings of previous field surveys within the landscape of the project area.

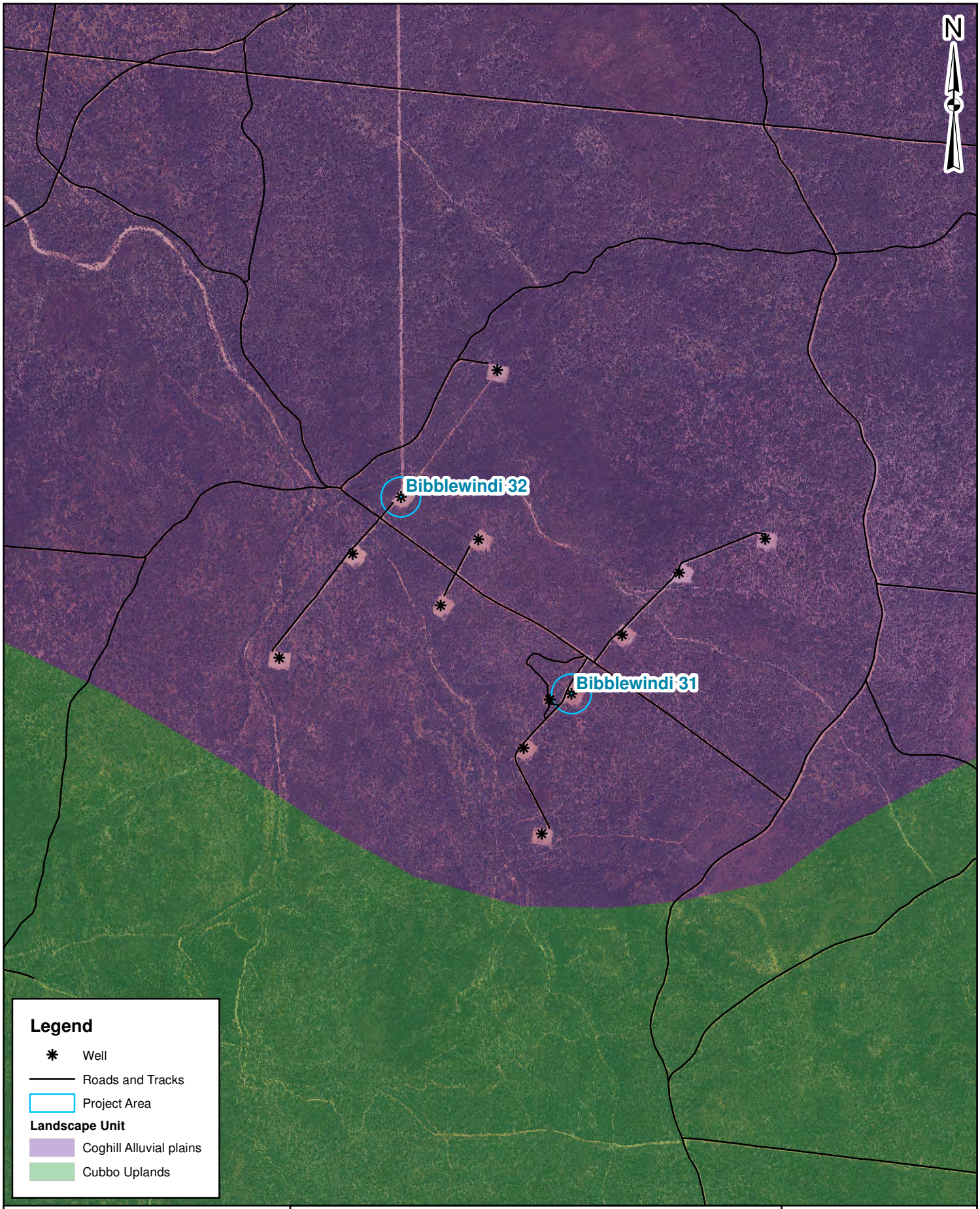
3.2.5.4 Airborne Gamma Radiation Survey Data

Ternary radiometric data images were sourced from Geoscience Australia using their Geophysical Archive Data Delivery System (**Figure 7**). The airborne gamma radiation survey data shows variations in levels of potassium (red), thorium (green) and uranium (blue) in the rocks and weathered materials (**Table 5**).

Table 5: Radiometric Method

Hues	Description
White-red	Actively eroding felsic volcanic and igneous rocks (high concentration of radioelements)
Green-blue	Ferruginous lags and weathered materials (relatively high thorium and low potassium responses)
Black	Ultramafic rocks and quartz-rich sandy materials such as quartzites, sandstones and unconsolidated sands (low radioelement concentrations)

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. As shown in **Figure 7**, the project area and nearby surrounds consist of weathered materials (green-blue) and quartz rich sandy materials (black). More importantly, the hue patterns in the ternary image 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.



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NSW Landscape Units

Figure 6

Project: Bibblewindi 31 & 32 BSAL Assessment

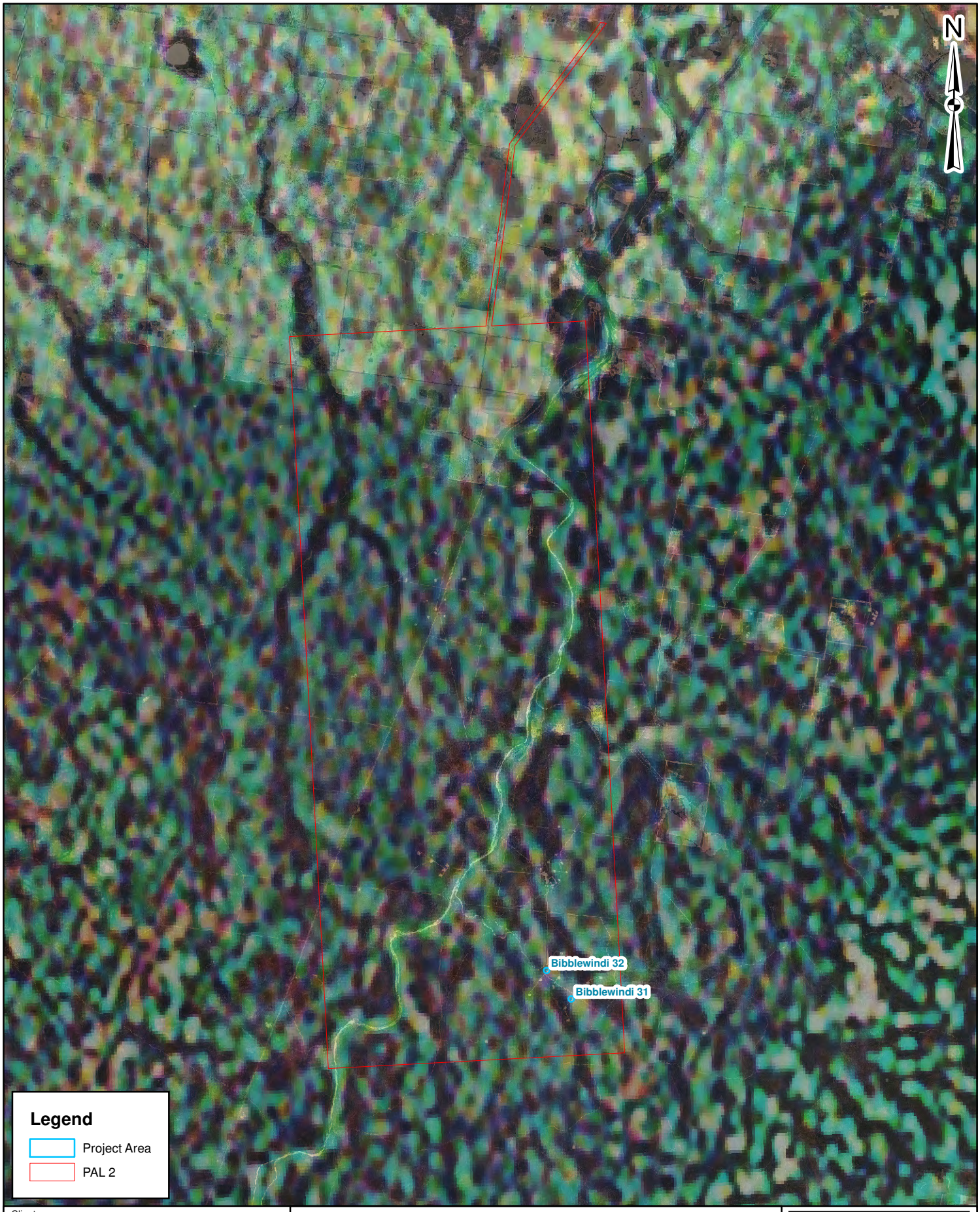
Disclaimer: While all reasonable care has been taken to ensure the informationcontained on this map is up to date and accurate, no guarantee is given that theinformation portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

Source : DLWC (2002)

0 0.25 0.5 1 1.5 Kilometers

Datum: GDA94





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Approved by:	LT	Date:	6/8/2013

Radiometric Survey

Figure 7

Project: Bibblewindi 31 & 32 BSAL Assessment

Disclaimer: While all reasonable care has been taken to ensure the informationcontained on this map is up to date and accurate, no guarantee is given that theinformation portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

Source : NSW DMR, Discovery 2000,1994-95

0 2.5 5 10 Kilometers

Datum: GDA94



3.2.5.5 Previous RPS Survey in Local Area

A site inspection of the project area was undertaken by RPS on 3 July 2013 which consisted of observations of vegetation types and noting features of the soil surface.

Vegetation adjoining the project area was dominated by eucalypt (*E. Crebra*) overstorey, Cypress and Casuarina understorey with shrubs, sedges and native grass species. Cypress and sedges are common to deep sandy and texture contrast soils (**Plate 2**). The vegetation community was described as open forest (**Plate 3**). The vegetation at the project area was consistent with the vegetation types previously observed by RPS associated with Sodosol soils in the Bibblewindi and Pilliga State Forests.



Plate 2 : Sedges forming the ground cover surrounding the project area



Plate 3: Example of cypress understorey and eucalypt overstorey

There was approximately 20 to 50 per cent grass cover and 70 per cent leaf litter surrounding the project area. The surface condition was described as soft with a thin surface crust. The topsoil of the undisturbed area surrounding the project area was pale orange and of a coarse sandy texture (**Plate 1**). 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.

An example of the upper 600 millimetres of a Sodosol soil profile at a site in the Bibblewindi State Forest from a previous RPS soil survey is provided in **Plate 4**. These soils typically include a shallow sandy A11 horizon overlying a lighter coloured A12 horizon. These upper horizons typically exhibit a singular or weak pedal structure. A conspicuously bleached A2 horizon is present in the profile due to the poor sub-soil drainage caused by the heavier textured, hard-set and strongly sodic B horizon (Exchangeable Sodium Percentage (ESP) ranging from 14 to 42 per cent).



Plate 4 : Example of Typical Sodosol Soil Profile from Bibblewindi State Forest

The vegetation associations and soil surface conditions noted during the site inspection were consistent with findings from a previous RPS survey and 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, with some sub-dominant occurrence of deep sandy, light textured Tenosol soils (typically associated with drainage features).

3.2.5.6 Eastern Star Gas Pipeline Soil Survey

Eastern Star Gas commissioned a soil survey of 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 findings of this survey were consistent with those made by RPS in a previous soil survey in a similar area of the Pilliga and Bibblewindi State Forests and support the conclusion that the likely soil type at the project area is a Sodosol.

3.2.5.7 Soil Landscapes of the Baan Baa

The NSW Soil and Land Information Systems (SALIS) database identified three local soil observations within 5 to 10 kilometres of the project 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 soil mapping from this project was used to inform the preparation of the ASC soil type mapping provided in **Figure 4** (OEH, 2012a).

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 Sodosol soils in the Pilliga area. 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.

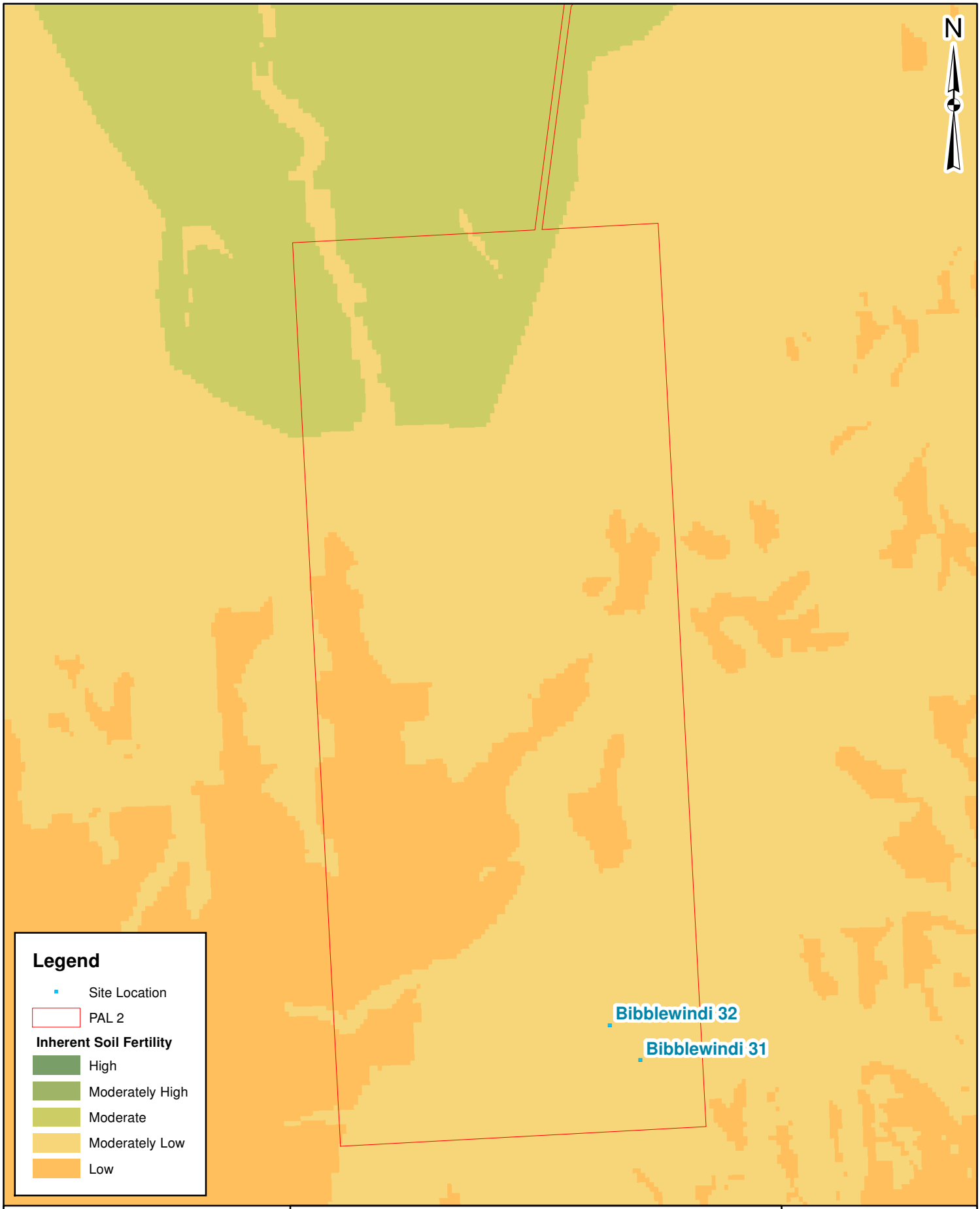
As the soil profile descriptions between the two surveys are very similar and convey physical characteristics that are typical of sodic soils, there is sufficient evidence to support the classification of the soil profiles observed in this earlier survey as Sodosols.

3.2.5.8 Soil Fertility Mapping

Soil fertility mapping produced by the Office of Environment and Heritage (2012b) shows that the project area is dominated by low and moderately low fertility soils (**Figure 8**). This reflects the properties of the dominant soils of the local area (i.e. Sodosols and Rudosols/Tenosols).

3.2.5.9 Summary of Soil Type and Fertility Assessment

The results of the desktop assessment and site inspection confirmed that the likely soils of the project area are Sodosols. The interim protocol identifies that a soil must be a type that has at least a moderate level of natural fertility to satisfy the BSAL verification criterion for soil fertility. Appendix 2, Table 6 of the interim protocol identifies Sodosols as having a ‘moderately low’ fertility ranking. As the soil type of the project area does not meet the natural fertility requirements for BSAL, the project area is not BSAL.



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RPS

Inherent Soil Fertility Mapping

Figure 8

Project: Bibblewindi 31 & 32 BSAL Assessment

Disclaimer: While all reasonable care has been taken to ensure the informationcontained on this map is up to date and accurate, no guarantee is given that theinformation portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

Source : Office of Environment and Heritage (OEH) (2012) Land and Soil Capability Assessment Scheme

0 0.75 1.5 3 4.5 6 7.5 9 Kilometers

Datum: GDA94



3.3 Synthesis of Verification Assessment

The findings of the verification assessment are summarised below:

- The project area is located in a region with a reliable water source;
- The project area meets the BSAL criteria for slope, gilgai, rock outcrop and surface rockiness;
- The likely soil type of the project area does not meet the BSAL soil fertility requirements. Therefore the project area is not BSAL; and
- As the project area is not BSAL there is no requirement under the interim protocol to continue the verification assessment against the remaining soil and landscape criteria.

4.0 Conclusion

- A BSAL assessment was undertaken for the Bibblewindi Gas Exploration Pilot Expansion Project within PAL 2;
- The approach to the verification assessment involved a desktop analysis of remotely sensed and modelled information, review of previous soil survey data from survey points in the Pilliga and Bibblewindi State Forests within close proximity to the project area and a site inspection;
- The project area is located in a region with a reliable water source;
- The project area meets the BSAL criteria for slope, gilgai, rock outcrop and surface rockiness;
- The likely soil type of the project area (i.e. Sodosol) does not meet the BSAL soil fertility requirements. Therefore the project area is not BSAL; and
- As the project area is not BSAL there was no further verification assessment undertaken against the remaining soil and landscape criteria.

5.0 References

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