Leewood Produced Water Treatment and Beneficial Reuse Project

Review of Environmental Factors

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Executive summary

Overview

Santos NSW (Eastern) Pty Limited (Santos) on behalf of the titleholders of Petroleum Assessment Lease (PAL) 2 is proposing to construct and operate a Water and Brine Treatment Plant (WBTP) and associated infrastructure at a property known as "Leewood" located within PAL 2 (the proposed activity).

The proposed activity is permissible without development consent and requires assessment and determination under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The Office of Coal Seam Gas within NSW Trade and Investment is the determining authority for the proposed activity.

RPS Australia East Pty Ltd has prepared this Review of Environmental Factors (REF) to assess the potential environmental impacts of the proposed activity. The REF addresses the requirements of section 111 of the EP&A Act, clause 228 of the *Environmental Planning and Assessment Regulation 2000* and *ESG2: Environmental Impact Assessment Guidelines; For exploration, mining and petroleum production activities subject to Part 5 of the Environmental Planning and Assessment Act 1979* (DTIRIS, 2012). The REF concludes that the proposed activity is unlikely to have a significant impact on the community and environment, including threatened species, populations or ecological communities, and that an environmental impact statement is not required.

Proposed activity

The primary objective of the proposed activity is to construct and operate a purpose built, centralised water treatment facility outside of the Pilliga State Forest, to treat, manage and beneficially reuse produced water and brine from coal seam gas (CSG) exploration and appraisal activities.

Produced water and brine management ponds have been constructed at Leewood (approved 19 March 2013). These ponds store produced water and brine from previous and future exploration and appraisal activities within Petroleum Exploration Licence (PEL) 238, PAL 2 and Petroleum Production Lease 3 (PPL3).

The scope of the proposed activity includes:

- a water treatment plant, including pre-treatment and reverse osmosis plant
- a brine treatment plant
- a brine distribution manifold and associated piping, to allow water distribution into the water treatment plant and associated return flows to brine storage ponds
- a treated water storage tank (five megalitre capacity)
- irrigation of treated water at the Leewood property through a managed irrigation system (including a centre pivot and sub-surface irrigation system)
- the construction of (and the ability to operate) a treated water pipeline extending to the Leewood property boundary to transfer water to another location for irrigation by a third party (if required)
- a small potable water treatment system for water extracted from the licensed bore
- other associated infrastructure, including a gas pipeline to fuel the generators
- amelioration of soils within the Leewood irrigation area by deep tillage, fertiliser, lime and gypsum in preparation for irrigation.

In addition, the treated water is to be used for other uses both on and off the site including dust suppression, drilling and construction and fire fighting. Santos is investigating the option of providing treated water to third parties for agricultural irrigation, although this potential use of treated water does not form part of the activity for the purposes of this REF and will be subject to separate assessment and approvals.

The water and brine treatment plant will have a capacity of 1.5 megalitres per day.

During operation, water from the produced water and brine management ponds will be pumped to the water treatment plant where it will undergo the removal of solids, reverse osmosis to separate the water and brine streams, and chemical and pH adjustment. The treated water will then be available for beneficial use with the treated water storage tank providing a water balance buffer. The brine will be transferred to the brine treatment plant for concentration and further recovery of treated water. Concentrated brine will be stored in the Leewood ponds.

Potential environmental impacts

Potential environmental impacts mostly relate to:

- construction activities – clearing of land, erosion and sediment control, traffic, noise and air emissions or other hazards and risks generally present during construction
- operational activities –irrigation practices to ensure soil structure and stability is maintained, management of waste streams (including concentrated brine) or other hazards and risks such as chemical spills or tank failure.

A range of mitigation measures will be put in place to avoid, mitigate or manage impacts. This includes infrastructure responses such as leak detection systems and bunding of areas where chemicals are stored, and management responses such as incident management plans.

The proposed activity will remove approximately 99.6 hectares of the Derived Grassland vegetation community. This includes approximately 97.8 hectares for the managed irrigation area and approximately 1.8 hectares for the WBTP. This vegetation community is currently in poor condition. No *Threatened Species Conservation Act 1995* or *Environment Protection and Biodiversity Conservation Act 1999* listed threatened species, populations, ecological communities, or their habitats are likely to be impacted. Appropriate erosion and sediment control measures will be put in place to manage any other impacts associated with clearing.

Two non-Aboriginal heritage items (pits associated with the Sydney University Giant Air-shower Recorder) and four Aboriginal heritage items (two quartz flake artefacts and two scar trees) have been identified at the Leewood property. The layout of the proposed activity and the protection measures that are already in place around each of these items ensures that these items will not be impacted. Management protocols will be implemented during site preparation works in the event that any further items are uncovered.

Noise, air and traffic studies concluded that impacts during operation and generally during construction will be minimal.

During some stages of construction, the nearest sensitive receivers could experience noise levels in excess of 40 dBA during standard construction hours. Appropriate construction noise management techniques will be implemented accordingly. Ongoing consultation with affected landowners prior to and during construction will ensure impacts are managed appropriately.

During operation, treated water will be used mostly for irrigation. An irrigation and water balance model has been developed to test a range of weather operating conditions and resultant impacts such as runoff, topsoil loss or changes to deep drainage. Under all scenarios surface water runoff will not increase significantly,

there will be minimal changes to deep drainage with no impact to groundwater quality, while topsoil losses and soil salinity will be within acceptable limits. An Irrigation Management Plan, including a soil monitoring program, will be implemented as part of the proposed activity.

Conclusion

A range of potential impacts to the environment and community may be associated with the proposed activity. These have been considered in detail in the REF. The proposed activity has been located and designed to avoid significant environmental and heritage constraints and to reduce impacts to the surrounding community.

There would be economic benefits to Narrabri and the surrounding region to be realised through the expenditure associated with the construction workforce required and the purchase of materials, fuels and consumables. In addition, indirect benefits will occur through associated service provision as well as the use of the site as productive irrigated agricultural land. During operation, there will be opportunities for employment of local people.

On balance, with the implementation of the mitigation measures identified in the Statement of Commitments outlined in the REF, the proposed activity will have a low adverse impact on the environment.

The proposed activity is not likely to significantly affect the community, environment or any threatened species, populations or ecological communities, their habitats or critical habitat and does not require preparation of an environmental impact statement or species impact statement.

1.0 Introduction

1.1 Background

Santos NSW (Eastern) Pty Limited (Santos) (or its assigned contractor) proposes to construct and operate a Water and Brine Treatment Plant (WBTP) and associated infrastructure, including a managed irrigation system, at a property known as "Leewood" (the proposed activity). This will be done for and on behalf of the titleholders of Petroleum Assessment Lease (PAL) 2.

Leewood is located within PAL 2, on the Newell Highway approximately 24 kilometres south-west of Narrabri, NSW. Santos has constructed two double lined 300 megalitre ponds and associated infrastructure at Leewood. These ponds are designed to store produced water and brine from Santos' past and ongoing coal seam gas (CSG) exploration and appraisal activities within PAL 2, Petroleum Exploration Licence (PEL) 238 and Petroleum Production Lease 3 (PPL 3). The construction and operation of this infrastructure at Leewood was assessed under the *Leewood – Produced Water and Brine Management Ponds REF (*RPS, 2012) and approved by the NSW Division of Resources & Energy (DRE) on 19 March 2013.

The proposed activity is designed to treat produced water stored at Leewood from Santos' CSG exploration and appraisal activities, and beneficially reuse the treated water for irrigation at Leewood, dust suppression, construction and drilling uses in Santos' activities. The treated water may also be used for firefighting if required. Santos is investigating the potential to provide treated water to third parties for use in off-site agricultural irrigation. The off-site use of any treated water by third parties for irrigation does not form part of the proposed activity and any such use would be subject to separate assessment and approvals.

The primary purpose of the proposed activity is to enable Santos to continue its CSG exploration and appraisal activities within PAL 2, PEL 238 and PPL 3. The WBTP will operate for up to five years. The further development of the CSG field will necessitate a larger water treatment facility and this will be subject to further assessment and regulatory approvals as part of the Narrabri Gas Project. The EIS for the Narrabri Gas Project is currently being prepared.

The proposed activity is permissible without consent and requires assessment and determination under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The Office of Coal Seam Gas (OCSG) within the Department of Trade and Investment is the determining authority for the proposed activity because approval is required for a Petroleum Operations Plan and in turn the proposed activity under the conditions of PAL 2.

RPS Australia East Pty Ltd (RPS) has prepared this Review of Environmental Factors (REF) to assess the potential environmental impacts of the proposed activity. The REF addresses the requirements of section 111 of the EP&A Act, clause 228 of the *Environmental Planning and Assessment Regulation 2000* and the *ESG2: Environmental Impact Assessment Guidelines; For exploration, mining and petroleum production activities subject to Part 5 of the Environmental Planning and Assessment Act 1979* (DTIRIS, 2012) (ESG2 Guidelines).

The REF demonstrates that the proposed activity is unlikely to have a significant impact on threatened species, populations or communities or their habitats, or the environment and community. It is considered that the potential impacts of the proposed activity are adequately addressed through the REF, proposed consultation and mitigation measures, and that an EIS is not required.

1.2 Structure of REF

This REF has been prepared having consideration of the NSW Government's ESG2: Environmental Impact Assessment Guidelines.

This REF comprises the following:

- **Section 1** Introduces the proposed activity and provides an overview of the REF
- **Section 2** Provides an overview of the proposed activity, including consultation activities
- **Section 3** Provides an overview of the site
- **Section 4** Discusses the existing environment in detail
- **Section 5** Discusses the relevant legislation associated with the proposed activity
- **Section 6** Considers the potential environmental impacts of the proposed activity and recommends mitigation measures to ensure these impacts are appropriately managed
- **Section 7** Provides a summary of the potential impacts
- **Section 8** Concludes the impact assessment
- **Section 9** Provides the Statement of Commitments for the proposed activity.

The following technical investigations and inputs have been prepared to assist in the preparation of this REF, and are appended:

- Ecological Assessment, prepared by Eco Logical Australia
- Aboriginal Cultural Heritage Due Diligence Report, prepared by Central Queensland Cultural Heritage Management
- Agricultural Impact Assessment (AIS), prepared by RPS
- Transport Assessment, prepared by GTA Consultants
- Noise and Vibration Impact Assessment, prepared by Pacific Environment
- Air Quality Impact Assessment, prepared by Pacific Environment
- SEPP 33 Hazard Assessment, prepared by Sherpa Consulting.

2.0 The proposed activity

2.1 Summary of the activity

Santos NSW (Eastern) Pty Limited is the proponent for the proposed activity on behalf of the titleholders of PAL 2. The proposed activity will include:

- construction and operation of:
  - a water treatment plant, including pre-treatment and reverse osmosis plant
  - a brine treatment plant
  - a brine distribution manifold and associated piping at Leewood, to allow water distribution into the water treatment plant and associated return flows to brine storage ponds
  - a treated water storage tank (five megalitre capacity)
  - a managed irrigation system including a centre pivot and sub-surface drip irrigation system
  - other associated infrastructure, including a gas pipeline to fuel the generators
  - a small potable water treatment system for water extracted from the licensed bore
- the construction of (and the ability to operate) a treated water pipeline extending to the Leewood property boundary to transfer water to another location for irrigation by a third party (if required)
- re-use of treated water for irrigation at the Leewood property and other uses both on and off site including dust suppression, drilling and construction and firefighting . Santos is investigating the option of providing treated water to third parties for agricultural irrigation, although this potential use of treated water does not form part of the proposed activity for the purposes of this REF and will be subject to separate assessment and approvals
- amelioration of soils within irrigation area by deep tillage, fertiliser, lime and gypsum in preparation for irrigation
- decommissioning and rehabilitation of the site, if the Narrabri Gas Project does not proceed.

Santos (or its assigned operator) will operate the proposed activity for up to five years. The WBTP will treat up to 1.5 megalitres per day of produced water from Santos' CSG exploration and appraisal activities within PEL 238, PAL 2 and PPL 3. The operational process is expected to involve, but is not limited to:

- pumping of produced water from the produced water pond to the water treatment plant
- treatment of produced water within the water treatment plant, including removal of solids by filter (pre-treatment), reverse osmosis to separate the water and brine streams (treatment), and chemical and pH dosing (post-treatment) to make the treated water appropriate for irrigation
- transfer of treated water to the treated water storage tank or directly to the on-site managed irrigation system for beneficial re-use
- beneficial re-use of treated water for irrigation, or other uses both on and off-site such as dust suppression, drilling and construction and firefighting
- transfer of brine to the brine treatment plant for concentration and further recovery of treated water
- storage of brine in the existing Leewood ponds.

The location of the proposed activity in relation to the storage ponds currently on site at Leewood are shown in Figure 2-1. An overview of the operational phase of the proposed activity is outlined in Figure 2-2.

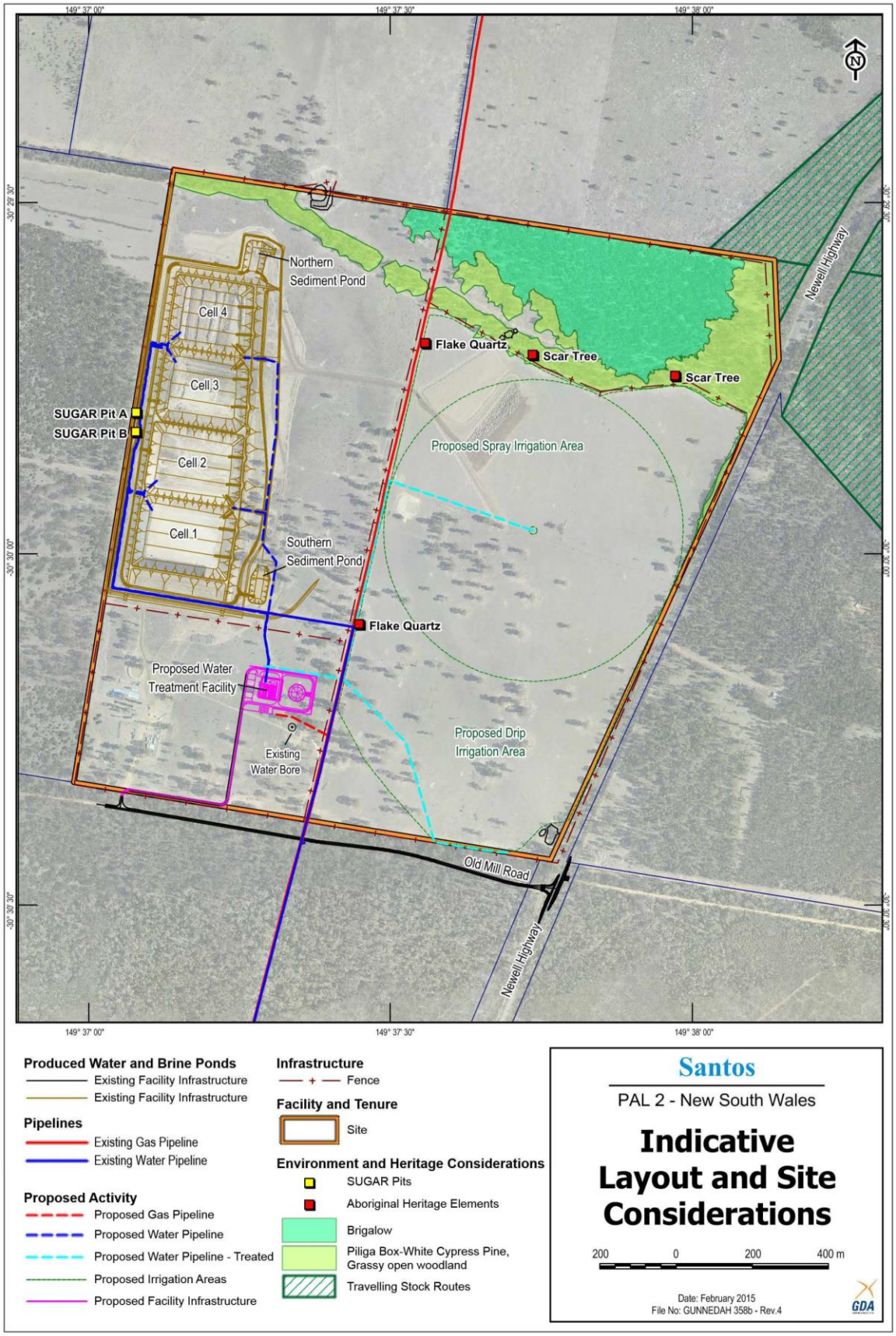

Figure 2-1 Indicative layout of produced water and brine ponds and site considerations

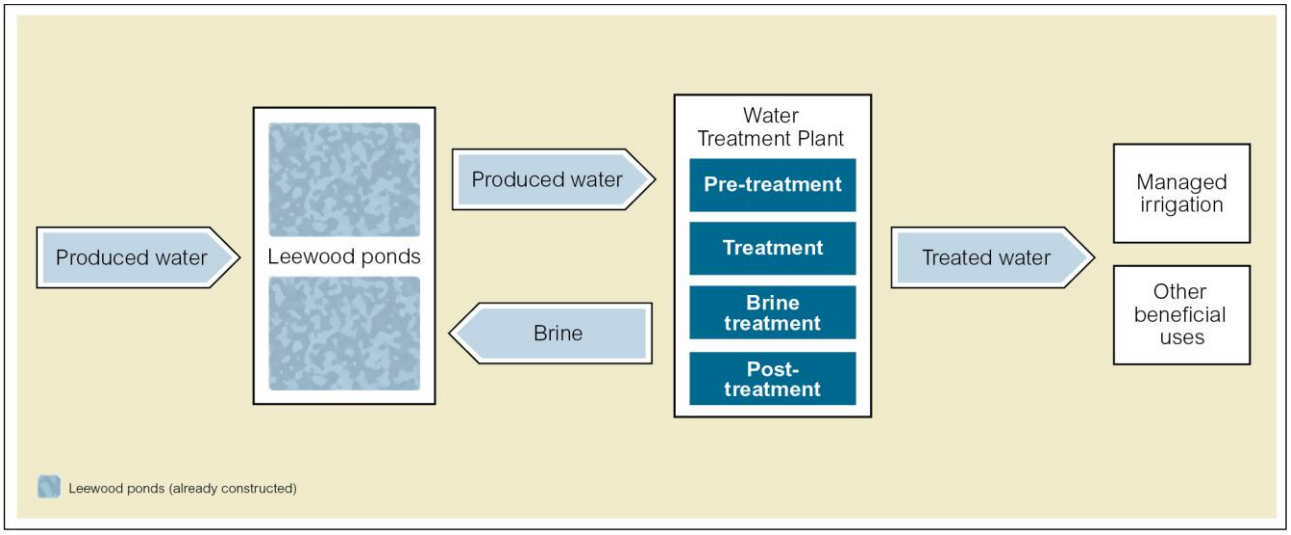

Figure 2-2 Overview of treatment process

The total area of potential disturbance from the proposed activity is approximately 99.6 hectares. This includes the:

- Irrigation area – 97.8 hectares
- WBTP, treated water storage tank and associated infrastructure – 1.8 hectares

References to 'the site' throughout this REF refer to the Leewood property. A detailed description of the construction and operation phases of the proposed activity is provided at Section 2.6.

2.2 Regional location and context

Figure 2-3 shows the regional location and context of the site.

No mineral or coal titles overlie or adjoin the site.

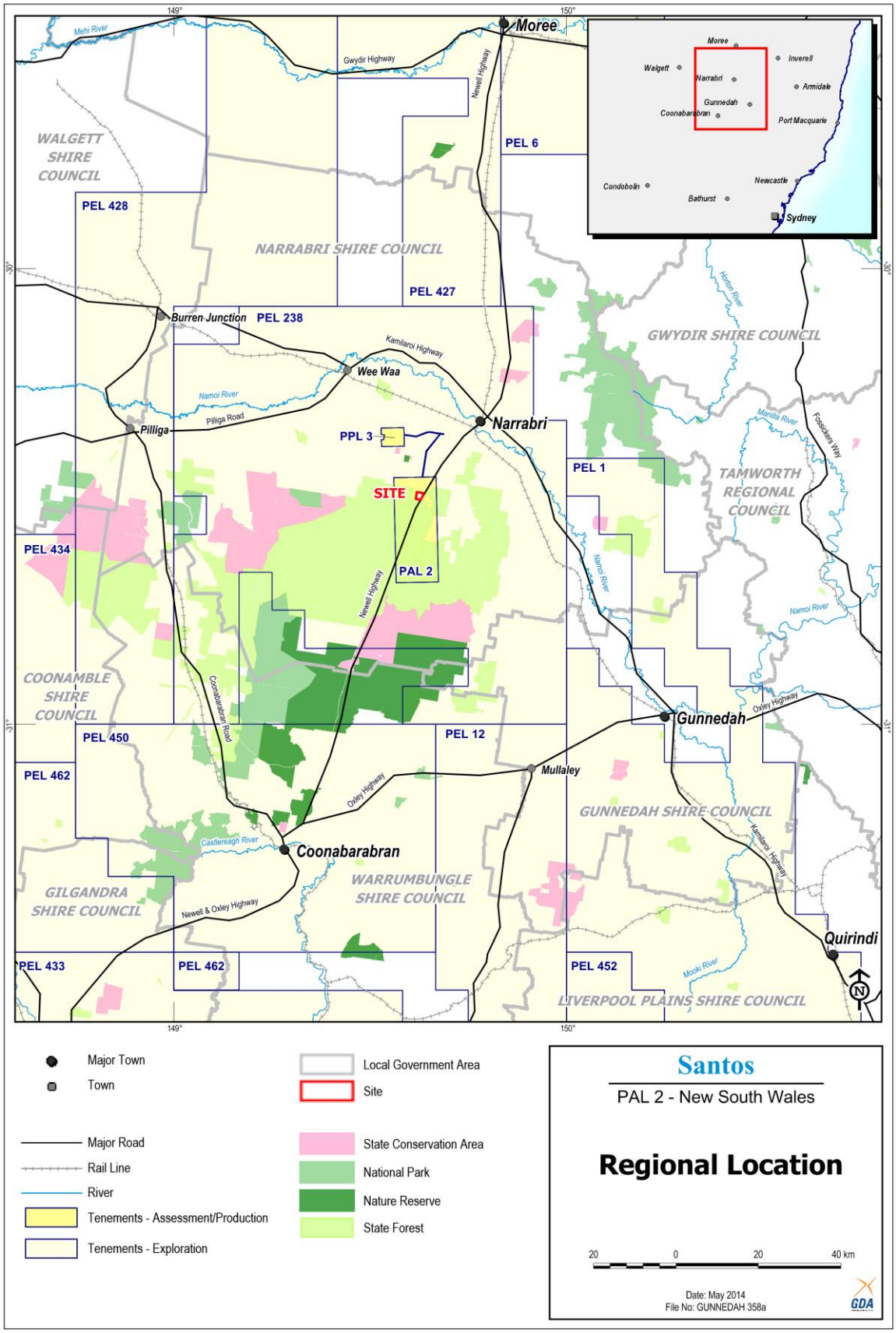

Figure 2-3 Regional location

2.3 Stakeholder consultation

2.3.1 Approach and objectives

Santos understands the importance of proactive and effective engagement with communities and stakeholders and undertakes general consultation in the area of its activities.

In addition, Santos has also developed a specific stakeholder engagement plan for the proposed activity. The objectives of the stakeholder engagement plan are to:

- increase overall awareness and understanding of the CSG industry and the proposed activity in particular
- keep landholders, neighbours, residents, local council and relevant government agencies informed of the proposed activity and progress
- consider the interests of stakeholders in the project design and implementation
- identify key issues or concerns for stakeholders and the community and address these through the environmental assessment process
- provide timely, accurate and credible information to stakeholders and the broader community
- stakeholders.

The following stakeholders have been identified for the proposed activity:

- state government:
  - Minister for Resources and Energy
  - State Member
  - OCSG
  - NSW Environment Protection Authority (EPA)
  - NSW Office of Water (NOW)
  - Forestry Corporation of NSW (FCNSW, neighbouring landholder)
  - Roads and Maritime Services (neighbouring landholder)
  - NSW Crown Lands Division (neighbouring landholder)
  - NSW Department of Health
  - Local Land Services (North West)
- local government – Narrabri Shire Council
- neighbouring private landowners
- Crown and Castle, an entity with a telecommunications tower lease on a neighbouring property
- Narrabri Gas Project Community Consultative Committee (Narrabri CCC)
- NSW Farmers
- Namoi Water
- Narrabri Local Aboriginal Land Council (Narrabri LALC)
- The Gomeroi People (Native Title claimants)
- Narrabri Chamber of Commerce.

- local contractors/service providers
- general community

2.3.2 Broad consultation activities

Santos uses a wide range of consultation tools to engage with various stakeholders as part of its overall community engagement program for its activities within PEL 238 and PAL 2. This includes providing general information through the Santos website, media announcements and shopfront at Narrabri, monthly activity updates in the local newspaper, a monthly activity update newsletter emailed to key stakeholders, operation of a 1800 information line and enquiry email address, monthly community site tours, information stands at local agricultural shows and community events. Santos continue to host community engagement activities on site at Leewood.

Santos participates in the independently chaired Narrabri Gas Project Community Consultative Committee (Narrabri CCC) that meets monthly in Narrabri and comprises a cross-section of representative bodies within the community. Topics discussed include detailed project and impact assessment briefings, activity updates and project planning. Communiques from these meetings are uploaded to the Santos website and also distributed by participants across their networks for broader community dissemination.

Neighbouring landholders receive regular neighbour advices and monthly activity updates for works undertaken on the Leewood property.

The types of broad consultation activities Santos carries out and the targeted stakeholders are summarised in Table 2-1.

Table 2-1 Broad consultation and targeted stakeholders

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	●		●		●	●	●	●
Landowners	●		●		●	●	●	●
Adjacent landowners	●	●	●			●	●	
Indigenous community	●	●	●			●	●	●
Special interest groups (e.g. environment and conservation groups)	●	●	●				●	●
Local business and contractors	●	●	●	●	●		●	●
Broader community	●	●	●	●			●	●

2.3.3 Activities under stakeholder engagement plan

Table 2-2 identifies specific engagement that has occurred under the stakeholder engagement plan for the proposed activity.

Table 2-2 Activities under stakeholder engagement plan

Stakeholder	Details of engagement
OCSG	A meeting with the EPA and OCSG was held on 20 March 2014 to discuss the proposed activity. A letter advising of the activity and an Activity Overview will be sent to the relevant regional agency staff member; updates are included in the monthly Activity Update; and project progress will be discussed at Government Information Forums. OCSG is represented on the Narrabri Gas Project CCC.
EPA	A meeting with the EPA and OCSG was held on 20 March 2014 to discuss the proposed activity. A more detailed discussion of the proposed irrigation system and the water balance was held with the EPA on 2 April 2014. A letter advising of the activity and an Activity Overview will be sent to the relevant regional agency staff member; updates are included in the monthly Activity Update; and project progress will be discussed at Government Information Forums. EPA is represented on the Narrabri Gas Project CCC.
NOW	A meeting with NOW was held on 5 August 2014 to discuss the proposed activity. A letter advising of the activity and an Activity Overview will be sent to the relevant regional agency staff member; updates are included in the monthly Activity Update; and project progress will be discussed at Government Information Forums. NOW is represented on the Narrabri Gas Project CCC.
FCNSW	A letter advising of the activity and an Activity Overview will be sent to the District Manager. Updates are included in the weekly report and progress updates will be discussed at monthly face to face meetings and Government Information Forums.
Roads and Maritime Services	A letter advising of the activity and an Activity Overview will be sent to the District Manager; updates are included in the monthly Activity Update; and project progress will be discussed at Government Information Forums.
NSW Crown Lands Division	A letter advising of the activity and an Activity Overview will be sent to the relevant regional agency staff member; updates are included in the monthly Activity Update; and project progress will be discussed at quarterly Government Information Forums.
NSW Department of Health	A letter advising of the activity and an Activity Overview will be sent to the District Manager; updates are included in the monthly Activity Update; and project progress will be discussed at Government Information Forums.
Local Land Services	A letter advising of the activity and an Activity Overview will be sent to the District Manager; updates are included in the monthly Activity Update; and project progress will be discussed at Government Information Forums. Local Land Services (North West) is represented on the Narrabri Gas Project CCC.
Narrabri Shire Council	A letter advising of the activity and an Activity Overview was sent to the Mayor and General Manager on 28 July 2014. A letter advising of the activity and an Activity Overview will be sent to the District Manager; updates are included in the monthly Activity Update; and project progress will be discussed at Government Information Forums. Narrabri Shire Council is represented on the Narrabri Gas Project CCC.
Neighbouring private landowners	A letter advising of the activity and an Activity Overview was sent to neighbouring landholders on 28 July 2014. An on-site visit of the Leewood facility was held for neighbouring landholders on 1 July 2014 and the proposed activity was discussed. Leewood neighbours meetings will be held quarterly and updates are included in the monthly Activity Update.
Narrabri Gas Project CCC	An overview of the proposed activity was presented at the (previous) Santos Narrabri CCC on 23 July 2014. A Santos representative answered questions during the meeting and provided follow up responses to technical questions, through the Chair, on 6 August 2014. An overview of the proposed activity was provided to the Narrabri Gas Project CCC in March 2015. Updates are included in the monthly Activity Update that goes to CCC members; and project progress will be discussed as required at CCC meetings.
NSW Farmers	A letter advising of the activity and an Activity Overview was sent to the Regional

Stakeholder	Details of engagement
	Manager Zone 1 and the Mining and Coal Seam Gas Officer on 28 July 2014. Updates are included in the monthly Activity Update and NSW Farmers is represented on the Narrabri Gas Project CCC.
Namoi Water	A letter advising of the activity and an Activity Overview was sent to the Executive Officer on 28 July 2014. Updates are included in the monthly Activity Update and Namoi Water is represented on the Narrabri Gas Project CCC.
Narrabri LALC and the Gomeroi People	Representatives of the Narrabri LALC and Gomeroi People inspected the eastern portion of the Leewood property (including the area to be impacted by the proposed managed irrigation system and the area of Brigalow and Pilliga Box/White Cypress Pine grassy open woodland in the north) on 11 April 2014. Four Aboriginal heritage sites were identified during the inspection including two scar trees within the area of vegetation in the northern part of the site and two quartz flakes in the proposed irrigation area. These finds are discussed further in Sections 4.13 and 6.5 of the REF. The representatives were consulted regarding adequate buffer distances and protection measures (refer to Section 6.5 of the REF).Updates are included in the monthly Activity Update and Narrabri LALC is represented on the Narrabri Gas Project CCC.
Narrabri Chamber of Commerce	A letter advising of the activity and an Activity Overview was sent to the President on 28 July 2014. Updates are included in the monthly Activity Update and the Narrabri Chamber of Commerce is represented on the Narrabri Gas Project CCC.
Local contractors/service providers	An email advising of the activity and an Activity Overview was emailed to contractors on 4 August 2014. Updates are included in the monthly Activity Update.
General community	Information and progress updates are included in the monthly Activity Update in advertisements in The Narrabri Courier. The monthly site tours to Leewood for the community are advertised locally.

2.3.4 Engagement outcomes

Table 2-3 identifies the issues raised and outcomes of engagement under the stakeholder engagement plan.

Table 2-3 Outcomes of engagement under stakeholder engagement plan

Stakeholder	Issues rated	How/where issue is addressed
EPA	▪ The REF must cover load-based licensing requirements for salt loads in the irrigation water.	▪ Addressed in Section 5.2.3 of the REF.
	▪ The REF must consider the Department of Environment and Conservation (DEC) Environmental Guidelines: Use of Effluent by Irrigation.	▪ Addressed in Section 2.6.3.4 of the REF, and Appendix 3 (Concept Irrigation Design Report) considered these guidelines.
	▪ The REF must describe an appropriate soil and groundwater monitoring program for the proposed activity.	▪ Addressed in Sections 2.7.1 of the REF.
	▪ The REF must describe the proposed brine disposal method.	▪ Addressed in Sections 2.6.3 and 2.6.4 of the REF.
	▪ The REF must assess potential impacts of permeate salts on soil quality.	▪ Addressed in Section 6.1.1 of the REF, and Appendix 3 (Concept Irrigation Design Report) considered these guidelines.
	▪ The REF must assess the potential for, and any impact of, salt passing through the irrigation zone.	▪ Addressed in Section 6.1.2.1 of the REF, and Appendix 3 (Concept Irrigation Design Report) considered these guidelines.
	▪ The REF must provide information on local groundwater systems.	▪ Addressed in Section 4.10 of the REF.
	▪ The REF must identify distances from the irrigation area to surface water bodies including Mollee and Bohena creeks.	▪ Addressed in Section 4.9 of the REF.

Stakeholder	Issues rated	How/where issue is addressed
OCSG	▪ The REF must describe the proposed brine disposal method.	▪ Addressed in Sections 2.6.3 and 2.6.4 of the REF.
	▪ The REF must identify planning for incident and plant failure management.	▪ Addressed in Section 2.7.4 of the REF.
	▪ The REF must identify waste streams of the proposed activity and how these are proposed to be managed.	▪ Addressed in Sections 2.7.3 and 6.1.7 of the REF.
NOW	▪ No issues were raised at the meeting on 5 August 2014 between representatives of the NOW and Santos. No subsequent queries were raised by the NOW.	▪ N/A
FCNSW, RFS	▪ The REF must identify if there is opportunity to use treated water for fire suppression activities.	▪ Addressed in Section 2.6.3.5 of the REF.
Narrabri LALC and the Gomeroi People	▪ The two scarred tree locations were requested to be avoided. ▪ The two isolated artefacts were requested to be avoided or relocated to avoid impact.	▪ Addressed in Section 6.5.2 of the REF.
Other stakeholders and general public	▪ The REF must identify how the treated water will be used.	▪ Addressed in Sections 2.6.3.4 and 2.6.3.5 of the REF.
	▪ The REF must identify indicative timing for the project.	▪ Addressed in Sections 2.1 and 2.6.2.1 of the REF.
	▪ The REF must identify how the facility is constructed to manage risks associated with plant failure.	▪ Addressed in Sections 2.6.1 and 2.7.4 of the REF.
	▪ The REF must identify what power source will be used for the facility	▪ Addressed in Section 2.6.1.8 of the REF.
	▪ The REF must assess how the reverse osmosis process deals with bacteria in the water.	▪ Reverse Osmosis (RO) is very effective at removing bacteria from water. RO removes salt at an ion level which has a particle size generally between 0.0001 and 0.001 microns. Bacteria particle size is generally 0.5 to 10 microns. This particle size is easily removed during the RO process.
	▪ The REF must assess how the treated water is assessed as being suitable for irrigation and pH levels are balanced to soil conditions.	▪ Addressed in Section 2.6.1.1 of the REF and Appendix 3 (Concept Irrigation Design Report).

Issues relevant to the Leewood property and/or the proposed activity that have been raised by stakeholders during broader consultation activities are identified in Table 2-4 below.

Table 2-4 Issues raised during broader engagement

Stakeholder	Issues raised	How/where issue is addressed
FCNSW	▪ Requested that information on bushfire risk management and mitigation be provided. ▪ Requested adequate notification of works undertaken on Old Mill Road, for which FCNSW is the road authority, and other activities undertaken on the site relevant to FCNSW.	▪ Regular meetings are held with FCNSW and feedback is incorporated into planning activities. ▪ Mitigation measures relating to fire management and preparedness are outlined in Section 6.3.1.2. ▪ Old Mill Road is not proposed to be upgraded as part of the proposed activity. The Newell Highway intersection was upgraded prior to construction of the

Stakeholder	Issues raised	How/where issue is addressed
		produced water and brine storage ponds. FCNSW will be notified prior to the works occurring.
Neighbouring private landowners	▪ Emphasised the importance of keeping neighbours informed of activities. ▪ Identified site security and boundary fencing as an important issue. ▪ Requested adequate notification of work activities that may impact on access along Old Mill Road.	▪ Monthly Activity Updates are provided to neighbouring landholders. ▪ Individual telephone calls to neighbours about activities directly relevant to their property. ▪ Neighbour on-site meetings will be held regularly to provide information and answer questions about the activities at Leewood. ▪ Old Mill Road is not proposed to be upgraded as part of the proposed activity. The Newell Highway intersection was upgraded prior to construction of the produced water and brine storage ponds. Neighbouring landowners will be notified prior to the works occurring.
Santos Narrabri CCC	▪ Enquiries have previously been made about: – how produced formation water is proposed to be managed – how salt by-products from water treatment are proposed to be managed – Santos' preparedness for fire management in State forest.	▪ The main objective of the proposed activity is to manage and treat produced water, as outlined in Section 2.6. ▪ The resulting concentrated brine from the brine treatment plant will be stored in the brine storage ponds on site and/or disposed of to landfill, as discussed in Sections 2.6.1.2 and 2.6.3.3. ▪ Santos has a fire response procedure developed in liaison with NSW Rural Fire Service (RFS) to address wildfire concerns in the local area. ▪ Santos will continue to participate in RFS and FCNSW fire management and preparedness planning. ▪ Mitigation measures relating to fire management and preparedness are outlined in Section 6.3.1.2.

2.3.5 Future and ongoing consultation activities

Santos will continue the broad consultation program described in Section 2.3.3 prior to and during construction and operation of the proposed activity. Further specific consultation for the proposed activity will occur prior to construction commencing. These activities are identified in Table 2-5.

Table 2-5 Proposed engagement prior to construction commencing

Stakeholder	Engagement activity
NOW	▪ Face to face briefing. ▪ Government Information Forum and field visit. ▪ Information for assessment officers. ▪ Representative is a member of Narrabri Gas Project CCC that will receive regular updates.
FCNSW	▪ Face to face briefing. ▪ Government Information Forum and field visit. ▪ Information for local officers. ▪ Updates in monthly Activity Update newsletter.

Stakeholder	Engagement activity
Roads and Maritime Services	▪ Government Information Forum and field visit. ▪ Information for local officers. ▪ Updates in monthly Activity Update newsletter.
NSW Crown Lands Division	▪ Government Information Forum and field visit. ▪ Information for local officers. ▪ Updates in monthly Activity Update newsletter.
NSW Department of Health	▪ Government Information Forum and field visit. ▪ Information for local officers.
Local Land Services	▪ Government Information Forum and field visit. ▪ Information for local officers. ▪ Updates in monthly Activity Update newsletter. ▪ Representative is a member of Narrabri Gas Project CCC that will receive regular updates.
Narrabri Shire Council	▪ Government Information Forum and field visit. ▪ Information for Council officers. ▪ Updates in monthly Activity Update newsletter. ▪ Representative is a member of Narrabri Gas Project CCC that will receive regular updates.
Immediate neighbours adjoining Leewood	▪ On-site neighbours meeting quarterly. ▪ Regular updates in monthly Activity Update Newsletter.
Landholders in immediate area	▪ Information. ▪ Community Site Tours.
Narrabri Gas Project CCC	▪ Face to face briefing. ▪ Information for members. ▪ Field visit. ▪ Updates in monthly Activity Update newsletter.
NSW Farmers (Narrabri Branch)	▪ Information. ▪ Community Site Tours. ▪ Representative is a member of Narrabri Gas Project CCC that will receive regular updates.
Namoi Water	▪ Information. ▪ Community Site Tours. ▪ Representative is a member of Narrabri Gas Project CCC that will receive regular updates.
Narrabri Chamber of Commerce	▪ Information for members. ▪ Community Site Tours. ▪ Representative is a member of Narrabri Gas Project CCC that will receive regular updates.
Contractors	▪ Contractor Forum. ▪ Information for existing contractors. ▪ Community Site Tours.
General community	▪ Monthly Community Site Tours. ▪ Updates in The Narrabri Courier, including monthly Activities Update advertisements. ▪ Pro-active articles in local media. ▪ Santos shopfront in Narrabri. ▪ 1800 freecall information number. ▪ Energy NSW information email.

Stakeholder	Engagement activity
	▪ Santos ENSW Website. ▪ Displays at local agricultural shows and field days. ▪ Staff briefings on project and key messages.

2.3.6 Stakeholder complaint and conflict management

Santos' primary approach to conflict management is open and proactive communications with all stakeholders.

The 1800 information line is available 24 hours per day, seven days per week and is provided on all project communication materials including community updates, fact sheets and stakeholder and community letters. Santos aims to respond to all enquiries or complaints received via the information line within two business days.

To manage enquiries or complaints received, Santos maintains a complaint register of:

- all project related concerns or complaints received from individual members of the community or representative bodies
- the response provided or action taken
- a system to track notes on progress to resolution.

Santos has a documented complaint management procedure which is communicated to relevant staff members. This procedure involves the following steps:

- capture enquiry or complaint and record details, including time and date the call/email is received, contact name, phone number, and nature of enquiry/complaint and any response provided
- assess and investigate enquiry/complaint by the relevant business unit and escalate if unable to be resolved
- where a complaint involves a reportable incident, notify OCSG and/or EPA as required by the relevant petroleum lease/licence or environmental protection licence and relevant legislation
- where possible, provide the enquirer/complainant a timeframe for responding to them or resolving the issue, and keep them updated on progress
- close out complaint/enquiry and record all communication actions and responses
- report all issues weekly to the Santos management team.

2.4 Justification of activity

2.4.1 Objectives

The overall objectives of the proposed activity are to:

- establish a purpose-built WBTP to treat and beneficially reuse produced water from Santos' exploration and appraisal activities.

The design objectives for the WBTP include:

- ensuring produced water can be treated to a quality suitable for managed irrigation
- incorporating plant/processes to reduce the overall volume of brine to be managed.

2.4.2 Method and scale

The WBTP will enable the treatment of the produced water via reverse osmosis technology, discussed in further detail in Section 2.6.3.2. The treated water will be of such quality to enable its reuse for irrigation and other beneficial uses. The proposed activity will also allow the study of brine reduction technology, which will in turn allow the overall volume of waste to be reduced.

The proposed activity has been designed to adequately cater for Santos' existing and proposed exploration and appraisal activities.

The appraisal program is estimated to produce a total approximate volume of 1.4 gigalitres of produced water from 2014 to 2018 with an average daily production of one megalitre and a peak daily production of 1.5 megalitres over the operational period.

The treated water will be used in the irrigation system at Leewood and other beneficial uses for CSG activities undertaken in PEL238, PAL 2 and PPL 3 such as construction, drilling, dust suppression and for fire fighting, if required.

2.4.3 Location

The proposed activity will be located on the Leewood property adjacent to Leewood produced water and brine storage ponds. The Leewood property was selected during early planning for the facility as it:

- was able to be acquired by Santos, thus allowing Santos flexibility to operate as needed and thereby avoiding disruption to another landowner's operations
- is outside the Pilliga forest and would minimise impacts on ecological values associated with the Pilliga forest
- has minimal other ecological values (refer to Section 4.11)
- does not represent high quality agricultural land (refer to Section 4.4) and is not within mapped Biophysical Strategic Agricultural Land (BSAL).

The property's proximity to Santos' existing infrastructure was also a key consideration during selection of the site. Leewood is located between Santos' existing facilities at Bibblewindi (including a gas compressor and produced water storage ponds) and Wilga Park Power Station. The buried pipeline which conveys gas from Bibblewindi to Wilga Park Power Station also crosses the property. This allowed the Leewood produced water flow line (approved by the DRE on 19 March 2013) to be constructed within the existing gas pipeline easement, avoiding significant vegetation removal. It will also allow the offtake of gas from the pipeline to provide gas-fired power generation at Leewood.

The proposed site is suitable for cropping and managed irrigation as it is relatively flat, will require removal of only low quality vegetation and is free of surface rock outcrops. Cropping and irrigation will also be consistent with surrounding land uses. While there are some limitations to irrigating the site, including the relatively low quality soils and potential partial flooding of the lower (central) part of the site during rain events up to twice a year on average, these can be overcome by soil amelioration, use of a sub-surface drip irrigation system in the flood affected area and appropriate site management.

2.4.4 Consistency with ecologically sustainable development

The proposed activity is considered to be justified in terms of its consistency with the principles of ecologically sustainable development. Ecologically sustainable development is a primary object 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,* being:

…ecologically sustainable development requires the effective integration of economic and environmental considerations in decision-making processes. Ecologically sustainable development can be achieved through the implementation of the following principles and programs:

(a) the precautionary principle—namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation,

(b) inter-generational equity—namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations,

(c) conservation of biological diversity and ecological integrity—namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration,

(d) improved valuation, pricing and incentive mechanisms—namely, that environmental factors should be included in the valuation of assets and services.

The proposed activity's consistency with these principles is outlined in Table 2-6.

Table 2-6 Consistency of proposed activity with ecologically sustainable development principles

Principle	Proposed activity's consistency
Precautionary principle	Measures to prevent the environmental degradation of the site will be implemented during all phases of the proposed activity. The soil and water monitoring program referred to in Section 2.7.1 will allow changes to the environment to be monitored and corrective action to be implemented if required. A precautionary approach was taken during the design phases of the proposed activity, which aimed to avoid significant environmental constraints, thereby minimising the risk of serious or irreversible harm to the environment as a result of the proposed activity. The site is located outside the Pilliga forest, to minimise impacts on ecological values associated with this area. During the environmental assessment process, investigation into a range of issues was carried out to determine the full potential impacts of the proposed activity. This included commissioning air quality, noise, greenhouse gas, transport, hazard assessment, agricultural and groundwater studies, and drawing on information from technical specialists including heritage consultants, ecologists, engineers, geologists and hydrogeologists.
Intergenerational equity	The proposed activity has been designed in accordance with sustainable management principles. It will assist in providing a comprehensive water management process for Santos' exploration and appraisal activities in the area, to ensure that potential impacts of the activities are not left to be addressed by future generations. Whilst the proposed activity will have limited impact on the local economy, the future development of a commercial gas project would have wider economic benefits both to the local and NSW economy. The proposed activity will consume minor quantities of non-renewable resources; concentrated brine will be disposed of to landfill.
Conservation of biological diversity and ecological integrity	The proposed activity has been located and designed to avoid potential impacts to biodiversity and ecological integrity. The proposed activity has been situated such that the sensitive vegetation will not be impacted by the proposed activity. Some areas of non-significant vegetation will be removed to facilitate the proposed activity; however this will not result in significant impacts to any threatened species, population or ecological community, or their habitat.
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 to avoid, minimise, mitigate and manage potential impacts of the proposed activity.

2.5 Alternatives

2.5.1 Water treatment plant processes

The produced water requires desalination prior to the proposed beneficial use for irrigation and other beneficial uses due to its salinity.

The following desalination technologies were considered as potential options:

- reverse osmosis (RO)
- forward osmosis
- ion exchange
- Higgins loop
- electrodialysis/electrodialysis reversal
- vibratory shear enhanced process
- capacitive deionization
- thermal processes.

Table 2-7 outlines the relative advantages and disadvantages for the technologies considered.

Table 2-7 Advantages and disadvantages of water treatment plant technology options

Technology	Advantages	Disadvantages
Reverse osmosis	▪ Proven technology for removing dissolved compounds from water. ▪ Capable of treating a wide range of TDS (1,000-35,000 mg/L). ▪ Commercially available from multiple vendors.	▪ Membranes require regular cleaning. ▪ Increased energy requirements (however, lower than thermal desalination). ▪ Pre-treatment processes are required.
Forward osmosis	▪ Capable of treating wide range of TDS, from brackish waters with TDS of 500 mg/L to seawater with TDS of 35,000 mg/L. ▪ High recovery. ▪ Low energy requirement.	▪ Currently in the development stage and not a commercial scale product ▪ Not a proven technology for treating produced water or similar.
Ion exchange	▪ High recovery. ▪ Low energy requirement.	▪ Large chemical usage to regenerate resins and therefore large waste stream produced. ▪ Significant resin cost associated with the size of plant required for use as sole treatment process.
Higgins loop	▪ High recovery. ▪ No pre-treatment process required.	▪ High chemical consumption for resin regeneration. ▪ Carbon dioxide by-product produced and vented. ▪ Large number of process valves required. ▪ High volumes of resin and ongoing resin loss.
Electrodialysis/electrodialysis reversal	▪ Limited pre-treatment required. ▪ Low scaling potential.	▪ Typically used on high hardness, lower salinity waters (TDS 200-500 mg/L).

Technology	Advantages	Disadvantages
		▪ Not cost effective at higher TDS due to high energy use. ▪ Not a proven technology for treating produced water or similar. ▪ Only available from one vendor in Australia.
Vibratory shear enhanced process	▪ High flux. ▪ High recovery.	▪ Many moving parts. ▪ Limited performance track record. ▪ Not a proven technology for treating produced water or similar.
Capacitive deionization	▪ High recovery. ▪ Low energy requirement.	▪ Not commercially supported in Australia nor available at the application size required. ▪ Influent TDS limited to 2,500 mg/L. ▪ Not a proven technology for treating produced water or similar.
Thermal processes: ▪ Multi-stage flash distillation. ▪ Multiple effect distillation with either mechanical vapour compression or thermal vapour compression. ▪ Membrane distillation. ▪ Brine concentrator with either mechanical vapour compression or thermal vapour compression.	▪ High recovery – each process uses heat to evaporate water, leaving a highly concentrated waste stream (TDS>20,000 mg/L).	▪ High energy requirement. ▪ High capital cost.

Of the technologies reviewed, only RO and thermal technologies were considered proven and capable of treating the produced water. RO was considered the most appropriate technology as it:

- is a proven technology that is widely available and used on a wide variety of applications, including all major CSG projects currently in operation or development
- has lower specific energy consumption than thermal treatment
- is highly modular, enabling relatively simple increases in plant capacity to allow for increases in produced water volume
- is more cost effective than thermal treatment.

2.5.2 Brine treatment plant processes

To reduce the overall volume of brine to be managed, it is necessary to further concentrate brine beyond the limit of conventional RO technology. A range of treatment technologies were considered for further processing the brine produced from the RO process.

Table 2-8 outlines the relative advantages and disadvantages for the technologies considered.

Table 2-8 Advantages and disadvantages of brine treatment plant technology options

Technology	Advantages	Disadvantages
Membrane Brine Concentrator (high pressure RO)	▪ Lower energy consumption. ▪ Utilised existing technology. ▪ Limited exotic materials required. ▪ Operates as ambient temperatures.	▪ Membranes require regular cleaning. ▪ Plant availability may be low.
Multi-stage flash distillation	▪ Longest track record. ▪ Low fouling propensity.	▪ Older technology that consumes 50% more energy than multi-effect distillation. ▪ Low concentration ratios.
Multiple-effect distillation	▪ Operates at low temperatures (<70°C). ▪ More efficient compared with multi-stage flash distillation. ▪ Less capital intensive compared with brine concentrator (mechanical vapour compression/ thermal vapour compression) and multi-stage flash distillation ▪ Utilises waste heat.	▪ Greater number of packages as not supplied with an integrated crystalliser. ▪ Issues with foam. ▪ Reliance on waste heat, therefore dependent on other infrastructure being in place before commissioning.
Brine concentration utilising mechanical vapour compression	▪ More efficient compared with multi-stage flash distillation. ▪ Foam is not an issue compared with multi-effect distillation. ▪ Less dependent on other infrastructure being in place prior to commissioning (mechanical vapour compression is an electrically driven process, rather than driven by waste heat). ▪ Less potential for noise issues compared with steam ejectors. ▪ No supplementary cooling required.	▪ High energy requirements. ▪ Tall units may result in increased visual impact. ▪ High capital expenditure compared to multi-effect distillation.
Brine concentration utilising thermal vapour compression	▪ More efficient compared with multi-stage flash distillation. ▪ Foam is not an issue compared with multi-effect distillation. ▪ Utilises waste heat.	▪ Higher capital expenditure compared with multi-effect distillation. ▪ Brine concentrators (mechanical vapour compression or thermal vapour compression) are tall units which in some circumstances can have a visual amenity impact. ▪ Reliance on waste heat, hence dependent upon other infrastructure being in place before commissioning. ▪ Noise from the thermo-compressor is a challenge. ▪ Requires supplementary cooling.
Membrane distillation	▪ Utilises a low-grade heat source. ▪ Maintains process performance almost independently of feed solution TDS concentration.	▪ Unproven technology in the industry.

Thermal concentration technologies typically employ thermal vapour compression or mechanical vapour compression to enhance the efficiency of the process. Thermal vapour compression processes require the addition of a heat source (typically steam) and also require supplementary cooling (usually provided by cooling towers), whereas the only energy input into mechanical vapour compression plants is electrical energy. Using semi-quantitative assessment criteria it was determined that for the relatively short term appraisal program the membrane concentrator technology is appropriate due to lower energy consumption and low environmental impacts of the process. The assessment included technical and non-technical parameters such as ease of delivery, operational requirements, cost and health and safety considerations.

2.6 Description of the activity

2.6.1 Design overview

Major water treatment process units within the WBTP will be enclosed within containers. Details of the proposed WBTP location are shown in the site layout drawing in Appendix 1.

2.6.1.1 Water treatment plant

The design layout and location of the water treatment plant (refer to site layout drawing in Appendix 1) shows the units will be housed within approximately 12, 12 metre long shipping containers. The footprint of the water treatment plant containerised-infrastructure will be approximately 50 by 50 metres within a bunded area situated within a platform of 110 by 180 metres to accommodate a five megalitre treated water storage tank and access roads.

The water treatment plant will treat up to 1.5 megalitres of produced water per day, converting 65-70 per cent of this volume to treated water and 30-35 per cent to brine. The ponds at Leewood currently hold about 150 megalitres of brine that was produced at the Bibblewindi Water Treatment Plant during previous exploration and appraisal activities. This brine will be processed through the produced water and brine treatment plant at Leewood as part of the proposed activity. The expected water quality of the produced water and brine that will enter the water treatment plant is provided in Appendix 2.

The water treatment plant is designed to treat produced water and brine in three stages, comprising of pre-treatment, treatment and post-treatment. The three process stages are shown in Figure 2-4, while further details of these processes are provided in Section 2.6.3.2.

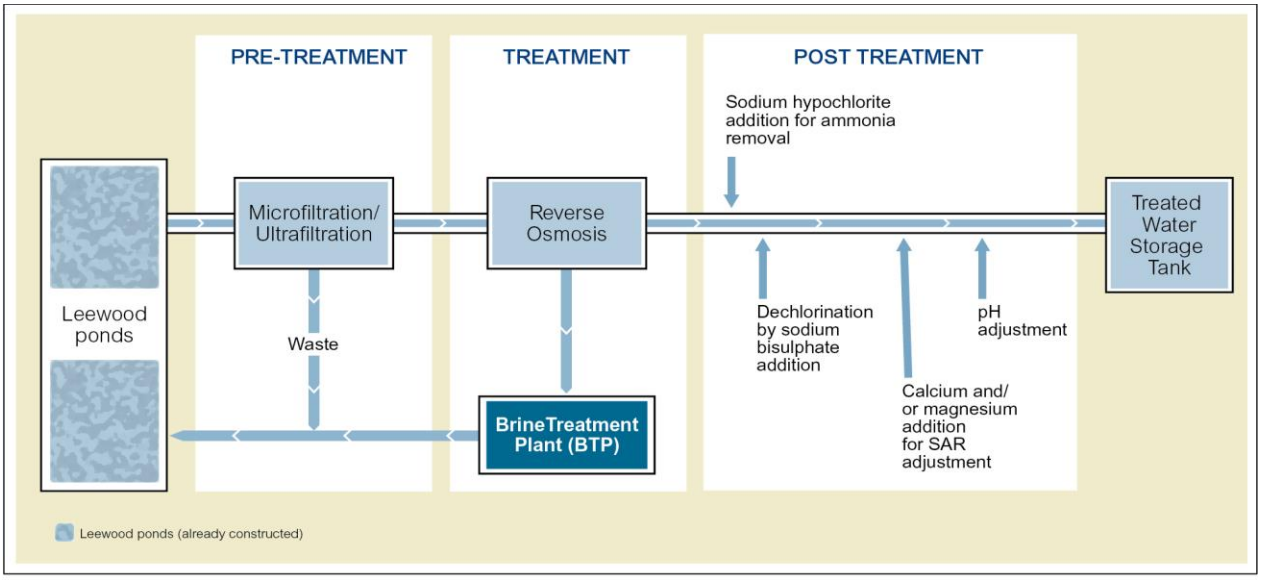

Figure 2-4 Water treatment plant process

Treated water from the RO is expected to have a total dissolved solids (TDS) content of less than 650 milligrams per litre, and a high sodium adsorption ratio (SAR) due to the low calcium and magnesium. The SAR of the treated water will be adjusted to appropriate levels for irrigation use during post treatment (discussed in further detail in Section 2.6.3.2).

The expected water quality of the treated water that will be used for irrigation is shown in Table 2-9. This water quality will be achieved for water fed from either the produced water or the brine stream. The chemical dosing will ensure that the water quality is optimal for soil /water interactions and ongoing soil structure maintenance during irrigation use.

Table 2-9 Expected irrigation water quality

Parameter	Expected treated water[1]
pH	6-8.5
TDS (mg/L)	<650
Salinity (mS/cm)	1.0
Turbidity (NTU)	<1
SAR	<5
Calcium (mg/L)	52
Magnesium (mg/L)	0.04
Sodium (mg/L)	131
Potassium (mg/L)	7
Ammonia-N (mg/L)	6
Boron (mg/L)	0.7
Alkalinity (mg/L $CaCO_3$)	262
Chloride (mg/L)	120
Fluoride (mg/L)	0.3
Sulfate (mg/L)	0.0
Total N (mg/L)	Feed reduced by 50%
Total P (mg/L)	Feed reduced by 94%
Silica (mg/L SiO_2)	0.9

2.6.1.2 Brine treatment plant

The brine treatment plant will concentrate brine from the water treatment plant to reduce the volume of brine required to be managed. The brine treatment plant will produce approximately 0.5 megalitres of brine per day.

The expected footprint for the brine concentrator is approximately 20 by 20 metres within a bunded area situated within a platform of 110 by 180 metres to accommodate a five megalitre treated water storage tank and access roads, refer to Appendix 1.

[1] Treated water following chemical dosing, prior to entering the irrigation system.

2.6.1.3 Water pumps and flowlines

Pumps will be located around the site to enable the transfer of water and brine between the storage and treatment and irrigation infrastructure components and will include:

- transfer pumps adjacent to the produced water, brine and treated water ponds
- within the water treatment plant as part of the treatment process
- transfer pumps within the WBTP to transfer flow from the water treatment plant and brine treatment plant to the various storage ponds and tanks.

The majority of the transfer pumps will be skid mounted (or in containers) equipment manufactured offsite and delivered to site for installation. Pumps will be in a duty/standby configuration and controlled via a local control panel which will be connected to the overall site system controls. These will be able to be operated remotely.

Water flowlines are proposed to be installed to allow transfer of water and brine for the treatment process. Flowlines will vary in size ranging from approximately 110 to 400 millimetres in diameter. In general, buried flowlines will be high density polyethylene, while above ground pipework will consist of high density polyethylene, polyvinylchloride, carbon steel and various grade of stainless steel depending on pressure and application.

Indicative pump and flowline locations are shown in the site layout drawing in Appendix 1.

2.6.1.4 Fuel gas conditioning skid and associated infrastructure

A new fuel gas conditioning skid (FGCS) will be provided at Leewood to treat field gas for use in power generation for the activity. The skid will remove all liquid droplets and solid contaminants from the gas, and adjust the gas temperature to the injection requirements of the gas generator. The FGCS will be supplied by field gas from a proposed connection to the existing buried gas flowline that runs in a north-south direction through the middle of the Leewood property. The new FGCS will be located on a reinforced concrete slab foundation.

Water drainage from the new FGCS will be directed to a concrete sump with instrumentation linked to the control system. Once the sump reaches a set level, water will be pumped from the sump to the water treatment plant waste collection system.

2.6.1.5 Treated water storage tank

A treated water storage tank will store water that has been treated in the water treatment plant prior to its reuse. It will comprise a galvanised steel panel tank with an internal polypropylene bladder. It will have roof bracing for structural integrity, but no roof panelling, to allow ventilation. The tank will be sized for a maximum operating volume of approximately five megalitres of treated water.

The tank will include level sensors and transmitters to:

- alert operators in the event of a high level in the tank level to initiate operator action if required
- close the tank discharge valve in the event of low tank level to avoid air entrainment and pump damage
- modulate discharge flow rate to maintain a tank level setpoint, under normal operation when the irrigation area can accept water.

2.6.1.6 Potable water treatment system

A small potable water treatment system will be installed to treat water extracted from the licenced bore at Leewood. This will consist of a sand or micro-filtration and chlorine dosing system.

2.6.1.7 Chemical storage

Chemicals will be stored adjacent to the water treatment plant in bunded containers with appropriate separation of chemical classes. The chemical storage and unloading areas will be designed in accordance with the relevant Australian Standards (including *AS 3780 The storage and handling of corrosive substances* and *AS1940 The storage and handling of flammable and combustible liquids*) requirements. Safety showers will be provided, in accordance with Australian Standards at each chemical storage area.

Chemical storage and mitigation measures are discussed in more details in Section 6.1.8 of this REF.

2.6.1.8 Power generation

Power generation infrastructure for the WBTP will consist of:

- one containerised gas generator of about 1,400 kWe
- one 800 kWe resistive load bank
- two backup diesel generators of approximately 800 and 200 kWe
- a HDPE pipeline running from the gas line riser and easement to the fuel gas conditioning skid.

The gas generator will be the primary source of power onsite. Gas will be supplied from the proposed fuel gas conditioning skid. If the gas generator is off-line or there is no gas supply to the site, then back up power supply will be generated via one of the diesel generators. The backup generators have been sized to supply only for critical equipment and lighting.

It is expected that the gas generator will be housed in a twelve metre container. The generator units are expected to be about 3.2 metres high. The additional exhaust and cooling system on top of the unit, incorporating a single stack, would add about another 6.8 metres in height (producing a resultant height of approximately 10 metres).

2.6.1.9 WBTP amenities and ancillary facilities

WBTP amenities including the control room will support the operation of the proposed activities at the site. The control room will oversee the WBTP operations including the transfer of produced water and brine between the infrastructure onsite via the pumps and flowlines. The onsite laboratory facility will allow for testing as required for the WBTP process control.

A site office area will be constructed in the area to the south of the ponds, which will comprise office space and amenities for employees, as well as associated car parking. It is anticipated the site office and car park will remain for the duration of operations. The proposed office and car park locations are shown in the site layout drawing in Appendix 1.

Sewage from the ablution facilities of the WBTP will be collected in an effluent tank and transported offsite for disposal at a licensed waste facility. Sewage will not be treated in the WBTP.

2.6.1.10 Irrigation infrastructure

The concept irrigation design, provided in Appendix 3, combines two technologies enabling irrigation of 97.8 hectares. It employs a centre-pivot irrigator fitted with Variable Rate Irrigation technology to cover 49.5 hectares and a subsurface drip irrigation system to cover 48.3 hectares. This configuration was designed to accommodate the area and soil types at the site. The dual system will be capable of delivering peak water demand of 12 millimetres per day across the 97.8 hectares. The maximum daily capacity would be 11.7 megalitres per day. The systems would be able to be operated simultaneously.

The centre-pivot irrigator and the subsurface drip irrigation systems will be supplied by separate mains and pumps, as detailed in Appendix 3. These will be separated as the subsurface drip irrigation system has extra requirements for filtration and disinfection. The whole irrigation system – pumps station, irrigation infrastructure and soil moisture sensors would be monitored and capable of being controlled remotely via telemetry.

2.6.1.11 Treated water pipeline

A pipeline is proposed to be constructed at Leewood, extending to the property boundary, which will enable the provision of treated water for third party beneficial use for agricultural irrigation offsite. Treated water consistent with the quality of water which is to be irrigated on the Leewood site will be able to be provided for third party use. The provision of treated water to third parties for off-site agricultural irrigation will be subject to separate assessment and approvals and does not form part of the activity for the purposes of this REF.

The exact location of the pipeline within the Leewood site is yet to be determined. However, the pipeline would not be located within the Brigalow and is expected to be contiguous with the existing gas pipeline alignment. It will be situated to avoid impacts to identified ecological and heritage values as outlined in Sections 6.2, 6.5 and 6.6.

2.6.1.12 Beneficial reuse of treated water for irrigation off-site

The operation of an offsite irrigation scheme by another user would be guided by an Irrigation Management Plan that seeks to ensure:

- the design takes into account baseline soil sampling and consideration of any sensitive environmental receptors
- soil structure, stability and productive capacity is maintained
- irrigation efficiency through use of control systems to adjust application rates or other factors to maintain performance
- erosion is minimised and effective stormwater runoff controls are implemented
- sufficient storage capacity within the system to address wet weather conditions, e.g. water storage dams
- a program of regular and appropriate monitoring is implemented to measure, record and identify any actions required to ensure the environmental performance of the system
- the productive use of the water resource for a beneficial use.

The supply of the treated water for irrigation will be the subject of an agreement between Santos and the user. Construction of a pipeline outside of the Leewood property and operation of an offsite irrigation scheme by another user are not considered part of the proposed activity, and are not assessed within this REF.

2.6.2 Construction

2.6.2.1 Construction activities

It is anticipated that construction activities will take place over a period of approximately 50 weeks, weather dependent. The works will be closely staged wherever possible to ensure timely delivery. Construction works will be managed by a Principal Contractor and be carried out in accordance with the *Work Health and Safety Act 2011* and associated regulations.

The typical construction process for the proposed activity is outlined in Table 2-10. The construction contractor appointed by Santos will determine the precise construction methodology.

Estimated cut and fill quantities for the civil works are provided in Table 2-11.

Table 2-10 Estimated WBTP construction activities

Stage	Activities
Mobilisation (6-8 weeks)	▪ Site establishment including services identification, survey, mobilisation, installation of temporary security fencing, amenities and exclusion fencing. ▪ Vegetation removal and removal of existing infrastructure, as required. Where possible, timber shall be mulched and stockpiled for reuse during restoration. ▪ Construction of erosion and sediment controls in accordance with *Managing Urban Stormwater: Soils and Construction – Volume 1* (Landcom, 2004) (the Blue Book). ▪ Clear, strip and stockpile topsoil in designated area to be established by the relevant construction contractor for use in site restoration on completion of works.
Amenities and services (2 weeks)	▪ Subgrade and grade layers installation and compaction. ▪ Set up/construction of demountable site offices, amenities buildings, storage compound and laydown area. ▪ Laying concrete slab foundations. ▪ Set up of temporary diesel generators for construction site power.
Earthworks (6-8 weeks)	▪ Excavation and construction of foundations to provide adequate structural support for buildings, unit processes for the WBTP, pumps, modular treatment units and chemical storage facilities. ▪ Cut and fill balancing to minimise need for additional fill materials to the site (refer to Table 2-11 of the REF). ▪ Pump out of groundwater and rainwater captured during excavation. ▪ Open trenching for the installation of buried services, conductions, connections to incoming flowlines and site drainage piping. ▪ Backfilling, compaction of backfilling materials and stockpiling. ▪ Spoil movements.
Structures (2 weeks)	▪ Delivery of demountable buildings to the site. ▪ Lifting and placing steel frames and demountables using cranes. ▪ Erection of steel frame buildings.
Internal roadworks (4-6 weeks)	▪ Construction of the internal permanent roadways including hardstand, turning and parking areas.
Mechanical and electrical (10-12 weeks)	▪ Unloading and installation of WBTP components and equipment. ▪ Installation of piping. ▪ Pipe welding and cutting. ▪ Installation of cable trays, lighting, etc. ▪ Testing of power and instrumentation wiring.
Flowlines (6-8 weeks)	▪ Trench excavation. ▪ Installation of piping.
Irrigation area (8 weeks)	▪ Land clearing. ▪ Amelioration of soils to enable the breakdown and stabilisation of the poorly drained soils on-site. This will be done via application of gypsum and lime, deep ripping, fertiliser and cultivation (refer to Appendix 3 for further details). ▪ Installation of centre-pilot, subsurface drip, pump station and main lines. ▪ Installation of a treated water pipeline extending to Leewood property boundary. ▪ Crop establishment (refer to Appendix 3 for further details).
Demobilisation and restoration (6-8 weeks)	▪ Removal of materials and plant from site. ▪ Restoration to occur in accordance with a final landscape plan to be developed, so that rehabilitation and reinstatement works can be undertaken as soon as practicable following completion of construction activities. ▪ Topsoil will be treated and spread over the disturbed area to encourage vegetation growth. ▪ Stockpiled mulch from vegetation clearing works will be distributed around the site to reduce the risk of erosion of topsoil.

Table 2-11 Estimated cut and fill volumes (may change subject to detailed design)

Construction element	Material	Volume (m^3)
Water treatment plant bunded platform and treated water storage tank platform	General excavation: Topsoil, maximum depth not exceeding 0.25m. (Disposal of excavated material, topsoil to location on Leewood site defined by Santos).	1,285
	Filling: General: General fill.	4,385
	Filling: General: Selected fill (gravel fill; access tracks, power generation compound, WTP area, site offices).	1,200
Site access track	(660m total length) General excavation: Topsoil, maximum depth not exceeding 0.25 m. (Disposal of excavated material, topsoil to location on Leewood site defined by Santos).	440
	(660m total length) Imported gravel: Depth not exceeding 100-150 mm.	740
Pipework – trench excavation	Surplus excavated material to location on Leewood defined by Santos.	500

2.6.2.2 Staff and recommended construction hours

The total number of staff required for the construction period will vary between each stage of works. The construction workforce is estimated at a maximum of 50 staff during peak activities.

Construction activities will generally be undertaken from 7:00am to 6:00pm Monday to Sunday. Refer to Section 2.7.6 for further details.

2.6.2.3 Construction vehicle movements

Table 2-12 shows the approximate number of external peak heavy vehicle movements during the construction period.

Table 2-12 Peak heavy vehicle external movements during construction

Construction Stage	Construction activity	Estimated duration	Peak trips per day	Vehicle type	Activity use
1	Mobilisation	6-8 weeks	20	▪ Standard flatbed trucks ▪ 19 m-25 m articulated heavy vehicles ▪ Low loader (minimal)	▪ Delivery of plant equipment, construction amenities to site and temporary services
	Irrigation area		10	▪ Standard flatbed trucks	▪ Land preparation
2	Earthworks	6-8 weeks	40	▪ Tippers for spoil transportation	▪ Excavation and trenching
	Irrigation area		10	▪ Standard flatbed trucks ▪ Articulated vehicles ▪ Semi-trailers ▪ Large Rigid Vehicles	▪ Land preparation and installation
3	Concrete	2 weeks	20	▪ Concrete trucks	▪ Concrete trucks deliveries for foundation pours
	Irrigation area		5	▪ Standard flatbed trucks ▪ Semi-trailers ▪ Large Rigid Vehicles	▪ Installation
4	Mechanical and electrical	10-12 weeks	20	▪ N/A	▪ Delivery and installation of WBTP plant and equipment

Construction Stage	Construction activity	Estimated duration	Peak trips per day	Vehicle type	Activity use
	Irrigation area	13 weeks	5	▪ Standard flatbed trucks ▪ Semi-trailers ▪ Large Rigid Vehicles	▪ Installation

2.6.2.4 Access and construction traffic management

Access to the site during construction of the proposed activity will be from Old Mill Road which runs directly off the Newell Highway, to the south of the Leewood site.

Further discussions on site access and traffic management are provided in Section 6.3.2, as well as the traffic impact assessment provided in Appendix 4.

2.6.2.5 Plant and equipment

Locally sourced equipment and materials that can be easily transported to and from the site will be used where practicable for all construction activities. Potential construction equipment to be used may include, but is not limited to:

- 4WD
- vacuum truck
- water cart
- dozer
- excavator
- tipper
- mulcher
- concrete truck
- kerb profiler
- dump truck
- generator
- grader
- rollers
- whacker
- crane
- elevated work platform (EWP)/cherry picker
- hand tools
- truck and dog
- backhoe
- welder.

2.6.2.6 Site water requirements

Construction activities will require approximately 100 megalitres of water which is proposed to be sourced from the licensed water supply bore already on the Leewood property or an alternative appropriately licenced water supply bore. In addition, approximately 0.01 megalitres per day of potable water will be required for facilities during construction. This will be sourced from Narrabri's town water supply or another lawful source and trucked to site.

Water licensing requirements are discussed in Section 5.2.4.

2.6.3 Operation

2.6.3.1 Operational activities

The WBTP operational activities will include:

- water treatment plant operations, monitoring and maintenance

- brine treatment plant operations, monitoring and maintenance
- ancillary activities to support the above, utilities, power generation and other site operations, monitoring and maintenance
- pond operations and monitoring.

Further activities include:

- onsite irrigation of the treated water and management of the irrigation operation, including appropriate crop, water and soil management
- use of treated water both on and off-site for dust suppression, construction and drilling activities and emergency firefighting
- monitoring of all chemical storage levels, re-ordering of chemicals and managing chemical deliveries
- bund inspections and leak detection.

2.6.3.2 Water treatment plant

Once at the water treatment plant, the produced water or feed water will undergo a series of treatments comprising pre-treatment, treatment and post-treatment, as shown in Figure 2-4 and described in further details below.

Feed water to the water treatment plant may include:

- produced water,
- brine,
- condensate water from the fuel gas conditioning skid; and,
- WBTP solids streams (e.g. membrane filtration backwash) which will need to go through a solids removal step before being returned to the feed. The solids will be disposed of to landfill.

Pre-treatment

Pre-treatment of feed water enables the removal of solids and/or scale-causing compounds from the water. To remove solids and/or scale causing compounds, produced water will first undergo microfiltration/ ultrafiltration to remove solids between 0.01 – 0.1 microns within the feed water. The final pre-treatment process involves using a biocide for bio-fouling control. This step controls the growth of microorganisms, both in the microfiltration/ultrafiltration and RO stages.

Treatment

Following pre-treatment, feed water is transferred to the RO plant for treatment. Here the produced water is pumped through a semi-permeable membrane, separating treated water into one stream and salts into another stream known as rejected concentrate or 'brine'. Feed water is pumped at high pressure through the membranes, typically separating over 99 per cent of the TDS from the water.

Post Treatment

Post treatment of the produced water involves a series of steps in order to chemically balance the treated water prior to its beneficial reuse, in particular its use for irrigation. This includes:

- dechlorination by sodium bisulphate addition (this is dosed prior to the RO to protect the RO membranes from oxidation by chlorine)

- addition of calcium and magnesium to lower the sodium adsorption ratio (SAR)
- adjustment of pH by acid or caustic addition, if required.

The SAR of the treated water is of particular importance as it will be used for irrigation. The SAR is an indicator of the relative proportion of sodium ions in water to those of calcium and magnesium. In general, the higher the SAR, the less suitable the water is for irrigation. Chemical dosing of the treated water to lower the SAR assists to maintain or improve soil structure stability.

Similarly, the elevated electrolyte concentration of the treated water following chemical dosing will encourage aggregation of soil particles and assist in soil permeability when applied as irrigation water. The added calcium may also assist with maintenance of soil structure.

Additional chemical treatments may be required for subsurface drip irrigation to avoid potential blockages and maintain the structural integrity of the soil profile over the life of the proposed activity.

Solids handling

Solids, mainly algae, removed in the microfiltration/ ultrafiltration process are backwashed from the system and further treated to remove the solids in the form of a wet cake and the water (filtrate) is returned to the head of the process.

Primary dewatering

To assist the removal of solids, a process known as coagulation and flocculation (whereby chemicals are dosed into the water in a tank and stirred to encourage the suspended solids particles to coalesce and produce a thickened sludge for further treatment) is utilised:

- coagulants (inorganic) and/or flocculants (polymer) are added to promote the agglomeration and flocculation of fine and colloidal material for fast settling, flotation or filtration
- acid may be added to adjust the pH to facilitate the effectiveness of the coagulant.

The clarified water is directed back to the head of the process for further treatment.

Secondary dewatering

The thickened sludge is then passed over a secondary dewatering device under slight pressure to remove more water and produce a wet cake of approximately 15 to 20% solids content. The wet cake is then discharged into skips for removal from site to an approved waste disposal facility. The clarified water is directed back to the head of the process for further treatment. A small amount of polymer is sometimes added to the thickened sludge to improve the solids content of the cake.

All equipment will be installed in a customised container.

2.6.3.3 Brine treatment plant

Brine from the reverse osmosis plant will be sent to the brine treatment plant to further recover treated water and concentrate brines beyond the limit of the water treatment plant. A membrane brine concentrator within the brine treatment plant will use a high pressure membrane process to concentrate dissolved solids in solution by using reverse osmosis and recovering additional treated water.

The main output from the membrane brine concentrator is concentrated brine which will be transferred to the brine storage ponds.

2.6.3.4 Managed irrigation system

There is approximately 100 hectares of irrigable land available on an adjacent paddock within the eastern portion of the Leewood property. A combination of centre-pivot and subsurface drip irrigation will be employed to irrigate approximately 97.8 hectares. At this stage, lucerne has been identified as a suitable crop for most of the site because of its perennial nature, high soil cover percentage, long growing season, and water use capacity. It is also a crop that has commercial value in the region. A blend of lucerne and pasture grasses has been identified for the subsurface drip irrigation areas. An alternative crop to lucerne and pasture grasses (i.e. another suitable fodder crop) may be used if determined to be suitable based on its planting, soil preparation and watering requirements.

Based on using lucerne as the crop species, it is anticipated that harvesting would occur five times per year. Ongoing operations would require annual fertilisation, weed control and possibly light cultivation to aid infiltration. Further details of the irrigation scheme, including a site water balance, are provided in the Concept Irrigation Design report in Appendix 3.

Small volumes of treated water will also be used for irrigation of landscaped areas, vegetated screenings and rehabilitated areas as required. In future, other crop types may be grown on the Leewood property. These crop types will be selected to meet the water balance requirements of the overall facility.

Following chemical dosing, the treated water would be classified as 'medium strength effluent' according to Table 3.1 of the *Environmental Guidelines: Use of Effluent by Irrigation* (DEC, 2004) as it was ranked as 'medium' in TDS concentration (600-1,000 mg/L). It would be considered 'low' in the other five categories listed (total nitrogen, total phosphorous, biochemical oxygen demand, grease and oil, and other pollutants (e.g. metals, pesticides)).

The salinity of the treated water following chemical dosing would be rated as 'low' (between 0.65 and 1.3 mS/cm) and suitable for moderately sensitive crops according to Table 3.4 of DEC (2004).

The guideline outlines a number of environmental performance objectives that apply to the use of effluent for irrigation. These performance objectives, and details of how the proposed activity meets them, are outlined in Table 2-13.

Table 2-13 Environmental performance objectives – Environmental Guidelines: Use of Effluent by Irrigation (DEC, 2004)

Environmental performance objective	Summary of how the proposed activity meets the objective
Protection of surface waters	The irrigation system is located, designed, constructed and operated to protect surface waters. The irrigation area is located approximately 450 m from the nearest natural water body (Bohena Creek). The Leewood irrigation system has been designed so that runoff will be predominantly driven by rainfall, and will not be highly altered from conditions under a dryland pasture regime. Refer to Appendix 3 for further details.
Protection of groundwater	The irrigation area is located, designed, constructed and operated so that groundwater quality and levels are not affected by the irrigation activities. The Leewood irrigation system has been designed so that runoff will be predominantly driven by rainfall, and will not be highly altered from conditions under a dryland pasture regime. Refer to Appendix 3 for further details.
Protection of lands	The irrigation system improves the capacity of the land to grow plants, and doesn't result in deterioration of land quality through soil structure degradation, salinisation, waterlogging, chemical contamination or soil erosion. The proposed irrigation scheme will include extensive amelioration by deep ripping, cultivation, fertiliser, lime and gypsum to improve production.
Protection of plant and	Design and management of the irrigation system does not compromise the health and

Environmental performance objective	Summary of how the proposed activity meets the objective
animal health	productivity of plants, domestic animals, wildlife and the aquatic ecosystem. The IMP will ensure the ongoing protection of plant and animal health. The treated water for irrigation will not be high in nutrients.
Prevention of public health risk	The irrigation scheme is sited, designed, constructed and operated so as not to impact public health. The closest residence is approximately 360 m to the east of the irrigation area. The Newell Highway is approximately 20 m to the east of the drip irrigation area and approximately 25 m to the east of the spray irrigation area, respectively. The treated water for irrigation sources will not be high in nutrients. It will also not contain heavy metals as these would be removed by membranes during treatment, nor would any organic compounds be expected to be found in the treated water. Therefore there will be minimal risk to public health, beyond those associated with standard fertiliser and chemical application.
Resource use	Water balance modelling indicates that the irrigation system at Leewood will be able to beneficially reuse at least 90 per cent of the available treated water from the WBTP, the remainder being used for construction, dust management, drilling and firefighting. Any use of the treated water by another user would also be a beneficial use of this water resource. Further, this approach minimises the use of other sources of water for these purposes, e.g. bore water and town water.
Community amenity	The irrigation system is located, designed, constructed and operated to avoid unreasonable interference with any commercial activity or the comfortable enjoyment of life and property offsite. The closest sensitive receiver to the irrigation area is approximately 360 m to the east. Potential impacts of the proposed irrigation activity relating to odour, dust, insects and noise are considered to be negligible and manageable, as outlined in Chapter 6.

The guideline also identifies sensitive receptors and requires an assessment of the potential impacts of an effluent irrigation scheme. These are identified in Table 2-14, along with the recommended and estimated buffer distances between the effluent irrigation area and water resources and public areas. The guideline states that the size of the buffer zone is to be based on the sensitivity of the receiving environment, the strength of the effluent, the level of effluent treatment, proposed impact mitigation strategies, the method of effluent application and irrigation management practices such as irrigation scheduling. Narrower buffers may be appropriate where high quality effluent, a low volume of effluent or vegetated filter strips are used. The treated water to be applied within the irrigation area is classified as “medium strength effluent” according to Table 3.1 of the guidelines because it was ranked medium in TDS concentration (600-1,000 mg/L). It would be ranked as low for the other categories listed in Table 3.1 of the guidelines including total nitrogen, total phosphorous, BOD, other pollutants like metals and pesticides, and grease and oil. Wider buffers may be necessary where there are limiting site characteristics such as soil or slope.

Table 2-14 Sensitive receptors of effluent irrigation schemes and associated buffer distances

Sensitive area	Recommended separation distance under the Effluent Irrigation Guidelines		Approximate separation distance for proposed activity
	Low strength effluent	Medium to high strength effluent	
Natural water bodies (e.g. rivers, lakes)	50 m	50 m	450 m (Bohena Creek).
Other waters: e.g. artificial waters with beneficial uses, drainage channels, small streams, intermittent streams, farm dams	Site-specific	Site-specific	370 m (farm dam).
Domestic well used for household water	Site-specific	250 m	1.7 km (registered bore).
Town water supply bore	Site-specific	1,000 m	> 3 km (vicinity of Narrabri township).
Where spray irrigation gives	50 m	50 m	360 m (residence).

Sensitive area	Recommended separation distance under the Effluent Irrigation Guidelines		Approximate separation distance for proposed activity
rise to aerosols near houses, schools, playing fields, roads, public open space and waterbodieS			25 m (Newell Highway) The only component of issue within the treated water is TDS. Potential spray drift from the irrigation system will be minimised (refer to Section 6.2.1).
Other sensitive areas (e.g. waters in drinking water catchments, aquatic ecosystems with high conservation value, wetlands, native stands of vegetation)	Site-specific	250 m	10 m (Pilliga Box Woodland community). The only component of issue within the treated water is TDS. Treated water will not be directly sprayed onto the vegetation within the Brigalow Woodland community exclusion zone, located in the northern portion of the site. Potential spray drift from the irrigation system will be minimised (refer to Section 6.2.1).

2.6.3.5 Other beneficial re-uses of treated water

Aside from the managed irrigation system, treated water will also be beneficially used in other operational activities both on and off site. These activities may include:

- dust suppression (to minimise the generation of dust)
- construction and drilling activities
- firefighting
- watering of landscaped and rehabilitation areas
- use for off-site irrigation of agriculture by another user (not assessed in this REF).

Similar to the post treatment requirements for irrigation, treated water that is used for operational activities may require SAR adjustment prior to its use.

A procedure for beneficially re-using the treated water (other than in on site irrigation) is provided in Section 2.7.2.

2.6.3.6 Chemical usage

Typical chemical types and volumes to be used for the WBTP are outlined in Table 2-15 with further detail provided in Appendix 5. Additional chemicals may be used, depending on operational requirements and final plant design. If required, any additional chemicals that are classed as a Dangerous Good will be notified to OCSG and Santos will comply with any necessary further assessment requirements for additional chemicals used during the activity.

Table 2-15 Typical chemical storage summary

Material	Dangerous Goods Class	Approximate quantity stored on site (tonnes)
Hydrochloric acid	8 PG II	1.8
Sulphuric acid	8 PG II	1.8
Caustic soda	8 PG II	1.3
Sodium hypochlorite	8 PG III	2.2
Aqueous ammonia	8 PG III	1.4
Sodium bisulphite	8 PG III	0.5
Citric acid	Non-Dangerous Good	1.0
Antiscalant	Non-Dangerous Good	0.3
Calcium chloride	Non-Dangerous Good	1.0
Ethylenediaminetetraacetic acid	Non-Dangerous Good	0.5
Polyaluminium chloride	Non-Dangerous Good	1.12
Aluminium chlorohydrate	Non-Dangerous Good	1.2
1,2-benzisothiazolin-3-one*	9 PG III	3.0
Osmocide (DBNPA)*	8 PG III	1.0
Kuriverter IK-110*	8 PG III	2.0

*Note: Additional biocides added to table as optional disinfection chemicals – final will be decided during process commissioning. Not all biocide chemicals will be stored on site at the same time.

Diesel fuel required for power generation will be stored in accordance with legislative requirements in a storage area adjacent to the generators, also shown in Appendix 1. It is anticipated that storage capacity of approximately 20,000 litres will be required at Leewood during construction and operation. The diesel will be stored and labelled in accordance with the *Work Health and Safety Regulation* (2011).

2.6.3.7 Staff and hours of operation

The proposed activity will operate 24 hours per day, seven days per week with staff in attendance on a regular day shift. There is likely to be two full time operators working day shift with 24 hour remote monitoring to a central control facility. Remote access is available via laptop computer, and alarm messages are sent to operators when the plant is unattended.

2.6.3.8 Operational vehicle movements

Access to Leewood during operation will be via the existing access driveway adjacent to the southern boundary. Operational traffic will generally be associated with employees travelling to and from site, deliveries, maintenance activities and occasional visitors.

Based on the likely number of employees accessing the site during operation, it is anticipated that there will be up to five vehicles arriving and leaving during each of the weekday AM and PM peak hours, with operational deliveries and visitors assumed to be less than five vehicles per week. Operational vehicle movements associated with irrigation activities will be minor, with up to 10 trucks per day associated with irrigation, harvesting and crop management generated during operation.

2.6.4 Decommissioning and rehabilitation

Once construction of the proposed activity is completed, disturbed areas of the site will be stabilised in accordance with *Managing Urban Stormwater: Soils and Construction – Volume 1* (Landcom, 2004), referred to as 'the Blue Book'.

The proposed activity will operate for up to five years to support Santos' exploration and appraisal activities. Any operation beyond this would be subject to further environmental assessment and approval. Should this not occur, the proposed activity would be decommissioned and the site rehabilitated in accordance with the conditions of PAL 2.

Decommissioning and rehabilitation of the ponds was considered under the *Leewood – Produced Water and Brine Management Ponds REF* (RPS, 2012).

The final landform of the site would depend on the requirements of the proposed future use. The western side of the property would be converted back to grazing land. However, the irrigation area may be retained if requested by the future user.

At the end of operations, up to approximately 500 megalitres of concentrated brine may be stored in the ponds. This would either be transported to a suitable waste management facility for disposal, or a salt crystalliser would be installed to crystallise the brine and reduce the overall volume of brine and salt product that would be transported to a waste management facility and/or another site for a lawful beneficial reuse.

Decommissioning and rehabilitation works for the proposed activity would generally involve (where necessary):

- draining any remaining produced water and brine from the ponds and processing it in the water treatment plant and brine treatment plant
- disposing of the concentrated brine and/or solid salt product to a licensed waste management or other facility
- decommissioning and removing the WBTP, treated water storage tank and other surface infrastructure
- capping and covering buried flow lines
- dismantling and removing temporary buildings and structures
- removing the centre pivot and sub-surface irrigation infrastructure (unless to be retained for the future user)
- levelling, ripping and contouring the site
- soil amendment of the irrigation area
- reseeding with suitable pasture grasses (as required by future user)
- weed control
- disposing any remaining wastes at a licensed landfill.

A detailed rehabilitation strategy for the site will be developed towards the end of the life of the proposed activity. If a salt crystalliser is proposed to be installed at the end of the project's operation to assist in further treatment of the brine, further approval would be sought from OCSG.

In the event that no further approvals are granted, the rehabilitation criteria provided in Table 2-16 would apply to the site.

Table 2-16 Rehabilitation completion criteria for Leewood site

Phase		Activity	Timing	Completion criteria
Decommissioning of site infrastructure	Produced water and brine ponds.	Empty waste from ponds and dispose at suitably licensed landfill. Remove pond lining and dispose. Demolish embankments and backfill ponds.	Within 12 months of cessation of operations.	Ponds levelled and site clear.
	Water and brine treatment plant, water storage tank and other above ground infrastructure.	Dismantle and remove all plant, equipment, containers, waste materials, tanks and temporary buildings.	Within 12 months of cessation of operations.	Site cleared of all above ground infrastructure.
	Subsurface flowlines.	Flush and cap pipes at each end and remain *in situ*.	Within 12 months of cessation of operations.	Decommissioning in accordance with APEA Code of Practice, Upstream PE Gathering Networks – CSG Industry, Version 2.0.
	Centre pivot and subsurface irrigation infrastructure.	Unless agreed with the future land user, dismantle and remove centre pivot and excavate and dispose of subsurface irrigation infrastructure.	Within 12 months of cessation of operations.	Site cleared of irrigation infrastructure (unless agreement to leave in place has been reached with future land user).
Landform establishment		Grade and shape site to reinstate, as far as practicable, the original contour and drainage. Install erosion and sediment controls to minimise runoff channelling/erosion.	Within 12 months of cessation of operations.	No areas of instability or slumping. No areas of active erosion. Site landform established that is suitable for final agricultural land use and compatible with surrounding landscape.
Ground cover establishment		Reseed suitable pasture grasses across site (except across irrigation area if to be retained).	Within 12 months of cessation of operations.	75% groundcover established (except across irrigation area if to be retained).
Weed management		Control weed species by physical and/or chemical means taking into account the requirements of the *Noxious Weeds Act 1993*.	Until ground cover achieves target rehabilitation performance criteria, as per above.	Weeds do not dominate after disturbance or after rain.
Monitoring and reporting		Report to be submitted to OCSG following completion of all rehabilitation activities in accordance with condition 3 of PAL 2.	At completion of rehabilitation.	Report submitted.

2.7 Mitigation strategy

Santos seeks to conduct its activities in a way that avoids and minimises potential impacts on the environment. This is based on developing a thorough understanding of the environment, and developing techniques tailored to specific locations. Santos' approach to sustainability seeks to:

- ensure that all employees and contractors receive appropriate training to fulfil their individual and environmental responsibilities
- proactively pursue the identification of all hazards and eliminate or, if not possible, manage the risk to as low as reasonably practicable
- establish annual environmental objectives and targets and implement programs to achieve them
- as a minimum comply with relevant legal and other requirements
- incorporate environmental performance in the annual appraisal of employees and contractors and recognise accordingly
- implement strategies to minimise pollution, manage waste effectively, use water and energy efficiently and address relevant cultural heritage and biodiversity issues.

In addition, Santos uses compliance tracking and incident management systems throughout its operations. These internal systems will be applied to monitor performance against legislative requirements.

A suite of mitigation measures and a statement of commitments have been developed, as outlined in Sections 6.0 and 9.0 of this REF and are based on a hierarchy of impact avoidance and management of residual risks. The commitments will be applied when carrying out the proposed activity and are consistent with many of the principles used in the various guidelines in NSW in relation to biodiversity conservation, Aboriginal cultural and other heritage protection, noise, dust, stormwater, sediment and erosion control, and waste management measures.

The following sections outline the strategies to be employed by Santos and contractors during the proposed activity to ensure appropriate management of soils, water, waste, greenhouse gases (GHG) and noise.

2.7.1 Soil and water protection strategy

2.7.1.1 Erosion and sediment control

Erosion and sediment controls will be implemented consistent with the guidelines, principles and recommended minimum design standards contained in *Managing Urban Stormwater: Soils and Construction – Volume 1* (the Blue Book), as necessary, through all stages of the proposed activity.

Erosion and sediment control measures will be finalised during detailed design. Various technologies to manage sedimentation and erosion during the construction of the proposed activity may include:

- silt fences and silt traps
- settlement/sedimentation ponds
- swale drains and bunds to divert surface water away from the construction works
- silt fencing
- mulching on slopes to reduce scouring and erosion
- erosion control blankets on batters to prevent erosion
- use of a previously developed Santos weed management procedure.

All works will be undertaken to minimise the impact of erosion and sedimentation on the surrounding environment.

2.7.1.2 Soil monitoring

Ten soil moisture monitoring stations will be located across the irrigation area. Five of the monitoring stations will measure the most active rootzone in the top 100 centimetres and the other five will be equipped to measure soil moisture and salinity flux throughout and at the bottom of the rootzone. The derived data will be used to estimate the volume and rate of water moving through the unsaturated zone. Based upon monitoring bore log data describing the unsaturated zone beneath the rootzone any potential impacts to groundwater can be estimated by hydrogeological modelling.

A soil sampling protocol will also be established that uses approximately 10 benchmark testing zones representing various soil types and positions on the landscape. The zones will be up to 2000 square metres in size. These zones will be sampled by coring at set locations annually to a depth of three metres. The core holes will be plugged with bentonite chips to prevent water from running into the holes and skewing future results. The composited samples will be analysed for pH, ECe, SAR and the results will be used to monitor any flux in salt in the soil profile.

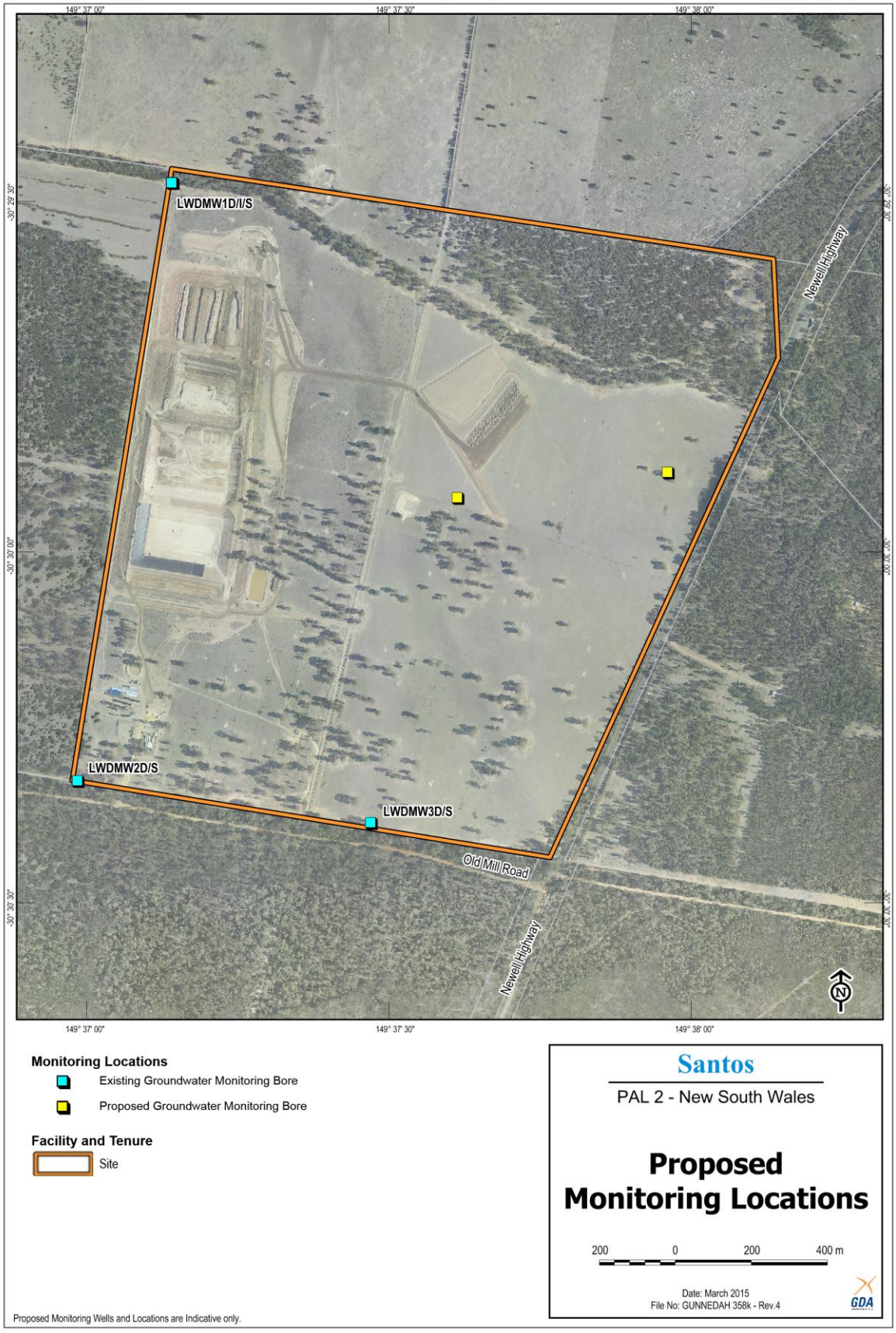

Figure 2-5 Existing and proposed water monitoring locations

2.7.1.3 Surface water protection

Potential surface water impacts and mitigation measures are identified in Section 6.1.3 of this REF.

Santos holds EPL 20350 and will ensure that all above ground tanks containing material that are likely to cause environmental harm are bunded or have an alternative spill containment system in place.

As outlined in Section 2.7.1.1, erosion and sediment controls consistent with the Blue Book will be implemented, as necessary, throughout all phases of the proposed activity. During site establishment, construction and rehabilitation activities, the site will regularly be inspected to ensure mitigation measures are effective and that risks to surface waters from pollution are mitigated.

2.7.1.4 Surface water monitoring

Surface water monitoring is important in predicting and measuring any 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 any change can be measured, monitored and investigated.

Environmental consultant URS has designed and implemented a baseline surface water sampling plan for Santos within the Narrabri region. The sampling program commenced in February 2012, with approximately 30 locations considered to be regular monitoring sites throughout the monitoring program period to date. Due to the ephemeral[2] nature of tributaries within the Namoi catchment, including Bohena Creek, most locations can only be sampled periodically. The closest regular monitoring points downstream to the proposed activity are described in Table 2-17.

Table 2-17 Regular surface water monitoring locations

Monitoring ID	Site description	Easting	Northing
NAR_7506_SURF_W	Bohena Creek off Newell Hwy picnic area	755014	6625004
NAR_7510_SURF_W	Bohena Creek crossing, Newell Hwy	756470	6628742

These monitoring points will be inspected monthly and sampled when water is present. 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)
- EC

[2] An ephemeral waterbody is one in which water flows for a short period following precipitation or snowmelt.

- 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 (2000). Comprehensive analysis is undertaken by a National Association of Testing Authorities (NATA) accredited laboratory. The analytic suite includes:

- physiochemical analytes
- dissolved anions
- dissolved cations
- dissolved metals
- total metals.

Reporting is undertaken monthly following completion of the laboratory analysis. It is anticipated that surface water sampling will continue for the life of the CSG program.

Water monitoring results are available on the Santos Water Portal: http://www.santoswaterportal.com.au/water-monitoring-map.aspx?extent=16561000,-3600000,16787000,-3491000.

2.7.1.5 Groundwater monitoring

Groundwater monitoring will be undertaken at Leewood to monitor groundwater levels and quality as part of Santos' broader groundwater monitoring program.

Existing and proposed groundwater monitoring bores at the site are identified on Figure 2-5.

In 2012, three sets of 'nested' groundwater monitoring bores were drilled to approximately 36 metres below ground level on the Leewood property. These bores provide baseline data regarding the unsaturated, static water levels and groundwater quality. As shown in Figure 2-5 the bore GW970427 is upgradient of the irrigation system but in the area influenced by seasonal inundation. GW970421, downgradient of the Leewood ponds and the irrigation area and GW970427 are also likely to be influenced by seasonal inundation.

Two additional monitoring wells are proposed to be installed to monitor groundwater in the vicinity of the irrigation area. One will be located near the edge of the centre-pivot, down-gradient from the existing groundwater monitoring bore (GW970427). The other monitoring well will be located at the edge of the irrigated area near the northeast corner of the property. These two new wells will be screened in the first groundwater encountered.

Once the wells are drilled and allowed to settle they will be sampled for static water level and chemical analysis and will be sampled six monthly.

The installation of pressure transducers with data recording capabilities within these two additional monitoring wells will assist in monitoring groundwater and soil moisture at the site during operations.

Results will be monitored and any significant variation from baseline conditions will be investigated. In addition to groundwater monitoring results being available on the Santos Water Portal, an annual Groundwater Monitoring Report will be submitted to the EPA. The report will provide an analysis and interpretation of monitoring results for groundwater monitoring locations across Santos' operating areas.

2.7.2 Beneficial re-use of treated water as dust suppression and rehabilitation

Only treated water will be used for dust suppression and in rehabilitation activities both on and off site as the water will meet ANZECC 2000 guidelines.

The operation of dust suppression and rehabilitation activities will take into consideration:

- management of spraying to avoid ponding and runoff of water
- avoiding of spraying during rainfall events
- adjustment of application rates based on road conditions and anticipated frequency of application
- routine visual inspection to check for any ponding or runoff.

2.7.3 Waste management strategy

The proposed activity will generate a number of waste streams. The main waste types that require offsite disposal and their estimated volumes generated during site establishment, construction and rehabilitation and operation activities are identified in Table 2-18.

Table 2-18 Estimated waste volumes for offsite disposal

Waste generating activity	Waste	Estimated volume
Construction	Construction material waste including plastics, asphalt, concrete, pipe off cuts, cabling and wiring, cured resins, paints and glues, etc.	Approximately 70 m^3
	Recyclables including glass, PET bottles, aluminium, scrap metal, rope spacers, paper and cardboard packaging waste.	20 m^3
	Chemical waste containers such as paint/solvent containers.	20 m^3
	Drained oil filters, empty oil containers and oil adsorbent materials that do not contain free liquids.	6 m^3
	General food and household waste.	10 m^3
Decommissioning	Concentrated brine	Up to approximately 500 ML

In addition to the above constant waste streams, there will be a number of intermittent waste producers during operation which include:

- microfiltration/ ultrafiltration system – intermittent cleaning waste
- RO system – intermittent cleaning waste
- waste associated with crop management and harvesting activities.

During operation the WBTP will generate a small amount of waste water from the pre-treatment, brine concentrator and pilot scale mixed salt brine crystalliser processes. General site wastes and food wastes will also be generated during this phase of the proposed activity.

Waste will be segregated according to its classification under the *Waste Classification Guidelines Part 1: Classifying Waste* (DECCW, 2009) and stored appropriately on site. These wastes will be removed from the site at the completion of construction and throughout operation for disposal or recycling at appropriately licensed waste management or recycling facilities.

Sewage waste, during both construction and operation, will be stored onsite and will be collected periodically and disposed of at a licensed facility.

2.7.4 Incident management strategy

Santos' Pollution Incident Response Management Plan provides information on site responsibilities, actions, reporting requirements, community consultation and resources available to ensure an effective and timely response is undertaken for pollution incidents or emergencies. It achieves this by:

- identifying the Santos incident management structure
- displaying notification and escalation criteria
- defining roles and responsibilities of the Incident Management Team members
- describing scenario based response procedures
- identifying key resource contact details
- describing community consultation requirements following an incident
- providing tools and templates for use in an incident response and recovery.

The Plan will be reviewed and updated to include the proposed activity, if approved, prior to commencement of construction.

Prior to Santos' acquisition of Eastern Star Gas in November 2011, a number of incidents had occurred at the Bibblewindi Water Treatment Plant. Santos carried out a review of operations and in December 2011, Santos temporarily shut down all operations in PEL 238 and PAL 2 near Narrabri, including the Bibblewindi Water Treatment Plant.

In early 2012 Santos released a report on the operational issues, including evidence of an unreported release of saline water from the Bibblewindi facility and brought them to the attention of the regulator. Santos has since decommissioned and removed the Bibblewindi Water Treatment Plant and is well advanced in rehabilitating the impacted area.

The design and operation of the Leewood WBTP will ensure that the risk of any uncontrolled release from the plant is minimised. Control and alarms systems which monitor and account for the volume of water pumped and processed from the produced water storage pond all the way through the water and brine treatment plant process to the treated water storage tank and brine storage ponds will assist in leak prevention. In addition to this the entire process plant area is contained within a bund so that any spill that potentially may occur in the plant area will be captured and contained.

Potential incidents at the site from the proposed activity and incident management measures are outlined in Table 2-19.

Table 2-19 Potential incidents and management measures at Leewood

Hazard	Description	Likelihood of causing environmental harm	Management measures
Failure of the WBTP to properly treat produced water	Treated water does not meet conductivity (TDS) limit or other parameters (e.g. calcium, magnesium, sodium).	Low	Electrical conductivity is measured online on a continuous basis. All treated water from the plant is contained in an interim treated water tank prior to post treatment. If the EC set point is not met and maintained, an alarm will trigger. The water will be reprocessed. EC meters are calibrated on a routine basis to ensure readings are within the specified requirements. It is noted that samples are undertaken on a periodic basis for other elements, with TDS being the online leading indicator of change.
Loss of containment from WBTP units, pipes or manifolds	Untreated produced water is released in an uncontrolled manner from the process plant.	Low	As stated in Condition O5.3 of EPL 20350, "all above ground tanks containing material that is likely to cause environmental harm must be bunded or have an alternative spill containment system in place". The entire process plant area is contained within a bund so that any spill that potentially may occur in the plant area will be captured and contained. Leaks are prevented by comprehensive control and alarms systems. The systems monitor and account for the volume of water pumped and processed from the produced water storage ponds all the way through the process to the treated water storage tank and brine storage ponds. If any discrepancy is detected the plant will automatically shut down and an alarm is sent to the plant operator. If the plant operator is not present on site, a remote access system can be used to shut the plant down.
Failure of the monitoring system to measure discharge	A measuring device required to detect a loss of containment fails leading to an uncontrolled release to the environment.	Low	HAZID, HAZOP and risk studies are undertaken during the design process to ensure that a rigorous structure process is used to identify, plan for and manage the risks associated with any process design. Where a risk of loss of containment due to failure of an instrument or measurement device is identified, this instrument is selected or backed up by additional equipment or safeguards.
Overtopping of treated water storage tank	The capacity of the tank is exceeded due to a rain event or blockage.	Low	Regular monitoring. Unblock spillway and drawdown tank. Divert treated water back to produced water storage pond.
Bush fire	Natural occurring bushfire burning surrounding vegetation and materials.	Medium	Severe weather warnings to be communicated to site staff. Emergency response will be under the direction of Santos who will have a representative in the Rural Fire Service response centre. Fire breaks and fire extinguishers will be located throughout the site. Chemical storage and unloading areas will be designed and managed in accordance with the relevant Australian Standards requirements.

Hazard	Description	Likelihood of causing environmental harm	Management measures
Man-made fire	Fire caused directly or indirectly by site activities.	Medium	Training for staff to prevent accidental ignition, provision of fire breaks and fire extinguishers located throughout the site. Chemical storage and unloading areas will be designed and managed in accordance with the relevant Australian Standards requirements.
Chemical spills	Loss of containment of a chemical from a chemical storage container, vessel or area of plant.	Medium	Chemical storage and unloading areas will be designed and managed in accordance with the relevant Australian Standards requirements. HAZID, HAZOP and risk studies are undertaken during the design process to ensure that a rigorous structure process is used to identify, plan for and manage the risks associated with any process design. This assessment process reviews chemical storage and handling within the plant and places strict controls. In addition, bunding will be in place to reduce the risk of loss of containment.

2.7.5 Greenhouse gas emission management strategy

Climate change is a long-term issue, requiring urgent but informed action to stabilise atmospheric GHG 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 organisation's 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' GHG 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.

Santos has publicly reported its GHG emissions since 2004 with independent assurance provided annually. As a result, Santos 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.

2.7.6 Noise management strategy

Noise generated by the proposed activity will be regulated under EPL 20350 for CSG exploration, assessment and production at the Narrabri Gas Field.

Condition L4 of EPL 20350 provides construction activity limits as follows:

L4 Hours of operation
Construction activities limits

L4.1 Standard construction hours

Unless otherwise specified by any other condition of this licence, all construction hours activities are:
a) restricted to between 7:00am and 6:00pm Monday to Friday;
b) restricted to between the hours of 8:00am and 1:00pm Saturday; and
c) not to be undertaken on Sundays or Public Holidays.

L4.3 Exceptions to standard construction hours

The following activities may be carried out outside of the hours permitted by Condition L4.1:

a) Construction work that causes $L_{Aeq(15\,minute)}$ noise levels that are not more than 5dB above rating background level at any residence not subject to a private negotiated agreement, in accordance with the Interim Construction Noise Guideline *(DECC, 2009);*

b) The delivery of plant, equipment and materials which is required to be delivered outside of the standard construction hours by Police and/or other authorised authorities; and

c) Emergency works to avoid loss of life, damage to property and/or environmental harm.

The licensee must on becoming aware of the need to undertake emergency work – notify the NSW Environment Protection Authority Environment Line on 131 555.

Construction for the proposed activity will generally be carried out from 7:00am to 6:00pm Monday to Sunday. The rating background level of the site is 30 dB(A) at all times (refer to Section 4.6). Therefore, construction work that causes noise levels no more than 35 dB(A) at any residence not subject to a private negotiated agreement, may be undertaken outside of standard construction hours in accordance with

condition (a) above. Construction activities will be managed to ensure that noise levels of 35 dB(A) are not exceeded at any residence outside of standard construction hours unless that residence is subject to a private negotiated agreement. Specific measures to ensure that this level is not exceeded are provided in Section 6.1.6.3.

Condition L3 of EPL 20350 provides noise limits for operational activities as follows:

L3 Noise limits
Operational activities limits

L3.1 Noise generated at the premises must not exceed the noise limits specified in the table below:

Location	Day Noise Limit $L_{Aeq(15\ minute)}$	Evening Noise Limit $L_{Aeq(15\ minute)}$	Night Noise Limit $L_{Aeq(15\ minute)}$
any residential sensitive receptor not subject to a private negotiated agreement.	35dB(A)	35dB(A)	35dB(A)

Compliance with these limits is generally expected. This is discussed further in Section 6.1.6.

2.8 Access arrangements

Leewood is a Santos owned property. Therefore no access agreement is required for works on this land.

2.9 Other approval requirements

Assessment and determination of the proposed activity under Part 5 of the EP&A Act, and approval under the *Petroleum (Onshore) Act 1991* (Petroleum Act), is required before the activity can commence.

An environment protection licence (EPL) is required under the NSW *Protection of the Environment Operations Act 1997* (POEO Act); refer to Section 5.2.3 for further details. Santos holds an EPL (EPL 20350) for coal seam gas exploration, assessment and production at the Narrabri Gas Field. Once the proposed activity is approved under Part 5 of the EP&A Act, Santos will apply to the EPA for a variation of the EPL seeking that the proposed activity be added to the existing EPL.

A water use approval under section 89 of the *Water Management Act 2000* will be required for the proposed use of treated water including the irrigation of agricultural land and other proposed beneficial reuses.

Section 5 sets out further details of regulatory requirements.

3.0 THE SITE

The site is located within the Santos-owned property known as Leewood, formally described as Lot 1 DP 771141.

Figure 2-1 illustrates the extent of the site, while a detailed survey of Leewood is provided in Appendix 6.

Leewood is predominantly cleared of vegetation and has been used in the past for grazing activities. Plates 3-1 to 3-9 illustrate Leewood. The site is currently accessed via Old Mill Road, a State forest road that runs along the southern boundary of the property. Leewood covers an area of approximately 246 hectares.



Plate 3-1 Leewood – view east along northern boundary



Plate 3-2 Leewood – vegetation in north-eastern portion of lot



Plate 3-3 Leewood – view east along southern boundary



Plate 3-4 Leewood – view south-east from centre of lot



Plate 3-5 Leewood – dam located in south-eastern corner of lot



Plate 3-6 Leewood – dam located in central portion of lot



Plate 3-7 Leewood – produced water and brine ponds



Plate 3-8 Leewood – site entrance looking towards from the site



Plate 3-9 Leewood – Old Mill Road looking toward intersection with the Newell Highway

4.0 EXISTING ENVIRONMENT

4.1 Topography

Leewood is relatively flat, with reduced levels ranging from 248.78 metres Australian Height Datum (AHD) along the eastern boundary (central section), to 244.79 metres AHD along the eastern boundary (northern section). Typical grades across the property are approximately one in 400. Refer Survey Plan (Appendix 6).

Leewood slopes generally towards an overland flow channel (drainage feature) from the south-east to north-west. There is also a slight depression in the land surface at the north-east of the site along the eastern boundary.

4.2 Climate

The Bureau of Meteorology weather station considered the most representative of the site is Narrabri West Post Office (station 053030, opened 1891); while Narrabri Airport AWS (station 054038, opened 2001) is the closest station to the site with recent temperature statistics (Narrabri West Post Office statistics end at 2002). The local climate is temperate with higher rainfall during the summer months. The average daily maximum temperature is 26.6°C, while the average daily minimum temperature is around 12.0°C (BoM, 2015). Annual rainfall is 661.6 millimetres and is known to range between 297.4 millimetres (lowest record) and 1012.1 millimetres (highest record).

As shown in Table 4-1, based on mean temperature records the warmest month is January and the coolest month is July. January receives the greatest rainfall and April the least.

Table 4-1 Mean climate data from February 1891 to December 2014

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean max temp (°C)[1]	34.5	33.2	30.6	26.9	22.4	18.3	17.9	20.0	24.2	28.2	31.1	32.4
Mean min temp (°C)[1]	20.0	19.6	16.3	12.3	7.1	5.7	4.0	4.8	8.2	12.0	16.4	18.1
Mean rainfall (mm)[2]	83.3	63.1	58.6	38.2	47.5	48.5	46.5	40.4	42.1	51.9	61.2	76.8

Note:
1. BoM station 054038 – from July 2001 to December 2014
2. BoM station 053030 – from February 1891 to December 2014

4.3 Soils

Thirty-four soil profiles within the site were described and sampled by BeneTerra Australia, as part of the investigation works for the irrigation concept design (refer to Appendix 3). Eighteen of these sites were soil pits dug to 140 centimetres with an excavator, while the remaining 16 were sampled to a depth of 150 cm using a hydraulic push tube corer.

4.3.1 Soil classification

Based on similarities in morphology, chemistry and management requirements, five soil units were defined for the proposed irrigation area within the site (shown in Figure 4-1):

- Red Chromosol (1ha) – a friable brown loam over a friable red clay loam. Well drained, and chemically and physically amenable to root growth.
- Brown Chromosol (4ha) – A friable brown loam over a hard brown clay. Moderately drained, and moderately chemically and physically amenable to root growth.
- Brown Sodosol-transitional (6ha) – very similar to the Brown Sodosol unit for most of its properties (see

description below). The soils of this unit were shallower than the other Sodosol units, with a sandstone parent material encountered at around 120 centimetres.

- Brown Sodosol (58ha) – A hardsetting brown sandy clay loam (or clay loam, sandy) over a very hard columnar brown clay. Well drained in the 15 centimetres or so of loam at the surface, changing sharply to much lower porosity clay upon which water perches for extended periods following heavy rainfall (remaining saturated for several days to a week). Root growth often extends to the full depth excavated, but is restricted by the coarse soil structure and moderate salinity of the subsoil, particularly below one metre.
- Grey/Brown Sodosol (31ha) – Similar to Brown Sodosol unit, but with the following distinctions. Often a thicker surface soil, possibly built up from erosion off the up-slope soils, usually with a distinctly bleached subsurface horizon above the coarsely structured subsoil. The subsoil is grey or grey brown, indicating poorer drainage than the other soil units. However, it appears this is due to landscape induced inundation i.e. due to drainage line flooding, rather than to lower internal permeability of the soil.

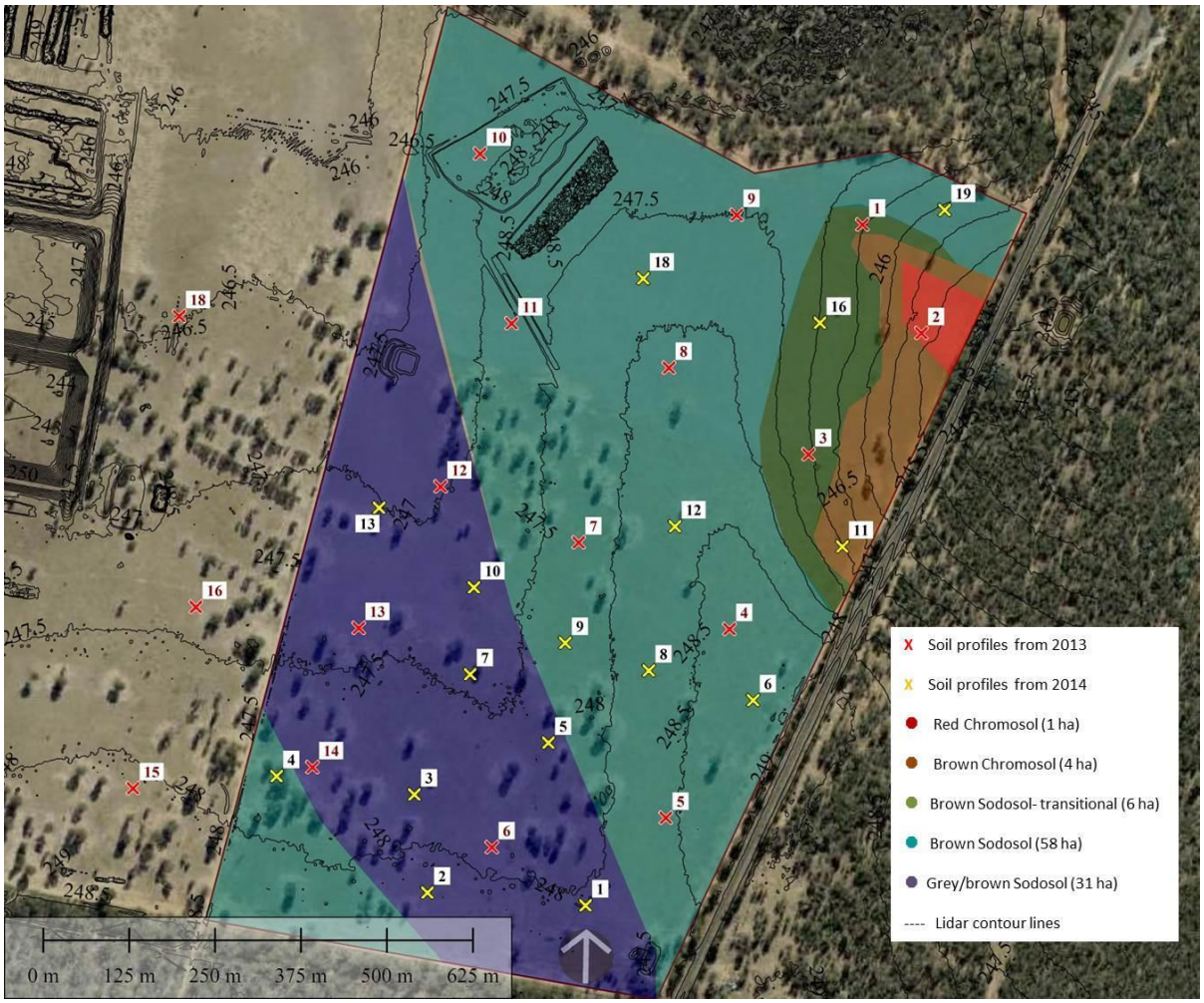

Figure 4-1 Soil sampling points and soil type distribution across irrigation area

The majority of the soils were identified as *Magnesic Mesonatric Grey or Brown Sodosols; medium, non-gravelly, clay loamy/clayey, deep* according to the Australian Soil Classification.

The soils in the northwest corner of the property tended to be shallower with most presenting a sandstone parent material within 1.2 metres. About half of these soils (five hectares) were identified as *Mottled,*

Mesotrophic Brown or Red Chromosol; medium or thick, non-gravelly, loamy/clay loamy, deep according to the Australian Soil Classification.

For the purposes of the irrigation concept design (Appendix 3) the soils on the irrigation areas of the site were further grouped into two irrigation management classes – A and B. These were differentiated primarily due to their landscape position:

- Class A soils: Chromosols and Brown Sodosols – more upland soils
- Class B soils: Grey/Brown Vertosols – lower lying soils.

4.3.2 Soil limitations

4.3.2.1 Chemical

All of the soil units exhibited exchangeable sodium percentages greater than 10 in the surface 40 centimetres which ranks as a 'severe limitation'. These soils are therefore considered to be sodic, and will exhibit dispersive qualities. Surface application of gypsum can decrease this limitation to slight or moderate. The ESP of the deeper soil, 40 to 100 centimetres, averaged 28 on the soils analysed but is not as critical a limitation as the surface ESP. This restriction can be mitigated through deep incorporation (e.g. via ripping) of gypsum into the soil.

Salinity posed a slight to moderate limitation for these soils in the 70 to 100 centimetre depth zone. However, some healthy roots were observed beyond 100 centimetres in many of the profiles. There were no indications that the water table or bedrock would be a limitation.

The saturated hydraulic conductivity of the subsoil presents the main limitation as it would likely be in the range of one millimetre per hour. This contrasts sharply with approximately 20 millimetres per hour in the surface soil. This can be mitigated through careful irrigation scheduling that fills the surface horizon and allows enough time for that soil water to drain into the subsoil. Soil amelioration techniques such as ripping and injection of gypsum (and possibly organic matter) will improve saturated hydraulic conductivity in the upper subsoil, possibly to as high as six millimetres per hour, reducing this limitation to a 'moderate' level.

These soils have ample water holding capacity. The surface pH is acidic (and commonly strongly acidic), but is easily amended with lime. Cation exchange capacity is not a concern as the soils have high clay content and, unlike most effluent waters, the irrigation source will not be nutrient rich. The site will require the addition of phosphorus (P), potassium (K) and sulphur (S) based fertilisers in order to optimise productivity of irrigated crops.

4.3.2.2 Physical limitations

The key physical limitations of the site relate to the impeded drainage of the majority of the soils. All the Sodosol units (95 per cent of the area) have coarsely structured, columnar subsoils which will perch water and drain slowly and unevenly. The poor subsoil drainage is greatly exacerbated for the 31 hectares of grey brown Sodosols that are subject to higher levels of overland flow associated with the drainage line.

The massive (structureless) clay loam and sandy clay loam surfaces of all the soils of the site have particle size distributions that make them highly susceptible to compaction when they are wet. Their lack of shrink/swell capacity also means they have little self-repair potential once compaction has occurred. As the subsoils will perch water, saturation of the surface soil following heavy rainfall is likely to extend for several days to a week after rain/overland flow stops. These drainage/waterlogging related issues will restrict water scheduling options, as well as the trafficability of the site. Mitigation measures to manage these limitations are detailed in Section 6.1.1.2.

4.3.3 Presence of metals in soil

Twenty-six soil samples taken from within the irrigation area of the site were analysed for heavy metals, including uranium and mercury. The soil profiles selected were chosen as a representation of the soil types described across the site, with the range of depths sampled including from the ground surface to 150 centimetres below ground level. The results of these analyses are provided in Appendix 3. None of the metals were measured at levels above the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (amended 2013) thresholds.

4.3.4 Contaminated land

A search of the list of NSW contaminated sites notified to the EPA (available at http://www.epa.nsw.gov.au/clm/publiclist.htm) indicated records of seven contaminated sites within the Narrabri LGA. None of these sites are located near the proposed activity. There are no known sites of contamination at the Leewood property.

4.4 Land use

The site is located on a property privately-owned by Santos. The site has been previously cleared for cattle grazing and currently comprises grassy paddocks with minimal scattered tree cover, as well construction works associated with the produced water and brine ponds (refer to Figure 2-1). The site is zoned for Primary Production (RU1) and is primarily surrounded by other primary production land, with the exception of land zoned for Forestry (RU3) to the south.

An Agricultural Impact Statement (AIS) has been prepared for the proposed activity (Appendix 7). The site is located within land zoned RU1 Primary Production under the Narrabri Local Environment Plan (LEP). It is bounded by the Pilliga East State Forest to the south, while the properties located to the north and west of the site contain cleared paddocks used for mainly grazing and cropping.

The dominant land use in the Namoi catchment is sheep and cattle grazing which accounts for 51 per cent of land use by area. Wheat, cotton and other broad acre crops are grown along the alluvial floodplains. Of the 801 square kilometres irrigated in the year 2011, around 718 square kilometres was used for cotton production in the Lower Namoi catchment (DECC, 2011).

The *Strategic Regional Land Use Plan – New England North West Region* (the SRLUP) includes Strategic Agricultural Land (SAL) mapping (refer Figure 4-2). SAL is highly productive land that has both unique natural resource characteristics as well as socio-economic value. Biophysical Strategic Agricultural Land (BSAL) is a particular category of SAL which is defined as land with the best quality landforms, soil and water resources which are naturally capable of sustaining high levels of productivity with minimal management practices. Leewood and the broader surrounding areas are not classified as BSAL. In addition, no Critical Industry Clusters (CICs) have been identified in the New England North West Region. CICs are defined as a localised concentration of interrelated productive industries based on an agricultural product.

Leewood has been mapped as having soils with inherent Class 3 and 5 land and soil capability (LSC). Lands in LSC Class 3 are described as having moderate limitations and are capable of sustaining high impact land uses using more intensive, readily available and accepted management practices. 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).

There are six potential sensitive receivers within two kilometres of the Leewood property boundary, the locations of which are shown in Figure 4-3. The nearest receiver (R4) to the proposed activity is located

approximately 360 metres to the east. The next nearest receiver (R5) is approximately 750 meters to the west; however consultation with the landowner has confirmed that this residence is not permanently occupied. There are two additional receivers (R3 and R6) located to approximately 1.3 kilometres east of Leewood, and two receivers (R1 and R2) located 1.4 kilometres to the north and 1.6 kilometres to the north west, respectively.

The site is not located within an Environmentally Sensitive Area of State Significance, as defined under the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (Mining SEPP) (refer Table 4-2).

Table 4-2 Environmentally sensitive areas

Is the proposed activity located on or within any of the following:	Yes/No
Coastal waters of the State	No
Lands protected under SEPP 14 – Coastal Wetlands?	No
Lands protected under SEPP 26 – Littoral Rainforests?	No
Aquatic reserves dedicated under the *Fisheries Management Act 1994* or a marine park under the *Marine Parks Act 1997*?	No
Wetland areas dedicated under the Ramsar Wetlands Convention?	No
A World Heritage Area declared under the World Heritage Convention?	No
Land identified in an environmental planning instrument as being of high Aboriginal cultural significance?	No
An area reserved or dedicated under the *National Parks and Wildlife Act 1974*?	No
Land, places, buildings or structures listed on the State Heritage Register?	No
Is the proposed activity located within land reserved or dedicated within the meaning of the *Crown Lands Act 1989* for preservation of flora, fauna, geological formations or for other environmental protection purposes?	No
Land identified as being critical habitat under the *Threatened Species Conservation Act 1995* or Part 7A of the *Fisheries Management Act 1994*?	No

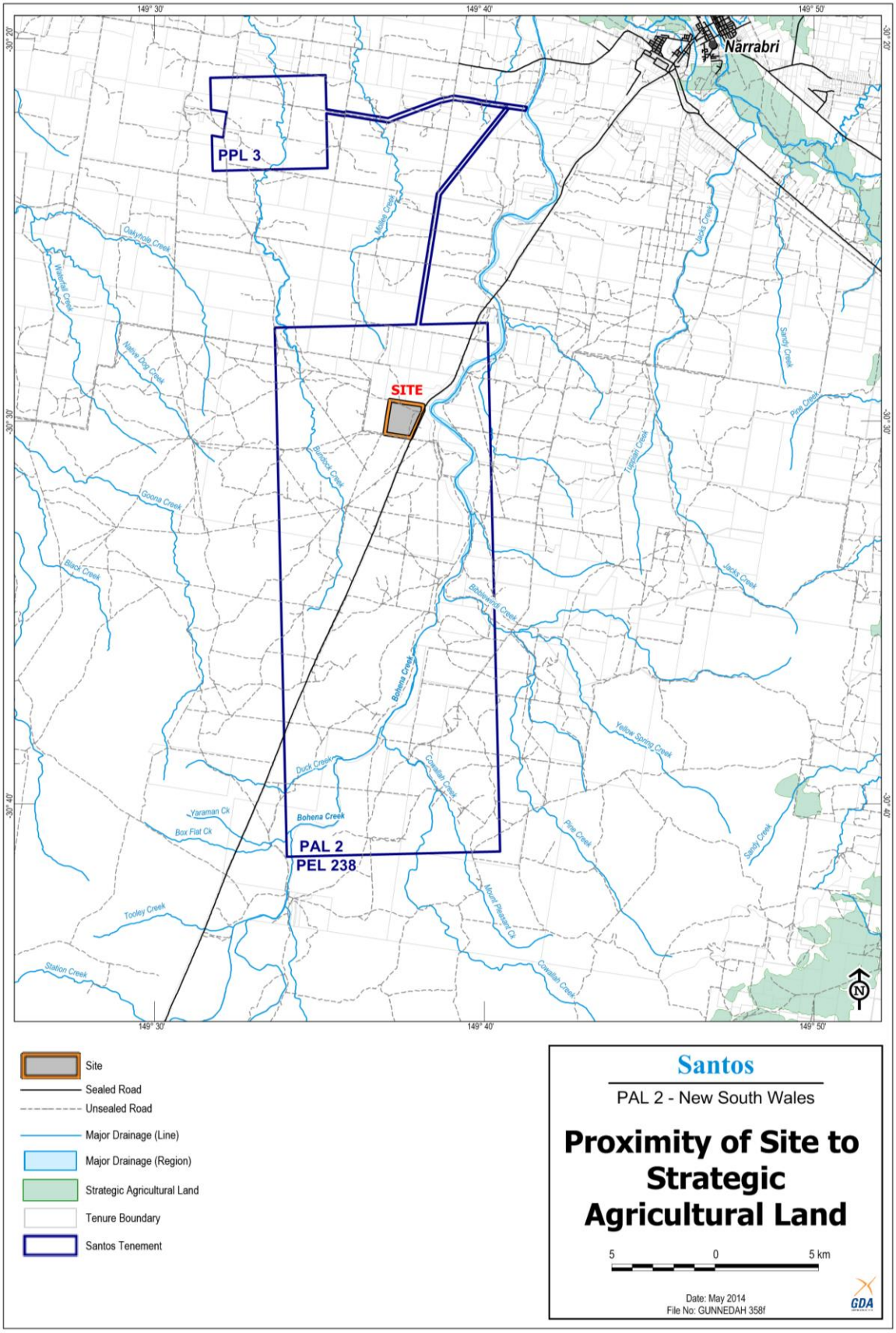

Figure 4-2 Proximity of site to Strategic Agricultural Land

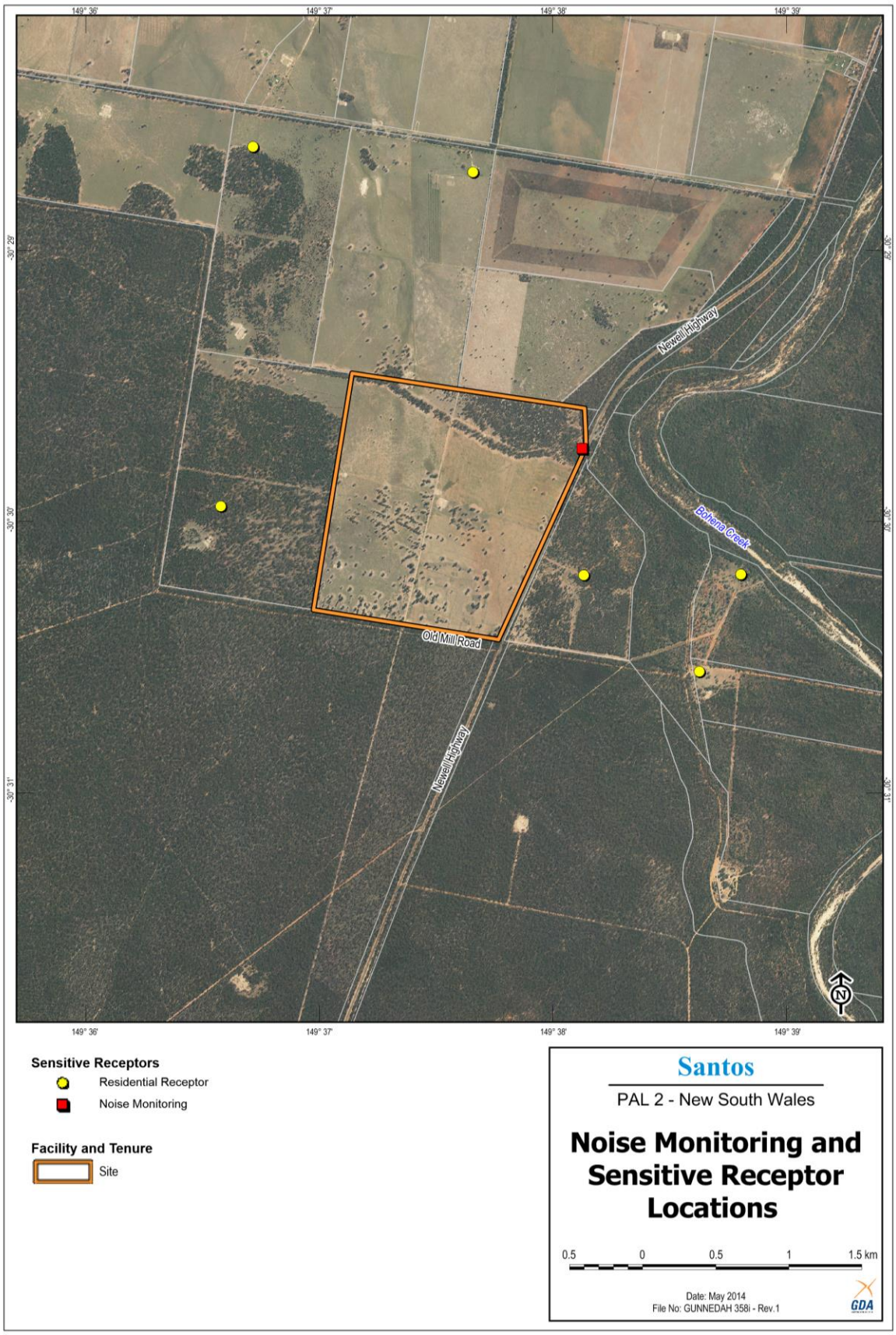

Figure 4-3 Noise monitoring and sensitive receptor locations

4.5 Air

The air quality in the vicinity of the site is influenced by the common land use practices in the area, including agricultural production and forestry operations. Regional air quality is likely influenced by additional land uses practices including mining activities, vehicle and heavy machinery movements, bushfires, burn-offs and use of combustion heaters.

There are no OEH air quality monitoring stations within the local vicinity of the site; however, the primary air pollutants of concern within the Narrabri region are likely to be dust (particulate matter PM_{10}) caused by mining operations, transport of coal and farming activities such as ploughing, and fine particulates ($PM_{2.5}$) from vehicle emissions. Fugitive dust and exhaust emissions from vehicles and machinery, particularly on dirt roads, and smoke from bushfires influence the local air quality of the site.

4.6 Noise

Unattended and attended noise monitoring at the project site was previously conducted by GHD in December 2013. Noise monitoring was conducted at the Leewood site in the north eastern corner near to the Newell Highway. The monitoring location is shown in Figure 4-3.

Table 4-3 presents a summary of the long term unattended noise monitoring results.

Table 4-3 Summary of unattended noise monitoring results (GHD, 2013)

Location	Rating background levels (L_{A90})			Ambient noise levels ($L_{Aeq\ ,15min}$)		
Leewood	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
	32	30	30[4]	65	64	61

Note:
1. Day is defined as 7:00 am to 6:00 pm, Monday to Saturday and 8:00 am to 6:00 pm Sundays & Public Holidays.
2. Evening is defined as 6:00 pm to 10:00 pm, Monday to Sunday and Public Holidays.
3. Night is defined as 10:00 pm to 7:00 am, Monday to Saturday and 10:00 pm to 8:00 am Sundays and Public Holidays.
4. Measured noise level was less than 30 dB(A). RBL set to 30 dB(A) in accordance with the *Industrial Noise Policy* (INP) (EPA, 2000).

Short term attended noise measurements were also carried out by GHD to characterise the existing noise environment. The attended measurements were carried out at the long term monitoring location. Table 4-4 presents a summary of the attended measurements. The measurements show that there is no significant industrial noise in the vicinity of the project site and that road traffic noise is a major contributor at the monitoring location.

Table 4-4 Attended noise measurement results (GHD, 2013)

Location	Date/time	Measured noise level (dB(A))		Notes
		L_{Aeq}	L_{A90}	
Leewood	10/12/2013 04.00 am	61	24	Road traffic noise from Newell Highway, mainly heavy vehicles and the occasional light vehicle, low insect noise, no wind.
	10/12/2013 04.16 am	60	23	Road traffic noise from Newell Highway, mainly heavy vehicles and the occasional light vehicle, low insect noise, no wind.
	11/12/2013 7.00 am	66	35	Road traffic noise from Newell Highway, mix of heavy vehicles and light vehicles, truck idling at truck stop, birds, light breeze, Leewood construction site not audible.
	11/12/2013 7.15 am	65	34	Road traffic noise from Newell Highway, mix of heavy vehicles and light vehicles, truck idling at truck stop, birds, light breeze, Leewood construction site not audible.

The water and brine storage ponds at Leewood were under construction during the noise monitoring period, however it is indicated by attended measurement that the construction works did not influence the long term noise monitoring.

The measured RBL for daytime is 32 dB(A) at the noise monitoring location, which is in close proximity to the Newell Highway. Figure 4-3 shows that the receiver locations are at a much greater offset distance to the highway than this monitoring location.

It is expected that at distances further from the Newell Highway, background noise levels would be lower as there are no other significant noise sources in the vicinity of the site and receivers. The lowest RBL that can be used for assessment under the *Industrial Noise Policy* (INP) (EPA, 2000) is 30 dB(A). In light of this, the daytime RBL has been set to 30 dB(A) for the proposed activity.

4.7 Geology

The surficial geological layer of the majority of the site is described as being Quaternary colluvium and/or residual deposits, and comprises talus, scree and sheet wash. These can take the form of boulder, gravel or sand, and may include minor alluvial or sand plain deposits. The southwest corner of the site is mapped as a Cainozoic sand plain, and may include some residual alluvium. It is sand dominant, also containing gravel and clay. Siliceous sands are dominant components of the parent material forming the soils, and consequently all the soils described at the site presented coarse sand fragments that were easily distinguishable in most horizons.

4.8 Availability of services

A buried gas pipeline associated with Santos' Wilga Park Power Station is located within an existing fenced right of way through the Leewood property. The existing Leewood water flowline from the Bibblewindi Facility (approved by DRE on 19 March 2013) runs parallel to the buried gas pipeline, terminating at the pond inlets.

Other various services are located both below and above ground within or adjacent to the site. The location, type and depth, or height, of all existing services will be confirmed and marked out in the interests of safety and protection of existing services prior to construction. Impacts to these services are not anticipated as a result of the proposed activity. Services include:

- electrical
- water
- gas.

4.9 Surface water

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 (Namoi Catchment Management Authority (NCMA), 2014).

Figure 4-4 shows the drainage in the vicinity of the site.

The site is located within the Bohena sub-catchment of the Namoi River catchment. The Bohena sub-catchment covers an area of approximately 830 square kilometres south of Narrabri and is the northern extension of the Borah sub-catchment. The sub-catchment is drained by Bohena, Cowallah and Bibblewindi

creeks (NCMA, 2014). Surface water quality within the catchment is influenced by agricultural runoff, spray drift, and vapour transport (NCMA, 2014).

There are no permanent, natural flows within the site, with Bohena Creek comprising the major drainage feature within the vicinity of the site. It is ephemeral in nature and flows only when significant rainfall occurs in the catchment. It is located approximately 450 metres to the east of the north-east corner of the Leewood property.

Mollee Creek is located to the north west of Leewood. A headwater tributary of Mollee Creek traverses Leewood and flows from the southeast to north through the property. Approximately one kilometre upstream (south east) of Leewood, it crosses the Newell Highway via two 1200 by 650 millimetre box culverts. The tributary is ephemeral and not well defined at the location of the proposed works. Mollee Creek enters the Namoi River more than 30 kilometres downstream of Leewood.

A flood study assessment for Leewood was undertaken by Golder Associates (Appendix 12 of RPS 2012). It identified those areas of the property affected by both the 50 year annual recurrence interval (ARI) and 100 year ARI (100 year ARI is shown in Figure 4-5). Flow velocities were also modelled and were low at rates between 0.33 and 0.80 metres per second.

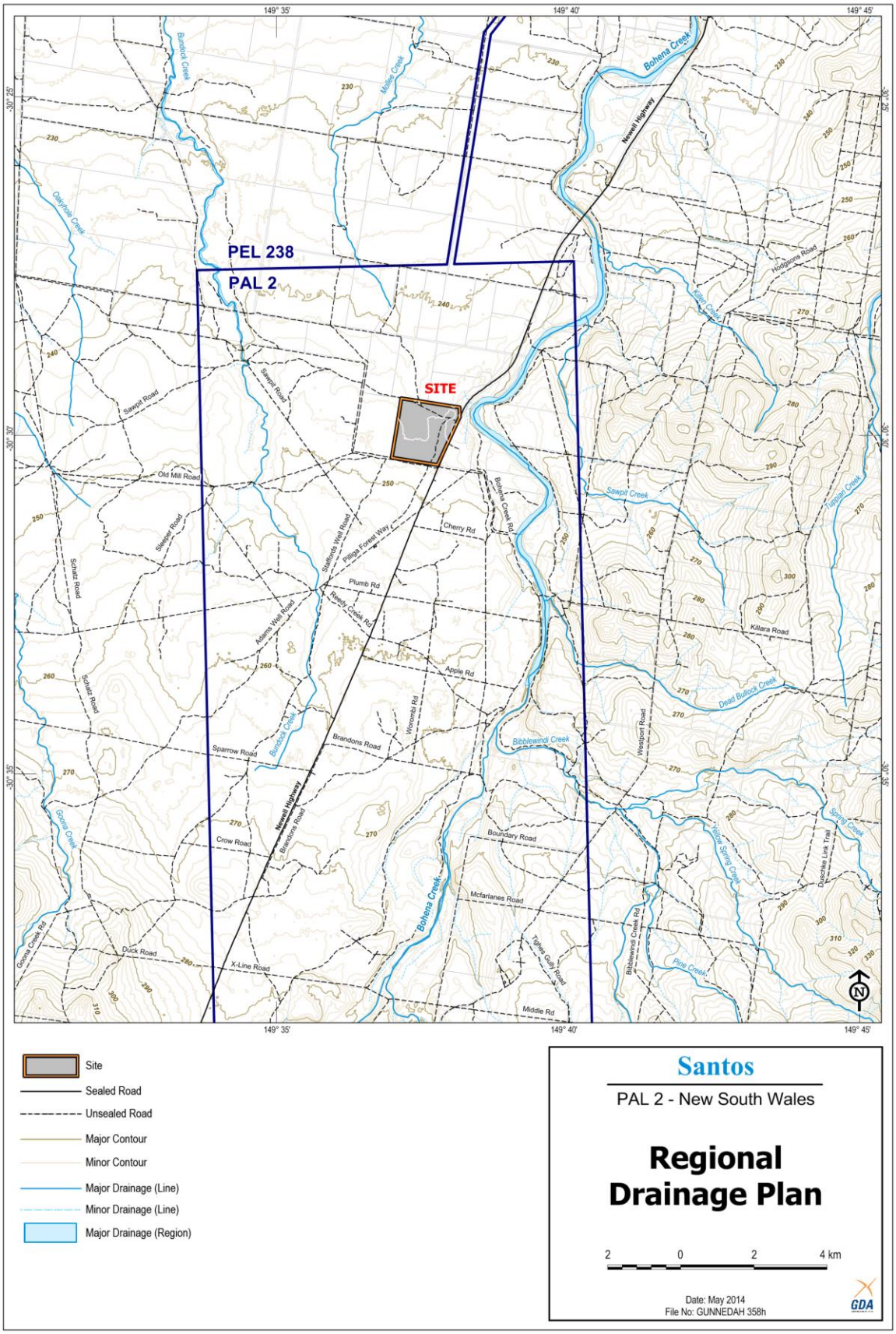

Figure 4-4 Regional drainage plan

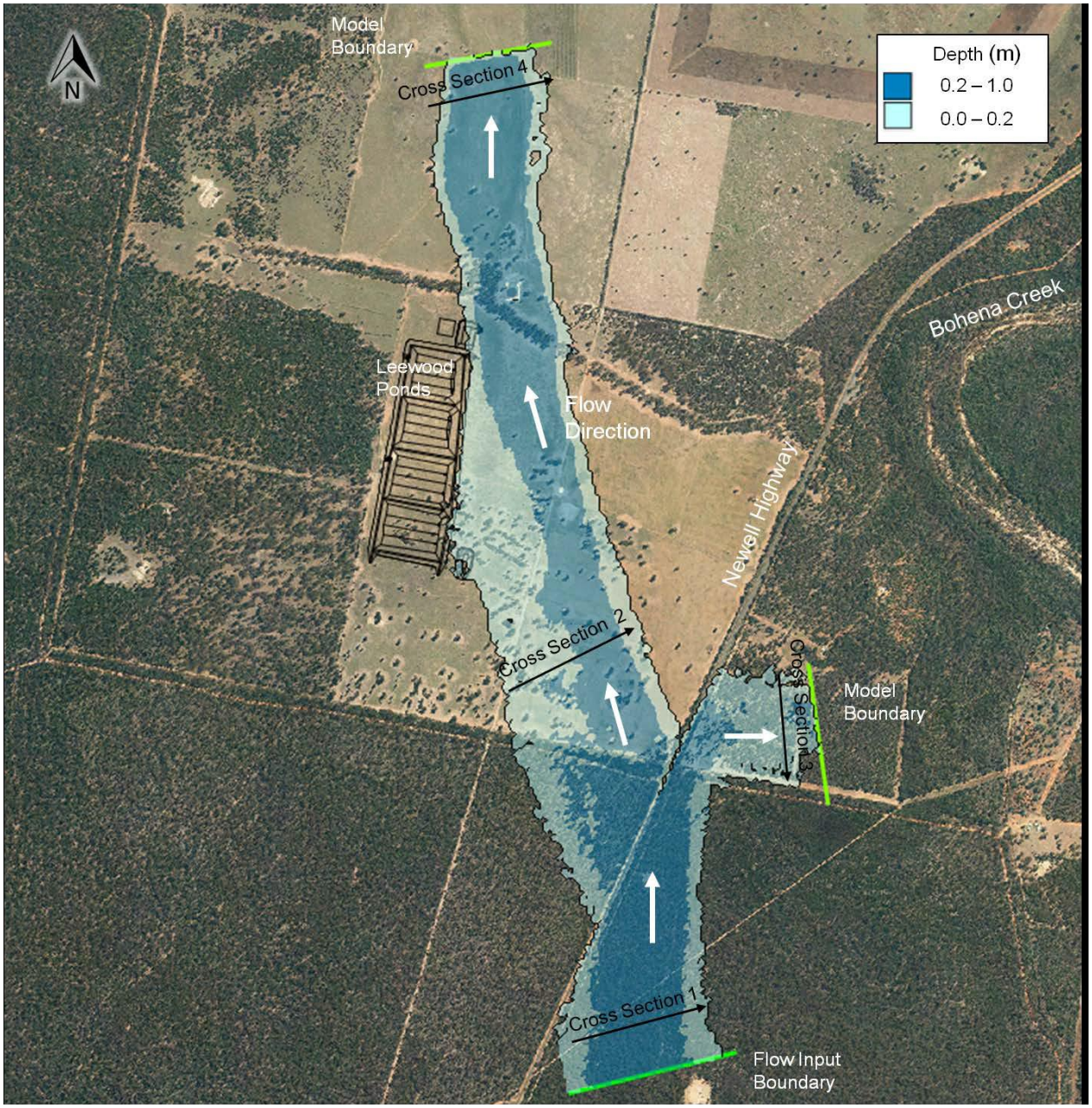

Figure 4-5 100 year ARI flood extent at Leewood (source: Flood Study Assessment, Golder 2012)

4.10 Groundwater

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 license holders in the Namoi River catchment. Groundwater sources include all water contained in the unconsolidated alluvial sediment aquifers associated with the Namoi River and its tributaries (NCMA, 2014).

The closest high priority groundwater dependent ecosystems (Hardy's Spring, Mayfield Spring and Eather Spring) are located more than 20 kilometres east of Leewood.

Five licensed groundwater bores are located within the Leewood property (NSW Government, 2014), as detailed in Table 4-5.

Table 4-5 Licensed groundwater bores within the Leewood property (source: NSW Government, 2014)

Well	Maximum depth (m)	Authorised purpose	Located within Southern Recharge groundwater source of the Great Artesian Basin
GW970421	36.1	Monitoring bore	Yes
GW970424	36.0	Monitoring bore	Yes
GW970426	17.7	Monitoring bore	Yes
GW970427	34.0	Monitoring bore	Yes
GW970656	204.0	Industrial (low security) mining	No

An additional nine licensed groundwater bores are located within three kilometres of the Leewood property (NSW Government, 2014), as detailed in Table 4-6.

Table 4-6 Licensed groundwater bores within 3km of the Leewood property (source: NSW Government, 2014)

Well	Maximum depth (m)	Authorised purpose	Located within Southern Recharge groundwater source of the Great Artesian Basin	Water bearing zone(s)
GW000017	124.8	Stock	No	39.6 m and 121.9 m (consolidated rock)
GW006577	67.7	Stock	Yes	23.1, 41.1 and 67.0 m (unconsolidated rock)
GW006594	68.5	Domestic/stock	Yes	53.3 and 68.5 m (unconsolidated rock)
GW033822	76.2	Domestic/stock	Yes	43.6 – 50.9 m (unconsolidated rock)
GW034495	57.9	Domestic/stock	Yes	49.6 – 51.4 m (unconsolidated rock)
GW070729	58.5	Domestic/stock	No	31.1 – 31.4 m and 50.9 – 51.2 m (unconsolidated rock)
GW965057	91.5	Irrigation/stock	Yes	41.2 – 41.3 m
GW966135	91.0	Domestic/stock	Yes	No water bearing zone details provided.
GW970567	2.2	Monitoring bore	No	1.0 – 2.2 m

As shown in Table 4-5, three groundwater monitoring bores were drilled to about 36 metres below ground level on the Leewood property. Static water levels ranged from 20.7 to 29.5 metres below ground level. This translates to water levels of 216.72 mAHD to 227.47 mAHD. Excavations for geotechnical test pits (up to five metres deep) and the produced water and brine ponds (up to 1.5 metres deep) near the proposed treated water storage tank did not encounter groundwater.

The alluvial aquifers within the vicinity of the site are associated with Bohena and Bibblewindi Creeks, with minor thin veneers of alluvium in some tributary creeks. The alluvial sandy soil veneer does not form an aquifer except where Bohena Creek meets the major alluvial aquifer system associated with the deep paleo-channels of the Namoi River.

The alluvium of Bohena Creek and major tributaries consist of clean, medium to coarse quartz sands which are up to about six metres thick. 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.

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.

4.11 Threatened species, populations and ecological communities

Ecological field surveys were undertaken at Leewood between 30 April and 11 May 2012 and again on 19 September 2012 as part of the *Leewood – Produced Water and Brine Management Ponds REF (*RPS, 2012). The results of these surveys, in relation to the proposed activity, are discussed in the Ecological Assessment in Appendix 8.

4.11.1 Flora

In total 59 flora species were recorded on the site during the field survey, including six weed species.

Targeted searches did not confirm the presence of any threatened flora species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or *Threatened Species Conservation Act 1995* (TSC Act) within Leewood.

4.11.2 Fauna

There are 24 species listed under the TSC Act and/or the EPBC Act that have potential or are known to occur on the site and that are considered to have potential to be impacted by the proposed activity. These species are listed in Table 4-7.

Table 4-7 Species and communities considered potential, likely or known to occur on the site with potential to be impacted

Scientific name	Common name	TSC Act[1]	EPBC Act[1]
Anthochaera phrygia	Regent Honeyeater	CE	E, M
Ardea alba	Great Egret, White Egret	–	M, Mar
Ardea ibis	Cattle Egret	–	M, Mar
Chalinolobus dwyeri	Large-eared Pied Bat	V	V
Chalinolobus picatus	Little Pied Bat	V	–
Chthonicola sagittata	Speckled Warbler	V	–
Circus assimilis	Spotted Harrier	V	–
Glossopsitta pusilla	Little Lorikeet	V	–
Hamirostra melanosternon	Black-breasted Buzzard	V	–
Hieraaetus morphnoides	Little Eagle	V	–
Lathamus discolor	Swift Parrot	E1	E, Mar
Macropus dorsalis	Black-striped Wallaby	E1	–
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V	–
Merops ornatus	Rainbow Bee-eater	–	M, Mar
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	–
Ninox connivens	Barking Owl	V	–
Nyctophilus corbeni (syn. Nyctophilus timoriensis (South-eastern form))	South-eastern Long eared Bat/Corben's Long-eared Bat	V	V
Phascolarctos cinereus	Koala	V	V
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	–
Pteropus poliocephalus	Grey-headed Flying-fox	V	V

Scientific name	Common name	TSC Act[1]	EPBC Act[1]
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	–
Stagonopleura guttata	Diamond Firetail	V	–
Tyto novaehollandiae	Masked Owl	V	–
Vespadelus troughtoni	Eastern Cave Bat	V	–

Note:
1. CE = critically endangered, E = endangered, V = vulnerable, M = migratory, Mar = marine.

A total of 53 fauna species were recorded on the site including 40 bird, two amphibian, two microchiropteran bat and nine mammal species. No threatened fauna or migratory species listed under the EPBC Act were recorded.

One species, the Grey-crowned Babbler, listed as Vulnerable under the TSC Act was recorded multiple times across the site. Nesting sites were also recorded for this species in the vegetation in the north east corner of the property.

No migratory species were identified during the targeted searches.

4.11.3 Vegetation

The north eastern portion of Leewood is vegetated. The remainder has been cleared and exists as grassland with scattered paddock trees. Leewood is surrounded by State forest to the west, south and east (beyond the Newell Highway).

Two vegetation communities were identified at the site (refer Figure 4.6):

(1) Pilliga Box – White Cypress Pine Grassy Open Woodland on Alluvial loams, Darling Riverine Plains and Brigalow Belt South

The condition of this community varied throughout the site. The remnant patches of intact Pilliga Box woodland were considered to be in moderate condition and had some impact from stock but retained high species diversity and covered an area of 17.4 hectares. These remnant patches are located in the north of the site and along the access road to the site and dominated by Pilliga Box (*Eucalyptus pilligaensis*) with other canopy species such as White Cypress Pine (*Callitris glaucophylla*) and Narrow-leaved Ironbark (*Eucalyptus crebra*). Bulloak (*Allocasuarina leuhmannii*) and Deane's Wattle (*Acacia deanei*) dominated the sub-canopy layer and the ground cover consisted mostly of native grasses including Tall Chloris (*Chloris ventricosa*), Bristly Lovegrass (*Eragrostis setifolia*), Purple Lovegrass (*Eragrostis lacunaria*), Hairy Panic (*Panicum effusum*) and Slender Bamboo (*Austrostipa verticillata*).

The 'poor condition' areas of this community were identified as the paddock areas where a few scattered paddock trees remain. These areas have been strongly influenced by stock grazing and consequently the shrub layer was almost non-existent and the ground layer was largely comprised of a few grass species. This area of the community covered 210 hectares and was identified as Derived Grassland.

This community is not commensurate with any Threatened Ecological Communities (TEC) listed under the *Threatened Species Conservation Act 1995* (TSC Act) or *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

(2) Brigalow Woodland

This community covers an area of 19.1 hectares in the far north east of the site and will not be impacted by the proposed activity. It comprises low woodland with a dense canopy dominated by Brigalow (*Acacia harpophylla*). Occasionally Pilliga Box (*Eucalyptus pilligaensis*) and Belah (*Casuarina cristata*) occur on the

edges of this community. The shrub and ground layers were sparse but consisted of species such as *Eremophila* species, *Sclerolaena* species, Small-leaf Bluebush (*Maireana microphylla*), Nardoo (*Marsilea hirsuta*) and Caustic Weed (*Chamaesyce drummondii*).

This community is considered to be in poor-moderate condition. The soil is compacted due to grazing, restricting the growth of understorey and ground layer species. As a result, the fauna guild which it attracts is limited. The dense array of Brigalow is healthy however its growth appears stunted likely due to poor soil quality.

This community is commensurate with the TEC '*Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions'* under the TSC Act and 'Brigalow (*Acacia harpophylla* dominant and co-dominant)' under the EPBC Act. This is discussed further in Section 6.2.1.

A total of six weed species were also recorded on Leewood. One of these species, *Opuntia* spp. Prickly Pear/Tiger Pear is considered to be a class 4 noxious weed in NSW under the *Noxious Weeds Act 1993* (NW Act).

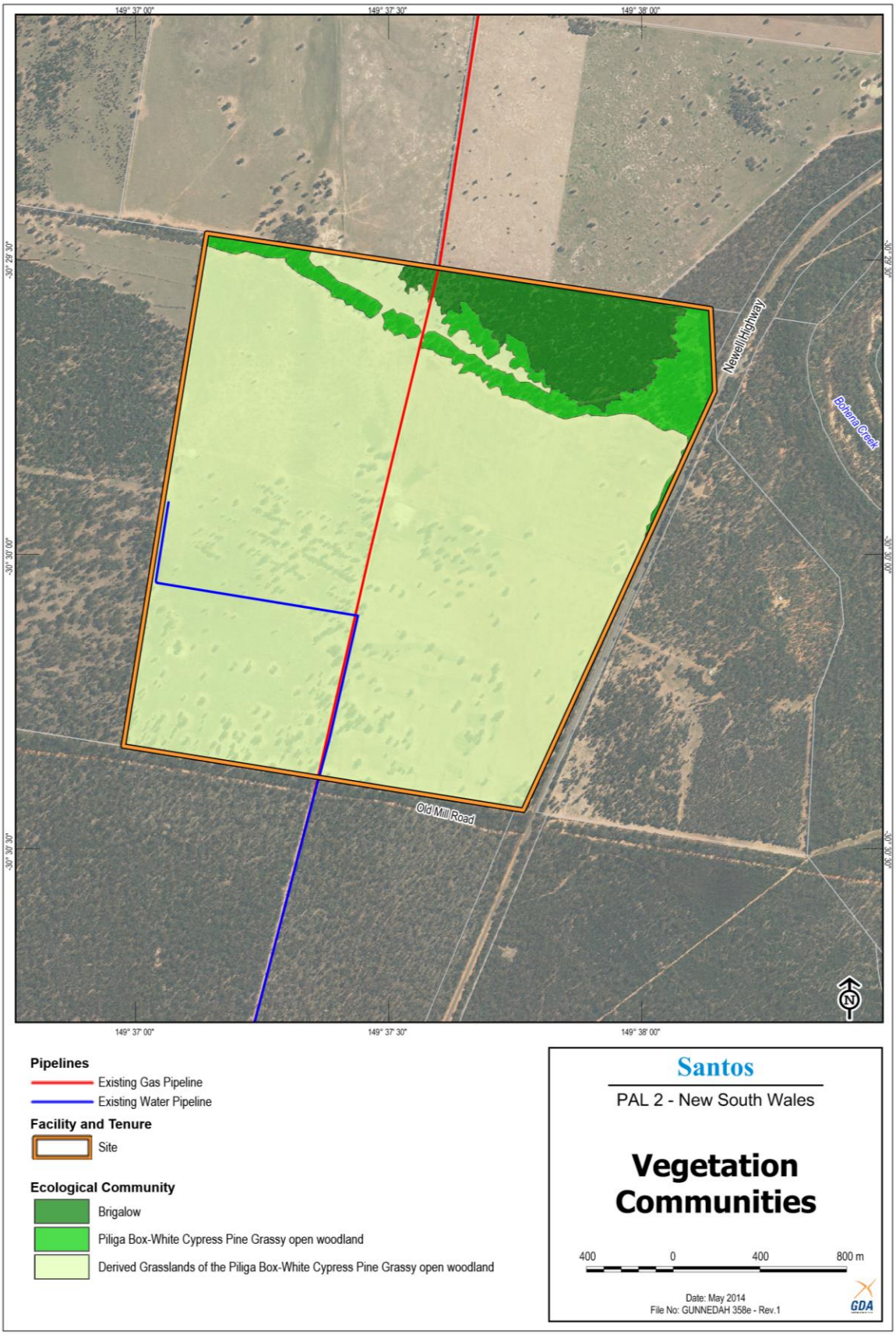

Figure 4-6 Vegetation communities

4.12 Traffic conditions

The site has frontages to the Newell Highway along the eastern boundary and Old Mill Road (also known as Dog Proof Fence Road) along the southern boundary. The latter is used as the main access route to the site.

4.12.1 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. Adjacent to the site, it is a two-way sealed rural highway configured with a two-lane, seven metre wide carriageway, with approximately 0.5 metre sealed shoulder. The current pavement condition is good in the vicinity of Old Mill Road, with no major defects. The posted speed limit is 110 kilometres per hour.

Traffic volume data collected on the Newell Highway throughout April 2012 indicates that the average daily traffic along the Newell Highway was approximately 1,860 vehicles, with peak hourly flows of 169 vehicles. The proportion of heavy vehicles on the Newell Highway is approximately 40 per cent of the average daily traffic.

The Level of Service (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, speed and proportion of heavy vehicles. In order to achieve a LOS B, traffic volumes are required to be less than 530 vehicles per hour with a 15 per cent heavy vehicle proportion. Assuming a 40 per cent 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 169 vehicles in any peak hour, the LOS along the Newell Highway is, at worst LOS B.

4.12.2 Old Mill Road

Old Mill Road is an unsealed forestry road travelling in an east-west direction for approximately 35 kilometres along the northern boundary of Pilliga East State Forest. It is understood to be managed and maintained by Forestry Corporation of NSW (FCNSW). There is an existing FCNSW speed limit of 60KPH.

Old Mill Road connects with the Newell Highway at a priority controlled T-intersection. Santos completed an upgrade of the intersection with the Newell Highway and Old Mill Rd as part of works associated with Leewood Phase 1. This upgrade ensures appropriate access for all vehicles including up to 25m long B-double trucks. The upgrade works included the following:

- drainage works
- installation of a clean gravel surface
- spray seal surface of Old Mill Road at the Newell Highway intersection over a distance of approximately 30 metres.

4.13 Aboriginal cultural heritage

The types of Aboriginal cultural heritage sites expected to occur within the site and surrounding region are influenced by a range of factors including the geology, vegetation, landform and the availability of natural resources and shelter. The main types of sites previously recorded in the Narrabri region and which might be expected to occur within the vicinity of the site are artefact scatters, scarred trees and open campsites.

A due diligence Aboriginal cultural heritage investigation was carried out for the site in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales 2010* (Appendix

9). As part of this investigation, Central Queensland Cultural Heritage Management (CQCHM) undertook a desktop review of the environmental and archaeological contexts, including an analysis of the surrounding landscape, a review of prior archaeological investigations, a search of the Aboriginal Heritage Information Management Systems (AHIMS) database maintained by OEH and a visual inspection of Leewood.

A search was undertaken of the National Native Title Tribunal (NNTT) registers in October 2013. This search identified one native title claimant, being the Gomeroi People. Their claim extends over an area of 111,340 square kilometres. This claim was filed with the NNTT on 20 December 2011 and has subsequently been registered by the NNTT. Santos is actively engaged with the Gomeroi native title claim group's elected representatives including inviting their participation in the due diligence cultural heritage investigation.

The AHIMS search results indicated that there were no previously recorded Aboriginal heritage sites within one kilometre of Leewood.

In accordance with the Santos Aboriginal Engagement Policy and consistent with leading industry practice, Santos sought the participation of local Aboriginal knowledge holders (Narrabri Local Aboriginal Land Council and Gomeroi native title representatives) in the archaeological field survey of Leewood. The survey was conducted by CQCHM over two days from 10 April 2014 to 11 April 2014. Four items of Aboriginal heritage were identified during the investigation, two scarred trees and two isolated quartz artefacts. The locations of these items are shown in Figure 2-1. These items have been fenced off and will remain fenced.

No other landscape features, such as sand dune systems, ridge lines, cliff faces, caves or rock shelters, which indicate the likely existence of Aboriginal objects, are located in the area of the proposed activity at Leewood.

4.14 Historic cultural and natural heritage

Searches of the Australian Heritage Database (National and Commonwealth heritage), the State Heritage Register (State heritage), the State Heritage Inventory (local and s170 heritage) and the Narrabri LEP 2012 were undertaken on 26 February 2014. The searches revealed no items of National, Commonwealth, State or local heritage items, nor items listed under s170 of the *Heritage Act 1977* (Heritage Act), on or near the site.

Components of the Sydney University Giant Air-shower Recorder (SUGAR) array were identified at Leewood during field investigations undertaken by RPS between 30 July 2012 and 5 August 2012. A SUGAR station, comprising two pits are located along the western boundary of Leewood (as shown in Figure 2-1). The SUGAR station is not registered on the SHR or Narrabri LEP 2012. These sites were fenced off prior to the construction of the Leewood ponds and will remain fenced. The pits will not be impacted by the proposed activity as they are located on the western boundary of the Leewood property.

Also present in the vicinity of the site is a Travelling Stock Route (TSR), located to the north east of the site (as shown in Figure 2-1). The TSRs were authorised public tracks used for the movement of stock from one location to another and have been in use since the early nineteenth century.

5.0 REGULATORY CONTEXT

5.1 Commonwealth legislation

5.1.1 Environmental Protection and Biodiversity Conservation Act

The EPBC Act provides for the protection of certain Matters of National Environmental Significance (MNES) listed under the Act, which are:

- 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
- water resources, in relation to coal seam gas and large coal mining development
- nuclear actions.

Under the EPBC Act, Commonwealth approval is required from the Minister for the Environment (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 activity 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 activity to the Minister for the Minister's decision whether or not the action is a controlled action.

An EPBC Act Protected Matters Search Report was generated for a 10 kilometre radius surrounding the site to determine whether any MNES will likely be affected by the proposed activity. In addition, an Ecological Assessment was prepared to determine whether the proposed activity will be likely to impact on any nationally listed threatened species or ecological communities, or migratory species.

An assessment of the proposed activity against MNES is provided in Section 6.7. The proposed activity will be unlikely to have a significant impact on any MNES or the environment on Commonwealth land and is not proposed to be taken by a Commonwealth agency. Therefore, the proposed activity is unlikely to constitute a controlled action and Santos does not propose to lodge a referral to the Minister.

5.1.2 Native Title Act

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

- recognise native title rights and sets down 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 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, and by which determinations can be made as to whether future grants can be made or acts done over native title land and waters
- provide for a range of other matters, including the establishment of a National Aboriginal and Torres Strait Islander Land Fund.

As detailed in Section 4.13, a search was undertaken of the NNTT registers which identified one native title claimant, being the Gomeroi People.

Santos has been in discussions with Native Title Services Corporation, which is the native title representative body for NSW. They have also engaged with the Gomeroi Native Title Applicants in preliminary negotiations towards a native title agreement. It is noted however that the Leewood property is a freehold estate granted prior to 23 December 1996 and is therefore not subject to native title claims.

5.2 NSW Legislation

5.2.1 Petroleum (Onshore) Act

The 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 an assessment lease has the exclusive right to prospect for petroleum and to assess any petroleum deposit on the land comprised in the lease. An assessment lease is designed to allow retention of rights over an area in which a significant petroleum deposit has been identified, if mining the deposit is not commercially viable in the short term but there is a reasonable prospect that it will be in the longer term. The holder is allowed to continue prospecting operations and to recover petroleum in the course of assessing the viability of commercial mining.

The proposed activity will be undertaken in accordance with PAL 2, granted under the Petroleum Act. The conditions of PAL 2 require activities to be undertaken in accordance with an approved Petroleum Operations Plan. The Petroleum Operations Plan for PAL 2 has recently been updated to reflect the proposed activity and other future operations within PAL 2 and has been approved by OCSG.

5.2.2 Environmental Planning & Assessment Act

5.2.2.1 Overview

The EP&A Act regulates development carried out in NSW. The carrying out of development is regulated under either Part 4 or Part 5 of the EP&A Act.

Development is required to be assessed under Part 5 of the EP&A Act if the relevant environmental planning instruments provide that the development does not require consent or is not exempt development, and the development is either carried out by a determining authority or requires the approval of a determining authority.

The *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (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. "Petroleum exploration" includes prospecting and assessment of petroleum under a PEL or a PAL. The proposed activity is being carried out for the purposes of petroleum exploration under PAL 2 and requires approval of the Director-General under the conditions of PAL 2. This has the effect that development consent is not required and the proposed activity is required to be assessed under Part 5 of the EP&A Act.

A determining authority, for the purposes of this activity, is defined in Part 5 to include a public authority whose approval is required before an activity may be carried out. The OCSG is the determining authority for the purposes of Part 5 of the EP&A Act for the proposed activity.

5.2.2.2 Determining authorities and the REF

Under Part 5 of the EP&A Act, a determining authority is required to examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the proposed activity.

Additionally, clause 228 of the *Environmental Planning and Assessment Regulation 2000* sets out the factors that must be taken into account concerning the impact of an activity on the environment.

The determining authority is required to consider whether the proposed activity is likely to significantly affect the environment or threatened species, populations or ecological communities, or their habitats to determine whether an Environmental Impact Statement (EIS) or Species Impact Statement (SIS) is required. In deciding whether there is likely to be a significant effect on threatened species, populations or ecological communities or their habitats, section 5A of the EP&A Act requires the following factors to be taken into account (the 'seven part' test of significance):

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

This REF has been prepared to assist the determining authority in meeting its obligations under section 111 of the EP&A Act. In particular, the "seven part" test has been applied to the proposed activity in Appendix 8 of the REF. The REF concludes that the proposed activity is not likely to significantly affect the environment or threatened species, populations or ecological communities or their habitats.

5.2.2.3 Narrabri Local Environmental Plan 2012

While the proposed activity does not require consent under Part 4 of the EP&A Act, consideration has been given to the relevant zone objectives under the Narrabri LEP. The site is located within land zoned RU1 Primary Production, the objectives of which are to:

- encourage sustainable primary industry production by maintaining and enhancing the natural resource base
- encourage diversity in primary industry enterprises and systems appropriate for the area
- minimise the fragmentation and alienation of resource lands
- minimise conflict between land uses within this zone and land uses within adjoining zones
- allow for non-agricultural land uses that will not restrict the use of other land for agricultural purposes.

The proposed irrigation activities fit with the zone and surrounding land uses, while other activities within the site will not restrict the use of other land for agricultural purposes. The natural resource base relied upon by the industries within the area will not be significantly affected by the proposed activity. The proposed activity will not significantly affect the development of agriculture, agricultural-related enterprises in the area nor will it result in fragmentation or alienation of resource lands. The proposed activity will not result in conflict between land uses within the RU1 Primary Production zone or land uses within adjoining zones. Therefore, the proposed activity is considered to be a suitable activity within the RU1 Primary Production.

5.2.3 Protection of the Environment Operations Act

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 NSW, having regard to the need to

maintain ecologically sustainable development'. The POEO Act requires EPLs be obtained for the carrying out of 'scheduled activities' or to pollute waters.

All petroleum exploration, assessment and production titles and activities are required to hold an EPL. Santos holds a licence (EPL 20350) for the Narrabri gas field which includes the produced water and brine storage ponds at Leewood. If the proposed activity is approved, Santos will apply to have EPL 20350 modified to include the proposed activity, including the discharge of treated water on-site through managed irrigation.

The load-based licensing (LBL) scheme under the POEO Act sets out limits on pollutant loads that can be emitted by holders of an EPL, including load-based fees. Schedule 1 of the *Protection of the Environment Operations (General) Regulation 2009* lists all licensed activities that attract load-based fees, including petroleum exploration, assessment and production. Assessable pollutants applying to petroleum exploration, assessment and production include:

- air pollutants
  - benzene
  - benzo(a)pyrene (equivalent)
  - fine particulates
  - hydrogen sulfide
  - nitrogen oxides and nitrogen oxides (summer)
  - sulfur oxides
  - volatile organic compounds (VOCs) and VOCs (summer).
- water pollutants
  - biological oxygen demand (BOD)
  - oil and grease
  - salt
  - suspended solids
  - total polycyclic aromatic hydrocarbons (PAHs)
  - total phenolics.

Load limits of these pollutants will need to be monitored and reported under the EPL. The main assessable pollutant in the irrigation water is salt and this is likely to be subject to load based licence fees calculated based on the amount of salt released during the irrigation activities.

5.2.4 Water Management Act 2000

5.2.4.1 Aquifer Interference Approval

The maximum depth of excavation for the proposed activity is approximately five metres, and would be unlikely to result in aquifer interference. Groundwater was not detected during the geotechnical investigation at Leewood or during construction of the produced water and brine ponds. Static water levels at the on-site groundwater monitoring bores ranged from 20.7 to 29.5 metres below ground level.

5.2.4.2 Water use approval

A water use approval under section 89 of the WM Act will be required for the proposed use of treated water including the irrigation of agricultural land and other proposed beneficial reuses. An exemption to this requirement applies where an aquifer interference approval under section 91 of the WM Act has been granted for an activity. This type of approval has not yet commenced; therefore a water use approval will be sought for these activities. If at any stage leading up to a water use approval being sought the aquifer interference approval commences, Santos may instead apply for an aquifer interference approval for the extraction activities.

5.2.4.3 Water access licences

Under Part 2 of Chapter 3 of the WM Act, it is an offence to take water from a source regulated by the WM Act unless in accordance with a water access licence. Water used for the construction of the proposed activity will be sourced from the licensed water supply bore already on the Leewood property or an alternative appropriately licenced water supply bore. Water treated onsite at the WBTP will be used to meet onsite operational water demands.

A WAL is also required for the taking of groundwater regulated by the WM Act, whether for consumption or incidentally, unless an exemption applies. The proposed activity is not expected to take any groundwater due to the shallow depth of the proposed earthworks (less than five metres) and known depths of those aquifers regulated by the WM Act (greater than 10 metres).

5.2.4.4 Flood work approval

Under section 90 of the WM Act, a flood work approval is required to construct and use flood work at a specified location. Flood work is defined within the WM Act and includes a work in the vicinity of a river or within a floodplain (as declared under the 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 WM Act provides that any land that was designated as a floodplain under Part 8 of the *Water Act 1912* is taken to be a floodplain for the purposes of the WM Act.

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: Narrabri to Wee Waa floodplain located approximately 22 kilometres north of the site. Therefore, a flood work approval is not required for the proposed activity.

5.2.5 Threatened Species Conservation Act

The TSC Act sets the 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 TSC Act also provides the mechanism for applying for and obtaining licences to take actions which could result in harm to a threatened species, population or ecological community, or their habitat, or damage to critical habitat.

Section 5A of the EP&A Act lists seven factors that must be taken into account in determining the significance of a potential impact on 'threatened species, populations or ecological communities (or their habitats)' listed under the TSC Act (included in Section 6.2.1). The assessment of significance (7-part test) is used to determine whether activities are 'likely' to cause 'a significant impact' on threatened biota and thus whether an SIS is required.

The ecological assessment prepared for the proposed activity identified 21 threatened fauna species listed under the TSC Act that are potential, likely or known to occur on the site with potential to be impacted upon by the proposed activity. In addition, the proposed activity requires the removal of 99.6 hectares of disturbed Derived Grassland. However, the ecological assessment concluded that the proposed activity is unlikely to have a significant impact on threatened species, populations or ecological communities (or their habitats). Potential impacts to biodiversity are discussed in Section 6.2.1.

5.2.6 National Parks and Wildlife Act

5.2.6.1 Threatened Species

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.

The NPW Act provides that these requirements do not apply if the action was essential for the carrying out of an activity in accordance with an approval of a determining authority under Part 5 of the EP&A Act where the determining authority has complied with Part 5.

5.2.6.2 Aboriginal Cultural Heritage

The NPW Act conserves places, objects and features of significance to Aboriginal people.

It is an offence under the NPW Act to:

- harm or desecrate an object that the person knows is an Aboriginal object except in accordance with an Aboriginal Heritage Impact Permit (AHIP)
- harm or desecrate Aboriginal objects and Aboriginal places except in accordance with an AHIP or where the person can show they exercised due diligence to reasonably determine that no Aboriginal object will be harmed.

A cultural heritage assessment of the site was prepared in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales 2010* (DECCW, 2010). The assessment determined that the proposed activity will not impact on any known Aboriginal objects or places, despite the presence of four Aboriginal objects within the site (two scarred trees and two isolated stone artefacts). Provided that the mitigation measures identified in Section 6.5.2 were carried out, impacts to any known or unknown Aboriginal objects or places should be avoided. Therefore, an AHIP is not required for the proposed activity.

5.2.7 Noxious Weeds Act

The NW Act is a NSW government instrument outlining the definition, declaration, and control of noxious weeds throughout the State. Local government bodies have the responsibility to ensure that the NW Act is complied with within their boundaries.

Landowners or occupiers have obligations under the NW Act to control any declared weed on their property. Council is required to conduct inspections of private properties to check compliance with the NW Act and Noxious Weed Officers have the authority to issue control notices for any breach.

Under the actions of this Act, a level of control can be applied to reducing the abundance and distribution of exotic weeds within Australia.

One noxious weed, *Opuntia* spp. Prickly Pear/Tiger Pear, was identified in the site. Under the provisions of the NW Act, this species is classified as a Class 4 weed. This means that the growth and spread of the plant must be controlled according to the measure specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed. Management of these species will be undertaken in accordance with the Narrabri Shire Council Management Plan for Prickly Pear (Plan No. PP01/2006, as revised 1 March 2011).

5.2.8 Heritage Act

The main objective of the *Heritage Act 1977* is to encourage the conservation of the heritage of NSW. The Leewood site is not listed on the State Heritage Register under the Heritage Act.

The Heritage Act also prevents impacts on 'relics', which are defined as:

> *any deposit, artefact, object or material evidence that:*
>
> *(a) relates to the settlement of the area that comprises New South Wales, not being Aboriginal settlement, and*
>
> *(b) is of State or local heritage significance.*

Under the Heritage Act, it is an offence to disturb or excavate any land knowing or having reasonable cause to suspect that the disturbance or excavation will or is likely to result in a relic being discovered, exposed, moved, damaged or destroyed unless the disturbance or excavation is carried out in accordance with an excavation permit.

Two items of potential heritage significance were identified at Leewood during the archaeological field surveys. The proposed activity will not impact these items provided that the mitigation measures identified in Section 6.6.2 are carried out.

6.0 ENVIRONMENTAL IMPACTS AND MITIGATION

This section of the REF addresses the potential environmental impacts associated with the proposed activity and identifies mitigation measures to ensure any impacts are appropriately managed. Potential impacts following the implementation of mitigation measures have been categorised in accordance with the ESG2 Guidelines. Impact categories include:

- negligible
- low adverse
- medium adverse
- high adverse
- positive.

The potential impacts associated with the proposed activity, including the impact categorisation following the implementation of mitigation measures are summarised in Section 7.

Table 6-1 addresses the specific impact assessment questions posed in Chapter 4 of the ESG2 Guidelines for each type of potential impact. Each of these questions has been discussed in detail in the following sections of the REF. The table responds to each question, identifies where in the REF it is discussed in further detail or why it has not been addressed.

Table 6-1 Compliance with Chapter 4 of the ESG2 Guidelines

Issue	Response/reference
4.1 Physical and chemical impacts	
Is the proposed activity likely to impact on soil quality or land stability?	No. The design and operation of the Leewood WBTP will ensure that the risk of any uncontrolled release from the plant is minimised. Comprehensive control and alarms systems which monitor and account for the volume of water pumped and processed throughout the entire system will assist in leak monitoring and prevention. The application of amended treated irrigation water and undertaking of land preparation activities, including soil amelioration, are likely to maintain or improve the soil quality and structure within the irrigation area on-site. Potential minor impacts during construction and operation associated with soil erosion and sediment loss, soil compaction and waterlogging, increased soil salinity and soil contamination can be adequately addressed with mitigation, including erosion and sediment control, appropriate irrigation practices, and management of topsoil and chemicals. Refer Sections 2.7.1, 2.7.4 and 6.1.1.
Is the activity likely to affect a waterbody, watercourse or wetland or natural drainage system?	No. The proposed activity will not result in the redirection of flow of any watercourse. It is considered highly unlikely that the proposed activity will result in the pollution of waters. Under certain irrigation scenarios there would be more surface runoff and deep drainage than the current land use, however the changes in water loss mechanisms are considered to be minimal. Surface water and groundwater monitoring will be undertaken throughout operation of the proposed activity. Refer Sections 2.7.1, 6.1.2 and 6.1.3.
Is the activity likely to change flood or tidal regimes, or be affected by flooding?	No. Leewood is affected by the 1:100 year flood level. Approximately one-third of the irrigation area is proposed within the 100 year ARI affected land, as

Issue	Response/reference
	well as a small section of hardstand area surrounding the treated water storage tank. Subsurface irrigation infrastructure will be installed in this part of the irrigation area rather than a pivot system, and irrigation scheduling would be managed to take into consideration prolonged rainfall. It is considered unlikely that the proposed activity would cause changes to the downstream flood regime and that the proposed activity would be unduly impacted by flooding. Refer Sections 4.9 and 6.1.3.
Is the activity likely to affect coastal processes and coastal hazards, including those under projected climate change conditions?	No. The site is not located within the coastal zone and will not be affected by coastal processes or hazards. Accordingly, this has not been addressed further in the REF.
Does the activity involve the generation or disposal of gaseous, liquid or solid wastes or emissions?	Yes. Small quantities of emissions and GHGs will be released due to the use of diesel and gas generators at Leewood during both construction and operation. These minor levels of emissions are not expected to affect air quality. Additional waste will be produced in small quantities during construction and operation, and will be recycled or disposed of at an appropriately licensed facility. Produced water will be treated for beneficial reuse, reducing the quantity of liquid wastes. The proposed activity will involve the generation of brine. The brine will be concentrated as much as possible via the treatment process and stored on site in the Leewood ponds. In the longer term, the ponds would be decommissioned and site rehabilitated, with the remaining pond contents being sent to the relevant licensed waste facility, as required. An EPL is required for the proposed activity. Refer Sections 6.1.4, 6.1.5 and 6.1.7.
Will the activity involve the emission of dust, odours, noise, vibration, or radiation in the proximity of residential/urban areas or other sensitive locations?	Yes. Construction activities will generate noise at some of the nearest residential receivers during both standard hours and outside of standard hours for certain construction scenarios. Impacts can be appropriately mitigated, in consultation with the landowners. Dust and vibration generated during construction activities will not significantly impact upon sensitive receivers as they do not exceed relevant criteria. Similarly during operation, dust, noise and vibration will have negligible impacts as they generally do not exceed relevant criteria. Refer to Sections 6.1.4 and 6.1.6.
Does the proposed activity involve the use, storage or transport of hazardous substances or the use or generation of chemicals which may build up residues in the environment?	Yes. Small quantities of chemicals and diesel fuel will be stored within the site and used during the proposed activity. Their use, storage and transport will be appropriately managed to minimise the risk of spills occurring. Refer Section 6.1.8.
4.2 Biological impacts	
Is any vegetation to be cleared or modified (including vegetation of conservation significance)?	Yes, however no vegetation of significance will be cleared. The construction of the proposed WBTP and associated infrastructure will be likely to result in the clearing of approximately 1.8 ha of Derived Grassland. The proposed irrigation area for the treated water will likely result in the disturbance of a further 97.8 ha of Derived Grassland. Refer Section 6.2 and Appendix 8.
Is the activity likely to have a significant effect on threatened flora or fauna species, populations, or their habitats, or critical habitat; or an endangered	No. No threatened ecological communities or threatened flora will be impacted by the proposed activity. While a number of threatened fauna species were identified as having the potential to occur within the site, the

Issue	Response/reference
ecological community or its habitat? (i.e. the threatened species *assessment of significance*)	proposed activity will not result in the removal of high quality habitat. Further, it is considered more likely that such fauna species would occur offsite due to better habitat characteristics. Refer Sections 6.2 and 6.7 and Appendix 8.
Does the activity constitute or is part of a key threatening process?	No. Refer Section 6.2 and Appendix 8.
Does the activity have the potential to endanger, displace or disturb fauna (including fauna of conservation significance) or create a barrier to their movement?	Yes, fauna may be disturbed or displaced. Removal of some vegetation may impact fauna. However, the quality of habitat to be removed is poor and impacts would be minor. Refer Section 6.2 and Appendix 8.
Is the activity likely to impact on an ecological community of conservation significance?	No. The proposed activity will not require the removal of any ecological community of conservation significance. Refer Sections 6.2 and 6.7, and Appendix 8.
Is the activity likely to cause a threat to the biological diversity or ecological integrity of an ecological community?	No. The proposed activity will predominantly impact previously disturbed land, including Derived Grassland. Refer Sections 6.2 and 6.7 and Appendix 8.
Is the activity likely to introduce noxious weeds, vermin, feral species or genetically modified organisms into an area?	No. *Opuntia* spp. Prickly Pear/Tiger Pear has been identified in the site. Mitigation has been proposed to ensure this species is appropriately managed. Refer Section 6.2 and Appendix 8.
4.3 Community impacts	
Is the activity likely to have an impact on the safety of the community?	No. All works are located within the Santos-owned Leewood property and is not accessible by the public. Refer Section 6.3.1.
Is the activity likely to cause a bushfire risk?	No. Parts of the site are expected to exhibit moderate to high bushfire hazard mainly due to the extent of vegetation cover. Standard site safety protocols and emergency procedures will be implemented to ensure that onsite bushfire risks are appropriately managed during both construction and operations. Refer Section 6.3.1.
Is the activity likely to affect existing community services or infrastructure?	No. All works are located within the Santos-owned Leewood property. The proposal will result in minor increases of traffic on the local road network, including the Newell Highway. There may be some impact to accommodation availability in Narrabri during construction; however this is not anticipated to be significant. Refer Sections 6.3.2 and 6.3.4.
Is the activity likely to cause impacts on the visual or scenic landscape?	Yes. Visual impacts associated with the proposed activity will mainly be in relation to the WBTP and associated infrastructure, as during operation the cropping activities within the irrigation area are consistent with surrounding land uses. Plant and equipment at the WBTP and associated infrastructure will be visible during construction and operation, but given its distance from the Newell Highway and neighbouring residences, will have a negligible impact on scenic amenity. Refer Section 6.3.3.

Issue	Response/reference
Does the activity affect sites of importance to the local or broader community for their recreational or other values or access to these sites?	No. All works are located within the Leewood property and is not accessible by the public. Refer Sections 6.3.3 and 6.3.4.
Is the activity likely to affect economic factors?	Yes. The proposed activity will have a negligible impact on the local economy, given the scale of the project. Refer Section 6.3.5.
4.4 Natural resource impacts	
Is the activity likely to result in the degradation of an area reserved for conservation purposes?	No. There are no areas reserved for conservation that would be affected by the proposed activity. This has not been addressed further in the REF.
Is the activity likely to affect the use of, or the community's ability to use, natural resources?	No. The proposed activity will not require significant quantities of natural resources. Refer Section 6.4.
Is the activity likely to involve the use, wastage, destruction or depletion of natural resources including water, fuels, timber, or extractive materials?	Yes. Once natural gas from the existing WPPS pipeline is connected to the site, approximately 63,000 GJ/yr gas will be used onsite during operation of the proposed activity. This is considered to be a beneficial use of CSG from exploration and appraisal activities. The proposed activity will not require significant quantities of other natural resources. Refer Section 6.4.
4.5 Aboriginal cultural heritage impacts	
Will the activity disturb the ground surface or any culturally modified trees (e.g. a scar tree)?	Yes, the proposal will disturb the ground surface. The proposed activity involves disturbance of approximately 99.6 ha for the construction of the WBTP and associated infrastructure, and preparation of the irrigation area. A cultural heritage assessment of the site was prepared in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales 2010* (DECCW, 2010). The assessment determined that while two scar trees have been identified on the site, the proposed activity will not impact on these trees as mitigation measures based on the Avoidance Principle will be implemented. Refer section 6.5 and Appendix 9.
Does the activity affect known Aboriginal objects or Aboriginal places?	No. A cultural heritage assessment of the site was prepared in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales 2010* (DECCW, 2010). The assessment determined that while two isolated stone artefact flakes have been identified on the site, the proposed activity will not impact on these objects and each flake is surrounded by fencing. Refer section 6.5 and Appendix 9.
Is the activity located in areas where landscape features indicate the presence of Aboriginal objects?	No. Refer section 6.5 and Appendix 9.
Can harm to objects or disturbance of landscape features be avoided?	Yes. No harm to objects or landscape features is proposed. Refer section 6.5 and Appendix 9.
Does the proposed activity affect areas subject to native title claims, indigenous land use agreements or joint	Yes. The Gomeroi People have filed a claim over an area of 111,340 km² which includes the Narrabri LGA and the site. Santos has engaged with

Issue	Response/reference
management?	Native Title Services, which is the native title representative body for NSW, in respect to this matter. Santos has also had preliminary discussions with the Gomeroi Native Title Applicants in the lead up to a native title agreement. Refer Sections 5.1.2 and 6.5.
4.6 Historic cultural or natural heritage impacts	
What is the impact on places, buildings, landscapes or moveable historic heritage items?	Nil. Two identified items of potential European heritage significance (i.e. SUGAR pits) have been identified on Leewood. The proposed activity will avoid impacts to the items. Refer Section 6.6.
Is any vegetation of cultural landscape value likely to be affected (e.g. gardens and settings, introduced exotic species, or evidence of broader remnant land uses)?	No. There is no vegetation of cultural landscape value within the site. This has not been addressed further in this REF.
4.7 Matters of National Environmental Significance	
Is the proposed activity likely to impact on MNES under the EPBC Act?	No. The proposed activity will not impact of any MNES. Refer Section 6.7.
4.8 Cumulative Impacts	
Is the proposed activity likely to have any significant cumulative impacts?	No. Refer Section 6.8.

6.1 Physical and chemical impacts

6.1.1 Soil quality and land stability

6.1.1.1 Impacts

Construction of the proposed activity will require vegetation clearing and land disturbance (see Section 6.2.1). These works, while temporary, have the potential to cause soil degradation and loss of topsoil, soil compaction and soil erosion, including sedimentation of waterways.

Should topsoil to be stockpiled at Leewood be stored for an extended period (i.e. greater than 12 months), impacts to the structure, biological activity, chemical properties and organic content may be affected.

During construction and operation, the proposed activity could result in soil contamination as a result of spilled or leaked chemicals, 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. Any incidence of spills or leaks on-site would likely be minor. Measures to reduce the risk of contamination as a result of the proposed activity are identified in Section 6.1.1.2.

Loss of containment of untreated produced water from WBTP units, pipes or manifolds could result in an uncontrolled release to the environment and subsequent soil contamination. The design and operation of the Leewood WBTP will ensure that the risk of any uncontrolled release from the plant is minimised. Comprehensive control and alarms systems which monitor and account for the volume of water pumped and processed throughout the entire system will assist in leak monitoring and prevention. Incident management measures to prevent leakages are outlined in Section 2.7.4.

During operation, the main potential impacts to soil will occur across the irrigation area. As stated in Section 4.3.1, the soils within the irrigation areas of the site were grouped into two management classes – A and B.

The irrigation system design and operations would treat these as different management zones, as outlined in the irrigation concept design report (Appendix 3). Therefore irrigation infrastructure, cropping and irrigation scheduling would vary according to the irrigation management class of the soil to minimise potential impacts.

As outlined in Section 4.3.2, the soil on-site has a number of inherent limitations due to its sodic nature. Without chemical dosing, the addition of irrigation water to the sodic soil could present the following issues:

- limiting of leaching, which could cause salt to accumulate over time and the development of saline subsoils, as sodicity reduces flow of water through soil
- crusting and sealing of the soil, which could impede water infiltration leading to potential increased runoff, as sodicity causes dispersion in the soil surface
- acceleration of erosion, which could cause the appearance of gullies and tunnels, as sodicity increases dispersion in the subsoil
- a dense, cloddy and structureless soil as it destroys aggregation.

However, as discussed in Section 2.6.3.2, prior to being used for irrigation purposes, water from the WBTP will be treated to a level that conforms with the *Environmental Guidelines: Use of Effluent by Irrigation* (DEC, 2004). The addition of chemicals to the treated water will make the water suitable for the intended soils and will serve to maintain or improve soil structure stability. This will be closely monitored as outlined in 2.7.1.2.

As outlined in Table 2-10 of Section 2.6.2.1, the following soil preparation activities will be undertaken during construction:

- application of gypsum – displaces the sodium within the soil, reducing its sodicity and dispersivity
- application of lime – neutralises soil acidity, and additional calcium would also ameliorate sodium
- deep ripping – breaks up the hard, coarse subsoil to assist in water infiltration
- application of fertiliser (during soil preparation, and continuing on throughout operation) – increases the nitrogen levels in soils, a limiting nutrient onsite.

The salinity of the treated water to be applied to the irrigation area would be rated as 'low' according to the DEC Guidelines (2004), as described in Section 2.6.3.4. Most irrigation waters carry a salt load that presents a risk of accumulation in the rootzone, particularly in arid regions or where high water tables exist. The annual rainfall of approximately 650 millimetres onsite will assist in offsetting salt deposition by irrigation water.

The expected EC of the treated water is 1.0 mS/cm. The estimated salt load of the treated water (using the calculation method described in DECC's *Load Calculation Protocol* (June 2009)) is 0.7004 mg/L. The total annual salt load to the soils over the irrigation area, based on an irrigation application rate of 372 millimetres per hectare or 3.7 ML/ha, is expected to be 1,859 kg/ha. Around 876 kg/ha of this is predicted to comprise sodium chloride salts. The remainder is attributed from calcium sulphate salts which have a positive effect on soil quality.

At an annual irrigation application rate of 372 millimetres or 3.7 megalitres per hectare, the annual salt input from irrigation is shown in Table 6-2.

Table 6-2 Annual salt loading from application of treated irrigation water

Salt added	Annual salt load (kg/ha)
Sodium	434
Calcium	242
Chloride	442
Sulphate	741
Total salts	**1,859**

The calcium sulphate salts typically have a positive effect on soil quality. Sodium chloride can impact soil stability (i.e. increased dispersibility), so the proposed irrigation system would provide control sensitivity such as deep drainage. Regular soil sampling and monitoring of salt accumulation in and beneath the rootzone would also be implemented.

The proposed irrigation area within the site is also prone to becoming waterlogged in the surface soil and would be untrafficable following extended rainfall periods, i.e. periods where continuous rainfall events exceed 50 millimetres. Land preparation and operational activities would be restricted during these periods. The irrigation schedule (application of the treated water) would be managed to minimise waterlogging and runoff. Traffic would also be kept to a minimum in the irrigation area to reduce soil compaction.

To gain a better understanding of the potential effects of irrigation of this site, three irrigation management schemes were modelled for comparison to the current rain-fed pasture setting. Details of this modelling are provided in the concept irrigation design report, provided in Appendix 3.

The four irrigation scenarios that were modelled using the HowLeaky modelling program were:

- Scenario 1 (baseline) – current dryland pasture under natural rainfall. This was simulated to compare the natural erosion, deep drainage and runoff from the site
- Scenario 2 – even irrigation of all 97.8 hectares, simulation based on an average year with one megalitre per day treated irrigation water
- Scenario 3 – even irrigation of all 97.8 hectares, simulation based on an average year with unlimited treated irrigation water
- Scenario 4 (likely management approach for the proposed activity) – irrigation split between Class A (68 ha) and B soils (30 ha), with priority given to watering Class B soils from October to May, and no irrigation of Class B soils from June to September. One megalitre per day treated irrigation water supply.

Irrigation events were set at 12 millimetres per application. An irrigation event was triggered once the soil water deficit reached 50 millimetres or 36 per cent of the 140 millimetre plant available water capacity (PAWC).

Three parameters having potential environmental impacts were modelled – runoff, deep drainage, and erosion and site sediment loss. The results of the modelling for these parameters are provided in Table 6-3.

Table 6-3 Water losses from system with potential environmental impacts = HowLeaky model output

Water loss mechanism	Scenario 1	Scenario 2	Scenario 3	Scenario 4 – Class A soils	Scenario 4 – Class B soils
Deep drainage (mm/yr)	4.0	3.9	16.9	4.3	5.7
Runoff (mm/yr)	14.2	13.5	39.6	14.6	17.6
Erosion and site sediment loss (t/ha-yr)	0.22	0.22	0.70	0.24	0.30

Discussions on the potential impacts of the proposed activity in relation to deep drainage and runoff are provided in Sections 6.1.2 and 6.1.3, respectively.

Under all four scenarios the paddocks were in permanent vegetative cover and the erosion and site sediments losses were predicted to be quite low at less than one tonne per hectare annually. The International Erosion Control Association best practices manual (IECA, 2008) states that erosion losses less than one tonne per annum are a desirable target and should result in less than 50 mg/L suspended solids which is necessary for maintaining pristine waterways.

6.1.1.2 Mitigation measures

The following measures will be implemented to avoid and/or minimise impacts on soil quality and land stability:

- Erosion and sediment controls will be implemented where necessary, in accordance with the guidelines, principles and recommended minimum design standards contained in *Managing Urban Stormwater, Soils and Construction – Volume 1* (the Blue Book). These controls will be maintained until disturbed areas of the site are stabilised
- A specific erosion and sediment control plan (ESCP) will be developed during detailed design and implemented for the proposed activity
- Any spills or leaks will be contained and cleaned up immediately. Contaminated material (such as contaminated soil or absorbent materials) will be removed from the site for disposal at a licensed waste facility
- Plant and equipment installed at the premises or used in connection with the licensed activity will be maintained and operated in accordance with condition O2.1 of EPL 20350
- A soil sampling and monitoring program, inclusive of the irrigation area will be implemented, as outlined in Section 2.7.1.2
- Soil amelioration, crop management and irrigation scheduling will occur generally as described in the concept irrigation design report (Appendix 3), to prepare and maintain the irrigation area throughout operation
- The site will be rehabilitated in accordance with Section 2.6.4 of the REF.

6.1.1.3 Potential impact category

The proposed activity will result in a negligible impact on soil quality and land stability. Construction related impacts will be temporary and managed using measures such as those outlined in *Managing Urban Stormwater*: Soils and Construction (Landcom 2004) ('the Blue Book'). While the total area of disturbance is 99.6 hectares, the majority of this will be for cropping and irrigation purposes. Soil amelioration will improve the productivity and structure of the soil over this area. The proposed soil monitoring program will ensure that there is no longer term degradation of the soil, including those caused by increased soil salinity and soil erosion and sediment loss.

6.1.2 Groundwater

6.1.2.1 Impacts

Minor impacts to groundwater may be associated with the construction and operation of the proposed WBTP and associated infrastructure, as well as the irrigation area.

Groundwater impacts during construction are considered to be highly unlikely, as the maximum depth of excavation for the proposed activity is approximately five metres and the known depths of those aquifers regulated by the WM Act is greater than 10 metres.

Under the irrigation scenarios that were modelled for the conceptual design irrigation report, deep drainage would increase slightly for the likely management approach for the proposed activity (Scenario 4 within Table 6-3) when compared to the current land use. The change in deep drainage is considered minimal as the greatest change modelled was an increase by 1.7 mm/yr. Therefore, no significant increase in groundwater level beneath the proposed irrigation site is likely to occur as a result of the proposed irrigation scheme.

Since deep drainage is minimally influenced by the proposed managed irrigation system, there is little likelihood of impacts on groundwater quality, including movement of salts and heavy metals.

The predicted salt concentrations of the treated irrigation water (TDS of less than 650 mg/L) indicates that it would not impact significantly upon groundwater quality as it would be similar to the highest quality groundwater (TDS of 631 mg/L) found on the site (refer to Appendix 3). Leaching of salts to maintain salinity levels within the soils of the irrigation area, as outlined in Section 6.1.1, may result in some additional release of ions to the soil solution with the input of irrigation water. This may lead to a negligible increase in salts entering groundwater.

Naturally occurring metals within the soils on-site were identified as low level and below *National Environment Protection (Assessment of Site Contamination) Measure 1999* (amended 2013) thresholds (Appendix 3), while the treated water is unlikely to contain heavy metals. The pH of applied treated water is also expected to be neutral and therefore not anticipated to result in any additional dissolution of heavy metal ions into the unsaturated zone and ultimately to groundwater.

6.1.2.2 Mitigation measures

The measures identified in Section 6.1.1.2 will also minimise potential impacts to groundwater. In addition, groundwater monitoring as per Section 2.7.1.5 will be implemented.

6.1.2.3 Potential impact category

The proposed activity will result in a negligible to low adverse impact on groundwater. With similar drainage rates as those associated with more vigorous vegetation under intensively managed irrigation activities, and good quality water being applied to the land, the risk of heavy metal and salinity movement to groundwater or changes in groundwater levels is considered unlikely. Ongoing groundwater monitoring on-site will ensure any adverse changes are able to be identified and are quickly addressed so that there is no significant impacts to the groundwater.

6.1.3 Water body, watercourse, wetland and natural drainage systems

6.1.3.1 Impacts

The potential impacts on surface water bodies associated with construction and operation of the proposed activity include erosion and sedimentation, surface water contamination due to chemical/fuel release, increase in runoff from the irrigation area, and impacts to flooding downstream of Leewood.

The likelihood of impacts due to erosion and sedimentation are discussed in Section 6.1.1.1. There is the risk that surface water contamination could occur during both construction and operation due to spills of oil, fuels or chemicals if not cleaned up appropriately.

Under the irrigation scenarios that were modelled for the conceptual design irrigation report (see Appendix 3), runoff would increase slightly for the likely management approach for the proposed activity (Scenario 4 within Table 6-3) when compared to the current land use. Scenario 4 shows runoff of 14.6 and 17.6 millimetres per year for Class A and B soils respectively, compared to 14.5 millimetres per year of runoff for Scenario 1 (pasture baseline).

Although the slopes are moderate and perennial cover will be maintained, the modelling indicates that some water will run off the irrigated area. The runoff will most likely be driven by rainfall events and is predicted to carry small amounts of sediment and possibly nutrients. As the irrigation schedule will be driven by crop water demand and availability of treated water, less (or no) water will be applied during periods of extended rainfall.

A key environmental performance objective of beneficial use of treated water for irrigation is to ensure that ground and surface waters do not become affected by any flow from irrigation areas. As the treated irrigation water is classified as medium strength effluent (refer to Section 2.6.3.4), it will be appropriately managed without a material change to the overland flow path.

Approximately one-third of the proposed irrigation area is located within flood-prone land (100 year ARI affected land, as shown in Figure 4-5), as well as a small section of hardstand area around the treated water storage tank. The irrigated land located within the flood-prone extent (Class B soil type) will occasionally be naturally inundated during prolonged rain events. However, the implementation of subsurface drip irrigation technology and targeted irrigation scheduling on this soil type will minimise the likelihood of inundation caused by the proposed irrigation activity. This has been demonstrated through the modelling, which indicates minimal changes in surface water runoff for the Class B soils (Table 6-3). It is considered unlikely that the proposed activity will cause significant changes to the downstream flood regime, or that the proposed activity will be significantly impacted by flooding.

Only treated water will be used for dust suppression and in rehabilitation activities. Management of these activities, as outlined in Section 2.7.2, will minimise the likelihood of ponding and runoff.

No surface water will be extracted for either the construction or operational phases of the proposed activity.

6.1.3.2 Mitigation measures

Implementation of the mitigation measures identified in Section 6.1.1.2 will ensure impacts in relation to erosion and sedimentation are minimised. Additional mitigation measures to minimise impacts to surface water include the following:

- Scheduling of irrigation activities will be managed generally in accordance with the concept irrigation design (Appendix 3), to minimise inundation and runoff
- During construction in the event that prolonged, severe wet weather or flooding is predicted, appropriate measures will be put in place to mitigate impacts of the wet weather
- The treated water storage tank will have high level alarms, or other appropriate controls, implemented to prevent overflows
- A surface water monitoring program will be implemented, as outlined in Section 2.7.1.4.
- Management measures for dust suppression and in rehabilitation activities will be implemented, as outlined in Section 2.7.2
- All above ground tanks containing material that is likely to cause environmental harm will be bunded or have an alternative spill containment system in place.

6.1.3.3 Potential impact category

The proposed activity will result in a negligible to low adverse impact on surface waterbodies, watercourses, wetlands and natural drainage systems. Construction related impacts will be temporary and managed using measures such as those outlined in the Blue Book. Potential issues associated with inundation and runoff from the irrigation area during operation will be mitigated through appropriate irrigation scheduling and management based on the soil types found on-site.

6.1.4 Air quality

An assessment of the potential air quality impacts, including odour, was prepared to consider the construction and operational noise associated with the proposed activity. This section provides a summary of the Air Quality and Odour Assessment, provided in Appendix 10.

6.1.4.1 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* (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 6-4 shows the impact criteria relevant to the proposed activity.

Table 6-4 EPA air quality impact assessment criteria

Pollutant	Averaging Period	Criterion
Particulate matter > 10 µm (PM_{10})	Annual mean	30 µg/m^3
	24-hour maximum	50 µg/m^3
Particulate matter < 2.5 µm ($PM_{2.5}$)[1]	Annual mean	8 µg/m^3
	24-hour average	25 µg/m^3
Nitrogen dioxide (NO_2)	1-hour	246 µg/m^3
	Annual	62 µg/m^3
Sulfur dioxide (SO_2)	10-minute	712 µg/m^3
	1-hr	570 µg/m^3
	24-hr	228 µg/m^3
	Annual	60 µg/m^3
Carbon monoxide (CO)	15-minute	100 mg/m^3
	1-hour	30 mg/m^3
	8-hour	10 mg/m^3
Volatile organic compound (VOC) (as Benzene)	1-hour	29 µg/m^3
Odour	1-hour	6 OU

Note:
1. From Ambient Air NEPM PM2.5 advisory reporting standards (NEPC, 2003)

The *Protection of the Environment Operations (Clean Air) Regulation 2010* specifies in-stack concentration criteria relevant to scheduled premises for general activities and plant. The generator stacks must operate within these limits. Table 6-5 summarises the in-stack concentration limits for particulate matter and other relevant air quality parameters.

Table 6-5 In-stack concentration criteria under the POEO (Clean Air) Regulation 2010

Air quality parameter	Source	Group 6 (mg/m^3)[1]
Solid Particles (TSP)[2]	Clean Air Regulation – Schedule 4 "Any activity or plant"	50
NO_2 or nitric oxide (NO) or both as NO_2 equivalent	Clean Air Regulation – Schedule 4 "Stationary reciprocating internal combustion engines"	450
VOCs, as n-propane	Clean Air Regulation – Schedule 4 "Any stationary reciprocating internal combustion engine using a gaseous fuel"	40 (125[3])
	Clean Air Regulation – Schedule 4 "Any stationary reciprocating internal combustion engine using a liquid fuel"	1,140 (5,880[3])

Note:
1. mg/m^3 – milligrams per cubic metre
2. Assumed to be also applicable to PM10 and PM2.5
3. as carbon monoxide (CO)

6.1.4.2 Ambient air quality

There is no onsite air quality monitoring data available for the Leewood property. Therefore the nearest locations with available data (Tamworth and Muswellbrook EPA monitoring sites, approximately 128 and 265 kilometres from the proposed activity) were used to provide an approximation of PM_{10}, $PM_{2.5}$, NO_2, and SO_2. Monitoring data for CO has been taken from Wyong.

The criterion and adopted background levels of these air quality parameters for the proposed activity are provided in Table 6-6. The adopted background levels for the assessment are likely to overestimate the expected levels of air pollutants at Leewood due to the presence of increased human activity surrounding the monitoring locations at Tamworth, Muswellbrook and Wyong including residential areas, major highways and industry.

Table 6-6 Ambient air quality

Parameter	Averaging Period	EPA Criterion	Ambient background level
PM_{10}	Annual	30 $\mu g/m^3$	16.6 $\mu g/m^3$
	24 hr	50 $\mu g/m^3$	47.5 $\mu g/m^3$
$PM_{2.5}$	Annual	8 $\mu g/m^3$	7.3 $\mu g/m^3$
	24 hr	25 $\mu g/m^3$	20.5 $\mu g/m^3$
NO_2	Annual	62 $\mu g/m^3$	19.1 $\mu g/m^3$
	1 hr	246 $\mu g/m^3$	86.1 $\mu g/m^3$
SO_2	Annual	60 $\mu g/m^3$	6.0 $\mu g/m^3$
	24 hr	228 $\mu g/m^3$	62.9 $\mu g/m^3$
	1 hr	570 $\mu g/m^3$	423.3 $\mu g/m^3$
	10 min	712 $\mu g/m^3$	616.7 $\mu g/m^3$
CO	8 hr	10 mg/m^3	1.0 mg/m^3
	1 hr	30 mg/m^3	3.0 mg/m^3
	15 min	100 mg/m^3	4.4 mg/m^3
VOCs	1-hour	29 $\mu g/m^3$	N/A
Odour	1 hr	6 OU	N/A

6.1.4.3 Impacts

Construction air quality impacts

Potential impacts to regional air quality associated with the construction of the proposed activity will include the generation of particulate emissions, including visible dust plumes and elevated particulate matter less

than ten micrometres (PM_{10}). Particulate emissions will mainly be generated during construction activities including site preparation, and construction of the WBTP and irrigation infrastructure. There will also be potential impacts associated with exhaust emissions generated from diesel powered construction plant and machinery, as well as vehicle movements to and from the site.

A qualitative approach was used by Pacific Environment (Appendix 10) to assess the potential air quality impacts due to construction, as effects on airborne particle concentrations are generally temporary and relatively short-lived. The approach used for this assessment was based on that described by IAQM (2014), with the aim to identify risks and recommend appropriate mitigation measures.

All six of the nearest sensitive receivers (human receptors) are located at least 350 metres away from the boundary of the WBTP. While the listed Brigalow Woodland community in the north of the Leewood property is located adjacent to the proposed irrigation area, it is over 50 metres from the WBTP and associated infrastructure areas, as well as irrigation infrastructure, where most of the construction activities will occur.

In view of the outcomes of the construction screening analysis potential construction impacts are considered to be minimal.

Operational air quality impacts

During operation of the WBTP, air emissions will directly relate to the onsite generators. Smaller volume fugitive emissions will be associated with vehicles and process operations within the plant.

In-stack concentrations have been calculated based on the provided exhaust flow and emission rate information and worse case pollution mass rates, and are provided in Appendix 10.

All in-stack concentrations comply with the *Protection of the Environment Operations (Clean Air) Regulation 2010* limits. The supplier of the gas and diesel engines has provided a performance guarantee (Appendix A of the Air Quality and Odour Assessment, provided in Appendix 10) that both engines will comply with the in-stack concentration limits.

The operational air quality assessment on sensitive receivers is based on the use of the computer-based dispersion model, AERMOD, to predict offsite air quality and odour levels. The assessment is based on a conventional approach following the procedures outlined in DEC (2005).

To assess the effect that potential emissions could have on existing air quality, the dispersion model predictions for the two scenarios (diesel generator and gas generator) have been compared to relevant regulatory air quality criteria. Tables 6-7 to 6-9 present the predicted incremental air quality impacts at the six nearest sensitive receivers due to the operation of the proposed activity. At all sensitive receptors these are well below the criteria.

Table 6-7 Predicted incremental operational air quality (Scenario 1 – gas generator)

Pollutant	Avg. period	Units	EPA Criteria	Residence					
				1	2	3	4	5	6
PM_{10}	Annual	$\mu g/m^3$	30	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	24 hr	$\mu g/m^3$	50	0.01	0.01	0.01	0.01	0.02	0.01
$PM_{2.5}$	Annual	$\mu g/m^3$	8	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	24 hr	$\mu g/m^3$	25	0.01	0.01	0.01	0.01	0.02	0.01
NO_2	Annual	$\mu g/m^3$	62	<0.1	0.1	<0.1	0.1	0.2	<0.1
	1 hr	$\mu g/m^3$	246	4.2	4.3	4.4	6.5	5.1	4.7
SO_2[1]	Annual	$\mu g/m^3$	60	N/A	N/A	N/A	N/A	N/A	N/A
	24 hr	$\mu g/m^3$	228	N/A	N/A	N/A	N/A	N/A	N/A
	1 hr	$\mu g/m^3$	570	N/A	N/A	N/A	N/A	N/A	N/A
	10 min	$\mu g/m^3$	712	N/A	N/A	N/A	N/A	N/A	N/A
CO	8 hr	mg/m^3	10	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	1 hr	mg/m^3	30	0.0002	0.0003	0.0003	0.0004	0.0003	0.0003
	15 min	mg/m^3	100	0.0003	0.0003	0.0004	0.0005	0.0004	0.0004
VOC (as Benzene)	1 hr	$\mu g/m^3$	29	0.3	0.3	0.3	0.5	0.4	0.4

Note:
1. Given the fuel source, there is not anticipated to be any SO_2 emissions associated with the combustion emissions from the gas generator and therefore this parameter has not been assessed within Scenario 1.

Table 6-8 Predicted incremental operational air quality (Scenario 2 – diesel generator)

Pollutant	Avg. period	Units	EPA Criteria	Residence					
				1	2	3	4	5	6
PM_{10}	Annual	$\mu g/m^3$	30	<0.01	0.01	<0.01	<0.01	0.01	<0.01
	24 hr	$\mu g/m^3$	50	0.06	0.08	0.05	0.10	0.15	0.09
$PM_{2.5}$	Annual	$\mu g/m^3$	8	<0.01	0.01	<0.01	<0.01	0.01	<0.01
	24 hr	$\mu g/m^3$	25	0.06	0.08	0.05	0.10	0.15	0.09
NO_2	Annual	$\mu g/m^3$	62	0.2	0.5	0.1	0.3	0.8	0.1
	1 hr	$\mu g/m^3$	246	51.8	59.0	33.8	48.4	58.9	49.8
SO_2	Annual	$\mu g/m^3$	60	<0.01	0.01	<0.01	<0.01	0.01	<0.01
	24 hr	$\mu g/m^3$	228	0.06	0.08	0.05	0.10	0.15	0.09
	1 hr	$\mu g/m^3$	570	0.86	0.98	0.56	0.80	0.97	0.82
	10 min	$\mu g/m^3$	712	1.25	1.42	0.82	1.17	1.42	1.20
CO	8 hr	mg/m^3	10	0.002	0.003	0.001	0.003	0.005	0.003
	1 hr	mg/m^3	30	0.012	0.013	0.008	0.011	0.013	0.011
	15 min	mg/m^3	100	0.015	0.018	0.010	0.014	0.018	0.015
VOC (as benzene)	1 hr	µg/m3	29	1.1	1.2	0.7	1.0	1.2	1.0

Table 6-9 Predicted 99th percentile odour concentrations at sensitive receivers

Pollutant	Units	Odour 99th percentile	Residence					
			1	2	3	4	5	6
Odour	OU	6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

With the addition of the measured and calculated ambient air quality estimates provided in Table 6-4, the total predicted impacts still do not exceed the EPA criteria, even at the nearest sensitive receiver (R3), located within one kilometre of the proposed activity. Therefore impacts are expected to be negligible.

6.1.4.4 Mitigation measures

Relevant mitigation measures to control dust are provided in Section 6.1.1.2. Additional mitigation measures that will be implemented to minimise impacts on air quality include:

- Air emissions from construction-related activities will not exceed the air quality criteria at any occupied residence on privately owned land, as set out in the table below (referenced from the Development Consent for the Bibblewindi Gas Exploration Pilot Expansion, dated July 2014).

Pollutant	Averaging period	Criterion[1]
TSP matter (long term criteria)	Annual	90 µg/m^3[2]
PM_{10} (long term criteria)	Annual	30 µg/m^3[2]
PM_{10} (short term criteria)	24 hour	50 µg/m^3[2]
Deposited dust PM_{10} (long term criteria)[3]	Annual	2 g/m^2/month (maximum increase)[4]
		4 g/m^2/month (maximum total)[2]

Note:
1. Excludes extraordinary events such as bushfires, prescribed burning, dust storms, sea fog, fire incidents, illegal activities or any other activity agreed to by the Secretary in consultation with EPA.
2. Total impact (i.e. incremental increase in concentrations due to the development plus background concentrations due to other sources).
3. Deposited dust is to be assessed as insoluble solids as defined by Standards Australia, AS/NZS 3580.10.1:2003: Methods for Sampling and Analysis of Ambient Air – Determination of Particulate Matter – Deposited Matter – Gravimetric Method.
4. Incremental impact (i.e. incremental increase in concentrations due to the development on its own).

- air emissions from operations-related activities will not exceed the air quality criteria at any occupied residence on privately owned land, as outlined in Table 6-4 (referenced from the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005))
- the proposed activity will be carried out by such practicable means as to prevent or minimize the emission of dust
- plant and equipment will be operated and maintained in a proper and efficient condition
- generator selection and exhaust configuration will be designed to ensure emission rates comply with the *Protection of the Environment Operations (Clean Air) Regulation 2010* in-stack concentration limits
- no offensive odours will be emitted from the proposed activity.

6.1.4.5 Potential impact category

The proposed activity will result in a negligible to low adverse impact on air quality. Particulate emissions are greatest during construction of the proposed activity; however the effects on airborne particle concentrations during this phase are generally temporary and relatively short-lived. Air emissions from generators during operation would have negligible impacts on sensitive receivers. The proposed mitigation measures would be effective in maintaining the existing amenity of nearby receivers during both construction and operation.

6.1.5 Greenhouse gases

6.1.5.1 Impacts

Direct GHG emissions (Scope 1 emissions) from the proposed activity include:

- removal of vegetation sinks for site preparation
- fuel use (diesel and gas) for site-based electricity generation
- fuel use on site for plant and equipment (including civil works)
- fuel use for transport of personnel and materials where this transport is under Santos operational control.

For this REF it has been assumed all delivery details provided by Santos fall within their operational control. In practice a portion of these emissions may more appropriately assigned to other organisations.

Scope 2 emissions cover those resulting from the purchase of energy (electricity or steam) originating from outside the project boundary. No Scope 2 emissions are relevant to the proposed activity as no electricity from the grid will be purchased.

Scope 3 emissions (indirect emissions) have not been considered in this assessment as they form Scope 1 emissions for other organisations and need to be considered separately to avoid 'double counting' of the emissions profile. This is consistent with Australia's National Greenhouse and Energy Reporting Scheme (NGERS) where only Scope 1 and 2 emissions are included in the mandatory reporting.

Table 6-10 provides a summary of the estimated GHG emissions for the construction and operation of the proposed activity.

Table 6-10 Scope 1 GHG emissions profile

Project element	Site establishment and construction (T CO_2^e)	Operation phase (T CO_2^e /year)	Decommissioning (T CO_2^e /year)
On-site power generation	2,100	4,385	315
Light vehicles (staff movements)	20	60	10
Heavy vehicles/deliveries	485	10	15
Construction equipment	215	2	185
Vegetation clearing	515	None	None
Estimated total	**3,335**	**4,457**	**525**
Estimated total 5 year program	**–**	**22,285**	**–**

Emissions will be monitored and reported in accordance with legislative requirements.

The primary risk associated with GHG emissions are their potential contribution to NSW and Australian GHG profiles. Australia's GHG Inventory for 2012 (the most current data available at the time of writing) is provided in Table 6-11. The potential GHG contribution of the proposed activity to Australia's existing GHG profile is extremely minor, being in the region of 0.0008 per cent and 0.0029 per cent of the national and State emissions profiles respectively.

Table 6-11 Australian and NSW GHG emissions profile

	Annual GHG emissions (T CO_2^e)
Australian emissions	554,568,840
NSW emissions	154,721,100
Average annual estimated project emissions (operations phase)	**4,457**

6.1.5.2 Mitigation measures

Relevant mitigation measures to minimise impacts on air quality, including emissions, are provided in Sections 2.7.5 and 6.1.4.4. Additional mitigation measures that will be implemented to minimise impacts on GHG emissions include:

- legislative reporting requirements for GHG emissions (such as to inform NGERS calculations) will be undertaken during both construction and operation
- natural gas fuel will be used in preference to diesel where practicable during operation
- plant and equipment will be operated and maintained in a proper and efficient condition.

6.1.5.3 Potential impact category

The proposed activity will result in a negligible to low adverse impact on GHG emissions. The contribution of the proposed activity to Australia's existing GHG profile is extremely minor. The proposed mitigation measures would be effective in minimising risk of impact from generation of GHG emissions. Ongoing monitoring in accordance with the *National Greenhouse and Energy Reporting Act 2007* will be undertaken to ensure that any issues are identified and mitigated.

6.1.6 Noise and vibration

An assessment of the potential noise and vibration impacts was prepared to consider the construction and operational noise associated with the proposed activity. This section provides a summary of the Noise and Vibration Assessment, provided in Appendix 11.

6.1.6.1 Assessment criteria

Construction noise criteria

The *Interim Construction Noise Guideline* (ICNG) (DECC, 2009) is considered to be appropriate for consideration of noise impacts. The noise management level for works during the recommended standard hours is the RBL plus 10 dB(A) and for works outside of recommended standard hours is background plus 5 dB(A). Above this noise level the proponent needs to implement all feasible and reasonable work practices, as defined in the ICNG, to minimise noise impacts.

Operation noise criteria

In accordance with EPA requirements, the proposed activity has been assessed with consideration to the INP. The INP requires the comparison of the derived intrusive and amenity criteria, and the most stringent criteria are selected to be assessed against. Table 6-12 shows that for the proposed activity, the intrusive criteria represent the project specific operational noise criteria for residential receivers.

Table 6-12 Operational Noise Criteria dB(A)

Receiver	Period[1]	Amenity			Intrusive		Project Specific Criteria
		ANL[2]	Existing Industrial Noise[3] $L_{eq,Industrial}$	Adjusted ANL $L_{eq,period}$	RBL	Intrusiveness Criteria RBL +5 $L_{Aeq15min}$	
R1-R6	Day	50	–	50	30	35	35
	Evening	45	–	45	30	35	35
	Night	40	–	40	30	35	35

Note:
1. Day (7.00am-6.00pm Monday to Saturday and 8.00am-6.00pm Sundays and Public Holidays), Evening (6.00pm-10.00pm), Night (10.00pm-7.00am, unless preceding a Sunday or Public Holiday).
2. ANL – 'acceptable noise levels' published in the INP.
3. No existing industrial noise was observed in the area.

The project specific operational noise criteria is set at 35 dB(A) for activities undertaken throughout the day, evening or night. It is consistent with Condition L3.1 of EPL 20350.

Sleep disturbance criteria

The EPA does not currently have an explicit policy regarding sleep disturbance caused by noise from construction or industrial operation activities. However there is some guidance mentioned in the INP application notes, which states *"The potential for high noise level events at night and effects on sleep should be addressed in noise assessments for both the construction and operational phases of a development."*

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.

Road traffic criteria

The *NSW Road Noise Policy* (RNP) (DECCW, 2011) provides guidance, criteria and procedures for assessing noise impacts from existing, new and redeveloped roads and traffic generating developments. Additional specific relative increase criteria apply to traffic generating developments. The Road Noise Policy Application Notes (EPA, 2013) states the following:

"any increase in the total traffic noise level as a result of the development should be limited to 2 dB above that of the noise level without the development. This limit applies wherever the noise level without the development is within 2 dB of, or exceeds the relevant day or night noise assessment criterion."

Vibration criteria

Impacts from vibration can be considered both in terms of effects on building occupants (human comfort) and the effects on the building structure (building damage). Of these considerations, the human comfort limits are the most stringent and the peak particle velocity (PPV) is set at 0.14 mm/s.

For unoccupied building structures, the British Standard (BS 7385) sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings is set at 15 mm/s at 4 hertz increasing to 20 mm/s at 15 hertz.

6.1.6.2 Impacts

Construction noise impacts

The greatest potential for construction noise generation will occur during construction of the WBTP and its associated infrastructure. It is noted however that there were no noise complaints received by Santos in relation to the construction of the ponds at Leewood, which was undertaken over about 15 months.

Construction scenarios and their associated significant items of equipment are summarised in Appendix 11. Predicted noise levels for the various construction scenarios are presented in Table 6-13 at the six identified sensitive receivers located within two kilometres of Leewood.

Table 6-13 Predicted construction noise levels

Construction scenario	Noise management level $L_{eq,15\ min}$ dB(A)		Predicted noise level $L_{eq,\ 15\ min}$ dB(A)					
	Standard hours[1]	Outside of standard hours[2]	Residence					
			1	2	3	4	5	6
1 – service location	40	35	21-22	<20-21	20-23	27-32	29-34	21-25
2 – clearing/stripping	40	35	28-30	26-29	28-31	35-40	37-42	28-32
3 – amenities	40	35	21-22	<20-20	<20-22	26-31	28-33	20-24
4 – earthworks	40	35	28-30	27-29	26-30	33-38	36-41	27-31
5 – structures	40	35	25-27	21-25	22-27	30-35	32-37	23-29
6 – mechanical	40	35	25-27	21-25	22-27	30-35	32-36	23-29
7 – electrical	40	35	24-26	20-24	21-27	29-34	31-36	22-28
8 – landscaping	40	35	22-24	20-22	21-24	29-33	31-36	22-26
9 – irrigation area land preparation	40	35	23-30	20-27	26-30	32-44	26-31	25-31
10 – centre pivot installation	40	35	20-26	<20-22	20-25	28-38	<20-25	20-25
11 – subsurface drip installation	40	35	<20-39	<20-34	<20-37	24-47	21-36	<20-35
12 – pump station	40	35	<20-21	<20	<20-22	25-30	23-27	<20-23

Note:
1. Standard hours are defined as Monday to Friday 7.00am to 6.00pm and Saturdays 8.00am to 1.00pm
2. Outside of standard hours are all times not included in Standard Hours.

A summary of the predicted noise impacts for the individual construction scenarios in Table 6-13 indicate that:

- during standard construction hours, an exceedance of the criteria is predicted at R4 for scenarios 9 and 11 and R5 for scenarios 2 and 4
- outside of standard construction hours, exceedance of the criteria is predicted at:
  - R1, R3, R4 and R5 for scenario 11
  - R4 and R5 for scenarios 2 and 4
  - R4 for scenarios 9 and 10
  - R5 for scenarios 5, 6, 7 and 8.

No receivers are expected to be highly noise affected (noise levels above 75dB(A)) at any time during the construction works.

In addition to the above construction scenarios, works may be carried out simultaneously at the WBTP (scenarios 1 – 8) and the irrigation area (scenarios 9 – 12). Construction noise levels for these scenarios were predicted and are presented in full in the Noise and Vibration Assessment (Appendix 11). No receivers are expected to be highly noise affected at any time during the construction works.

During standard construction hours, the noise predictions indicate that:

- works carried out simultaneously for scenario 9 (irrigation area land preparation) and construction of the WBTP may exceed criteria at R4 by up to five dB(A) for scenarios 1-8 and at R5 by up to two dB(A) for scenarios 2 and 4
- works carried out simultaneously for scenario 10 (centre pivot installation) and construction of the WBTP may exceed criteria at R4 and R5 by up to two dB(A) for scenarios 2 and 4
- works carried out simultaneously for scenario 11 (sub-surface drip installation) and construction of the WBTP may exceed criteria at R4 by up to eight dB(A) for scenarios 1-8 and at R5 by up to three dB(A) for scenarios 2 and 4
- works carried out simultaneously for scenario 12 (pump station installation) and construction of the WBTP may exceed the criteria at R5 by up to two dB(A) for scenarios 2 and 4.

Works will be undertaken seven days per week, (i.e. not standard construction hours), however the construction noise management levels at an occupied sensitive receiver are to be met unless there is an agreement in place with the landholder. This applies for both standard construction hours and outside of standard construction hours.

As exceedances of the noise management levels are predicted, noise mitigation measures will be implemented during construction, as outlined in Section 6.1.6.3.

Operational noise impacts

During operation, noise generation will be minor and occur during operation of generators, pumps and other minor infrastructure, as well as harvesting of the irrigation area. Table 6-14 shows that the predicted operational noise levels from the WBTP and harvesting of the irrigation area are generally expected to comply with the project specific criteria.

A marginal one dB(A) exceedance at R4 was identified during harvesting operations. This will only occur when the tractor is at the eastern extent of the irrigation area, closest to R4. This exceedance is not considered significant as a difference in noise level of two dB(A) or less is generally not perceptible. The harvesting operations occur five times a year for a short period, limiting the likelihood of an exceedance. Compliance is predicted at all other receivers during harvesting.

Table 6-14 Predicted operation noise levels from the WBTP and harvesting of the irrigation area

Receiver	Project specific criteria (dB(A))	Predicted noise level $L_{Aeq,\ 15\ min}$ dB(A) during neutral weather	Comply
R1	35	<20	Yes
R2	35	<20	Yes
R3	35	<20-21	Yes
R4	35	27-36	Marginal exceedance
R5	35	28-29	Yes
R6	35	<20-22	Yes

Sleep disturbance impacts

It is expected that the major sources of maximum noise level events would be a compressor release/pressure relief, the use of light vehicles door slamming or engines starting and the processing equipment occasionally starting or stopping.

The noisiest source is likely to be a compressor release and the maximum noise level assumed was L_{Amax} 120 dB(A).

The noise level at the closest sensitive receiver was calculated using the noise model to be L_{Amax} 44 dB(A). This level is one dB(A) below the sleep disturbance screening criteria and as such no sleep disturbance impacts are expected.

Traffic noise impacts

The project is expected to generate road traffic during both the construction and operation phase. The predicted noise levels were predicted for distances from 10 to 600 metres from the road. The maximum predicted increase in road traffic noise is presented in Table 6-155 for receivers within 600 metres of the subject road.

Predicted increases in total traffic noise levels as a result of project generated traffic for the worst-case construction and operation scenarios are expected to comply with the RNP criteria.

Table 6-15 Predicted maximum increase in traffic noise levels

Road	Condition	RNP Criteria $L_{Aeq,\ 15\ min}$ noise levels (dB)	Predicted increase in total traffic $L_{Aeq,\ 15\ min}$ noise levels (dB)	
			Construction	Operations
Newell highway	Peak	2.0	0.4	0.1
	Low	2.0	0.4	0.1

Construction vibration impacts

Table 6-166 provides indicative vibration levels for different construction activities. The criteria presented for comparison represent the most stringent criteria applicable to the sensitive land use. For residential receivers, the human comfort criteria are the most stringent and for the SUGAR pits, the cosmetic damage criteria are the most stringent.

The predicted PPV indicates that vibration levels from construction will be well below the most stringent criteria applicable to the sensitive receivers R4 and R5 and at the SUGAR pits. Therefore impacts are expected to be negligible.

Table 6-16 Predicted construction vibration levels

Receiver	Approximate distance to works (m)	Criteria PPV (mm/s)	Predicted PPV (mm/s)		
			Dozer	Roller	Whacker
R4	360	0.14	0.02	0.04	0.03
R5	742	0.14	0.01	0.01	0.01
SUGAR pits	50	15	0.4	0.7	0.6

Operational vibration impacts

No significant operational vibration sources were identified and subsequently the impacts are considered to be negligible.

6.1.6.3 Mitigation measures

Noise from the activity will meet the noise levels in the table below at occupied residences unless a written agreement is in place with the landholder.

Time period		Construction noise (where written agreement is not in place)	Operational noise (where written agreement is not in place)
Day	7am to 6pm Monday to Friday and 8am to 1pm Saturday	See Note 1	35 dB(A) $L_{Aeq(15min)}$
	7am to 8am and 1pm to 6pm Saturday; 8am to 6pm Sunday and public holidays	35 dB(A) $L_{Aeq(15min)}$	35 dB(A) $L_{Aeq(15min)}$
Evening	6pm to 10pm	35 dB(A) $L_{Aeq(15min)}$	35 dB(A) $L_{Aeq(15min)}$
Night	10pm to 7am Monday to Saturday; 10pm to 8am Sunday and public holidays	35 dB(A) $L_{Aeq(15min)}$ 45 dB(A) L_{Amax}	35 dB(A) $L_{Aeq(15min)}$ 45 dB(A) L_{Amax}

Note:
1. For construction between the hours of 7 a.m. and 6 p.m. Monday to Friday and 8 am to 1 pm Saturday, 40 dB(A) (or background plus 10 dB(A)) is the noise management level where feasible and reasonable work practices would be implemented.

The following measures will be implemented to minimise noise impacts of the proposed activity:

- community notification will be undertaken prior to commencement of construction
- potentially impacted occupied residences will be informed of the nature of the works, duration of works and a method of contact to raise any complaints
- in the event of a noise complaint, the effectiveness of noise mitigation measures will be assessed and additional feasible and reasonable measures implemented, where necessary. This may include noise monitoring.

6.1.6.4 Potential impact category

The proposed activity will result in a low adverse impact on noise and vibration. Noise generated during operation will generally be within acceptable guideline limits (35 dB(A)). During some stages of construction, the nearest sensitive receivers could experience noise levels in excess of 40 dBA during standard construction hours. Appropriate construction noise management techniques will be implemented accordingly. Ongoing consultation with affected landowners prior to and during construction will ensure impacts are being managed appropriately.

6.1.7 Waste

6.1.7.1 Impacts

Waste generating activities, waste streams and estimated volumes during both construction and operation are identified in Section 2.7.3.

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

- leaching of chemicals and other pollutants into soils or surface water
- pollution or contamination of land or water due to 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
- use of landfill capacity due to waste storage.

6.1.7.2 Mitigation measures

The following measures will be carried out to minimise waste and potential impacts associated with waste generation and disposal:

- mitigation measures provided in the waste management strategy will be implemented, as outlined in Section 2.7.3
- management of waste, including its transport, will comply with the POEO Act and *Protection of the Environment Operations (Waste) Regulation 2005* (POEO (Waste) Regulation)
- waste identified for recycling will be stored separately from other waste
- waste will be assessed and classified in accordance with the DECC Waste Classification Guidelines
- all site personnel will be made aware of waste management procedures during the site induction and through toolbox talks.

6.1.7.3 Potential impact category

The proposed activity will result in a low adverse impact due to the generation or disposal of gaseous, liquid or solid wastes. A number of waste streams will be generated during construction and operation of the proposed activity. In line with relevant regulations, the low levels of waste will be sorted on site and transported to the appropriate facilities for treatment and disposal. Treated water will be separated and beneficially reused on site. Brine will be stored onsite in ponds and in the longer term, the remaining contents will be sent to the relevant licensed waste facility.

6.1.8 Chemicals and hazardous substances management

6.1.8.1 Impact

Potentially hazardous industry

Chemicals or hazardous substances to be used within the proposed activity include hydrochloric acid and diesel fuel. A full list of chemicals or hazardous substances is listed in the *State Environmental Planning (SEPP) No. 33 – Hazardous and Offensive Development Application Guidelines (*SEPP 33) assessment (Sherpa, 2014) in Appendix 5 and summarised in Section 2.6.3.6.

The proposed activity will require the use of chemicals, fuels and oils, during both construction and operational activities, for uses such as vehicles, plant and machinery, and treatment of produced water and brine at the WBTP, as described in Appendix 5.

The SEPP 33 screening assessment of the proposed activity determined that the proposed activity is not considered to be potentially hazardous, as defined under SEPP 33, and a Preliminary Hazard Analysis or route evaluation study is not required. This is based on the estimated volumes of chemical and hazardous substances to be transported, stored and used on site in comparison to screening thresholds defined in SEPP 33.

While substances are not considered to be potentially 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 as a spill or leak. Such impacts could include outbreak of fire, or pollution of land, water or air. These impacts have been discussed further in Sections 6.1.1, 6.1.2 and 6.1.3.

Potentially offensive industry

The SEPP 33 Guidelines state that if a proposed activity requires a licence under any pollution control legislation the proposed activity should be considered to be potentially offensive. As discussed at Section 5.2.3, the proposed activity will be required to be included on the EPL for the petroleum activities under the POEO Act. The key consideration in the assessment of a potentially offensive industry is that the EPA is satisfied that there are adequate safeguards to ensure emissions can be controlled to a level at which they are not significant. If the EPA is not satisfied, the proposed activity may be an offensive industry. The minimum test for such development is meeting the requirements for licensing by the EPA.

If the proposed activity is approved, Santos will apply to have EPL 20350 modified to include the proposed activity. The proposed activity will then operate in accordance with the requirements of EPL 20350. As such the proposed activity will not constitute an offensive industry and no further consideration of potentially offensive industry under SEPP 33 is required.

6.1.8.2 Mitigation measures

The measures identified in Section 6.1.1.2 will minimise potential impacts and risks associated with the use of hazardous substances and chemicals. In addition, the following mitigation measures will be implemented:

- all above ground tanks containing material that is likely to cause environmental harm must be bunded or have an alternative spill containment system in place
- a spill kit will be available within the site during construction and personnel will be trained in its use
- chemicals and potentially hazardous substances will be used and stored according to regulatory requirements including the *Work Health and Safety Act 2011* and *Australian Standard 1940–2004; The Storage and Handling of Flammable and Combustible Liquids* or other relevant guidelines
- any dangerous goods will be transported according to regulatory requirements under the *Dangerous Goods (Road and Rail Transport) Act 2008.*

6.1.8.3 Potential impact category

The proposed activity will result in a negligible to low adverse impact due to the use of hazardous substances and chemicals. A small number of chemicals and hazardous substances will be stored onsite during both construction and operation activities. Chemicals will be stored to ensure appropriate separation of chemical classes within storage areas designed in accordance with the relevant regulatory requirements. With the implementation of the proposed mitigation measures, potential impacts would be low.

6.2 Biological impacts

6.2.1 Impacts

An ecological assessment was undertaken for the proposed activity by Eco Logical Australia (refer Appendix 8).

The proposed activity will be likely to result in the removal of 99.6 hectares of the Derived Grassland vegetation community. The largest source of impact will result from the irrigation area for the treated water, with approximately 97.8 hectares proposed to be disturbed. The proposed WBTP, treated water storage area and associated infrastructure will impact on approximately 1.8 hectares.

One EEC, the '*Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions*' (EPBC Act) commensurate with 'Brigalow (*Acacia harpophylla* dominant and co-dominant)' (TSC Act), was recorded on Leewood. This area will be retained and protected as part of the proposed activity. The treated water pipeline that will extent to the property boundary will be located as to avoid this listed ecological community.

No impacts to threatened flora are expected from the proposed activity.

Twenty-one threatened fauna species were identified as having potential or are known to occur on the site and have potential to be impacted by the proposed activity. Only one threatened species, the Grey-crowned Babbler, was identified on site during the field surveys. Application of the seven part test found that the proposed activity is unlikely to significantly impact any potentially occurring species listed under the TSC Act, including the Grey-crowned Babbler. Due to the lack of structural diversity in the understorey and ground cover and lack of habitat features such as fallen logs within the area to be disturbed by the proposed activity, the area would primarily be used as foraging habitat for this species. The Grey-crowned Babbler is a mobile species, and the resources within the site are present throughout the immediate and wider area.

Based on the Significant Impact Guidelines (DoE, 2013), assessment under the EPBC Act found that the proposed activity is unlikely to significantly impact on any potentially occurring species listed under the EPBC Act.

There would be a direct loss of approximately 99.6 hectares of potential foraging habitat for fauna as a result of the proposed activity. However, there is no breeding or roosting habitat on the site for any of the potential threatened fauna species.

The increase in soil moisture as a result of the irrigation has the potential to impact on the flora and fauna habitats within the site. The increase in moisture content may benefit some local weed and pasture species and further increase their presence within native vegetation communities.

Habitat fragmentation is considered to be minimal and connectivity will not be impacted. The site is currently largely cleared and disturbed, with only marginal habitat contained within the site boundary. The areas of habitat in the central portion of the site that will not be impacted by the proposed activity will still be connected to habitat to the south of the site. The proposed activity will not increase fragmentation with the surrounding vegetation being highly connected. No patches of habitat would be isolated as a result of the proposed activity.

Potential indirect impacts to neighbouring native vegetation may arise from spray drift of the treated permeate water during irrigation. To limit the impact of spray drift into the adjoining vegetation, engineering and management solutions will be used. These may include:

- use of low pressure drop nozzles operating at approximately 100 cm above the ground
- variable rate irrigation systems allowing for the shutdown of various spans or individual nozzles in susceptible areas
- regular visual inspections along the boundary of the sprinkler system
- an automated control system linked to an anemometer to shut down the system in unfavourable wind speeds and directions.

The ecological assessment concluded that the proposed activity will be unlikely to have a significant impact on threatened species, populations or ecological communities in the locality providing that the recommended mitigation measures are adopted. The proposed activity does not constitute, and is not part of, a key threatening process under the TSC Act.

6.2.2 Mitigation measures

The site will be rehabilitated in accordance with Section 2.6.4 of the REF. In addition, the following measures will be implemented to further minimise impacts on flora and fauna:

- the site boundary will be clearly marked in the field to ensure all clearing and construction activities occur within the approved footprint
- management measures will be implemented to minimise the potential for spray drift from the irrigation system to impact the stand of Brigalow on the northern boundary of the site will be minimised
- prior to earthworks, weeds listed as Noxious under the NSW *Noxious Weeds Act 1993* that are present on the site would be removed or treated with herbicide to prevent or reduce their spread
- if any hollow-bearing trees are detected on-site and require removal, this will be undertaken with the supervision of an ecologist.

6.2.3 Potential impact category

The proposed activity will result in low adverse biological impacts. Up to approximately 99.6 hectares of land that has been mostly previously cleared for agricultural purposes will be disturbed. The ecological assessment for the proposed activity determined that it is unlikely to have a significant impact on threatened species, populations or ecological communities in the locality.

6.3 Community impacts

6.3.1 Public Safety

6.3.1.1 Impacts

Safety implications of the proposed activity include hazards associated with moving vehicles and machinery; construction and operation of infrastructure and plant; use of chemicals, fuels and oils; and bushfire.

The hazards associated with the storage and use of chemicals and hazardous substances on-site are detailed in Section 6.1.8.

The site is adjacent to the Pilliga East State Forest and contains other areas of reasonably dense vegetation. Parts of the site will be expected to exhibit moderate to high bushfire hazard mainly due to the extent of vegetation cover.

The potential for a 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 due to the presence of flammable substances and potential for accidental ignition by vehicles or machinery.

Santos has developed a Bushfire Management Plan in consultation with relevant agencies and an emergency response plan that details the broad responsibilities and duties of personnel during an emergency event such as a bushfire.

The bushfire management plan provides guidance for onsite 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 is relevant to both private land and State forest.

6.3.1.2 Mitigation measures

Implementation of the mitigation measures identified in Section 6.1.8.2 will ensure impacts in relation to the hazards associated with the storage and use of chemicals and hazardous substances are minimised. Additional mitigation measures to ensure public safety is maintained include the following.

- general site safety protocols, incident management and emergency procedures (including bushfire risk) will be implemented during the construction and operation works
- construction and operational sites will be fenced and locked after construction hours
- the Bushfire Management Plan will be reviewed and updated as required to address the proposed activity
- an induction for staff and contractors regarding the hazards and risks will be implemented.

6.3.1.3 Potential impact category

The proposed activity will result in a low adverse impact on public safety. Risks to public safety during both construction and operation, including bushfire, will be minimised through design and implementation of general site safety protocols, incident management and emergency procedures. This would enable any potential impacts that result to be small and short term.

6.3.2 Traffic

An assessment of the potential traffic impacts during construction and operation of the proposed activity was prepared. This section provides a summary of the Traffic Impact Assessment, provided in Appendix 4.

6.3.2.1 Impacts

All construction vehicles and worker vehicles will access Leewood via the Newell Highway and Old Mill Road. The majority of truck arrivals and departures will be via the north, to/ from Narrabri, with minor interstate deliveries expected to also approach/ depart via the south. All trucks would be accommodated within the site for deliveries throughout the construction period.

The proposed activity will generate up to approximately 88 trips on a peak day with 20-25 trips generated during a site activity peak hour throughout all construction work stages, including all worker vehicles, shuttle buses and trucks. Table 6-177 details peak construction vehicle trips during the construction works.

Table 6-17 Peak construction vehicle trips

Period of activity	Number of trips			Total
	Trucks	Shuttle buses	Worker vehicles	
Daily	50	20	18	88
Hourly	5-10	10	5	20-25

The traffic volumes detailed above equates to 60 per cent of the projected peak daily traffic generation associated with the previous construction works at Leewood. Given that the extent of traffic-related impacts would be less than that already experienced during the construction of the ponds at the Leewood site, the intersection upgrade made at the intersection of Old Mill Road and the Newell Highway will adequately service the construction vehicle movements for the proposed activity. Despite this, the intersection arrangements were assessed for completeness as part of the Traffic Impact Assessment. The results of this assessment are detailed in Appendix 4.

It is anticipated that the Newell Highway will experience an increase in total traffic volumes of five to six per cent, with an increase in truck volumes of six to seven per cent. The Newell Highway will continue to operate at existing Level of Service B. Impacts to emergency and heavy vehicle movements along the Newell Highway are considered unlikely.

A small on-site staff presence will be associated with the day to day operation of the proposed activity. The worker traffic associated with the Leewood site would be minor, with less than 10 vehicle trips during each of the weekday AM and PM peak hours. In addition, up to 10 trucks per day associated with irrigation, harvesting and crop management would be generated during operation, while deliveries and visitors would be minor and total less than five vehicles per week. As such, the operational traffic impacts associated with the proposed activity will present a negligible impact to the operation of the Newell Highway at Old Mill Road.

Construction and personnel vehicles exiting the site may track sediments and other pollutants onto the Newell Highway.

6.3.2.2 Mitigation measures

The following measures will be carried out to minimise potential impacts associated with traffic generated during construction and operation and potential impacts to the road network:

- access to and from adjacent properties will be maintained for the duration of construction
- parking for staff during construction and operation will be accommodated within the site
- construction traffic will not be permitted to queue or park on Old Mill Road, other State forest roads or the Newell Highway
- all truck movements would be restricted to the direct route via the Newell Highway. Truck drivers will be advised of the designated truck routes to/ from the site
- oversized vehicles required for transporting earthmoving equipment will be undertaken in accordance with the relevant requirements of Roads and Maritime Services
- the site access plan outlined in the transport assessment (Appendix 4) will be implemented during construction and traffic managed accordingly
- construction and operational traffic will only access Leewood via Old Mill Road.

6.3.2.3 Potential impact category

The proposed activity will result in a low adverse impact on traffic. Traffic volumes will be greatest during construction activities, which will be short term. No road/intersection upgrades are required as a result of the proposed activity, and the mitigation measures identified would be effective in minimising risk of potential impact to the community.

6.3.3 Amenity

6.3.3.1 Impacts

Amenity impacts associated with the proposed activity will include visual, dust, noise, and traffic impacts.

Visual impacts associated with the proposed activity will mainly be in relation to the WBTP and associated infrastructure, as during operation the cropping activities within the irrigation area are consistent with surrounding land uses.

Plant and equipment at the WBTP and associated infrastructure may be visible during construction and operation, but given its distance from the Newell Highway and neighbouring residences, will have a negligible impact on scenic amenity. In addition, the topography of the surrounding area is relatively flat which will reduce the visibility of the WBTP from surrounding areas.

The proposed activity will result in minor increases in traffic along Newell Highway and Old Mill Road throughout construction. These impacts are addressed in Section 6.3.2.

The proposed activity may temporarily increase dust and noise levels within the vicinity of the site, though these will be controlled with the measures outlined in Sections 6.1.4 and 6.1.6 respectively.

6.3.3.2 Mitigation measures

Mitigation measures to control dust, noise and traffic impacts are addressed in Sections 6.1.4, 6.1.6 and 6.3.2, respectively. Additional measures to manage amenity impacts include:

- Where practicable, existing vegetation along the site boundary will be maintained to provide screening of the site.
- The site will be kept in a clean and tidy manner during site preparation, construction activities and operation.

6.3.3.3 Potential impact category

The proposed activity will result in a low adverse impact on public amenity. The proposed activity is located entirely within the Santos owned Leewood property. Visual amenity impacts are confined to the property and its immediate surrounds i.e. vehicles travelling along the Newell Highway and neighbouring residences. Any visual impacts would be minor in nature and not inconsistent with the surrounding landscape.

6.3.4 Community services, infrastructure and sites of importance

6.3.4.1 Impacts

The works are not likely to affect community services or infrastructure, or sites of importance to the local community. All works are located within the Santos owned Leewood property and are not accessible by the public.

There may be some impacts to accommodation availability within Narrabri during construction.

6.3.4.2 Mitigation measures

The consultation activities outlined in Section 2.3 will be implemented.

6.3.4.3 Potential impact category

The proposed activity will result in a low adverse impact on community services, infrastructure and sites of importance. Any impacts will be small and short term, as the temporary construction workforce is small and will be accommodated by existing social infrastructure. Any concerns of the community will be managed through implementation of the stakeholder engagement plan outlined in Section 2.3.1.

6.3.5 Economic impacts

6.3.5.1 Impacts

As the scale of the project is small, the proposed activity is not expected to significantly alter the economic base of the region. The proposed activity may provide minor economic benefits for Narrabri as well as the broader area through employment for construction activities and ongoing operations, as well as the purchase of materials, fuels and consumables.

Many of the site preparation, earthworks and field services employed during this project will be sourced from local suppliers, where practicable. This will have a positive impact on the local economy through direct and indirect means.

No existing jobs will be lost as a direct result of the proposed activity. This includes employment opportunities in the agricultural industry which has historically been one of the main economic drivers for Narrabri. The proposed irrigation area may provide minor agricultural employment and economic development due to the conversion of low productivity pasture land to productive agricultural activities.

6.3.5.2 Mitigation measures

The current procurement and logistics policy would apply to this project and gives preference to local businesses, suppliers and labour.

6.3.5.3 Potential impact category

The proposed activity is considered to have a minor positive impact on the economy due to the scale of the project.

6.4 Natural resource & land use impacts

6.4.1 Impacts

Leewood is a Santos owned property which is designated Zone RU Primary Production under the Narrabri LEP 2012.

Leewood is not currently used for agricultural purposes and is located on land with low potential for commercial agricultural use. An AIS has been prepared to evaluate the impact of the proposed activity on agricultural resources and production at Leewood and within the surrounding Narrabri LGA (Appendix 7).

Based on the Agricultural Impact Risk Rating System, the proposed activity has been classified as a low to medium risk activity due to the following:

- it is not located on or near BSAL or CIC under the SRLUP
- it is located on land with a current low value commercial agricultural land use
- the proposed irrigation regime will increase the net productivity of the area from the current low productivity pasture
- all surface disturbance areas will be fully rehabilitated to the pre-existing land condition, except across the irrigation area if to be retained, subject to requirements of future land use.
- there will be no permanent land capability reduction of agricultural resources
- there are potential impacts on groundwater or surface water resources, however these are the subject of appropriate mitigation measures as outlined in Sections 6.1.2.2 and 6.1.3.2 respectively.

The lucerne, or alternate crop, will be cut and bailed approximately five times per year. As the irrigation area is only 97.8 hectares and the irrigation scheme will run for up to approximately five years, the removal of agricultural support infrastructure and services from within the region is considered minimal.

Once gas from the existing WPPS pipeline is connected to the site, power will be supplied by a 1.4 megawatt gas-powered generator. The natural gas from this pipeline will be sourced from the CSG pilot wells within Santos' existing and proposed exploration and appraisal activities within PEL 238 and PAL 2. Approximately 63,000 gigajoules per year of natural gas will be used onsite during operation of the proposed activity.

6.4.2 Mitigation measures

Implementation of the mitigation measures identified in Section 6.1.1.2 will ensure impacts to soils (and future agricultural potential at Leewood) are minimised. In additional, works associated with the proposed activity will not impact on agricultural production at any adjacent properties.

6.4.3 Potential impact category

The proposed activity will result in a low adverse impact on natural resources and land use. While there are potential impacts on groundwater and surface water resources, as identified in Sections 6.1.2 and 6.1.3 respectively, the proposed irrigation regime will also improve the productivity of the site. There would be no ongoing impacts on natural resources or land use.

6.5 Aboriginal cultural heritage impacts

6.5.1 Impacts

Up to approximately 99.6 hectares of ground surface would be disturbed for construction of the proposed activity.

A due diligence Aboriginal cultural heritage investigation was carried out for Leewood and is provided as Appendix 9. No registered Aboriginal cultural heritage items occur within or near the site, nor do any features that conform to a highly sensitive landscape. As part of the investigation an archaeological field survey of the site was undertaken, and two scarred trees and two isolated quartz artefacts were identified.

The proposed activity, including construction of the treated water pipeline, would not have a direct impact on the identified objects as the Avoidance Principle will be applied, as follows:

- the two scarred trees would be avoided by their inclusion in the exclusion area designed to protect them

and other native vegetation at the northern end of the site (Brigalow Woodland community exclusion zone)

- the two isolated stone artefact (quartz) flakes would be avoided by fencing that has been installed around each location to ensure no disturbance of those areas was to occur during the proposed activity.

These sites will be managed in order to avoid any impact during the project and an Aboriginal Heritage Impact Permit (AHIP) under section 90 of the *National Parks and Wildlife Act 1974* will not be required.

Due to the presence of Aboriginal objects on-site, notably the isolated stone artefacts, the potential exists for previously unidentified Aboriginal objects/sites to be identified during the proposed activity.

6.5.2 Mitigation measures

The following measures will be implemented to reduce potential impacts on Aboriginal heritage:

- no works will be undertaken in the vegetated (Brigalow) area in the north-east corner of the site to avoid the scar trees (refer Figure 2-1)
- the isolated stone artefact (quartz) flakes will remain fenced off with a three metre buffer around each location
- project staff and contractors will be made aware of their statutory obligations for heritage under the NPW Act and the Heritage Act, as well as the location of the identified cultural objects through the site induction and toolbox talks
- monitoring will be undertaken immediately following earth-moving activities in the vicinity of the isolated quartz artefacts. This will consist of two persons jointly nominated by the Narrabri LALC and the Gomeroi native title claim group
- if any previously unidentified Aboriginal site/s are identified during works, then works 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 and managed
- in the event that skeletal remains are uncovered, work must cease immediately in that area and the proponent, Santos must contact the NSW Police Coroner to determine if the material is of Aboriginal origin. If determined to be Aboriginal, the OEH Enviroline 131 555 and relevant Aboriginal stakeholders must be contacted to determine an action plan for the management of the skeletal remains prior to works re-commencing.

6.5.3 Potential impact category

The proposed activity will result in a negligible to low adverse impact on Aboriginal cultural heritage. Four items of potential Aboriginal cultural heritage significance were identified within the site, however the proposed activity has been designed to avoid these items. The area of disturbance is relatively small (approximately 99.6 hectares) within a previously disturbed agricultural property. Implementation of the mitigation measures will minimise impacts on identified and unidentified potential Aboriginal cultural heritage material on-site.

6.6 European cultural heritage impacts

6.6.1 Impacts

No registered cultural heritage items occur within or near Leewood. The archaeological survey noted items of potential heritage significance within Leewood including the SUGAR stations and the TSR.

The proposed activity would not have a direct impact on the identified remains of the SUGAR array.

The TSR is located outside the proposed activity and as such, there would be no direct impact on the TSR. There is low potential for artefacts associated with the TSR to be identified within the site.

The treated water pipeline that will extend to the property boundary will be located as to avoid the identified remains of the SUGAR array and TSR.

There is considered to be no potential for inadvertent impacts to the SUGAR array and TSR. The proposed activity is not near the SUGAR pits and they are fenced off. In addition, the activities are located on the eastern side of the ponds and will not impact them. The TSR is not located on the property and is on the other side of the road.

6.6.2 Mitigation measures

The following measures will be implemented to reduce potential impacts on European heritage:

- the temporary barriers erected around the SUGAR pits will remain in place until the completion of rehabilitation activities. No works will occur within these fenced areas
- if any previously unidentified European cultural heritage material is identified during works, then works in the immediate area will cease, and advice sought from a suitably qualified archaeologist.

6.6.3 Potential impact category

The proposed activity will result in a negligible impact on European cultural heritage. Two items of potential European cultural heritage significance were identified within the site, however the proposed activity has been designed to avoid these items. The area of disturbance is relatively small (approximately 99.6 hectares) within a previously disturbed agricultural property. Implementation of the mitigation measures will minimise impacts on identified and unidentified potential European cultural heritage material on-site.

6.7 Matters of National Environmental Significance

The proposed activity will not impact any MNES as detailed in Table 6-188.

Table 6-18 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 or within 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:	A number of threatened species listed under the EPBC Act have been recorded within a 10 kilometre radius of Leewood. None of the species listed were recorded during the field surveys. The likelihood of occurrence and potential impact of the abovementioned species is assessed in the Ecological Assessment (Appendix 8) and is discussed in Section 6.2.1. It is considered unlikely that the proposed activity will have a significant impact on any of the species. One threatened ecological community listed under the EPBC Act, Brigalow (*Acacia harpophylla* dominant and co-dominant), was recorded at Leewood. This ecological community will be retained and protected as part of the proposed activity.
Migratory species	Three migratory bird species listed under the EPBC Act were identified having the potential to occur within the site. None of these species were identified during the field surveys. Impacts to these species are considered unlikely.
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.
Water Resources from CSG development and large coal mining development	N/A – According to the *Significant impact guidelines 1.3: Coal seam gas and large coal mining developments— impacts on water resources* (DoE, 2013), if there is no extraction of CSG involved as part of the proposed activity, it is not a 'CSG development' or 'large coal mining development' for the purpose of the water trigger.

6.8 Cumulative impacts

The Narrabri Shire is recognised for its coal seam gas and mining resources. A number of mining exploration and production licences cover the area.

Existing and proposed mining occurs at a number of Whitehaven Coal mines approximately 28 kilometres south of Narrabri and at the Boggabri coal mine approximately 15 kilometres north of Boggabri. The Maules Creek Mine (Whitehaven Coal) has recently been granted approval and would extract up to 13 million tonnes of run-of-mine coal each year for 21 years. Expansion plans for these mines include a rail spur and coal handling facility.

Narrabri Sewage Treatment Works is an existing sewage treatment facility near the township of Narrabri. The facility is licensed to discharge to water and/or a discharge utilisation area. Discharges to waters are limited at 20 megalitres per day.

Wilga Park power station is an existing 16 megawatt gas-fired power station about 15 kilometres north of Leewood. Approval to expand Wilga Park power station to 40 megawatt capacity was approved in December

2008. The installed generating capacity at Wilga Park is currently 16 megawatts, however the power station rarely operates at full capacity due to limited fuel gas supplies.

The potential for cumulative impacts between the proposed activity and other existing or proposed projects in the public domain is considered to be minor. These developments are large in scale compared to the proposed activity, not located within the vicinity of the proposed activity, and, in the case of the coal mines, will utilise a purpose built workers camp minimising impacts on the Narrabri township.

The cumulative impact assessment has therefore considered:

- operation of the Leewood produced water and brine management ponds. Construction activities associated with this activity will be completed prior to construction commencing for the proposed activity
- other proposed exploration and appraisal activities within PEL 238 and PAL 2, particularly when construction will occur concurrently or where similar vegetation types have been or will require clearing.

Cumulative impacts during operation of other exploration and appraisal activities are expected to be minor as activities are of a sufficient distance to not generate cumulative noise, air quality, surface or ground water or any other impacts.

Cumulative impacts, where expected, are summarised in Table 6-19. Any community concern regarding potential cumulative impacts will be addressed through ongoing consultation.

6.8.1 Mitigation measures

Santos will work with Narrabri Shire Council to ensure issues relating to increased pressure on labour resources, temporary and permanent accommodation, road infrastructure and telecommunications as a result of cumulative Santos activities are addressed appropriately.

Table 6-19 Potential cumulative impacts

Area of impact	Potential cumulative impacts	
	Construction and operation activities at Leewood	***Other proposed exploration and appraisal activities***
Soil quality and land stability	The land area cleared at Leewood will increase with the construction of the WBTP increasing the potential for erosion. The sediment and erosion plan developed to manage impacts during construction will accordingly take into consideration all activities occurring at Leewood.	No cumulative impacts expected.
Groundwater	No cumulative impacts expected.	No cumulative impacts expected.
Surface water	No cumulative impacts expected.	No cumulative impacts expected.
Air quality	Air quality impacts during operation for both activities are expected to be minimal and well within acceptable air quality standards.	No cumulative impacts expected.
Greenhouse gas emissions	Scope 1 GHG emission estimates for the operation of existing and currently planned exploration and appraisal activities including the proposed activity are 220 and 230 kT of CO_2^e annually for flaring and on site power generation. The proposed activity contributes 1.95 per cent to this total. These contribute marginally to NSW and Australian emission targets.	
Noise	Noise impacts during operation for both activities are expected to be minimal and well within acceptable regulatory limits.	No cumulative impacts expected.
Waste	Potential impacts relate to addition to landfill and capacity of management, disposal or recycling facilities to cope with the cumulative volumes produced. Given the very low volumes of waste to landfill contributed by construction and operation of the Leewood produced water and brine management ponds, cumulative impacts are expected to be minimal.	The proposed activity treats produced water to minimise this waste stream across all exploration and appraisal activities.
Chemicals and hazardous substances management	No cumulative impacts are expected. The operation of the produced water and brine ponds do not require the storage or use of hazardous chemicals.	No cumulative impacts expected.
Biological	A total of 41.4 ha of derived native grassland was removed for construction of the Leewood produced water and brine management ponds. With the addition of the proposed activity, an estimated 144 ha of derived grassland will be cleared at Leewood. Within PEL 238, approximately 158,384 ha of derived grassland exists. The removal of less than 0.10 per cent is expected to have a negligible cumulative impact. No other vegetation type will be cleared for the proposed activity.	A total of approximately 74.9 ha of derived grassland has been removed for exploration activities within PEL 238 since 2002. With the addition of the proposed activity, an estimated 177.5 hectares will be cleared. Within PEL 238, approximately 158,384 ha of derived grassland exists. The removal of less than 0.15 per cent is considered to have a negligible cumulative impact.
Community safety	No cumulative impacts expected.	No cumulative impacts expected.

Area of impact	Potential cumulative impacts	
Traffic	Traffic volumes during the operation of Leewood are expected to be significantly less than construction. Accordingly the upgraded intersection of Old Mill Road and Newell Highway will easily accommodate operational traffic movements.	An additional 44 daily and 14 hourly trips along the Newell Highway may to be generated. This equates to a less than eight percent increase on existing traffic volumes along the Newell Highway. The Newell Highway has been assessed as having spare capacity in accommodating such additional traffic volumes. Therefore cumulative traffic impacts are considered minor.
Visual amenity	Cumulative impacts to visual amenity are expected to be minimal as the produced water and brine management ponds are not visible from the Newell Highway or dwellings to the north.	No significant cumulative impacts expected, as the cleared areas for pilot wells and other infrastructure are spread throughout the Pilliga forest and are generally set back from the road network and not in view from neighbouring properties. They would have a minor visual impact when viewed from the air.
Community services, infrastructure and sites of importance	Employees associated with the operation of the produced water and brine management ponds are all locally based and do not rely on temporary accommodation needs.	There may be pressure on temporary accommodation in Narrabri area, due to the increased presence of construction workers however the Westport drillers camp will minimise these impacts.
Economic	No cumulative impacts expected.	No cumulative impacts expected
Natural resource and land use	Approximately 41.4 ha of agricultural land were impacted by construction of the produced water and brine management ponds. The proposed activity will convert about 97.8 ha of land from low potential for commercial agricultural land use to high intensity agricultural activities. Therefore, a positive cumulative impact is expected.	Approximately 52 ha of agricultural land will be impacted by other exploration activities however the proposed activity will convert about 97.8 hectares of land from low potential for commercial agricultural land use to high intensity agricultural activities.
Cultural heritage	No cumulative impacts expected.	No cumulative impacts expected.

7.0 Summary of impacts

The potential impacts associated with the proposed activity are summarised in Table 7-1.

Table 7-1 Summary of primary potential impacts

Aspect	Potential impacts	Potential impact category (with mitigation measures)
Soil quality and land stability	▪ Improvement in soil quality and structure due to water and soil amendments. ▪ Increase in soil erosion and sediment loss. ▪ Increase in soil compaction and waterlogging. ▪ Increase in soil salinity. ▪ Land contamination in event of a leak or spill.	Negligible
Groundwater	▪ Changes in groundwater levels due to minor increase in deep drainage under the irrigation area. ▪ Increase in salt transport and salinity levels.	Negligible to low adverse
Surface water	▪ Sedimentation of surface waters due to increased erosion and site sediment loss during both construction and operation. ▪ Contamination of surface waters in event of a leak or spill. ▪ Increase in runoff from irrigation area during operation. ▪ Changes in local surface water discharge volumes in event of flooding and inundation of the site.	Negligible to low adverse
Air quality	▪ Generation of exhaust emissions, dust and other particulates, particularly during construction.	Negligible to low adverse
Greenhouse gases	▪ Generation of GHG emissions.	Negligible to low adverse
Noise	▪ Generation of noise and vibration, particularly during construction.	Low adverse
Waste	▪ Generation and disposal of various wastes, including concentrated brine. ▪ Contamination of groundwater, soils or surface water from waste. ▪ Litter due to lack of suitable waste containment odours from improper storage or treatment of putrescible waste.	Low adverse
Hazardous substance and chemical use	▪ Land, water or air pollution, or fire, from improper use or storage of hazardous substances or chemicals.	Negligible to low adverse
Flora and fauna	▪ Disturbance of approximately 99.6 hectares of non-significant vegetation. ▪ Temporary disruption to sheltering and foraging behaviour of fauna species. ▪ Potential increase in presence of local weed and pasture species within the native vegetation communities as a result of increased soil moisture content.	Low adverse
Public safety	▪ Introduction of additional hazards, such as moving vehicles, plant and machinery, and chemicals, fuels and oils with potential safety implications. ▪ Bushfire risk.	Low adverse
Traffic	▪ Increase in traffic on Newell Highway and Old Mill Road. ▪ Tracking of sediment onto Newell Highway.	Low adverse
Amenity	▪ Visual impact of proposed activity from Newell Highway and surrounding properties.	Low adverse

Aspect	Potential impacts	Potential impact category (with mitigation measures)
	▪ Temporary reduced amenity for adjacent landowners from noise and dust. ▪ Increase in traffic on Newell Highway and Old Mill Road.	
Community services, infrastructure and sites of importance	▪ Pressure on temporary accommodation in Narrabri area.	Low adverse
Economic issues	▪ Economic benefits to Narrabri and broader area.	Minor positive
Natural resources and land use impacts	▪ Increase in net productivity of the area from the current low productivity pasture. ▪ Impacts on agricultural resources including soil, surface water and groundwater. ▪ Beneficial reuse of produced water and gas from coal seams. ▪ Spread of weeds or pathogens.	Low adverse
Aboriginal cultural heritage	▪ Disturbance of unknown Aboriginal objects.	Negligible to low adverse
European cultural heritage impacts	▪ Disturbance of unknown European heritage items.	Negligible

7.1 Clause 228 Guidelines

Clause 228 of the *Environmental Planning and Assessment Regulation 2000* identifies factors that must be taken into consideration in assessing an activity under Part 5 of the EP&A Act. An assessment of the clause 228 factors is provided in Table 7-2.

Table 7-2 Clause 228 factors

Factor	Impact
Any environmental impact on a community	Minor short-mid term. Potential impacts to the community during construction will be short term and localised. The nearest permanently occupied residential dwelling is located approximately 360 metres to the east of the site. The proposed activity will generate additional traffic (mainly during construction) but this will be unlikely to significantly impact the local road network. Impacts associated with the proposed activity will be virtually imperceptible to the wider community.
Any transformation of a locality	Negligible. The eastern side of the Leewood property is being transformed from sparsely vegetated grazing land to cropping, while the western side of the property was transformed during the construction of the approved water and brine storage ponds.
Any environmental impact on the ecosystems of the locality.	Negligible. The proposed activity will require the disturbance of up to approximately 99.6 hectares of non-significant vegetation (Derived Grassland) at Leewood.
Any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality	Minor short-mid term. Plant and equipment at the WBTP and associated infrastructure will be visible during construction and operation, but given its distance from the Newell Highway and neighbouring residences, will have a negligible impact on scenic amenity. In addition, the topography of the surrounding area is relatively flat which will reduce the visibility of the WBTP from surrounding areas. The proposed irrigation regime will increase the net productivity of the area from the current low productivity pasture, improving the productivity of the site.
Any effect on a locality, place or building having	Nil. With the implementation of the mitigation measures outlined in the Statement of

Factor	Impact
aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations	Commitments (Table 9-1), no locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations will be impacted upon by the proposed activity.
Any impact on the habitat of protected fauna (within the meaning of the National Parks and Wildlife Act 1974)	Negligible. The site provides marginal foraging and nesting habitat for a range of protected fauna species within the meaning of the NPW Act. There are larger areas of more suitable habitat for threatened species nearby (Pilliga forest, approximately 160,000 hectares) and the proposed activity will affect a small area of sub-optimal habitat.
Any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air	Nil. The proposed activity will not endanger any species of animal, plant or other form of life, whether living on land, in water or in the air.
Any long-term effects on the environment	Nil. The proposed activity will not have any long-term effects on the environment.
Any degradation of the quality of the environment	Minor short term. The application of the treated irrigation water and undertaking of land preparation activities, including soil amelioration, are likely to maintain or improve the soil quality and structure within the irrigation area on-site. The proposed activity may cause a minor short term increase in soil erosion and sediment loss, runoff and deep drainage, however these will be adequately addressed with mitigation, including erosion and sediment control, appropriate irrigation practices, and management of topsoil and chemicals. There is also a potential for minor short term environmental degradation as a result of air and noise emissions during the works.
Any risk to the safety of the environment	Minor long term. The proposed activity could also result in short term potential risks to the safety of the environment due to incidents and spills.
Any reduction in the range of beneficial uses of the environment	Nil. The proposed activity will not result in any reduction in the range of beneficial uses of the environment.
Any pollution of the environment	Minor short term. The proposed activity could also result in short term potential risk of pollution of the environment due to incidents and spills or as a result of air or noise emissions or salt discharge from the effluent irrigation scheme. These will be monitored and managed in accordance with the requirements of EPL 20350.
Any environmental problems associated with the disposal of waste	Nil. Wastes generated by the proposed activity will be collected, classified and removed from site for recycling, disposal or disposal at a licensed waste facility, as required.
Any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply	Minor short term. Resources required for the proposed activity are not in limited supply in the area.

8.0 CONCLUSION

Santos has a long term commitment to the development of new gas supplies to the growing NSW market. The proposed activity has been developed to assist with this objective, while taking into account environmental, economic and social considerations.

The proposed activity is permissible without consent and requires assessment and determination under Part 5 of the EP&A Act in accordance with the Mining SEPP.

The REF assesses the potential environmental impacts of the activity in accordance with the requirements of section 111 of the *Environmental Planning & Assessment Act 1979*, clause 228 of the *Environmental Planning and Assessment Regulation 2000*, and the ESG2 Guidelines. It has identified the potential impacts together with measures to mitigate those potential impacts.

The proposed activity is temporary and minor in scale. The site for 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 will improve soil structure and quality of the area under irrigation
- the proposed activity is unlikely to have a significant effect on surface water or groundwater resources
- 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 REF the impact of the activity will be negligible to low adverse provided that the mitigation measures identified in the REF are employed.

9.0 STATEMENT OF COMMITMENTS

Table 9-1 provides a statement of commitments for the proposed activity.

Table 9-1 Statement of Commitments

Item	Commitment
Activity type and location	▪ The proposed activity will be carried out at Leewood, as described in Section 2.6 of the REF. It will include: – Construction and operation of: – a water treatment plant, including pre-treatment and reverse osmosis plant – a brine treatment plant – a brine distribution manifold and associated piping at Leewood, to allow water distribution into the water treatment plant and associated return flows to brine storage ponds – a treated water storage tank (five megalitre capacity) – a managed irrigation system including a centre pivot and sub-surface drip irrigation system – other associated infrastructure, including a gas pipeline to fuel the generators – a small potable water treatment system for water extracted from the licensed bore. ▪ The construction of (and the ability to operate) a treated water pipeline extending to the Leewood property boundary to transfer water to another location for irrigation by a third party (if required) ▪ Re-use of treated water for irrigation at the Leewood property and other uses both on and off site including dust suppression, drilling and construction and firefighting . Santos is investigating the option of providing treated water to third parties for agricultural irrigation, although this potential use of treated water does not form part of the proposed activity for the purposes of this REF and will be subject to separate assessment and approvals. ▪ Amelioration of soils within irrigation area by deep tillage, fertiliser, lime and gypsum in preparation for irrigation. ▪ Decommissioning and rehabilitation of the site, if the Narrabri Gas Project does not proceed. ▪ The operational process is expected to involve, but is not limited to: – pumping of produced water from the produced water pond to the water treatment plant – treatment of produced water within the water treatment plant, including removal of solids by filter (pre-treatment), reverse osmosis to separate the water and brine streams (treatment), and chemical and pH dosing (post-treatment) to make the treated water appropriate for irrigation – transfer of treated water to the treated water storage tank or directly to the on-site managed irrigation system for beneficial re-use – beneficial re-use of treated water for irrigation, or other uses both on and off-site such as dust suppression, drilling and construction and firefighting – transfer of brine to the brine treatment plant for concentration and further recovery of treated water – storage of brine in the existing Leewood ponds.
Hours of operation	▪ Construction activities will usually be between 7am till 6pm, seven days a week and will comply with EPL 20350. ▪ The WBTP will operate up to 24 hours a day, seven days a week.
Activity duration	▪ Construction will be approximately 50 weeks in duration. ▪ The proposed activity will operate for up to five years.
Proposed commencement date	▪ Works will commence in the third quarter of 2015.
Maximum area of disturbance	▪ Approximately 99.6 hectares.
Rehabilitation commitments and	▪ Any operation beyond five years would be subject to further environmental assessment and approval. Should this not occur, the proposed activity would be decommissioned and the site

Item	Commitment
timeframes	rehabilitated in accordance with the conditions of PAL 2. ▪ The final landform of the site would depend on the requirements of any future user or proposed future use. The western side of the property would be converted back to grazing land. However, the irrigation area may be retained if requested by the future user. ▪ A detailed rehabilitation strategy for the site will be developed at the end of the life of the proposed activity.
Community consultation and complaint management	▪ Community consultation and complaint management will be undertaken in accordance with Section 2.3 of the REF.
Soil quality and land stability	▪ Erosion and sediment controls will be implemented where necessary, in accordance with the guidelines, principles and recommended minimum design standards contained in *Managing Urban Stormwater, Soils and Construction – Volume 1* (the Blue Book). These controls will be maintained until disturbed areas of the site are stabilised. ▪ A specific erosion and sediment control plan (ESCP) will be developed during detailed design and implemented for the proposed activity. ▪ Any spills or leaks will be contained and cleaned up immediately. Contaminated material (such as contaminated soil or absorbent materials) will be removed from the site for disposal at a licensed waste facility. ▪ Plant and equipment installed at the premises or used in connection with the licensed activity will be maintained and operated in accordance with condition O2.1 of EPL 20350. ▪ A soil sampling and monitoring program, inclusive of the irrigation area will be implemented, as outlined in Section 2.7.1.2. ▪ Soil amelioration, crop management and irrigation scheduling will occur generally as described in the concept irrigation design report (Appendix 3), to prepare and maintain the irrigation area throughout operation. ▪ The site will be rehabilitated in accordance with Section 2.6.4 of the REF.
Groundwater	▪ Groundwater monitoring as per Section 2.7.1.5 will be implemented.
Surface water	▪ Scheduling of irrigation activities will be managed generally in accordance with the concept irrigation design (Appendix 3), to minimise inundation and runoff. ▪ During construction in the event that prolonged, severe wet weather or flooding is predicted, appropriate measures will be put in place to mitigate impacts of the wet weather. ▪ The treated water storage tank will have high level alarms, or other appropriate controls, implemented to prevent overflows. ▪ A surface water monitoring program will be implemented, as outlined in Section 2.7.1.4. ▪ Management measures for dust suppression and in rehabilitation activities will be implemented, as outlined in Section 2.7.2. ▪ All above ground tanks containing material that is likely to cause environmental harm will be bunded or have an alternative spill containment system in place, in accordance with condition O5.3 of EPL 20350.
Air quality	▪ Air emissions from construction-related activities will not exceed the air quality criteria at any occupied residence on privately owned land, as set out in the table in Section 6.1.4.4 of the REF (referenced from the *Development Consent for the Bibblewindi Gas Exploration Pilot Expansion*, dated July 2014). ▪ Air emissions from operations-related activities will not exceed the air quality criteria at any occupied residence on privately owned land, as outlined in Table 6-4 (referenced from the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005)). ▪ The proposed activity will be carried out by such practicable means as to prevent or minimize the emission of dust. ▪ Plant and equipment will be operated and maintained in a proper and efficient condition. ▪ Generator selection and exhaust configuration will be designed to ensure emission rates comply with the *Protection of the Environment Operations (Clean Air) Regulation 2010* in-stack concentration limits. ▪ No offensive odours will be emitted from the proposed activity.

Item	Commitment
Greenhouse gases	▪ Legislative reporting requirements for GHG emissions (such as to inform NGERS calculations) will be undertaken during both construction and operation. ▪ Natural gas fuel will be used in preference to diesel where practicable during operation. ▪ Plant and equipment will be operated and maintained in a proper and efficient condition.
Noise	▪ Noise from the activity will meet the noise levels in the table provided in Section 6.1.6.3 of the REF at occupied residences unless a written agreement is in place with the landholder. ▪ Community notification will be undertaken prior to commencement of construction. ▪ Potentially impacted occupied residences will be informed of the nature of the works, duration of works and a method of contact to raise any complaints. ▪ In the event of a noise complaint, the effectiveness of noise mitigation measures will be assessed and additional feasible and reasonable measures implemented, where necessary. This may include noise monitoring.
Waste	▪ Mitigation measures provided in the waste management strategy will be implemented, as outlined in Section 2.7.3. ▪ Management of waste, including its transport, will comply with the POEO Act and *Protection of the Environment Operations (Waste) Regulation 2005* (POEO (Waste) Regulation). ▪ Waste identified for recycling will be stored separately from other waste. ▪ Waste will be assessed and classified in accordance with the DECC Waste Classification Guidelines. ▪ All site personnel will be made aware of waste management procedures during the site induction and through toolbox talks.
Hazardous substance and chemical use	▪ A spill kit will be available within the site during construction and personnel will be trained in its use. ▪ Chemicals and potentially hazardous substances will be used and stored according to regulatory requirements including the *Work Health and Safety Act 2011* and *Australian Standard 1940–2004; The Storage and Handling of Flammable and Combustible Liquids* or other relevant guidelines. ▪ Any dangerous goods will be transported according to regulatory requirements under the *Dangerous Goods (Road and Rail Transport) Act 2008*.
Biological impacts	▪ The site boundary will be clearly marked in the field to ensure all clearing and construction activities occur within the approved footprint. ▪ Management measures will be implemented to minimise the potential for spray drift from the irrigation system to impact the stand of Brigalow on the northern boundary of the site will be minimised. ▪ Prior to earthworks, weeds listed as Noxious under the NSW *Noxious Weeds Act 1993* that are present on the site would be removed or treated with herbicide to prevent or reduce their spread. ▪ If any hollow-bearing trees are detected on-site and require removal, this will be undertaken with the supervision of an ecologist.
Public Safety	▪ General site safety protocols, incident management and emergency procedures (including bushfire risk) will be implemented during the construction and operation works. ▪ Construction and operational sites will be fenced and locked after construction hours. ▪ The Bushfire Management Plan will be reviewed and updated as required to address the proposed activity. ▪ An induction for staff and contractors regarding the hazards and risks will be implemented.
Traffic	▪ Access to and from adjacent properties will be maintained for the duration of construction. ▪ Parking for staff during construction and operation will be accommodated within the site. ▪ Construction traffic will not be permitted to queue or park on Old Mill Road, other State forest roads or the Newell Highway. ▪ All truck movements would be restricted to the direct route via the Newell Highway. Truck drivers will be advised of the designated truck routes to/ from the site. ▪ Oversized vehicles required for transporting earthmoving equipment will be undertaken in accordance with the relevant requirements of Roads and Maritime Services.

Item	Commitment
	▪ The site access plan outlined in the transport assessment (Appendix 4) will be implemented during construction and traffic managed accordingly. ▪ Construction and operational traffic will only access Leewood via Old Mill Road.
Amenity	▪ Where practicable, existing vegetation along the site boundary will be maintained to provide screening of the site. ▪ The site will be kept in a clean and tidy manner during site preparation, construction activities and operation.
Community services, infrastructure and sites of importance	▪ The consultation activities outlined in Section 2.3 will be implemented.
Economic issues	▪ A procurement and logistics policy would be implemented that gives preference to local businesses, suppliers and labour.
Natural resources	▪ Works associated with the proposed activity will not impact on agricultural production at any adjacent properties.
Aboriginal cultural heritage	▪ No works will be undertaken in the vegetated (Brigalow) area in the north-east corner of the site to avoid the scar trees (refer Figure 2-1). ▪ The isolated stone artefact (quartz) flakes will remain fenced off with a three metre buffer around each location. ▪ Project staff and contractors will be made aware of their statutory obligations for heritage under the NPW Act and the Heritage Act, as well as the location of the identified cultural objects through the site induction and toolbox talks. ▪ Monitoring will be undertaken immediately following earth-moving activities in the vicinity of the isolated quartz artefacts. This will consist of two persons jointly nominated by the Narrabri LALC and the Gomeroi native title claim group. ▪ If any previously unidentified Aboriginal site/s are identified during works, then works 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 and managed. ▪ In the event that skeletal remains are uncovered, work must cease immediately in that area and the proponent, Santos must contact the NSW Police Coroner to determine if the material is of Aboriginal origin. If determined to be Aboriginal, the OEH Enviroline 131 555 and relevant Aboriginal stakeholders must be contacted to determine an action plan for the management of the skeletal remains prior to works re-commencing.
European cultural heritage	▪ The temporary barriers erected around the SUGAR pits will remain in place until the completion of rehabilitation activities. No works will occur within these fenced areas. ▪ If any previously unidentified European cultural heritage material is identified during works, then works in the immediate area will cease, and advice sought from a suitably qualified archaeologist.
Cumulative	▪ Santos will work with Narrabri Shire Council to ensure issues relating to increased pressure on labour resources, temporary and permanent accommodation, road infrastructure and telecommunications as a result of cumulative Santos activities are addressed appropriately.

Terms and abbreviations

Term/abbreviation	Meaning
AHD	Australian Height Datum
AHIMS	Aboriginal Heritage Information Management System
AHIP	Aboriginal Heritage Impact Permit
AIS	Agricultural Impact Statement
ARI	Average Recurrence Interval
Blue Book	*Managing Urban Stormwater: Soils and Construction – Volume 1* (Landcom, 2004)
BoM	Bureau of Meteorology
BSAL	Biophysical Strategic Agricultural Land
CIC	Critical Industry Cluster
Consequence category	Category assigned to a dam according to the seriousness, and magnitude, of the adverse consequences affecting the community's interests, including environmental effects, which could be expected to result from that dam's failure. In assigning such consequence categories, no account is taken of the likelihood of dam failure.
CSG	Coal seam gas
dB(A)	A-weighted decibels. An expression of the relative loudness of sounds in air as perceived by the human ear.
DEC	Department of Environment and Conservation
DO	Dissolved oxygen
DoE	Department of Environment (Commonwealth)
DRE	Division of Resources and Energy (under DTIRIS)
DSC	Dam Safety Committee
DTIRIS	NSW Department of Trade, Investment, Regional Infrastructure and Services
EC	Electrical conductivity
EEC	Endangered ecological community
EFT	Equivalent full time
EHSMS	Environmental, Health and Safety Management System
EIS	Environmental Impact Statement
EPA	NSW Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPL	Environment Protection Licence
ESCP	Erosion and sediment control plan
ESG2 Guidelines	*ESG2: Environmental Impact Assessment Guidelines; For exploration, mining and petroleum production activities subject to Part 5 of the Environmental Planning and Assessment Act 1979* (DTIRIS, 2012)
EWP	Elevated work platform
FCNSW	Forestry Corporation of NSW
FGCS	Fuel gas conditioning skid. A machine that delivers clean and treated natural gas to gas turbines, gas engines, and other equipment which needs clean fuel.
Flowline	A pipeline which conveys fluid or gas from once location to another.

Term/abbreviation	Meaning
Gathering system	Large systems of pipelines that gather water and gas, typically associated with CSG projects.
GHG	Greenhouse gases
Heritage Act	*Heritage Act 1977*
ICNG	*Interim Construction Noise Guideline* (DECC, 2009)
IECA	International Erosion Control Association
INP	*NSW Industrial Noise Policy* (EPA, 2000)
LA_{90}	Noise level which is exceeded for 90 per cent of the sample period.
LA_{eq}	Equivalent continuous sound level. The energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment.
LALC	Local Aboriginal Land Council
LEP	Local Environmental Plan
LGA	Local government area
LoS	Level of Service
LSC	Land and Soil Capability
Mining SEPP	*State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*
ML	Megalitres
MNES	Matter of National Environmental Significance
MOWL	Maximum Operating Water Level
Narrabri CCC	Narrabri Community Consultative Committee
NATA	National Association of Testing Authorities
NGER Act	*National Greenhouse and Energy Reporting Act 2007*
NGERS	National Greenhouse and Energy Reporting Scheme
NOW	NSW Office of Water
NPW Act	*National Parks and Wildlife Act 1994*
NNTT	National Native Title Tribunal
NSW	New South Wales
NV Act	*Native Vegetation Act 2003*
NW Act	*Noxious Weeds Act 1993*
OCSG	NSW Office of Coal Seam Gas
OEH	Office of Environment and Heritage
PAL	Petroleum Assessment Lease
PAWC	Plant available water capacity
PEL	Petroleum Exploration Licence
Petroleum Act	*Petroleum (Onshore) Act 1991*
PPL	Petroleum Production Lease
PM_{10}	Particulate matter less than ten micrometres
POEO Act	*Protection of the Environment Operations Act 1997*
POEO (Waste) Regulation	*Protection of the Environment Operations (Waste) Regulation 2005*

Term/abbreviation	Meaning
PPV	Peak particle velocity
Produced water	Also known as CSG water or wastewater, this is the water that is pumped out of coal seams in order to release CSG.
RBL	Rating background level
REF	Review of Environmental Factors
RFS	NSW Rural Fire Services
RNP	*NSW Road Noise Policy* (DECCW, 2011)
RO	Reverse osmosis
Roads and Maritime Services	NSW Roads and Maritime Services
RPS	RPS Australia East Pty Ltd
SAL	Strategic agricultural land
Santos	Santos NSW (Eastern) Pty Limited
SAR	Sodium adsorption ratio
SDS	Safety data sheet
SEPP 33	*State Environmental Planning (SEPP) No. 33 – Hazardous and Offensive Development Application Guidelines*
SIS	Species Impact Statement
SMS	Safety management system
SRD SEPP	*State Environmental Planning Policy (State and Regional Development) 2011*
SRLUP	*Strategic Regional Land Use Plan New England North West* (DP&I, 2012)
SUGAR	Sydney University Giant Air-shower Recorder
TDS	Total dissolved solids
TEC	Threatened ecological community
TSC Act	*Threatened Species Conservation Act 1995*
TSR	Travelling stock route
WBTP	Water and brine treatment plant
WMA	*Water Management Act 2000*
WPPS	Wilga Park Power Station

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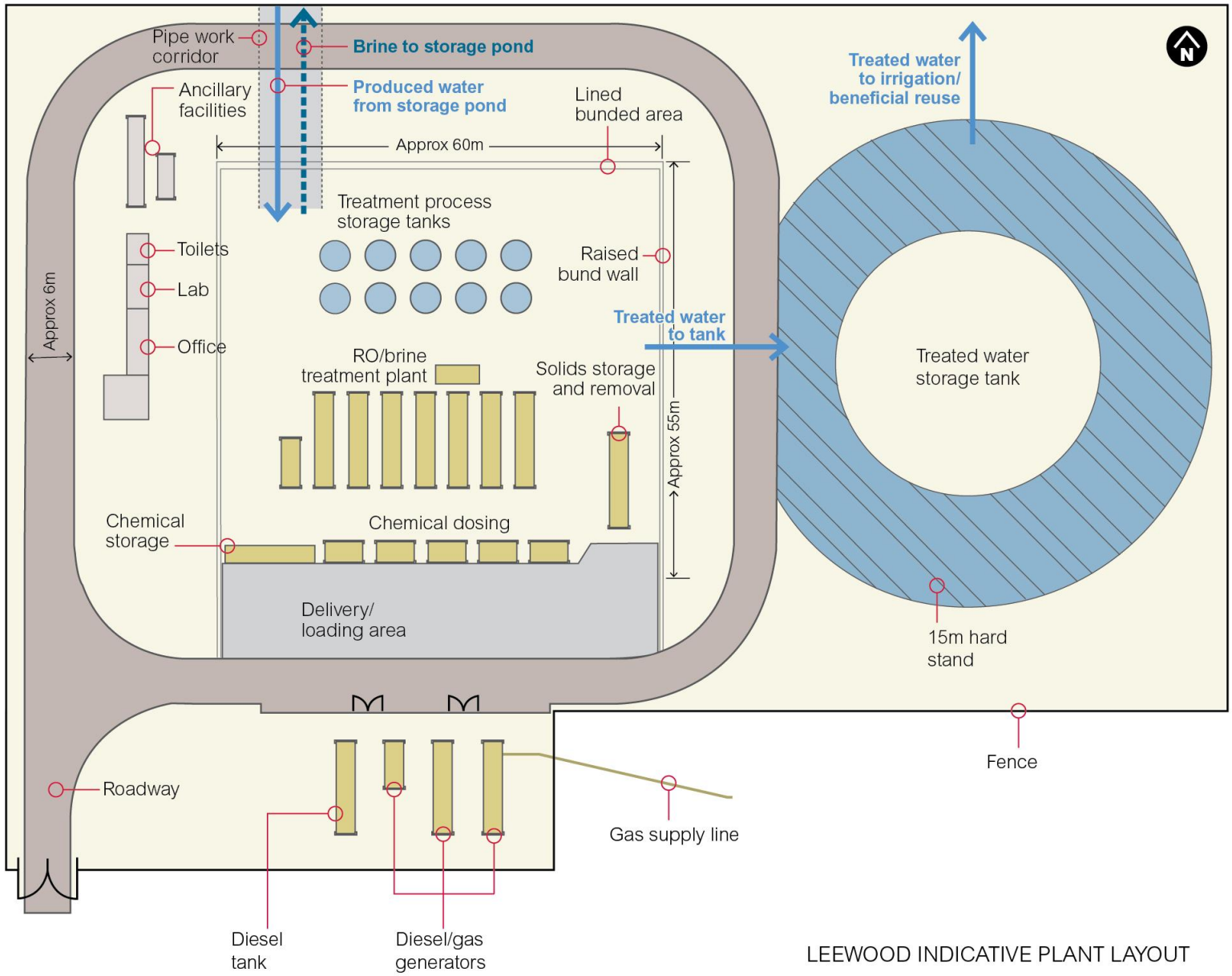
Appendix 1

Indicative plant layout



LEEWOOD INDICATIVE PLANT LAYOUT

Appendix 2

Water quality parameters for produced water

Table A2-1 Produced water quality parameters

Parameter	Units	Produced Water (90th percentile)	Legacy Brine (90th percentile)
Total Dissolved Solids (TDS)	mg/L	23,800	31,500
Electrical Conductivity	mS/cm	19.9	48,400
pH		8.57	9.0-9.84
Total Suspended Solids (TSS)	mg/L		<15
Total Algae Count	Cells/mL	<400,000	<400,000
Carbonate (CO3)	mg/L as CaCO3	730	<19,600
Bicarbonate (HCO3)	mg/L as CaCO3	12,400	<12,200
Alkalinity (Total)	mg/L as CaCO3	12,600	< 31,800
Total Organic Carbon	mg/L	60	<3,290
Dissolved Organic Carbon	mg/L	14	<3,340
Chemical Oxygen Demand	mg/L	2,300	<1,920
Biochemical Oxygen Demand (5 day)	mg/L	16	<598
Chloride (Cl)	mg/L	2,100	<5,510
Sodium (Na)	mg/L	6,500	<18,600
Sulphate (SO4)	mg/L	18	<18
Calcium (Ca)	mg/L	15	<15
Magnesium (Mg)	mg/L	9.2	<13
Potassium (K)	mg/L	81	<530
Strontium (Sr)	mg/L	24.6	<2.53
Barium (Ba)	mg/L	15	<9.3
Fluoride (F)	mg/L	6.4	<19.3
Silica (SiO2)	mg/L	24	<50
Boron (B)	mg/L	1.3	0.25-2.35
Iron (Fe, dissolved)	mg/L	0.52	Not analysed
Cyanide (Total)	mg/L	0.004	0.004
Manganese (Total)	mg/L	0.18	<0.048
Aluminium (Total)	mg/L	6.1	<7.69
Phosphorus (Total)	mg/L	0.63	Not analysed
Ammonia	mg/L as N	16	<16
Nitrate	mg/L as N	0.10	Not analysed
Nitrite	mg/L	0.04	Not Analysed
Nitrogen (Total)	mg/L	40	Not analysed
Total Kjeldahl Nitrogen	mg/L	39	Not Analysed
Copper (Total)	mg/L	0.14	0.001
Zinc (Total)	mg/L	0.15	0.01
Arsenic (Total)	mg/L	0.036	0.001
Chromium (Total)	mg/L	0.04	0.001
Hexavalent Chromium	mg/L	<0.05	Not analysed
Cadmium (Total)	mg/L	0.036	0.0002
Mercury (Total)	mg/L	0.0015	Not analysed
Molybdenum (Total)	mg/L	0.0069	Not analysed
Nickel (Total)	mg/L	0.013	Not analysed
Antimony (Total)	mg/L	0.0011	Not analysed
Selenium (Total)	mg/L	0.054	Not analysed
Tin (Total)	mg/L	0.0027	Not analysed
Uranium (Total)	mg/L	0.0007	Not analysed
Lead (Total)	mg/L	0.013	Not analysed
Beryllium (Total)	mg/L	0.001	Not analysed
Cobalt (Total)	mg/L	0.0035	Not analysed
Iodide (I)	mg/L	0.2	<0.1
Lithium (Total)	mg/L	2.9	Not analysed
Thallium (Total)	mg/L	0.0005	Not analysed
Vanadium (Total)	mg/L	0.016	Not analysed

Appendix 3

Conceptual Irrigation Project Design (BeneTerra)



integrating land and water stewardship BeneTerra Pty Ltd PO Box 12580, George St. Post Brisbane, QLD 4003	**CLIENT** **Santos Energy NSW** **PROJECT** **Leewood Irrigation Project** **DOCUMENT** **REF -Leewood- concept irrigation design**

Concept Design - Leewood Irrigation Project REF

AUTHOR(S) Glenn Bailey, John Zupancic, Rory van Niekerk

BeneTerra	PROJECT NO.	DISC	TYPE	DOC NO.
	0990.3			BT-L-SNSW-004

CLIENT DOC NO.:	CLIENT DOC REVISION:

REV	DATE	REASON(S)	RVW	APR	CLIENT
0	2014-04-11	Issued for Client comment	GB	JZ	Santos ENSW
1	2014-06-23	Issued for Use	RvK	JZ	Santos ENSW
3	2014-02-10	Amendments	GB		Santos ENSW
4	2014-02-24	Amendments	GB		Santos ENSW
5	2014-03-06	Amendments	GB		Santos ENSW

Executive Summary

The concept irrigation design presented herein for the Leewood project area was built upon a pre-feasibility study by BeneTerra in June 2013. In that exercise eighteen soil pits were analysed and ideas were presented as to how to design and manage irrigation at this site. Since then a comprehensive soil survey was performed using electromagnetic soil imaging to guide further soil core sampling. That information was combined with the earlier soil pit data to build a detailed soil map of the available project area. The soils were grouped into two irrigability classes – A and B.

The concept design utilises approximately all of the available land for irrigation. At peak production the Leewood water treatment plant will produce 365 ML/yr of high quality water that would be amended to lower SAR and raise EC. The soils across the site are primarily Sodosols having a low permeability layer 20 cm beneath the surface. These soils are both sodic and acidic but not saline. They are hard-setting and prone to compaction. As such they will require extensive amelioration by deep tillage, fertiliser, lime and gypsum to make them irrigable and productive. Thirty percent of the irrigable area, Class B soils lie within a drainage way that can be occasionally inundated. This area can be irrigated but will require specialised treatment.

The upland, Class A, soils would be managed differently than the wetter Class B soils of the drainage way. A sophisticated irrigation design that employs a variable rate centre-pivot and subsurface drip irrigation make it possible to irrigate this site. A perennial lucerne crop planted on the more elevated and drier Class A soils, would be harvested about five times annually. The B class soils occur on an ephemeral drainage depression that can be periodically inundated by overland flow. As this part of the landscape may become too wet to sustain a healthy lucerne stand, a blend of lucerne, white clover and fescue grass would be sown on the Class B soils. This mix would be more tolerant of occasional standing water.

Several irrigation scenarios were modelled using the HowLeaky water balance program. The modelling showed that if unlimited permeate supply was provided, the crop of lucerne would utilise 2.5 times (902 ML) the annual production at 1 MLD.

Irrigation scheduling should be supported with a variety of monitoring tools. Standard operating procedures should be developed for routine operations and maintenance procedures. Experts should be engaged for specific technical support to ensure that the mechanical and biological systems meet performance expectations. It is essential to maintain a healthy crop capable of optimal water use. Harvest operations should be conducted in a manner that minimises soil compaction.

Although this project presents little environmental risk, for quality assurance purposes we recommend a network of ten soil moisture monitoring sensors, and installation of two monitoring wells.

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LIST OF ABBREVIATIONS

AHD	Australian height datum
AIS	Agricultural Impact Statement
BOD_5	biological oxygen demand (5 day test)
BOM	Australian Bureau of Meteorology
BT	BeneTerra
bgl	below ground level
CP	centre-pivot sprinkler system
CSG	coal seam gas
dS/m	deciSiemens per metre
EC	electrical conductivity
EC_e	electrical conductivity of a soil paste extract
EHS	environment health and safety
EM38	electro-magnetic induction device
ESP	exchangeable sodium percentage
h	hour
ha	hectare
IAR	instantaneous application rate
K	potassium
kg/ha	kilograms per hectare
LF	leaching fraction
LR	leaching requirement
m^3/h	cubic metres per hour
mg/L	milligrams per litre
ML	megalitre
MLD	megalitres per day
ML/ha	megalitres per hectare
ML/ha-yr	megalitres per hectare per annum
mm	millimetre
mm/h	millimetres per hour
mS/cm	millisiemens per centimetre
N	nitrogen
NSW	New South Wales
ORP	oxidation reduction potential
P	phosphorus
PAWC	plant available water capacity
REF	Review of Environmental Factors
RO	reverse osmosis
S	sulphur
Santos ENSW	Santos Energy New South Wales
SAR	sodium adsorption ratio
SAR_e	sodium adsorption ratio of soil paste extract
SCADA	supervisory control and data acquisition
SDI	subsurface drip irrigation
SHC	saturated hydraulic conductivity

t	tonnes
t/ha	tonnes per hectare
t/ha-yr	tonnes per hectare per year
TOC	top of casing
µS/cm	microsiemens per centimetre
VFD	variable frequency drive
VRI	Variable Rate Irrigation system
yr	year

1 Introduction

This report is built upon an earlier pre-feasibility study performed by BeneTerra in 2013 wherein irrigation of the Leewood site was deemed to be feasible given adequate soil amelioration and a management strategy sensitive to soil classes.[1] The new information presented herein includes details from additional soil measurements, water balance modelling, concept irrigation design, and a description of operational activities.

2 Project activities

The following activities have been undertaken as part of the concept design:

- Desktop review of Phase 1– Review of Environmental Factors[2]
- Pre-feasibility study
- Interviews with key local people
- Soil sampling and EM38 mapping of soils
- Concept design of irrigation system
- Water balance modelling
- Interpretation and reporting

3 Assumptions

We have arrived at the following assumptions through review of the Phase 1 REF, discussions with Santos ENSW staff and review of documents presented to BeneTerra. The base assumptions used for the design of this project were:

- Project design life will be four to five years
- Maximum irrigation water production will be 1 MLD, 365 ML/yr
- Treated (desalted) irrigation water will be derived from reverse osmosis treatment and will be of suitable irrigation quality with no toxic elements or excessive nutrients
- The relevant local historical climate data for modelling purposes was the period of January 1963 to April 2013
- The designated paddock for irrigation can be cleared of existing vegetation
- There are no identified legal, cultural heritage or ecological issues to prevent development and operations

[1] Bailey, G and J Zupancic.2013-06-25. Irrigation feasibility at Leewood project site. For Santos ENSW by BeneTerra.
[2] RPS. 2012. Leewood-Produced Water & Brine Management Ponds Review of Environmental Factors (Phase 1). For Santos.

4 Site description

4.1 Location

The prospective irrigation site is located on the eastern half of Santos ENSW's Leewood Block, approximately 24 km southwest of Narrabri on the Newell Highway. The property borders the Pilliga State Forest on the south and west boundaries. It is bounded on the southwest corner at MGA 55, 751072 E, 6622328 S and northeast corner at 55, 752849 E, 6623255 S. The property is accessible by the Newell Highway which runs along the eastern boundary and Dog Fence Road which runs westward along the southern boundary into the Pilliga State Forest.

4.2 Climate

Australian Bureau of Meteorology records from January 1963 to April 2013, Narrabri post office [station 053030] were utilised to develop the climate statistics and design basis for this project.[3] The climatic regime is characterised by a slightly summer dominated rainfall pattern, with almost half the annual rainfall (46%) falling between November and February. Over the 50-year period mean annual rainfall at nearby Narrabri was 644 mm (Figure **1**) whereas annual mean pan evaporation was 1,966 mm. Evaporation exceeded rainfall in all months (**Figure** 2).

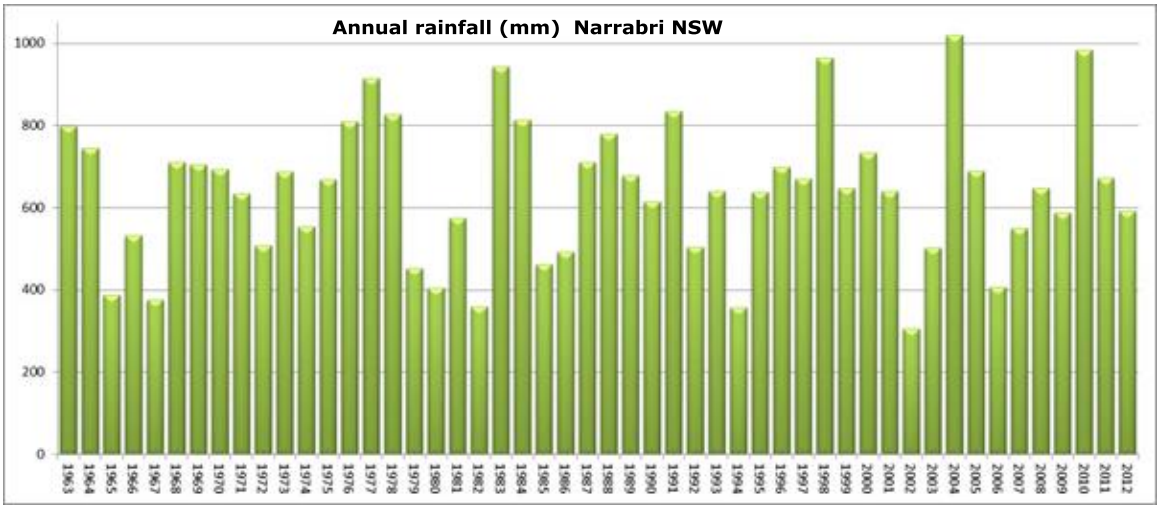

Figure 1 Annual rainfall at Narrabri NSW - 1963 – 2012

[3] Bureau of Meteorology [internet]. 2014 [cited 2014-03-28]. Available from: http://www.bom.gov.au/

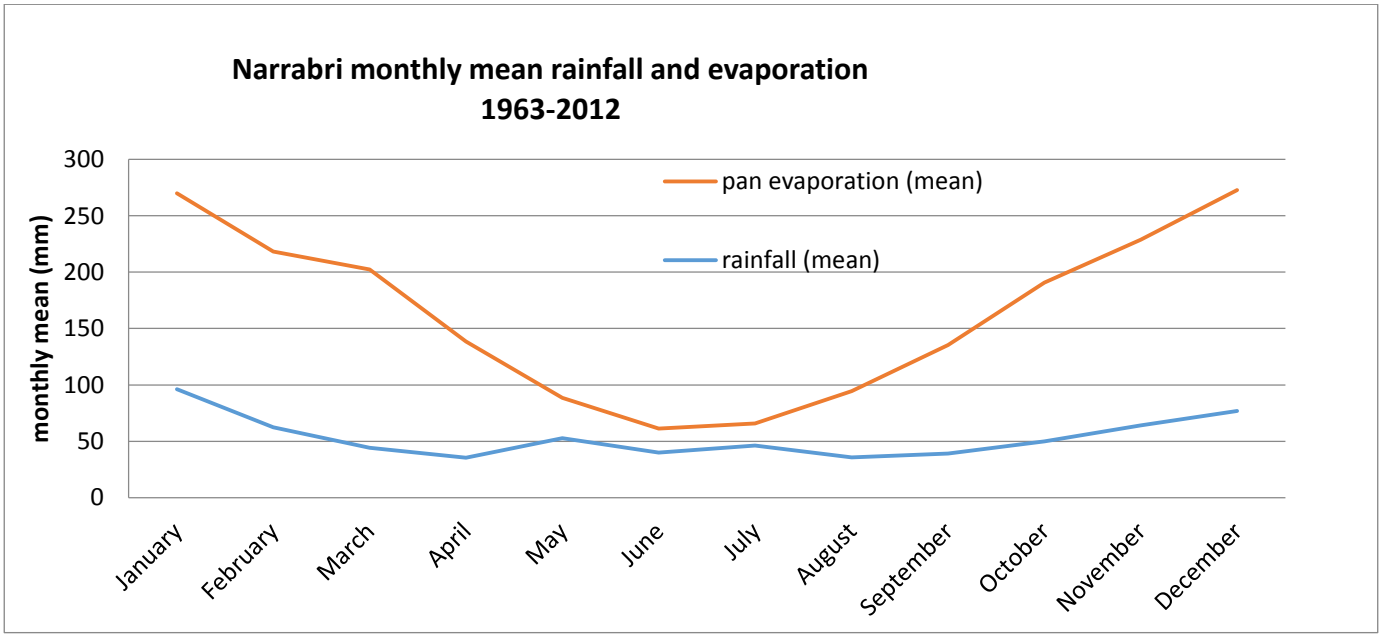

Figure 2 Mean rainfall and evaporation at Narrabri NSW (1963 - 2012)

Frosts can occur between May and October, and are common between June and August. Temperatures over 40°C have been recorded between October and March. The growing season for lucerne and pasture grasses is predominantly September to April, with growth during the winter months being approximately a third to a quarter of the summer growth rate.

4.3 Geologic setting

The surficial geological layer of the majority of the site is described as being Quaternary colluvium and/or residual deposits, and comprise talus, scree and sheet wash. These can take the form of boulder, gravel or sand, and may include minor alluvial or sand plain deposits. The southwest corner of the parcel is mapped as a Cainozoic sand plain, and may include some residual alluvium. It is sand dominant, also containing gravel and clay[4]. Further discussion of the geology of the site can be found in the Phase 1 REF (pp. 63).[5] Siliceous sands are dominant components of the parent material forming the soils, and consequently all the soils described at the site presented coarse sand fragments that were easily distinguishable by feel in most horizons.

4.4 Topography

The site is relatively flat, with elevations ranging from 245 m to 249 m. The median slope for the irrigation area is 0.4%. The minimum slope for the area is 0.2% and maximum slope is 1.2%. The steepest slope drains a small catchment toward the northeast toward the Newell highway and the Bohena Creek. This corner also presents the best drained soils. The land rises away slightly from this corner towards the southwest, then slopes down toward a minor depression forming the drainage line that flows across the parcel from the southeast corner to the middle of the western boundary (Figure **3**). Most of the property drains toward the northwest and overland flow enters from the southeast corner of the parcel.

[4] Geological Survey of New South Wales, Statewide Geodatabase, 1:250,000 scale or better, 2005 updated data (unpublished). Geoscience Australia

[5] RPS. 2012. Leewood-Produced Water & Brine Management Ponds Review of Environmental Factors (Phase 1). For Santos.

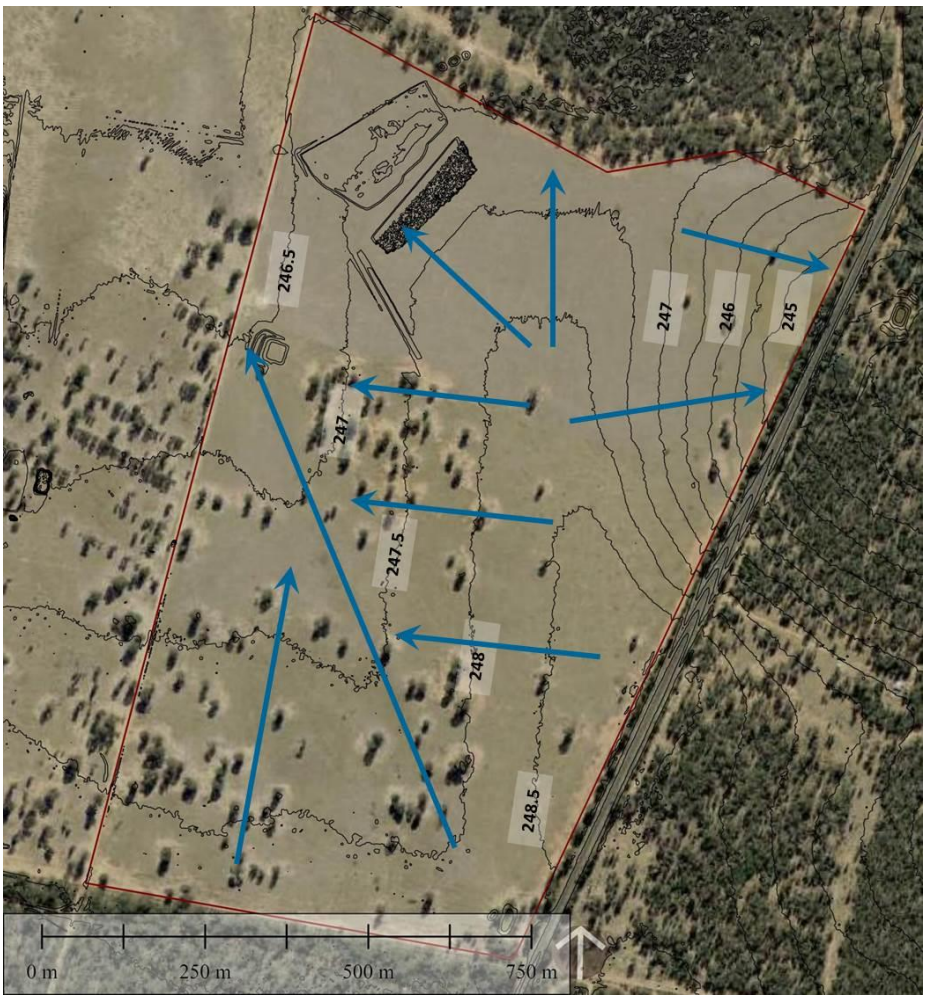

Figure 3 Topography and drainage patterns of prospective irrigated area

4.4.1 Limitations of landscape

The slopes on this site present no limitations for sprinkler or drip irrigation (Table **1**). Occasional flooding or inundation of the lower elevations presents a “moderate” limitation. The drainage line is considered a “severe” landform limitation according to Table **1** because of potential erosion and waterlogging. A mitigation strategy is proposed for selectively irrigating this area. There are no surface outcrops of rock to interfere with irrigation of this property.

Table 1 Landscape slope limitations for irrigation technologies (after NSW effluent guidelines Table 2.1)[6]

	Limitation			
Property 1	**Nil or Slight**	**Moderate**	**Severe[2]**	**Restrictive Feature**
Slope (%) (for following irrigation methods)				
– flood/surface/ underground	< 1	1–3	> 3	excess runoff and erosion risk
– sprinkler	< 6	6–12[3]	> 12[3]	
– trickle/microspray	< 10	10–20[3]	> 20[3]	
Flooding	none or rare	Occasional	frequent	limited irrigation opportunities
Landform	crests, convex slopes and plains	concave slopes and foot-slopes	drainage lines and incised channels	erosion and seasonal water- logging risk
Surface rock outcrop (%)	Nil	0–5	> 5	interferes with irrigation and/or cultivation equipment; risk of runoff

Source: Based on Hardie and Hird (1998), NSW Agriculture, Organic Waste Recycling Unit

Notes:
1. Careful consideration should also be given to potential impacts on groundwater (see 2.6 Groundwater).
2. Sites with these properties are generally not suitable for irrigation.
3. Slopes over 12% may be acceptable provided runoff and erosion risks are identified in the site selection process.

4.5 Vegetative cover

The property is primarily covered with low quality pasture grasses and scattered remnant trees (**Figure 4**). The dominant tree species is *Eucalyptus pilligaensis* (Pilliaga box), with occasional *E. crebra* (narrow leaved ironbark) also occurring. Approximately 150 medium to large woodland trees occur within the proposed irrigation area. Aside from these scattered remnant trees, there was no native vegetation cover aside from some native grasses that comprise part of the pasture mix.



Figure 4 View of landscape and vegetation of prospective irrigated area

[6] Dept. Environment & Conservation (NSW).2004. Environmental Guidelines - Use of Effluent by Irrigation.

5 Water supply for irrigation

5.1 Water volume

Associated water from CSG wells will be collected in holding ponds at Leewood and treated by reverse osmosis (RO) technologies. At peak production it is expected that 1 MLD (365 ML/yr) desalted, RO permeate water will be available for irrigation.

5.2 Water quality

Expected permeate water quality data was provided by Santos ENSW for the Leewood project. The expected RO permeate water reflects amendment of that water for irrigation purposes such that it is optimal for soil /water interactions and longevity of the soil structure maintenance. Additional chemical treatments may be required for subsurface drip irrigation (SDI) to avoid potential blockage of emitters and maintain the structural integrity of the soil profile over the life of the project. BeneTerra has determined the expected water quality for irrigation purposes as shown in Table **2**. Permeate water quality from the RO process was provided by Santos ENSW and BeneTerra determined the expected irrigation water quality for both these temperatures post amendment.

Table 2 Expected irrigation water quality

Parameter	Expected treated water[7]
pH	6-8.5
TDS (mg/L)	<650
Salinity (mS/cm)	1.0
Turbidity (NTU)	<1
SAR	<5
Calcium (mg/L)	52
Magnesium (mg/L)	0.04
Sodium (mg/L)	131
Potassium (mg/L)	7
Ammonia-N (mg/L)	6
Boron (mg/L)	0.7
Alkalinity (mg/L $CaCO_3$)	262
Chloride (mg/L)	120
Fluoride (mg/L)	0.3
Sulfate (mg/L)	0.0
Total N (mg/L)	Feed reduced by 50%
Total P (mg/L)	Feed reduced by 94%
Silica (mg/L SiO_2)	0.9

5.3 Suitability for irrigation

The added calcium may reduce the need for future gypsum treatment of soils but care must be taken that calcium carbonate precipitation does not cause drip emitter plugging. Sulphuric acid amendment will

[7] Treated water following chemical dosing, prior to entering the irrigation system.

remove bicarbonate to minimise the prospects of carbonate deposits in the SDI system and negative effects of bicarbonate on soils.

This water would be classified as "medium strength effluent" according to Table 3.1 of the NSW effluent guidelines only because it was ranked as medium in TDS concentration (600-1000 mg/L).[8] It would be ranked as low in the other five categories listed. It will carry 6 mg/L of nitrogen as ammonium, and no metals or sources of nutrients or BOD_5. Fluoride concentration will be very low at 0.2 mg/L. Boron at 0.78 mg/L would be safe for the chosen forage crops according to the short-term trigger values (20 yr life cycle) of the ANZECC/ARMCANZ 2000 guidelines.[9]

The RO permeate should contain no heavy metals or organic compounds as these relatively coarse materials would be rejected by membranes in the treatment train.

5.4 Salinity and salt contribution to soils and vadose

The salinity of the amended water would be rated as "low" and suitable for moderately sensitive crops according to Table 3.4 of the NSW effluent guideline. Amendment of the water to EC of 1.0 mS/cm (Table **2**) makes the water more suitable for the intended soils.

Most irrigation waters carry a salt load that presents a risk of accumulation in the rootzone particularly in arid regions or where high water table exists. Annual rainfall of 644 mm will offset some of the effects of salt deposition by irrigation water. Given average rainfall the weighted average EC of water applied to the crop would be 0.4 mS/cm. The average rootzone salinity, EC_e, of the Leewood soils is currently 1.5 mS/cm. Based upon BeneTerra's experience growing lucerne with effluent a reasonable rootzone target EC_e of 4.0 mS/cm would be acceptable before yield declined excessively.

At an irrigation application rate of 372 mm or 3.7 ML/ha-yr (365 ML/ha applied evenly across 98 ha) the annual salt input from irrigation is shown in Table 3. The calcium sulphate salts will have a positive effect on soil quality so are not of concern. Annual salt inputs of sodium chloride from 644 mm rainfall are fairly small, estimated to be about 31 kg/ha.[10] Whereas the permeate would add 490 kg/ha sodium and 440 kg/ha of chloride annually.

Table 3 Annual salt loading from 3.7 ML/ha of irrigation water

Salt added (kg/ha-yr)	Amended permeate
Sodium	490
Calcium	190
Chloride	440
Sulphate	0
Bicarbonate	1200
Total salts	**2320**

[8] Dept. Environment & Conservation (NSW).2004. Environmental Guidelines - Use of Effluent by Irrigation. pp 19.
[9] ANZECC and ARMCANZ 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality.Natl Water Qual Mgmt Strategy. Aus & NZ Env & Conservation Council, Agric & Resource Mgmt Council of Aus & NZ.
[10] Biggs, AJW.2004. Rainfall salt loads in southern Queensland, Australia, ISCO 13th International Soil Conservation Organisation Conference – Brisbane, July 2004 Conserving Soil and Water for Society: Sharing Solutions Paper No. 680

A yield of 15 tonnes of dry matter per year should be easily achievable at this site. Based on laboratory work previously performed by BeneTerra, on average lucerne will take up approximately 0.25% NaCl (2,500 ppm) in the dry matter. This equates to approximately 40 kg NaCl/ha-yr removed in the dry matter for the lucerne crop accounting for rainfall accessions plus a small amount of that from irrigation water. Thus it will be necessary to continually move a portion of the salts through and out of the rootzone via leaching – also referred to as deep drainage.

The leaching requirement can be estimated from the following equation:[11]

$LR = EC_w / ((5*EC_e)-EC_w)$

where:

LR = leaching requirement as a fraction of applied water and rainfall

EC_w = the electrical conductivity of irrigation water plus rainfall (weighted average)

For the water plus rainfall EC_w would be 0.4 mS/cm.

EC_e = paste extract electrical conductivity of rootzone threshold for yield suppression

A leaching requirement of 0.05 (50 mm) would be required to maintain the current rootzone ECe and 0.02 (20 mm) would maintain a rootzone ECe of 4.0 mS/cm. Salts leached beyond the rootzone would then accumulate in the vadose at a rate matching the additions from irrigation and rainwater. These salts would gradually leach down toward the watertable, with movement coinciding with flushing events when rainfall and irrigation exceed evapotranspiration and soil water storage capacity. The estimated distance of travel for the leachate from the bottom of the 1.5m root zone to the static water level at 20 m is 18.5 m.

At the estimated volume of leachate produced annually and assuming a vadose water holding capacity of 100 mm/m, and assuming uniform saturated hydraulic conductivity, it would take approximately 80 years for the deep drainage leachate to reach groundwater.

The modelling discussed in Section 9.1.7 predicts deep drainage of approximately 5 mm/yr. The shortfall in deep drainage can be overcome in the irrigation scheduling with good management and precision application irrigation systems (Variable Rate Irrigation VRI on the CPs and the sub-surface drip irrigation system). During periods of low ET an excess LF can be applied in order to achieve the theoretical LF requirement for the year. This can be achieved effectively by monitoring and applying the excess LF every few years as required. The soil will also encounter a large dilution of salinity due to heavy rainfall events. A large percentage of the soils at Leewood (30 ha of Class B) will be leached by occasional overland flow. Modelling indicates that overland flow events occur once or twice per year in most years.

[11] Ayers, RS and DW Westcott.1994.Water quality for agriculture. FAO Irrigation and Drainage Paper 29 rev 1.

6 Soil investigations

It is important to understand the soil qualities prior to designing an irrigation / cropping system. The soil serves as a medium for crop growth, a reservoir for water storage, a source of plant nutrients and a buffer to water and solute movement between the atmosphere and groundwater.

A total of 34 soil profiles were described and sampled by a Certified Professional Soil Scientist and a soil distribution map of the subject site was generated (**Figure 7**). Eighteen of these sites were soil pits dug to 140 cm with an excavator. These were located using topographic position, seasonal inundation maps from the Phase 1 REF[12] and gamma radiometric data as a part of the initial pre-feasibility study. The pits provided a superior means to observe the soil qualities visually (Figure **5**). They were distributed across the property relatively evenly. The pits were sampled and described on 25 April 2013. Then on 11 February 2014, an electromagnetic induction (EM38) survey was carried out providing spatial data on the relative electrical conductivity of the soil (**Figure 6**). The map derived from the EM38 survey was used to assist with delineation of soil property boundaries and location of a further 16 soil investigation sites. On 13 February 2014 these were sampled to a depth of 150 cm using a hydraulic push tube corer.

Field inspection and subsequent characterisation of these soil profiles included:

- Identification and measurement of soil horizon depths
- Observation of soil structure (macropores, cracks, aggregates)
- Observation of plant rooting patterns
- Soil texture estimation (clay percentage)
- Colour determination
- Consistency observation
- Field pH and presence of carbonate

Selected samples from these sites were sent to laboratories for chemical analyses. The analyses included pH, elements of soil salinity, base saturation and fertility.

These assessments provided important insights into the soil qualities of the site, their spatial occurrence, and how these soils might be managed under various irrigation scenarios.

6.1 Soil descriptions

The soils were initially grouped into “soil units” based on similarities in morphology, chemistry and management requirements. Five soil units were defined for the Leewood property. The morphological differences between individual profiles within any given soil unit were very slight (Appendix A), with physical appearances of each unit being well represented by the images in Figure **5**.

- Red Chromosol (1 ha)

[12] RPS. 2012. Leewood – Produced Water and Brine Management Ponds – Review of Environmental Factors. For Santos.

- Brown Chromosol (4 ha)
- Brown Sodosol-transitional (6 ha)
- Brown Sodosol (58 ha)
- Grey/Brown Sodosol (31 ha)

All five soil units shared the characteristics of being loamy and acidic in the surface grading to less acidic below the surface horizon with most becoming near neutral in the subsoil. Plant nutrients phosphorus, potassium and sulphur are marginal to deficient. Phosphorus buffering, estimated from soil type and surface texture, were moderate in the soil surface and high in the subsoil.

The two Chromosol units were only found in the northeast corner of the property and only comprise 5% of the available area. These are friable and moderately to well-drained and would be well suited for irrigation purposes.

The three Sodosol soil units are all very similar, and share the characteristics of being hardsetting in the surface, and having a very hard, coarse and physically constraining subsoil. The subsoil is capped by hard clay columns approximately 10 cm across and 40 cm long. These are characteristic of many sodic soils and create a physical barrier that reduces the options for water and root movement. Root and water movement are strongly preferential, and are concentrated on the edges of these clay structures. Roots generally extended to 140 cm in depth.

The subsoil becomes moderately saline below 50 cm depth; however, this feature will not be a constraint if suitable crop species are grown under irrigation.

Base cation measurements show that the soils are extremely deficient in calcium from the perspective of soil stability. The subsoils are highly magnesium dominated, and magnesium is less able to oppose the destabilising effects of sodium than is calcium. Exchangeable sodium is high, inducing a hardsetting surface, and is causing high dispersibility, hardness and low porosity in the first subsoil horizon of all the Sodosol soils.

Some of the soils also have dispersive properties in the lower subsoil. Exchangeable sodium increases with soil depth, becoming very high in the lower subsoil. However, the dispersion effect of the sodium is offset by the electrolyte effect of the increased salinity, resulting in the soil being more stable at this depth than in the surface layers.

Red Chromosol soil unit (2013 profile 2) - A friable brown loam over a friable red clay loam. Well drained, and chemically and physically amenable to root growth. Approximately 1 ha in area.

Brown Chromosol soil unit (2014 profile 11) - A friable brown loam over a hard brown clay. Moderately drained, and moderately chemically and physically amenable to root growth. Approximately 4 ha in area.

Transitional Brown Sodosol soil unit (2013 profiles 1, 3 and 2014 profile 16) - This unit is very similar to the Brown Sodosol unit for most of its properties (see description below). The soils of this unit were shallower

than the other Sodosol units, with a sandstone parent material encountered at around 120 cm. The soils of this unit also exhibited a very slightly brighter surface colour than the other Sodosol units. Additionally, boundaries derived from the EM38 scan and the surface topography appear to correlate with this unit. Approximately 6 ha in area.

Brown Sodosol soil unit (2013 profiles 4, 5, 7-11 and 2014 profiles 4, 6, 8, 9, 12, 18, 19) - A hardsetting brown sandy clay loam (or clay loam, sandy) over a very hard columnar brown clay. Well drained in the 15 cm or so of loam at the surface, changing sharply to much lower porosity clay upon which water perches for extended periods following heavy rainfall (remaining saturated for several days to a week). Root growth often extends to the full depth excavated, but is restricted by the coarse soil structure and moderate salinity of the subsoil, particularly below 1 m. Approximately 58 ha in area.

Grey/Brown Sodosol soil unit (2013 profiles 6, 12-14 and 2014 profiles 1-3, 5, 7, 10, 13) - Similar to Brown Sodosol unit, but with the following distinctions. Often a thicker surface soil, possibly built up from erosion off the up-slope soils, usually with a distinctly bleached subsurface horizon above the coarsely structured subsoil. The subsoil is grey or grey brown, indicating poorer drainage than the other soil units. However, it appears this is due just to landscape induced inundation i.e. due to drainage line flooding, rather than to lower internal permeability of the soil. Root development and clay structure are similar to the other Sodosols, indicating that the landscape effect is more important than differences in soil morphology. These cover approximately 31 ha in area.

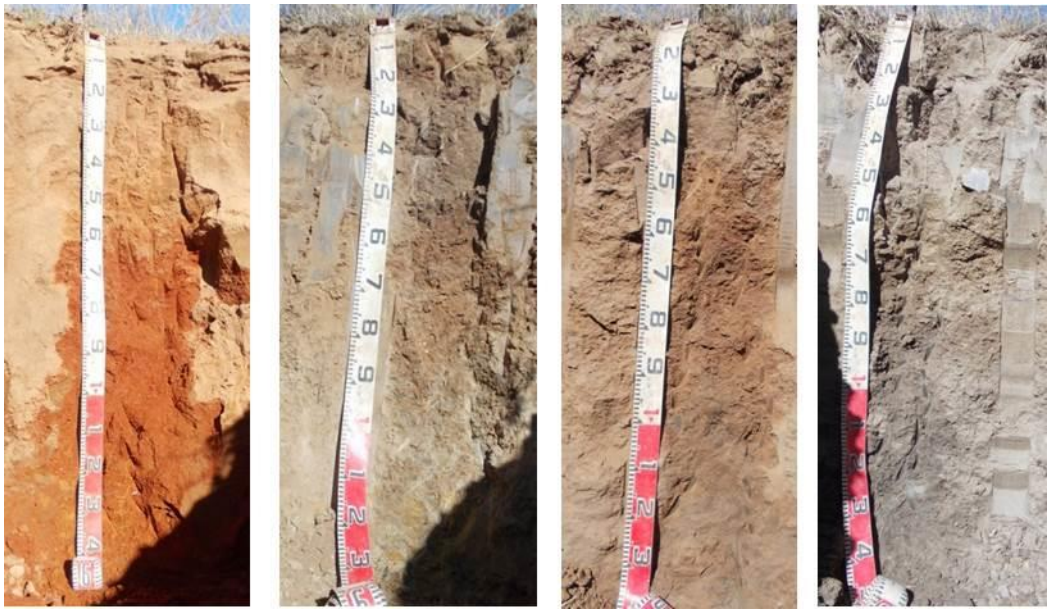

Figure 5 Soil pits with profile examples. L to R Red Chromosol, transitional Brown Sodosol, Brown Sodosol, Grey Sodosol

6.2 Soil classification

The soils of the site were relatively uniform, with the EM38 survey (**Figure 6**) and the new soil core sites confirming the soil distribution estimated from the original mapping process. The majority of the soils were

identified as “Magnesic Mesonatric Grey or Brown Sodosols; medium, non-gravelly, clay loamy/clayey, deep” according to the Australian Soil Classification[13].

The soils in the northwest corner of the property tended to be shallower with most presenting a sandstone parent material within 1.2 m. Only about 11 ha consisted of these soils, with 6 ha of Brown Sodosols, and the remaining 5 ha being Red or Brown Chromosols- “Mottled, Mesotrophic Brown or Red Chromosol; medium or thick, non-gravelly, loamy/clay loamy, deep”.

For the purposes of this irrigation project design the soils on this site were further grouped into two irrigation management classes – A and B. These were differentiated primarily due to their landscape position and susceptibility to inundation.

- Class A soils: Chromosols and Brown Sodosols – more upland soils
- Class B soils: Grey/Brown Sodosols – lower lying soils

[13] Isbell, Raymond. The Australian Soil Classification. CSIRO Pub. Rev. 2002.

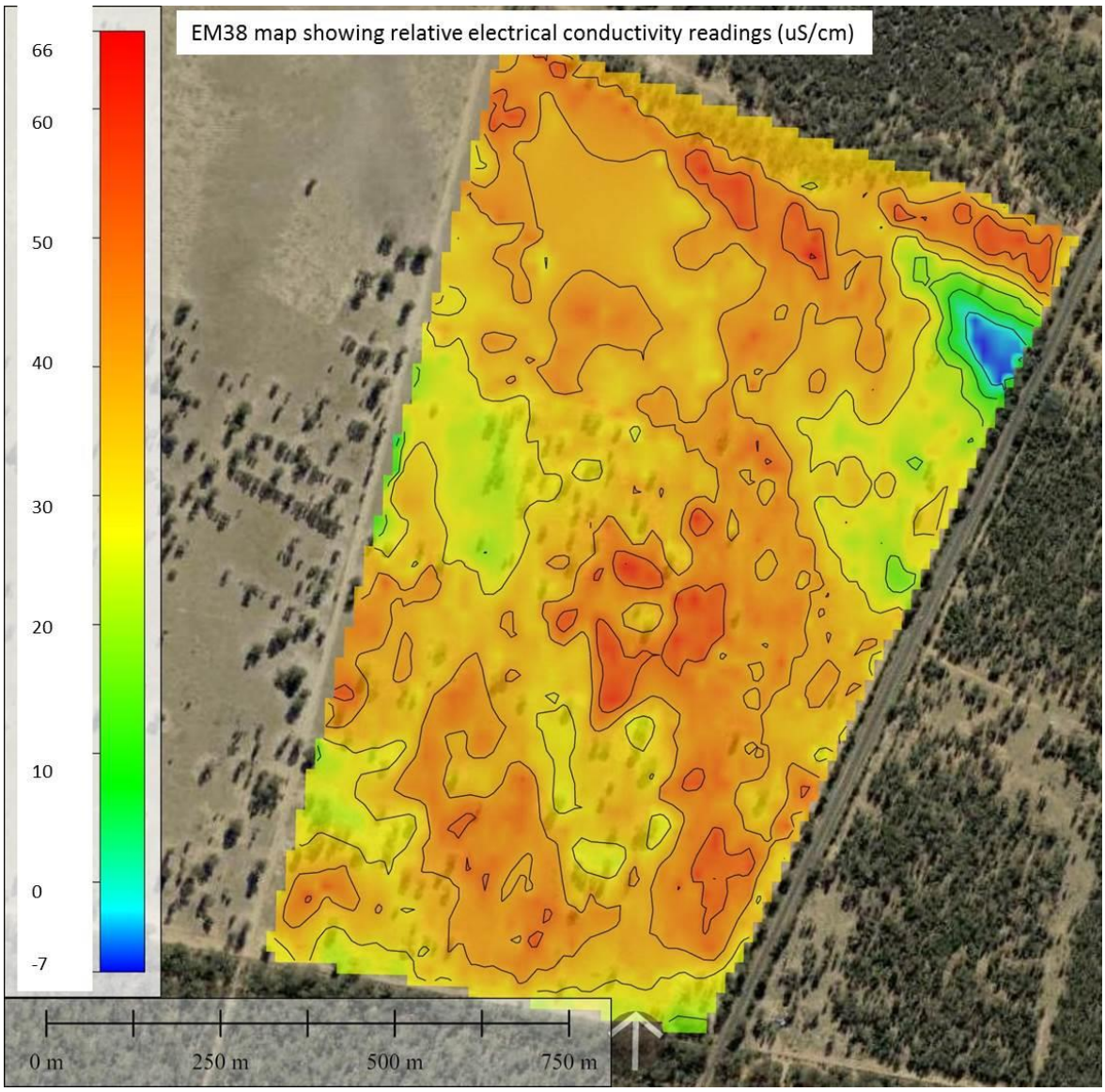

Figure 6 Results of EM38 survey illustrating varying soil conductivity across the project area

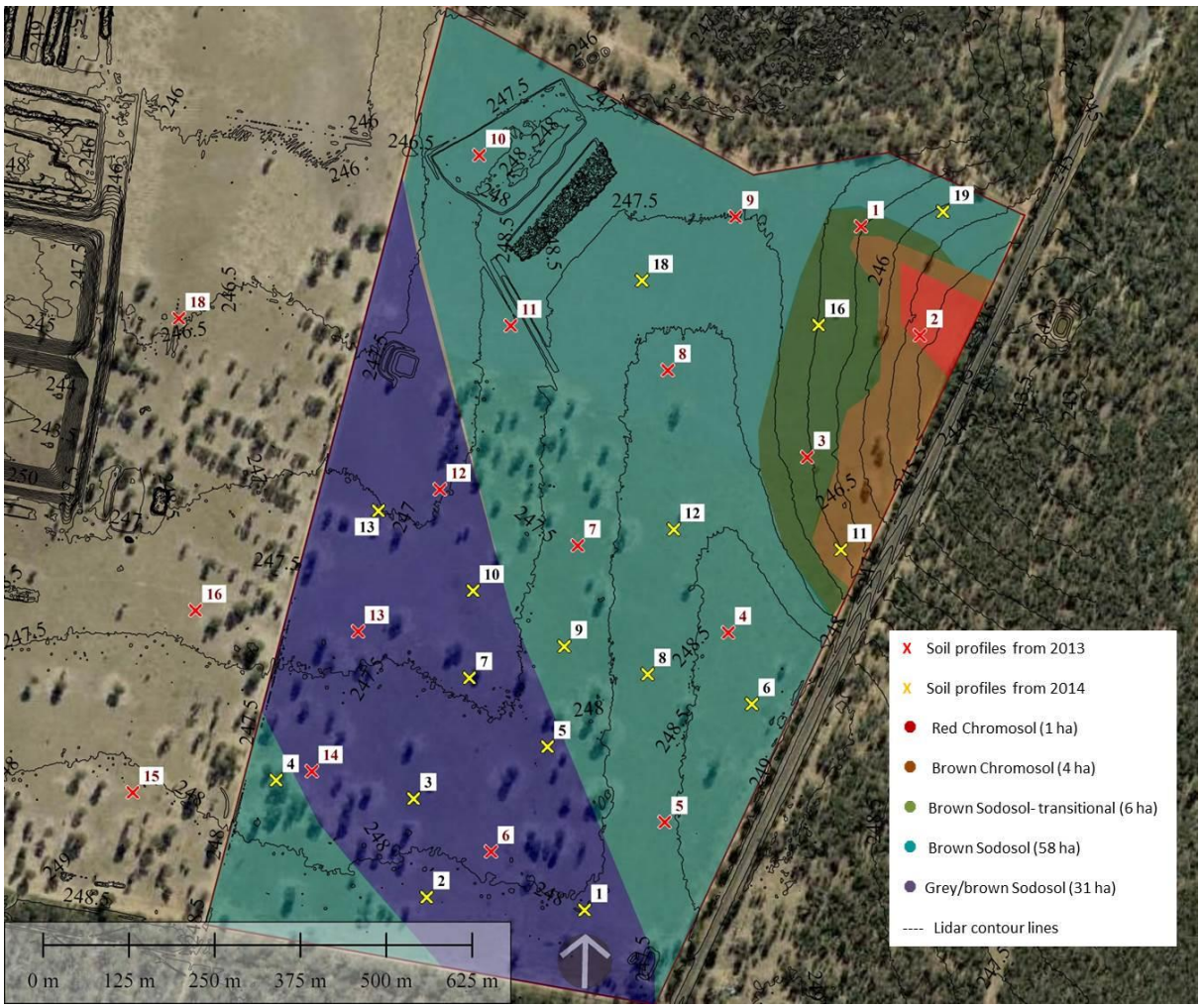

Figure 7 Soil sampling points and soil type distribution across irrigation area

The irrigation system design and operations would treat these as different management zones. Thus irrigation infrastructure, cropping and irrigation scheduling would vary according to the irrigation management class.

6.3 Soil metals

A subset of the soil cores from the 2014 soil survey of the site were analysed for heavy metals, including uranium and mercury. The results of these analyses are provided in Table **12** of Appendix A. The soil profiles selected were selected based on spatial distribution and their representativeness of the more prominent soil units described across the site. The range of depths sampled including from the ground surface to 150 cm below ground level. None of the metals were measured at levels above regulation thresholds.

6.4 Limitations

6.4.1 Soil chemistry

Note that details of soil chemistry for each sample tested can be found in Appendix A. All of the soil units exhibited exchangeable sodium percentages (ESP) greater than 10 in the surface 40 cm (**Figure 8**) which ranks as a "severe limitation" (Table 4). However surface application of gypsum can decrease this limitation to slight or moderate.

The ESP of the deeper soil, 40 to 100 cm, averaged 28% on the soils analysed but is not as critical a limitation as the surface ESP. This restriction can be mitigated through deep incorporation of gypsum into the soil.

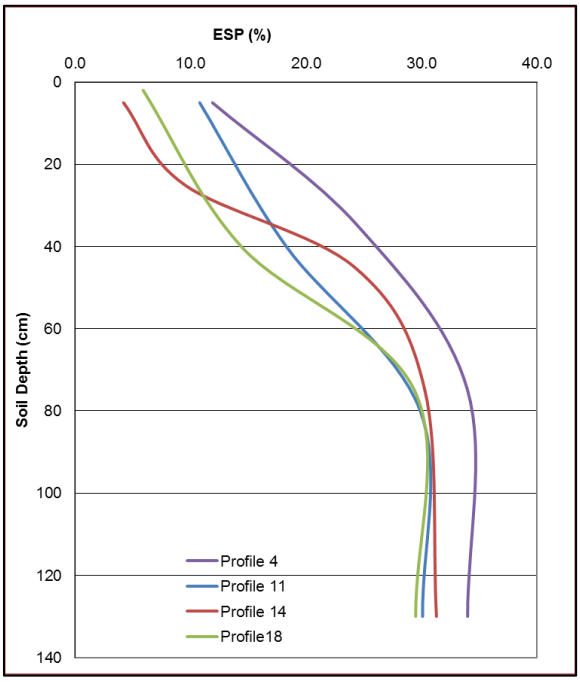

Figure 8 Exchangeable sodium percentage increases by depth until about 60 cm from four representative sampling locations.

Salinity posed a slight to moderate limitation for these soils in the 70 to 100 cm depth zone. However, some healthy roots were observed beyond 100 cm in many of the profiles. There were no indications that the water table or bedrock would be a limitation.

The saturated hydraulic conductivity (SHC) of the subsoil presents the most severe limitation as it would likely be in the range of 1 mm/hr. This contrasts sharply with approximately 20 mm/hr in the surface soil.[14] This can be mitigated through careful irrigation scheduling that fills the surface horizon and allows enough time for that soil water to drain into the subsoil. Soil amelioration techniques such as ripping and injection of gypsum (and possibly organic matter) will improve SHC in the upper subsoil, possibly to as high as 6 mm/hr, reducing this limitation to a moderate level.

[14] McDonald, R., Isbell, RF, Speight, JG, Walker, J and Hopkins, MS (1990). Australian Soil and Land Survey Field Handbook. Goanna Print. Canberra. Australia, pp. 150.

These soils have adequate water holding capacity. The surface pH is acidic (and commonly strongly acidic), but is easily amended with lime. The cation exchange capacity limitation is related to sandy soils and their ability to retain nutrients. This is irrelevant in this case because the soils have high clay content and, unlike most effluent waters, the irrigation source will not be nutrient rich. The site will require the addition of phosphorus (P), potassium (K) and sulphur (S) based fertilisers in order to optimise productivity of irrigated crops.

The second last limitation listed in (Table **4**) relates to dispersibility, a result of sodicity, and is addressed above. These soils have dispersive qualities but amendment with lime and gypsum will mitigate that restriction.

6.4.2 Physical limitations

The key limitations of the site relate to the impeded drainage of the majority of the soils. All the Sodosol units (95% of the area) have coarsely structured, columnar subsoils which will perch water and drain slowly and preferentially (unevenly). The poor subsoil drainage is greatly exacerbated for the 31 ha of grey brown Sodosols that are subject to higher levels of overland flow associated with the drainage line.

The massive (structureless) clay loam and sandy clay loam surfaces of all the soils of the site have particle size distributions that make them highly susceptible to compaction when they are wet. Their lack of shrink/swell capacity also means they have little self-repair potential once compaction has occurred. As the subsoils will perch water, saturation of the surface soil following heavy rainfall is likely to extend for several days to a week after rain/overland flow stops. These drainage/waterlogging related issues will restrict water scheduling options, as well as the trafficability of the site.

6.5 Soil management

These soils are susceptible to compaction and runoff. It will require amelioration by deep ripping and application of gypsum to improve the permeability of these Sodosols. Ongoing calcium additions with irrigation water will assist this process. Traffic on the site needs to be restricted when soils are wet. It will be important to dry the soils out prior to harvest activities. A perennial lucerne crop will be recommended as it will reduce the need for ongoing soil disturbance. The crop will be harvested for hay or silage thus eliminating livestock traffic.

The upper horizons of these soils are acidic to the degree that crop growth would be inhibited. Application of 8 to 10 t/ha of lime will alleviate this problem. The extra calcium from the lime will ameliorate the effects of sodium as well.

Soil fertility will require ongoing monitoring to assess requirements. Initial fertiliser applications include P to address soil deficiencies. This will be followed by annual applications of P and K as necessary to maintain soil levels and replace removals from the crop. Trace elements will be monitored using plant symptoms and foliage analysis. Sulphur will be abundant due to the gypsum application.

Table 4 Range of soil qualities from all described units found at Leewood site and expected effect of amendment (shaded) in reference to Table 2.2 NSW effluent guide.[15]

Property	minimum	Maximum	mean	Limitation rating
ESP (0-40 cm)	10	25	18	severe
ESP (0-40 cm)- if amended	3	10	8	moderate
ESP (40-100 cm)	20	35	28	severe
ESP (40-100 cm)- if amended			na	na
ECe (0-70 cm) dS/m	0.5	1.0	0.8	nil
ECe (70-100 cm) dS/m	3.5	5.5	4.8	slight /moderate
Water table depth	>5 m		na	nil
Depth to C horizon	>1.5 m		na	nil
SHC top 1m (mm/hr)	1	20	na	severe
SHC top 1m (mm/hr)- amended	5	30	na	moderate
PAWC (mm/m)	110	110	110	nil
pH surface	5.2	5.9	5.5	moderate
pH surface- amended	7.0	7.0	7.0	nil
CEC (0-40 cm)	10	16	12	moderate
Dispersion	1	1	1	severe
Dispersion- amended	4	4	4	nil
P buffer	high	high	high	nil

6.6 Soil salinity

The baseline soil paste extracts (EC_e) showed salt content to be relatively low in the upper solum and subsoil. The amended irrigation water will contribute sodium and calcium salts in approximately equal quantities. This combination should ameliorate the effects of dispersion however the EC_e could rise to an inhibitory level if some leaching does not occur.

As mentioned in the NSW effluent guideline, “modelling the movement of salt through the soil is particularly difficult.” Salt accumulation is diminished by applying excess water beyond crop needs – known as a leaching fraction - to encourage downward movement of salts. This is best managed through annual soil sampling, EM38 scans and instrumental monitoring of salt accumulation in the rootzone and beneath (refer to Section 5.4).

The leaching fraction need not be considered just an exceedance of total annual consumption but can be seasonally targeted toward periods when ET is low. The proposed irrigation system would also provide the control sensitivity such that leaching can be targeted to specific areas in need of leaching. It is likely that

[15] Dept. Environment & Conservation (NSW).2004. Environmental Guidelines - Use of Effluent by Irrigation.

leaching fractions need only be applied to Class A soils as occasional inundation of the Class B soils should serve that purpose.

7 Irrigation design

The concept irrigation design (Appendix B) combines two technologies enabling irrigation of 97.8 ha. It employs both a centre-pivot irrigator (CP) fitted with Variable Rate Irrigation (VRI) technology covering 49.5 ha and subsurface drip irrigation (SDI) covering 48.3 ha. This configuration was designed to accommodate the limited space available at the site, the soil intake limitations and the dissection of the Class A soils by the drainage line containing the Class B soils. The dual system will be capable of delivering peak water demand of 12 mm/day across the 97.8 ha. The maximum daily output would be 11.7 MLD. Both systems can be operated simultaneously. The whole system - pump station, irrigation infrastructure and soil moisture sensors would be monitored and capable of being controlled remotely via telemetry or internet connections.

The CP and the SDI systems will be supplied by separate mains and pumps (Appendix B). These need to be separated because of the extra requirements of the SDI system for filtration and disinfection.

7.1 Pump station requirements

It is envisioned that a redundant pump would serve each system (see process flow diagram in Appendix B). Each set of dual pumps would be controlled by a variable frequency drive (VFD) to accommodate the varying flow rates required for sensitive control of water application by management zone. Small jockey pumps would maintain pressure in the lines when the systems were not running to minimise the effects of water hammer on pipelines and protect irrigation infrastructure.

The water supplied to the SDI system should be filtered and disinfected, typically with hypochlorite, to prevent emitter plugging. The system should be capable of injection of sulphuric acid to prevent carbonate accumulation in the emitters.

Provisions should be made for safe storage of acid and chlorination products. Specialised injection pumps would also be employed along with a static in-line mixer. Chemicals would be injected prior to filtration.

The pumps supplying the CP system do not require the same level of variable flow control as the SDI system. Some level of filtration should be provided to prevent nozzle clogging but a coarser hydraulic screen-type filter can be utilised.

7.2 Centre-pivot features

The CP system (Table **5**) will cover 49.5 ha - traversing 42.2 ha of Class A soils and 7.3 ha Class B soils. The design flow rate will be 248 m^3/h with an instantaneous application rate of 50 mm/h under the outer span. The variable rate system can be programmed to modulate the application rate by pulsing flow to the nozzles via on-board solenoid valves. As the CP travels over Class B soils the selected nozzles can be programmed to deliver less water or none at all. This technology makes it possible to decrease the output in any area under the CP and will be especially useful in areas where runoff has the potential to occur.

Table 5 Centre-pivot features as per concept design (after WaterBiz)

Centre-pivot feature description	Specification
Radius (m)	397
Number of spans	8
Span lengths (m)	49.1
Span diameters (mm)	168/219
Overhang (m)	4.2
Area (ha)	49.5
Centre pressure (m)	30
Total dynamic head (m)	55
Nozzles	Rotators
Spreader bars	Yes
3-wheel base beams outer spans	Yes
Maximum IAR (mm/h)	50
Gross design capacity (mm/day)	12
Flow rate (m^3/h)	248

7.3 Subsurface drip irrigation features

The SDI system (Table **6**) will cover 48.3 ha in total – 25.7 ha of Class A and 22.6 ha of Class B soils. The SDI system makes it possible to irrigate corners and odd-shaped parcels. Small individualised management zones (blocks) will be assigned to Class A and B soils for fine control of water placement.

The design breaks the SDI system into 13 blocks with average cover of 3.7 ha. Seven of which irrigate Class A soils and six irrigate Class B soils. Each block will be controlled separately with electric/telemetry controlled, adjustable, pressure reducing valves. Maximum flow capacity of the SDI system will be 240 m^3/h and would be capable of supplying 12 mm/day across the entire irrigated area.

The drip tubing laterals would be of medium wall thickness with pressure compensating emitters spaced at 50 cm. The laterals would be buried 30 cm deep and spaced 100 cm apart.

Table 6 Concept design of subsurface drip irrigation system (after WaterBiz).

Subsurface drip irrigation system feature	**Specification**
Lateral spacing (cm)	100
Emitter spacing (cm)	50
Emitter type	Pressure compensating, medium wall thickness
Number of blocks	13
Operating hours per day (h)	24
Shifts per day	4
Total area (ha)	48.3
Gross design capacity (mm/day)	12
Application rate (m^3/h)	240
Flow per shift (m^3/h)	240
Avg valve pressure (m)	12
Total dynamic head (m)	50

8 Land preparation

The proposed irrigation site on the Leewood property is prone to becoming waterlogged in the surface soil and untrafficable following extended rainfall periods, i.e. periods where continuous rainfall events exceed 50 mm. The land preparation operations will be restricted during these periods.

8.1 Land clearing

Approximately 150 scattered remnant woodland trees occur on the site. All of the trees will require removal where the irrigation systems are to be located. A tracked excavator will be used to push out the trees, grub out the roots, level the soil, and place the trees into piles or windrows. This process will involve the excavator travelling to each tree, pushing it out with the bucket/grapple attachment, and carrying the tree to a disposal pile. Limbs and branches will be cleaned up using a stick rake, and placed with the tree remains outside the irrigated areas and traffic ways. The stacks can be left in place or mulched.

8.2 Soil preparation

The majority of the soils of the property are sodic and dispersive, particularly in the subsoil. This has resulted in the formation of hard, capped, columnar structures at a depth of around 15 cm below the soil surface. If the site is to be irrigable, these poorly draining structures need to be broken down and stabilised. The stabilising of the soil requires a high application of gypsum to displace the sodium in the soil.

8.2.1 Gypsum and lime

In order to displace the majority of the sodium[16] within the upper rootzone of the soil, we calculated[17] that 20 tonnes of gypsum be applied per hectare. Gypsum is far more efficient in reducing sodicity and dispersion if it is worked into the affected parts of the soil. Initially 15 t/ha of the gypsum is to be spread across the site prior to any tillage operations. This will be achieved using a truck mounted agricultural lime/gypsum spreader. The subsequent cultivation will result in some of the gypsum being worked deeper into the soil profile. The remaining 5 t/ha of gypsum is to be spread following discing to ensure the surface soil is evenly covered and so less prone to surface crusting. Finally lime would be applied at a rate of 8 t/ha as the final surface dressing to neutralise the soil acidity. The additional calcium will also ameliorate sodium, and has been subtracted from the gypsum requirement. Lime is a sparingly soluble salt, and any that doesn't participate in soil reactions can be expected to be retained within the surface soil for the long term. Gypsum is more soluble than lime, but is also a slow moving salt through the soil profile and vadose. Some gypsum will be used in cation exchange reactions. Unreacted gypsum is likely to remain within the rootzone for many decades.

8.2.2 Deep ripping

Deep ripping using a large bulldozer or tractor capable of pulling a series of deep tynes will be undertaken in order to break up the hard, coarse subsoil. Ideally, this operation will take place when the soil is relatively dry so as to maximise the shattering effect of the tynes. The primary root zone of the soil extends to around 100 cm depth, and ripping to most of this depth will be advantageous. A minimum depth of 60 cm, and tyne spacing of less than 100 cm is recommended. If the initial ripping operation is either too

[16] Sodium in the soil leads to clay dispersion and reduces a soil's porosity and capacity to drain freely

[17] Based on inherent fertility of the soil, soil density, exchangeable sodium displacement, depth of treatment, gypsum quality

shallow or too widely spaced due to the hardness of the soil, it is recommended that cross ripping at a depth greater than 60 cm be undertaken.

8.2.3 Cultivation

Following the deep ripping, the soil will be left in a very rough state, with large clumps of soil and subsoil thrust up onto the surface. Offset discs will be run across the site in various directions as needed to level the soil and possibly harrowed to produce a tilth suitable for sowing. Once the site has been ripped and cultivated, irrigation infrastructure will need to be installed in quick succession so as to minimise the risk of interference from wet weather. The ripped soil will initially be prone to bogging once it is wetted.

8.3 Irrigation systems installation

8.3.1 Pump station and main lines

It is best to install the pump station and mainlines feeding the system prior to installation of the in-field irrigation infrastructure. This allows for testing of the system as it is built or shortly thereafter.

There will be two mains leading from the pump station because of the need to treat the water in the SDI system differently. These along with necessary wiring/telemetry should be laid and capped at the edge of the paddock until the CP and SDI are ready for connection.

8.3.2 Centre-pivot sprinkler system

The centre-pivot should be erected once the paddock has been disced. The various components would arrive on a B-double semi-truck and offloaded with a telehandler and then laid out across the paddock. The spans would be assembled and erected with the same telehandler supported by two utility vehicles carrying tools and personnel. Care should be taken when driving equipment on the soft ground.

Once erected and the wiring is completed, several dry runs of the circle should be completed to create tracks. Shallow trenches should then be cut in the tracks along those areas likely to be inundated and on slopes. A layer of rock should be laid in the tracks to aid in traction and prevent the machine from getting stuck.

8.3.3 Subsurface drip irrigation system

There are a number of mains and sub-mains associated with the SDI system. Some of the mains can be installed prior to laying the drip tubing laterals and some would be installed afterwards. All of the work would be done after the last discing. All of the materials would arrive on two semi-trucks – one carrying pipe and the other carrying drip tubing for laterals. Workers would utilise as many as two ATVs and three utility vehicles.

A tractor will install the SDI laterals at a depth of 30 cm and spaced 100 cm apart. Depending upon the equipment available as many as eight laterals can be installed in a single pass. Once the laterals are installed the trenches for the header and flush manifolds are cut through the tag ends of the laterals and connected. The complete installation should take 60 to 90 days.

After installation of the SDI system the paddock will likely require a light discing or harrowing to smooth the soil from the disruption created by installation. An SDI system has thousands of connections and some

failures are inevitable. The best time to locate these is while the land is bare so the system should be tested thoroughly as construction progresses if possible and definitely post construction prior to seeding.

8.4 Crop establishment

It is best to sow into a firm seedbed thus it may be helpful to pre-water the area under centre-pivot lightly. It may also be helpful to run a packing implement across the paddocks to firm the soil particularly where SDI was installed. The SDI system will require testing and this offers the opportunity to wet the upper rootzone and as close to the surface as possible.

Although the paddock has been in pasture for some period there still may be a case for application of a pre-emergent herbicide depending upon the time of year that sowing occurs. An agronomist should make that assessment prior to ripping and other cultivation.

8.4.1 Seed selection for upland Class A and lowland Class B soils

A lucerne variety suited to local conditions and heavy soils should be selected.

Some desirable qualities of the selected lucerne seed variety for Class A soils include:

- winter active to encourage year-round water consumption
- broad disease resistance
- inoculated with Rhizobium
- fungicide treated seed
- tolerant of sodic soils
- potentially high forage production and water use
- drought resistance

Other desirable qualities of varieties and species (lucerne and/or clover/grass mix) for Class B soils include:

- deep rooted
- tolerant of waterlogging
- compatible species in terms of competition and growth habit

8.4.2 Sowing

It is important to ensure firm seed to soil contact. A seeding drill outfitted with packing wheels serves this purpose best. When blending grasses with lucerne it is best to use a seeder with multiple seed boxes. BeneTerra has been successful planting mixed species in separate rows – often in pairs to minimise competition between the species.

The Class A soils are found on the more elevated parts of the landscape, and due to their favourable surface drainage they will be planted to lucerne only at a seeding rate of 15 kg/ha. The Class B soils are confined to a drainage depression that can be periodically inundated by overland flows. Consequently, they will be seeded to a blend of lucerne (10 kg/ha), white clover (2 kg/ha) and tall fescue (20 kg/ha). Seed will be coated with an insecticide and a fungicide to ensure viability. Where only lucerne is grown there may be an advantage to cross-seeding to maximize ground coverage. The seed should be placed only 10 to 15 mm deep.

Timing prior to rain is most critical for the drip irrigated areas. The soil can be wetted up with the SDI system but it requires rainfall to complete germination.

Crop under the centre-pivot can be pre-irrigated prior to sowing to wet the upper 30 cm. Then once the seed is sown it can be lightly irrigated to encourage germination. Surface crusting will inhibit seedling emergence so heavy irrigation must be avoided at that time.

The crop can be seeded in either autumn or spring. If planted in autumn it should be done early enough to allow seedlings time to mature adequately to withstand frost.

Once the crop is growing and in a tender state it should be checked frequently for insects and mites then treated if necessary. There also may be a need to apply a post-emergent herbicide as weeds will compete with the young seedlings.

9 Water balance modelling

9.1 Gross water balance estimate

The water treatment plant is expected to produce 1 MLD of high quality irrigation water at peak production, i.e. 365 ML/yr. Based upon the annual production of desalted irrigation water and the 98 ha land area under irrigation, the gross annual application rate would be 3.7 ML/ha. However in order to better predict the effects of irrigation of this site several management schemes were modelled for comparison to the current rain fed pasture setting.

In order to get a more detailed and time sensitive understanding of the water balance we employed the HowLeaky modelling program which integrates a variety of factors (Figure **9**) such as historic climate data, rainfall, evaporation and evapotranspiration, irrigation, soil infiltration rates, plant available water capacity of soils and crop water consumption.[18] This daily time step model incorporated a given set of criteria – climatic year or average, crop, soils, etc. and the output predicted:

- Crop water consumption
- Losses from the system
- Irrigation schedules

9.1.1 Climate data

The BOM climatic data set for the 50 years spanning January 1963-April 2013 from the Narrabri post office [station 053030] was used as the basis for rainfall and evapotranspiration (ET) input in the HowLeaky modelling simulations.

[18] McClymont et al. 2011. HowLeaky v 5.47. Available from http://www.howleaky.net/

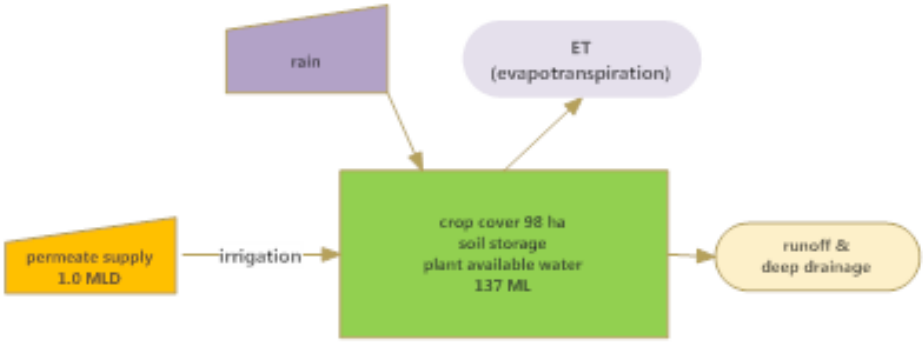

Figure 9 Simple flow diagram of water balance model

9.1.2 Soil considerations in the model

A Sodosol database was used to provide the soil data for the irrigation modelling. The key parameters used in the model were:

- 140 mm plant available water capacity (PAWC) of the soil profile
- 1.5-1.6 g/cm^3 bulk density
- 0.5% slope
- 0.3 mm/day maximum drainage beyond the rootzone

9.1.3 Cropping: Two choices - uplands and drainage depression

Lucerne was the chosen crop for modelling purposes. It is well-suited because it is perennial in nature and does not require annual planting and soil preparation, nor is there a delay for root development in the early growing season. Thus it essentially has a longer growing season than most crops and while it can withstand periods of drought, it will consume large amounts of water if available. Lucerne is the preferred choice for the upland areas where inundation is not expected. For the periodically inundated drainage depression associated with the Class B soils, a blend of fescue, white clover and lucerne would be used. The fescue and clover will compensate for the lucerne should it underperform due to sustained wet conditions. This cropping scenario was not differentiated for modelling purposes because mixed lucerne/clover/grass crops have similar water use patterns.

9.1.4 Land area

For modelling purposes the irrigation system covered 98 ha. Centre-pivot or SDI were not differentiated and the system was capable of delivering 12 mm/day across the land base with an average application efficiency of 90%. There were:

- 68 ha Class A soils under irrigation
- 30 ha Class B soils under irrigation

9.1.5 Irrigation rate scenarios

Three irrigation scenarios were modelled using the HowLeaky model for the purposes of this report. Specifically these scenarios were chosen to estimate the effects of irrigation on runoff, erosion and deep drainage compared to the native setting. Actual management practices would take this into account and timing adjusted according to irrigation water requirement and soil water status.

- ***Scenario 1*** Current dryland pasture under natural rainfall. This was simulated to compare the natural erosion, deep drainage and runoff from the site
- ***Scenario 2*** Even irrigation of all 98 ha, simulation based on an average year with 1 MLD permeate supply
- ***Scenario 3*** Even irrigation of all 98 ha, simulation based on an average year with unlimited permeate supply
- ***Scenario 4*** Irrigation was split between the Class A (68 ha) and B soils (30 ha), with priority given to watering the Class B soils from October to May, and no irrigation of the Class B soils from June to September. 1 MLD permeate supply

Irrigation events were set at 12 mm per application. An irrigation event was triggered once the soil water deficit reached 50 mm or 36% of the 140 mm PAWC.

9.1.6 Model predictions – irrigation application rate

Scenario 1 was not relevant to application rate because it only represented the current rain fed pasture situation and no irrigation was imposed. The irrigation schedule in the model was set to a maximum of 12 mm per daily irrigation event, as per the irrigation system design.

Under conditions of Scenario 2 irrigation supply to the crop was limited due to available permeate supply being capped at 1 MLD, climate, crop water demand and soil moisture status. Based upon the input conditions the model predicted that a total of 234 mm (2.3 ML/ha-yr) or 225 ML (62% of supply @ 1 MLD permeate) could be applied and utilised by a lucerne crop across the 98 ha. Effectively, providing 1 ML/day permeate supply for irrigation results in approximately 131 days with no irrigation for this scenario due to a combination of crop irrigation demand outstripping permeate supply and due to wet periods of the year. Essentially, the Class A and B soils will hold similar amounts of water under the same climatic conditions and were treated the same for modelling purposes where the entire 98 ha were modelled.

Under conditions of Scenario 3 irrigation supply to the crop was unlimited, however, governed by climate, crop water demand and soil moisture status. Based upon the input conditions the model predicted that a total of 920 mm (9.2 ML/ha-yr) or 902 ML could be applied and utilised by a lucerne crop across the 98 ha. Scenario 3 shows the maximum irrigation rates that can theoretically be applied to the soils on site. It illustrates that the total annual permeate production can easily by utilised at this site through proper management.

Scenario 4 prioritises irrigation of the Class B soils (**Figure 10**) between the months of October and May while no irrigation occurs on those soils between June and September when evapotranspiration (ET) is low and the soils are most susceptible to overland flow from high rainfall. Conversely, the Class A soils are irrigated only if water availability is in excess of Class B requirements. Thus there is a sharp increase in irrigation in June as the Class B soils are not irrigated and the high Class A soil water deficit is finally quenched.

Under Scenario 4, the model predicted that splitting and prioritising the irrigation events resulted in 5.1 ML/ha-yr applied on the 30 ha of Class B soil and 2.4 ML/ha-yr on the 68 ha of Class A soil for a combined total of 316 ML/yr across the site– 87% of production. The weighted average water use was calculated as 3.2 ML/ha-yr for the full 98 ha crop. The reduced rate of 2.4 ML/ha-yr on Class A soils is a result of insufficient supply and wet periods resulting in reduced irrigation rates.

Although this appears to be a high application rate for the Class B land it illustrates that when the Class B soils received priority during the periods of the year with the highest ET, these soils can handle additional

irrigation in the profile. Furthermore there is ample capacity for the Class A soils to receive more irrigation than was provided in the model output.

Scenario 4 would be a potential management approach for this project, i.e. irrigate the Class B soils preferentially as they may not be available through parts of the year. This creates a larger deficit or potential reservoir to be filled in the Class A soils as illustrated by the spike in water usage when the Class B soils are not irrigated in winter.

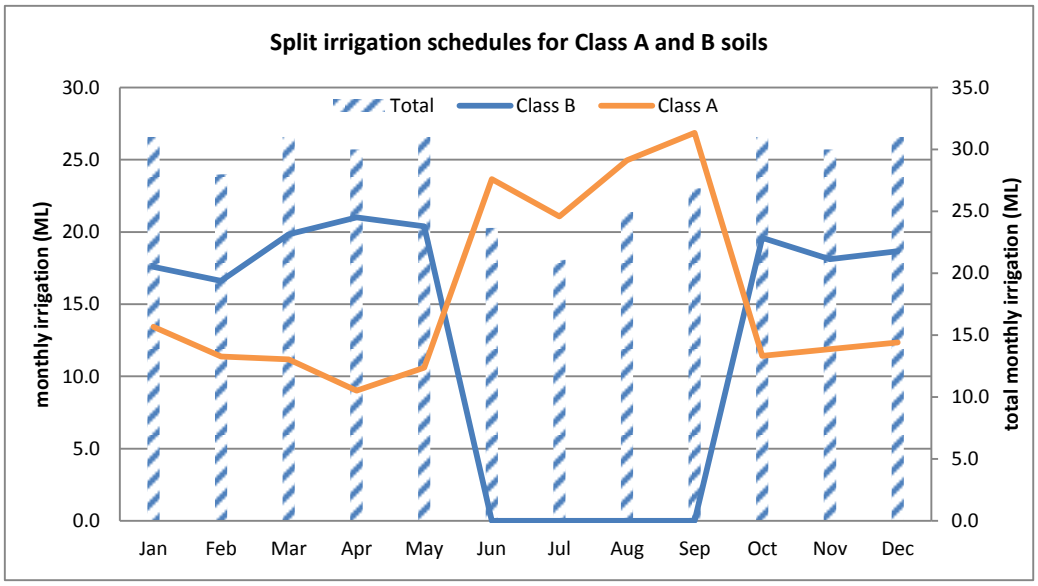

Figure 10 Effect of supply on average monthly irrigation – Scenario 4

At peak water use a lucerne crop can utilise as much as 9 mm/day, and without rainfall input one day's demand in summer could reach 8.8 MLD or 8.8 times the supply rate of 1 MLD. Consider that the plant available soil moisture storage capacity across the entire irrigated area is 137 ML (140 mm x 98 ha), and that in summer a full soil profile could be entirely depleted in 15.6 days. It would require 137 days permeate production to replenish that volume of soil water. In contrast, the winter crop demand can be less than 1 mm/day and permeate production would well exceed irrigation demand.

These modelled application rates reflect what may be possible under "average" climate and ideal crop production conditions. It should be noted that the results from the modelling vary considerably based on limited or unlimited permeate supply, climate, crop water demand and soil moisture conditions. There are many variables that contribute to the crop water use throughout a single season, including the management of the crop and irrigation.

It should be reiterated that the modelled scenarios are purely illustrative. Through a combination of management practises employed (crop management, irrigation scheduling, inter alia), the 98 ha of irrigation area is sufficient to deal with the suggested 1 MLD permeate supply. As shown in Scenario 3 above, the soil and crop will handle a much larger permeate production rate under the correct management and scheduling.

9.1.7 Water and soil losses to system

Three parameters having potential environmental impacts were modelled. These results (Table**7**) compare what may occur under current pasture conditions with natural rainfall against the three irrigation scenarios modelled.

Table7 Water losses from system with potential environmental impacts - HowLeaky model output

Water Loss Mechanism	**Scenario 1 -pasture**	**Scenario 2 – limited 1MLD**	**Scenario 3 – unlimited**	**Scenario 4 Class A**	**Scenario 4 Class B**
Rainfall (mm/yr)	644	644	644	644	644
Irrigation (mm/yr)		230	920	240	510
Runoff (mm/yr)	14.2	13.5	39.6	14.6	17.6.
Deep drainage (mm/yr)	4.0	3.9	16.9	4.3	5.7
Erosion-& site sediment loss (t/ha-yr)	0.22	0.22	0.70	0.24	0.30

Runoff modelled for Scenario 1 was 14.2 mm/yr. The greatest runoff was modelled under the split irrigation (Scenario 3) at 39.6 mm/yr, mainly because of the high irrigation volume applied. As rainfall occurs the soil becomes more prone to run off. Irrigation Scenario 2 lost 13.5 mm/yr to runoff. Scenario 4 showed 14.6 and 17.6 mm/yr of runoff for Class A and B soils respectively.

Deep drainage is primarily a concern where groundwater may be affected by irrigation activities. Deep drainage losses followed the same pattern as runoff with Scenario 3 at 16.9 mm/yr, Scenario 4 Class A soil at 4.3 mm/yr, Class B losing 5.7 mm/yr, Scenario 2 at 3.9 mm/yr and Scenario 1 at 4 mm/yr. Refer to Section 5.4 for a general discussion on deep drainage and leaching fraction.

Erosion and site sediment losses can affect surface waters carrying sediment and nutrients into rivers and streams. Under all four scenarios the paddocks were in permanent vegetative cover and the losses were predicted to be quite low at less than one tonne per hectare annually. The International Erosion Control Association best practices manual states that erosion losses less than one tonne per annum are a desirable target and should result in less than 50 mg/L suspended solids which is necessary for maintaining pristine rivers and streams.[19]

[19] IECA Best practice erosion and sediment control manual Vol 1. pp 1.7

10 Operations and maintenance guidelines

It is important that the mechanical irrigation infrastructure is well maintained to ensure the viability of the water dispersal system. All of the equipment must be kept in proper working order.

It is perhaps more important that a healthy crop is ready and able to reliably utilise the available water. It is easier to repair mechanical problems in a timely fashion than to recover from a crop failure. Expert agronomic advice will help to ensure successful cropping.

Detailed standard operating procedures should be written or adapted to cover all aspects of operations and maintenance. Specific preventive maintenance programs for each bit of equipment should be developed or adapted. Operations personnel should be trained in the routine operations and maintenance of these systems and the appropriate experts should be utilised for other key aspects. Examples of outside experts would include electricians, agronomists, soil scientists, chemists and irrigation engineers.

10.1 Irrigation systems

The irrigation system infrastructure consists of pumps, filters, pipelines, valves, centre-pivot sprinkler and a subsurface drip distribution network. Some companies choose to manage the water amendment facility as part of the water treatment system separate from the irrigation system. BeneTerra typically manages the water amendment facility as an integrated part of the irrigation system. Either approach works but the former approach requires close communication with the irrigation managers for a successful outcome.

Most functions of the irrigation system can be monitored electronically through a variety of market-available SCADA systems. Remote control and data tracking options are recommended.

It is also important to create and maintain an accurate set of as-built drawings for the entire system. These are especially critical when problems occur so that isolation valves can be found or work-arounds can be created in order to continue operations while awaiting repairs to parts of the system.

10.1.1 Water amendment

The water amendment would be adequate to decrease SAR to between 4 and 5 and raise EC to approximately 1.0 mS/cm. The water can be amended by injecting the required chemicals directly into the lines feeding the irrigation system, but prior to any filtration. Some pH neutralisation with acid may be desirable depending upon the alkalinity of the permeate water. Chemical treatments required for subsurface drip irrigation (SDI) need to be considered at this stage to avoid potential blockage of emitters and maintain the structural integrity of the soil profile over the life of the project.

A disinfectant would be injected into the water entering the drip irrigation system to prevent biofouling and emitter plugging.

Water amendment facilities require diligent attention as there are potentially dangerous and corrosive materials involved. Another challenge relates to the limited solubility of some chemicals. If chemicals are not fully dissolved suspended particles may plug filters and drip emitters or collect in areas of slow water movement. The quality of the materials used must be checked regularly. Mixers, pumps, sensors and other related equipment must be maintained regularly.

10.1.2 Pump and filter station

Two sets of variable speed, centrifugal pumps (with built in redundancy) will supply separate mainlines for the CP and the SDI. The centrifugal pumps should be regularly inspected and maintained according to the manufacturer's recommendations. Tracking of amperage on each pump will provide a record of pump wear and indicate when replacement or repair may be needed.

Each centrifugal pump and jockey pump will have an associated Y-strainer filter on the intake side which must be periodically cleaned and maintained according to the amount of suspended solids in the incoming water.

The water going to the CP will pass through a rotating mechanical screen before going through the field main. While the water going to the SDI will require finer filtration (≈120 microns) and disinfection.

Filter banks require constant monitoring. Differential pressure will indicate the need for backwashing the filters and decreasing time between backwashes is an indicator of when the filters require cleaning.

The chemical injection system is typically monitored and controlled by EC, pH and sometimes ORP probes downstream of the injection point. These probes require regular calibration and cleaning and should be part of a regular maintenance program. The volume of injectate should be tracked and recorded along with influent water quality. Influent and amended water should be analysed on a regular schedule by both an in-house and outside laboratory.

10.1.3 Pipelines, valves and flow sensors

Each of the mains leaving the pump station would be outfitted with a flow meter that measures both flow rate and total volume. These sensors should be cleaned and maintained regularly. The frequency of maintenance will depend upon the nature of the incoming water and the meter design.

The flow meters on either main would be used in the pump station logic to ramp up line filling and detect leaks or line breaks. Excessive flows will trigger the pumps to shut down. Smaller increases in flow rate will indicate smaller, less obvious leakage. Constant flow monitoring of the SDI system will indicate emitter plugging and the need for system flushing or other remediation to maintain emitter flow.

Mains and sub-mains should be inspected regularly by the operators for leaks. These are most likely to occur at junctions and corners. The system will have a series of isolation valves that should be checked on a regular basis to assure that they function as intended. There will also be pressure reduction valves located throughout the system that require checking and calibration on a regular schedule.

It is also anticipated that electrical supply and control wires would follow the mains, unless a telemetry control unit is installed. This utility corridor should be inspected for burrowing animals or anything else that could intersect and damage these wires.

10.1.4 Centre-pivot system

Centre-pivots require regular inspection and maintenance. On a more frequent basis (daily or weekly) this would include, visual inspections of sprinkler nozzle plugging, track erosion or runoff. The variable rate solenoids controlling nozzle output will require regular testing as well. Gearboxes and wheel drive motors

will require at least annual maintenance. Cables should also be inspected for damage from wildlife. The steel structure should be inspected for corrosion at least annually.

The travel and output of the CP should be tracked remotely and daily inspections of its progress should be made. It will be important to ensure that the variable rate is applied properly to Class A and B soils. Catch can (rain gauge) tests should be performed to test the CP outlet under various settings of the VRI to ensure adequate control for sensitive areas.

10.1.5 Subsurface drip irrigation system

SDI systems are not visible from the surface so a combination of methods are used to inspect them. The first is daily review of electronic records for each block to ensure that the target volume was applied and at the correct nominal design rate. Initially each block should be run separately to ascertain the nominal flow rate and then tracked. These rates will decline over time and indicate the need for flushing. Increased flow indicates leaks in the system.

Regular field inspections should be done to check for leaks, evenness of irrigation (as evidenced by the crop health), burrowing animals, and access to isolation and block control valve operation. Tests for disinfectants should be carried out at the distal reaches to assure adequate disinfection throughout the system of pipes and laterals. A regular flushing schedule should be developed to remove sediment from the SDI lateral tubing. Initially this should be at least every 8 to 10 weeks but can be adjusted based upon experience.

10.1.6 Recordkeeping

It is important to keep certain records. These assist with environmental reporting, troubleshooting and hand-over between employees.

Records should be kept for:

- Water volume applied through each system
- Nominal flow rate by SDI block
- Amendments used and concentration as evidenced by sensors and field tests
- Filter backwash and cleaning intervals
- SDI flushing events
- Repairs to the system
- Weather
- Equipment maintenance records
- Changes in irrigation programs
- Water analyses

10.2 Crop Management

10.2.1 Early crop care for two land classes

It may be necessary to apply both pre and post-emergent herbicides if weed infestations are imminent. The young seedlings should be inspected frequently by a qualified agronomist for insect and mite predation. If this occurs the paddocks should be treated with an appropriate insecticide.

It is anticipated that the lucerne stand on the upland Class A soils will be viable for five to seven years before it needs to be rotated out of and back into lucerne. Typically there is one growing season between lucerne crops where another crop is grown. This timing will be dependent upon successful selection of varieties, soil preparation and how well the crop is managed in general. It is best to rotate and re-establish portions of the paddocks in phases to ensure there is always a crop to use the available water supply.

The blend of species on the lowland Class B soils will likely change due to ensuing weather and degrees of inundation. The white clover and tall fescue will be more likely to succeed if inundation is prolonged. Paddocks with this blend can stay in production for decades depending upon the degree of waterlogging or weed infestation. A wait and see approach should be used before planning rotations on the Class B soils.

10.2.2 Irrigation scheduling

The irrigation schedule will be driven by crop water demand and availability of permeate water. The HowLeaky model parameters were set so that irrigation would only occur once a 50 mm soil water deficit occurred and that only 12 mm would be applied in an irrigation event. A proposed scheduling strategy could be similar to that in Scenario 4 where the Class B soil deficit is replenished before Class A soils, or a combination of all four scenarios based on monitoring results. This makes room for the maximum irrigation inputs throughout the year.

In reality these parameters may represent average conditions for irrigation but other extenuating factors may override this. For example the modelled rate of permeate production was a peak target that may not be reached. In that case it may be necessary to give Class A soils priority to maintain them in a healthy condition. Crop management is another variable that will influence the irrigation scheduling.

An onsite weather station will record rainfall, temperature, solar radiation and wind speed. The collected data will calculate evapotranspiration (ET) in real time for that location.

Soil moisture monitoring devices should be placed one for every 10 ha and the data collected and reviewed weekly against the weather station data. The soil moisture data collection should be supplemented by spot checks with a hand auger. Then irrigation rates should be adjusted by soil and crop type as often as necessary to optimise crop health and water use.

Some of the soil moisture monitoring devices will also be placed at least 150 cm deep to estimate root uptake of deep moisture and deep drainage.

10.2.3 Agronomy

A healthy, actively growing crop is required to utilise the produced water. Crop failure puts the whole system in jeopardy. Therefore it is important to optimise the agronomic care and inputs necessary. Regular field inspections by a qualified agronomist will enhance the likelihood of success.

The crop should be inspected for weeds and insects at key intervals and appropriate treatments recommended. Irrigation distribution can be spot checked at the same time. Leaf and forage analyses should be performed occasionally to assess plant nutrition.

The agronomist should also make recommendations for harvest timing. This should optimise forage quality but more importantly minimise soil compaction and weed distribution. The agronomist would also make recommendations for the crop rotation sequences suitable to the goals of the project.

The surface 15 cm of topsoil should be sampled annually and the soil analysed for nutrients and salinity. This data will provide the basis for ongoing fertiliser and amendment applications. Subsequent deeper soil analysis to at least 100 cm should be done to assess the success of the soil amelioration program.

10.2.4 Harvest

It is anticipated that the forage crop would be harvested five times annually with adequate water available. Harvest operations should be done carefully to minimise soil compaction. Therefore the soils should be dried out prior to harvest operations. Then once the crop is swathed and baled, traffic patterns related to bale removal should minimise travel upon the irrigated areas of the paddock. Bales should be stored in a place that encourages careful traffic management.

10.2.5 Fertiliser

Soil tests have indicated that the limiting nutrients at the site are nitrogen (N) and phosphorus (P). Potassium (K) is marginal to adequate. Most of the N that the lucerne crop will require over time will come from the legume itself. P is rapidly immobilised in soil, and so surface applied P will be held in the surface soil. This can lead to availability restrictions when the surface soil is dry. The opportunity is available prior to crop establishment to work a number of year's supply of P into the profile during the process of ripping and cultivating. Consequently, 100 kg/ha P will be applied as monoammonium phosphate prior to ripping. However it will still be necessary to test the soil and leaf tissue to ensure adequate plant nutrition. It is common and expected to make annual applications of P and K fertiliser to lucerne crops as per crop removal calculations and soil test results.

11 Environmental monitoring

It is expected that given the high soil water deficit schedule being applied that runoff and deep drainage will be predominantly driven by rainfall, and will not be highly altered from conditions under a dryland pasture regime. The HowLeaky model suggests there will be small amounts of deep drainage beyond the root zone under irrigation as with the current pasture condition. Water and salts should be tracked as they pass through and beyond the root zone. Fluxes in groundwater static level and quality should also be tracked.

11.1 Groundwater monitoring

There are already three monitoring wells (piezometers) in place on the Leewood property (Figure **11**) which provide baseline data regarding the vadose, static water levels and groundwater quality. The well LWD-3 is up-gradient of the irrigation system but in the area influenced by seasonal inundation. LWD-1, down-gradient from LWD-3, is and also likely to be influenced by seasonal inundation. We suspect that the drainage channel running across the property is the primary source of local groundwater recharge.

In order to assess the effects of the irrigation system upon groundwater we propose placement of monitoring well 4 near the edge of the centre-pivot (Figure **11**) but out of the potentially inundated zone and down-gradient from LWD-3. Monitoring well 5 would be placed at the edge of the irrigated area in the northeast corner of the property where the soils are better drained. These two new wells would be screened in the first groundwater encountered.

Once the wells were drilled and allowed to settle they should be sampled for static water level and a thorough suite of chemical analyses. To track the effects of the irrigation system wells 3, 4 and 5 should be purged and sampled quarterly. The quarterly sampling should include static water level and TDS analysis. If significant changes in TDS are noted then a more thorough chemical analysis should be performed as a follow-up to the quarterly sampling. The full suite of analytes should be measured annually.

The installation of pressure transducers with data recording capabilities will assist in the detection of deep drainage from the irrigated area. These coordinated with soil moisture monitoring devices can be used to track the effects of rain and irrigation upon groundwater at the site.

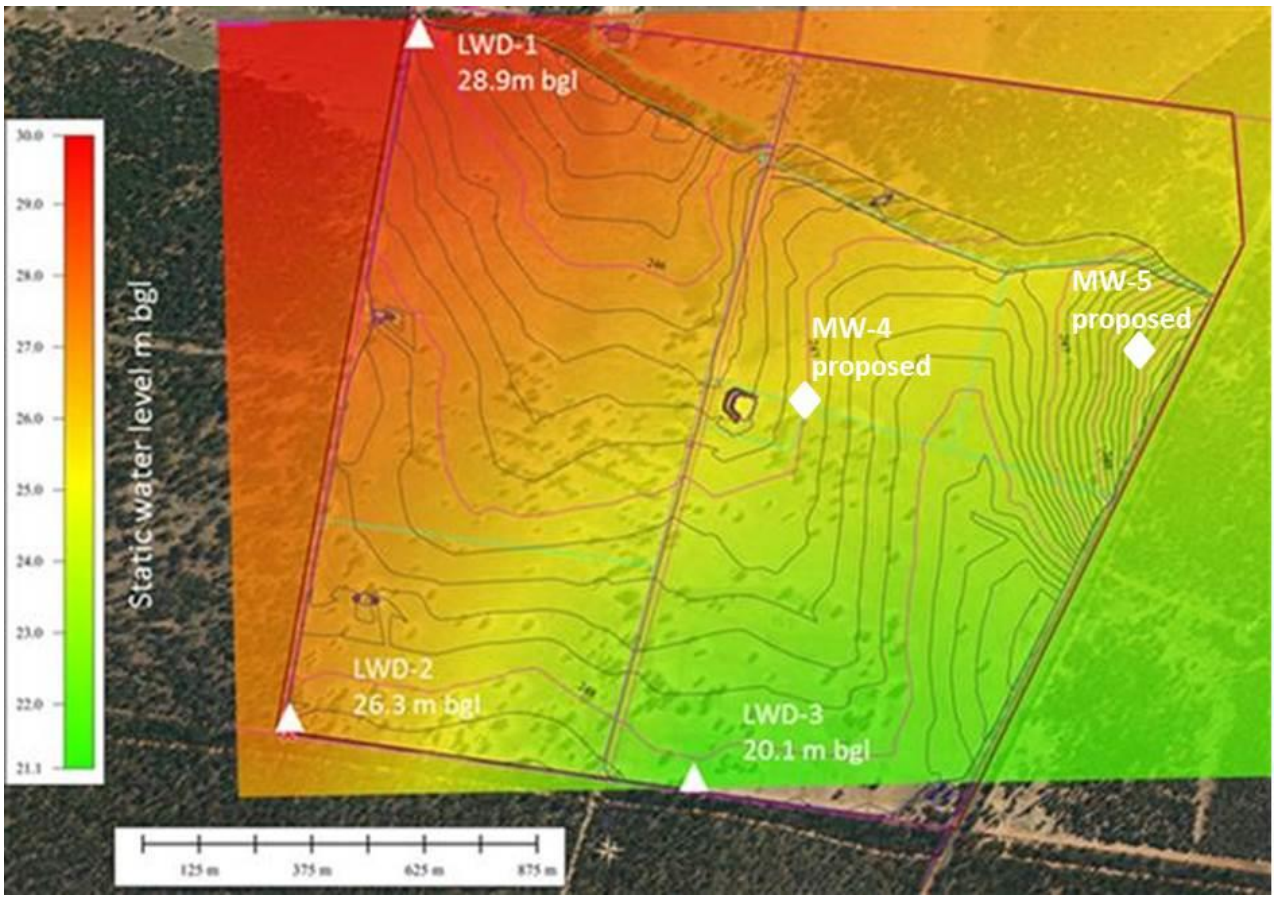

Figure 11 Proposed location of additional monitoring wells (diamonds)

11.2 Soil and vadose monitoring

Ten soil moisture monitoring stations would be scattered across the project area. Five would measure the most active rootzone in the top 100 cm and the other five would be equipped to measure soil moisture and salinity flux throughout and at the bottom of the rootzone. The derived data would be used to estimate the volume and rate of water moving through the vadose. Based upon monitoring bore log data describing the vadose beneath the rootzone, potential impacts to groundwater can be estimated by hydrogeologic modelling.

A soil sampling protocol should be established that utilises about 10 benchmark testing zones representing various soil types and positions on the landscape. The zones should be no more than 2,000 m^2 in size. These zones would then be sampled annually to a depth of 3 m. Three cores would be advanced per zone annually and composited by depth segments of approximately 1 m each except for the top 2 m which would be segmented in four parts. The core holes should be plugged with bentonite chips to prevent water from running into the holes and skewing future results. The composited samples would be analysed for pH, EC_e, SAR and any other constituents that may be of concern. The results of these can be presented graphically with concentrations on the X-axis and depth on the negative Y axis. The annual plotting of this data will indicate the flux in salt accumulation in these zones and provide important information to managers regarding salt management.

12 Conclusion

This concept design integrates both mechanical and biological systems for utilising the treated water at Leewood. A system for monitoring climate and environmental impacts was recommended as well. From this concept design a generalised construction, operations and maintenance plan were put forward and cost estimates derived.

Should Santos ENSW go forward with this project a detailed engineering design, construction and operations plan should be produced. The detailed engineering design would provide enough specific information to prepare bid packages.

The detailed construction and operations plan would include items such as:

- land clearance instructions
- traffic management
- EHS measures
- emergency response plans
- standard operating procedures
- system control logic
- specific crop varietal selection
- recordkeeping forms and registers
- monitoring schedules

The timing for land preparation, delivery of materials and construction of the irrigation systems should be done with consideration for the eventual planting of crops at critical windows in autumn or spring. It must also be recognised that there is a lag period to when the crops begin to utilise adequate amounts of water to keep up with production.

13 References

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14 Appendix A – Supplementary soil data

Table 8 Soil profile descriptions

Profile name	bag #	Santos label	Depth (cm)		Horizon	Munsell	Colour	Mottles	Texture	Est clay %	Structure	Moisture content	Strength	Roots	pH	Comments
			Top	Bot.		Colour					Type			Rank		
L2-01	1	7343_SOIL_0.1_1402131005	0	10	A1	10YR3/2	very dark grey brown	-	sandy clay loam	25%	massive	dry	hard	3	5.5	hard setting-pugged
	2	7343_SOIL_0.5_1402131005	10	50	B21	10YR3/3	dark brown	-	medium clay	45%	coarse	dry	very hard	2	5.5	
	3	7343_SOIL_1_1402131005	50	100	B22	10YR4/3	brown	-	medium clay	45%	coarse	dry	hard	2	6	
	4	7343_SOIL_1.5_1402131005	100	150	B23	10YR4/2	dark grey brown	-	light medium clay	40%	coarse	slightly moist	hard	1	7	
L2-02	1	7342_SOIL_0.15_1402130945	0	15	A1	10YR3/3	dark brown	-	light sandy clay loam	20%	massive	dry	firm	3	5.25	hard setting-pugged
	2	7342_SOIL_0.2_1402130945	15	20	A2e	10YR5/2	grey brown	-	light sandy clay loam	20%	massive	dry	-	2	-	
	3	7342_SOIL_0.5_1402130945	20	50	B21	10YR3/4	dark yellow brown	-	light medium clay	40%	coarse	dry	very hard	2	6	
	4	7342_SOIL_1_1402130945	50	100	B22	10YR4/3	brown	-	light clay	35%	coarse	dry	firm	1	6.5	
	5	7342_SOIL_1.5_1402130945	100	150	B23	10YR4/3	brown	-	light clay	35%	coarse	dry	firm	0	7	
L2-03	1	7341_SOIL_0.15_1402130920	0	15	A1	10YR3/3	dark brown	-	sandy clay loam	25%	massive	dry	hard	3	6	hard setting-pugged
	2	7341_SOIL_0.5_1402130920	15	50	B21	10YR4/3	brown	-	light medium clay	40%	coarse	dry	very hard	2	6	
	3	7341_SOIL_1_1402130920	50	100	B22	10YR3/3	dark brown	-	light medium clay	40%	coarse	slightly moist	hard	0	6.5	
	4	7341_SOIL_1.5_1402130920	100	150	B23	10YR3/3	dark brown	-	medium clay	45%	coarse	slightly moist	hard	0	6	
L2-04	1	7340_SOIL_0.15_1402130900	0	15	A1	10YR3/4	dark yellow brown	-	sandy clay loam	25%	massive	dry	-	3	5.5	hardsetting- level
	2	7340_SOIL_0.2_1402130900	15	20	A2e	10YR4/3	brown	-	sandy clay loam	25%	massive	dry	-	2	6	
	3	7340_SOIL_0.5_1402130900	20	50	B21	10YR4/3	brown	-	medium clay	45%	coarse	dry	very hard	2	6.75	
	4	7340_SOIL_1_1402130900	50	100	B22	10YR4/3	brown	-	light medium clay	40%	coarse	dry	hard	1	6	
	5	7340_SOIL_1.5_1402130900	100	150	B23	10YR4/3	brown	-	medium clay	45%	coarse	slightly moist	hard	0	6	
L2-05	1	7344_SOIL_0.1_1402131050	0	10	A1	10YR3/3	dark brown	-	light sandy clay loam	20%	massive	dry	-	3	6	hardsetting-pugged
	1A	7344_SOIL_0.15_1402131050	10	15	A2e	10YR5/2	grey brown	-	light sandy clay loam	20%	massive	dry	-	2	-	
	2	7344_SOIL_0.5_1402131050	15	50	B21	10YR4/3	brown	-	light medium clay	40%	coarse	dry	very hard	2	7.5	
	3	7344_SOIL_1_1402131050	50	100	B22	10YR4/2	dark grey brown	-	light medium clay	40%	coarse	slightly moist	hard	1	7.5	

Profile name	bag #	Santos label	Depth (cm)		Horizon	Munsell	Colour	Mottles	Texture	Est	Structure	Moisture content	Strength	Roots	pH	Comments
	4	7344_SOIL_1.5_1402131050	100	150	B23	10YR4/2	dark grey brown	orange & white	light medium clay	40%	coarse	slightly moist	hard	0	7	
L2-06	1	7348_SOIL_0.1_1402131320	0	10	A1	10YR3/4	dark yellow brown	-	sandy clay loam	25%	massive	dry	firm	3	5.5	hardsetting-pugged
	5	7348_SOIL_0.15_1402131320	10	15	A2e	10YR5/2	grey brown	-	sandy clay loam	25%	massive	dry	-	2	-	
	2	7348_SOIL_0.5_1402131320	15	50	B21	10YR3/4	dark yellow brown	-	medium clay	45%	coarse	dry	very hard	2	7.5	
	3	7348_SOIL_1_1402131320	50	100	B22	10YR3/3	dark brown	-	light medium clay	40%	coarse	dry	very hard	1	8	
	4	7348_SOIL_1.5_1402131320	100	150	B23	10YR3/2	very dark grey brown	-	medium clay	45%	coarse	slightly moist	hard	0	8	
L2-07	1	7345_SOIL_0.1_1402131140	0	10	A1	10YR3/4	dark yellow brown	-	sandy clay loam	25%	massive	dry	-	3	5.5	hardsetting-pugged
	1A	7345_SOIL_0.15_1402131140	10	15	A2e	10YR5/2	grey brown	-	sandy clay loam	25%	massive	dry	-	2	-	
	2	7345_SOIL_0.5_1402131140	15	50	B21	10YR4/2	dark grey brown	-	medium clay	45%	coarse	dry	very hard	2	6.25	
	3	7345_SOIL_1_1402131140	50	100	B22	10YR4/3	brown	-	light medium clay	40%	coarse	dry	hard	2	7	
	4	7345_SOIL_1.5_1402131140	100	150	B23	10YR4/3	brown	-	medium clay	45%	coarse	slightly moist	hard	1	6	
L2-08	1	7347_SOIL_0.1_1402131240	0	10	A1	10YR3/4	dark yellow brown	-	clay loam	30%	massive	dry	-	3	5.5	hardsetting-pugged
	2	7347_SOIL_0.5_1402131240	10	50	B21	7.5YR3/4	dark brown	-	medium clay	45%	coarse	dry	very hard	2	6	
	3	7347_SOIL_1_1402131240	50	100	B22	10YR4/3	brown	-	light clay	35%	coarse	dry	hard	1	7.5	
	4	7347_SOIL_1.5_1402131240	100	150	B23	10YR4/4	dark yellow brown	-	light clay	35%	coarse	moist	soft/firm	0	7.5	
L2-09	1	7346_SOIL_0.1_1402131210	0	10	A1	10YR3/4	dark yellow brown	-	clay loam	30%	massive	dry	hard	3	6	hardsetting-pugged
	2	7346_SOIL_0.5_1402131210	10	50	B21	7.5YR3/4	dark brown	-	medium clay	45%	coarse	dry	very hard	2	6.5	
	3	7346_SOIL_1_1402131210	50	100	B22	10YR3/3	dark brown	-	medium clay	45%	coarse	dry	very hard	2	7	
	4	7346_SOIL_1.5_1402131210	100	150	B23	10YR3/3	dark brown	-	light medium clay	40%	coarse	slightly moist	hard	0	7.5	
L2-10	1	7349_SOIL_0.1_1402131340	0	10	A1	10YR3/2	very dark grey brown	-	light sandy clay loam	20%	massive	dry	-	3	6.5	hardsetting-pugged
	2	7349_SOIL_0.5_1402131340	10	50	B21	10YR3/3	dark brown	-	medium clay	45%	coarse	dry	very hard	2	7.5	
	3	7349_SOIL_1_1402131340	50	100	B22	10YR4/2	dark grey brown	-	light medium clay	40%	coarse	slightly moist	hard	2	8	
	4	7349_SOIL_1.5_1402131340	100	150	B23	10YR3/2	very dark grey brown	-	light medium clay	40%	coarse	slightly moist	hard	0	7.5	
L2-11	1	7352_SOIL_0.1_1402131500	0	10	A1	7.5YR3/4	dark brown	-	light sandy clay loam	20%	massive	dry	soft	3	6	hardsetting- level. Refusal at 1m.

Profile name	bag #	Santos label	Depth (cm)		Horizon	Munsell	Colour	Mottles	Texture	Est	Structure	Moisture content	Strength	Roots	pH	Comments
	4	7352_SOIL_0.15_1402131500	10	15	A2e	7.5YR4/4	brown	-	light sandy clay loam	20%	massive	dry	-	2	7.5	
	2	7352_SOIL_0.6_1402131500	15	60	B21	7.5YR4/4	brown	-	medium clay	45%	coarse	dry	very hard	2	8	
	3	7352_SOIL_1_1402131500	60	100	C	7.5YR4/4	brown	grey and brown	weathered sandstone	-	massive	slightly moist	hard	0	-	
L2-12	1	7351_SOIL_0.15_1402131430	0	15	A1	10YR3/4	dark yellow brown	-	sandy clay loam	25%	massive	dry	-	3	5	hardsetting- level
	2	7351_SOIL_0.5_1402131430	15	50	B21	10YR3/4	dark yellow brown	-	medium clay	45%	coarse	dry	very hard	2	6.5	
	3	7351_SOIL_1_1402131430	50	100	B22	10YR3/3	dark brown	-	light medium clay	40%	coarse	dry	firm	1	7.5	
	4	7351_SOIL_1.5_1402131430	100	150	B23	10YR4/3	brown	-	light medium clay	40%	coarse	slightly moist	firm	0	7	
L2-13	1	7350_SOIL_0.2_1402131410	0	20	A1	10YR3/2	very dark grey brown	-	sandy clay loam	25%	massive	dry	-	3	4.5	hardsetting- level
	5	7350_SOIL_0.3_1402131410	20	30	A2e	10YR5/2	grey brown	-	sandy clay loam	25%	massive	dry	-	2	-	
	2	7350_SOIL_0.5_1402131410	30	50	B21	10YR3/3	dark brown	-	medium heavy clay	50%	coarse	dry	very hard	2	6	
	3	7350_SOIL_1_1402131410	50	100	B22	10YR3/3	dark brown	-	medium clay	45%	coarse	slightly moist	hard	2	6.5	
	4	7350_SOIL_1.5_1402131410	100	150	B23	10YR3/1	very dark grey	-	medium clay	45%	coarse	slightly moist	very hard	1	7.5	
L2-16	1	7354_SOIL_0.1_1402131600	0	10	A1	5YR3/3	dark red brown	-	sandy clay loam	25%	massive	dry	hard	3	5.5	hardsetting- level. Refusal at 1m.
	2	7354_SOIL_0.5_1402131600	10	50	B21	5YR4/4	dark red brown	-	medium clay	45%	coarse	slightly moist	hard	2	6.5	
	3	7354_SOIL_1_1402131600	50	100	B22	5YR3/3	dark red brown	-	medium clay	45%	coarse	slightly moist	hard	2	7	
L2-18	1	7355_SOIL_0.1_1402131640	0	10	A1	10YR3/4	dark yellow brown	-	sandy clay loam	25%	massive	dry	-	3	6	hardsetting- level
	5	7355_SOIL_0.2_1402131640	10	20	A2e	10YR5/2	grey brown	-	sandy clay loam	25%	massive	dry	-	2	-	
	2	7355_SOIL_0.5_1402131640	20	50	B21	10YR4/4	dark yellow brown	-	medium clay	45%	coarse	dry	very hard	2	6.5	
	3	7355_SOIL_1_1402131640	50	100	B22	10YR3/4	dark yellow brown	-	light medium clay	40%	coarse	dry	hard	1	7.5	
	4	7355_SOIL_1.5_1402131640	100	150	B23	10YR3/3	dark brown	-	light clay	35%	coarse	slightly moist	hard	0	7.5	
L2-19	1	7353_SOIL_0.1_1402131530	0	10	A1	10YR3/4	dark yellow brown	-	clay loam	30%	blocky	dry	hard	3	6	hardsetting with some cracks- level
	2	7353_SOIL_0.5_1402131530	10	50	B21	10YR3/4	dark yellow brown	-	medium heavy clay	50%	coarse	dry	very hard	2	7	
	3	7353_SOIL_1_1402131530	50	100	B22	7.5YR3/4	dark brown	-	medium clay	45%	coarse	dry	very hard	2	7	
	4	7353_SOIL_1.5_1402131530	100	150	B23	2.5Y4/2	dark grey brown	red & brown	medium clay	45%	coarse	moist	very hard	1	5.75	

Table 9 Soil chemistry values for selected soil cores.

Name	Code	N NH4+NO3	Phosphorus Colwell	Potassium Colwell	Sulphur	Organic Carbon	Conductivity	pH Level (CaCl2)	pH Level (H2O)	ECe	Saturation Paste exch. Ca	Saturation Paste exch. K	Saturation Paste exch. Mg	Saturation Paste exch. Na	Saturation Paste %	SAR	CROSS	Ca:Mg
			mg/Kg	mg/Kg	mg/Kg	%	dS/m	pH	pH	dS/m	meq/L	meq/L	meq/L	meq/L	%			
L4.1	7340_SOIL_0.15_1402130900	4	14	128	3	0.69	0.04	4.2	5.5	0.42	0.45	0.33	0.52	2.03	68.94	2.91	3.59	0.865385
L4.3	7340_SOIL_0.5_1402130900									2.24	1.69	1.44	11.12	19.43	49.46	7.68	9.90	0.151978
L4.4	7340_SOIL_1_1402130900						0.309	5.1	6	3.25	0.42	0.82	7.86	25.66	48.93	12.61	16.30	0.053435
L2.1	7342_SOIL_0.15_1402130945									0.43	0.35	0.26	0.63	2.54	40.88	3.63	4.45	0.555556
L2.3	7342_SOIL_0.5_1402130945									0.92	0.56	1.82	12.39	8.95	52.44	3.52	4.99	0.045198
L2.4	7342_SOIL_1_1402130945						0.107	5.8	6.6	1.31	0.42	0.7	4.4	10.5	44.7	6.76	8.81	0.095455
L5.1	7344_SOIL_0.1_1402131050	9	8	214	4.2	1.16	0.037	5	5.8	0.38	0.81	0.49	0.76	0.98	43.44	1.11	1.58	1.065789
L5.2	7344_SOIL_0.5_1402131050						0.184	6.2	7	1.59	0.47	0.7	6.82	11.86	50.91	6.21	8.11	0.068915
L5.3	7344_SOIL_1_1402131050									2.6	0.63	0.2	3.08	19.73	62.46	14.49	17.83	0.204545
L9.1	7346_SOIL_0.1_1402131210									0.56	0.5	0.22	0.87	2.87	48.1	3.47	4.19	0.574713
L9.2	7346_SOIL_0.5_1402131210						0.159	5.2	6.2	1.3	1.25	1.76	14.33	10.01	53.06	3.59	4.96	0.08723
L9.3	7346_SOIL_1_1402131210									3.36	0.82	0.19	6.69	24.15	54.58	12.46	15.60	0.122571
L6.1	7348_SOIL_0.1_1402131320									0.41	0.47	0.19	0.67	2.27	37.28	3.01	3.60	0.701493
L6.2	7348_SOIL_0.5_1402131320						0.283	5.9	6.9	2.6	0.59	0.55	5.49	20.67	49.88	11.86	15.05	0.107468
L6.3	7348_SOIL_1_1402131320									3.64	0.63	0.16	3.85	30.15	63.29	20.14	24.94	0.163636
L13.1	7350_SOIL_0.2_1402131410	7	10	87	2.8	1.95	0.031	4.1	4.7	0.4	0.95	0.28	0.94	1.4	48.35	1.44	1.79	1.010638
L13.2	7350_SOIL_0.5_1402131410						0.149	4.5	5.5	1.41	0.46	0.56	4.38	11.45	49.81	7.36	9.47	0.105023
L13.3	7350_SOIL_1_1402131410									3.07	0.99	1.59	15.17	26.74	56.8	9.41	12.30	0.06526
L12.1	7351_SOIL_0.15_1402131430	7	6	168	11.4	1.52	0.063	4.3	5	0.78	0.59	0.26	1.01	5.4	51.21	6.04	7.17	0.584158
L12.2	7351_SOIL_0.5_1402131430						0.203	5.2	6.2	1.55	0.64	0.57	4.55	12.26	54.28	7.61	9.69	0.140659
L12.3	7351_SOIL_1_1402131430									2.1	0.64	0.15	1.88	17.72	64.96	15.79	18.94	0.340426
L11.1	7352_SOIL_0.1_1402131500									0.53	0.46	0.16	0.73	2.7	36.21	3.50	4.16	0.630137

Name	Code	N NH4+NO3	Phosphorus Colwell	Potassium Colwell	Sulphur	Organic Carbon	Conductivity	pH Level (CaCl2)	pH Level (H2O)	ECe	Saturation Paste exch. Ca	Saturation Paste exch. K	Saturation Paste exch. Mg	Saturation Paste exch. Na	Saturation Paste %	SAR	CROSS	Ca:Mg
L11.2	7352_SOIL_0.6_1402131500						0.136	6.7	8.1	0.8	0.59	1.83	15.31	8.08	67.11	2.87	4.12	0.038537
L19.1	7353_SOIL_0.1_1402131530	7	18	151	3.8	1.19	0.032	4.6	5.6	0.26	0.26	0.19	0.63	1.44	51.5	2.16	2.74	0.412698
L19.2	7353_SOIL_0.5_1402131530						0.11	4.8	5.8	0.96	0.64	0.61	5.87	5.85	52.23	3.24	4.29	0.109029
L19.3	7353_SOIL_1_1402131530									3.24	0.85	0.15	7.9	21.87	64.41	10.46	13.13	0.107595
L16.1	7354_SOIL_0.1_1402131600	10	16	234	5.7	1.17	0.088	4.6	5.6	0.44	0.6	0.36	0.74	1.98	45.47	2.42	3.02	0.810811
L16.2	7354_SOIL_0.5_1402131600						0.172	4.9	5.9	1.39	1.03	2	15.25	11.79	51.48	4.13	5.72	0.067541
L16.3	7354_SOIL_1_1402131600									2.9	0.7	0.27	5.15	21.86	58.42	12.78	15.99	0.135922

Summary of key soil data

Measurements of soil cations, salinity and pH were made on samples from nine representative profiles from the 2014 survey. Soil solution cations were analysed from a saturated paste extract. Exchangeable cations were also analysed. The solution cations were used to calculate both SAR and CROSS[20], with the CROSS values deemed to be more appropriate for assessing dispersion potential due to the highly magnesic nature of the soil (Ca:Mg ratio is generally close to 0.1 in the subsoil). The ESP values were calculated from the sum of exchangeable cations, with the values likely to be elevated by the influence of pH dependant variable charge and unaccounted for exchangeable hydrogen.

Table 10 Average pH, salinity and sodicity of nine representative profiles

Depth	pH	ECe (mS/cm)	CROSS	SAR	ESP (%)
0-15 cm	4.47	0.45	3.57	2.91	-
15-50 cm	5.24	1.55	8.02	6.13	17.29
50-100 cm	5.45	2.83	15.98	12.77	23.92

Average surface nutrition from six points, with units being mg/kg. The values in the table relate to combined nitrate and ammonium nitrogen content, Colwell extractable P and K, and KCl-40 extractable sulphur.

Table 11 Average plant nutrient concentrations in surface soil (mg/kg).

N (NH4 +NO3)	P (Colwell)	K	S
7	12	163.	5

[20] [20] Marchuk, A., Rengasamy, P. and McNeill, A. (2013) Influence of organic matter, clay mineralogy, and pH on the effects of CROSS on soil structure is related to the zeta potential of the dispersed clay. *Soil Research* 51(1) 34-40

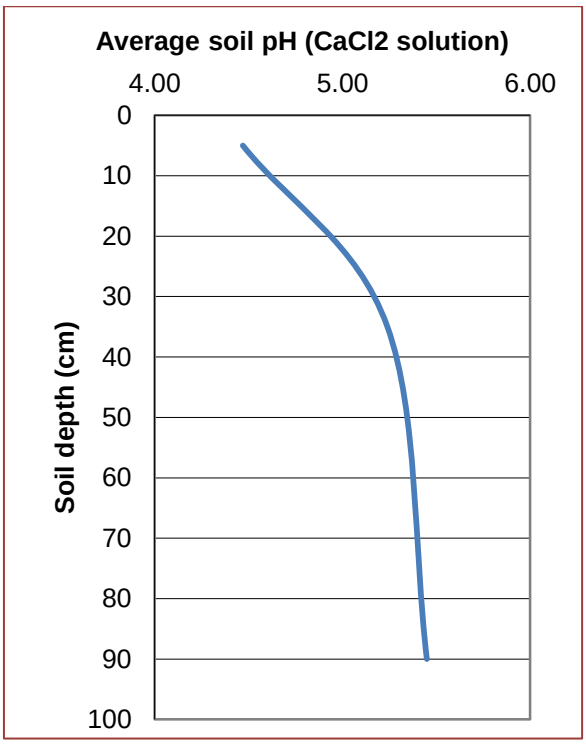


Figure 12 Average soil pH by depth

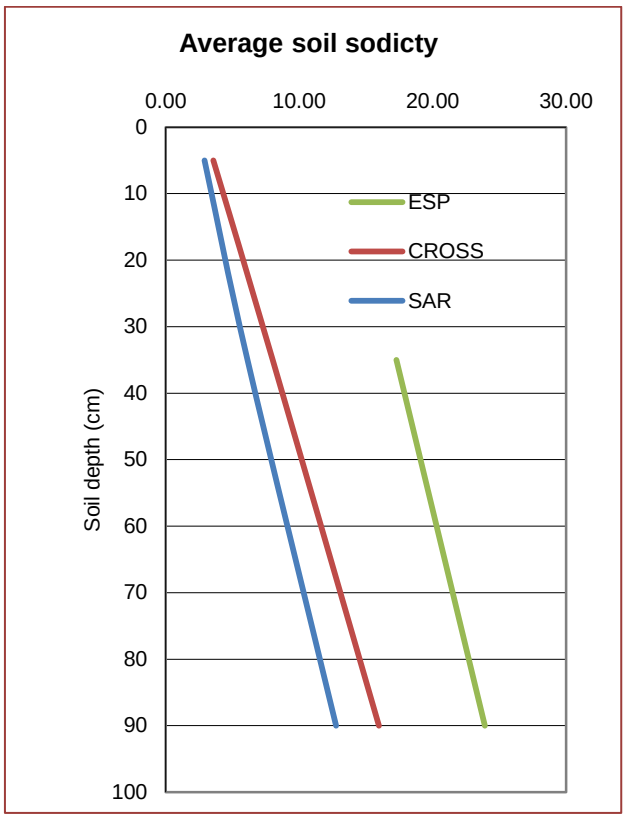


Figure 13 Average soil sodicity by depth

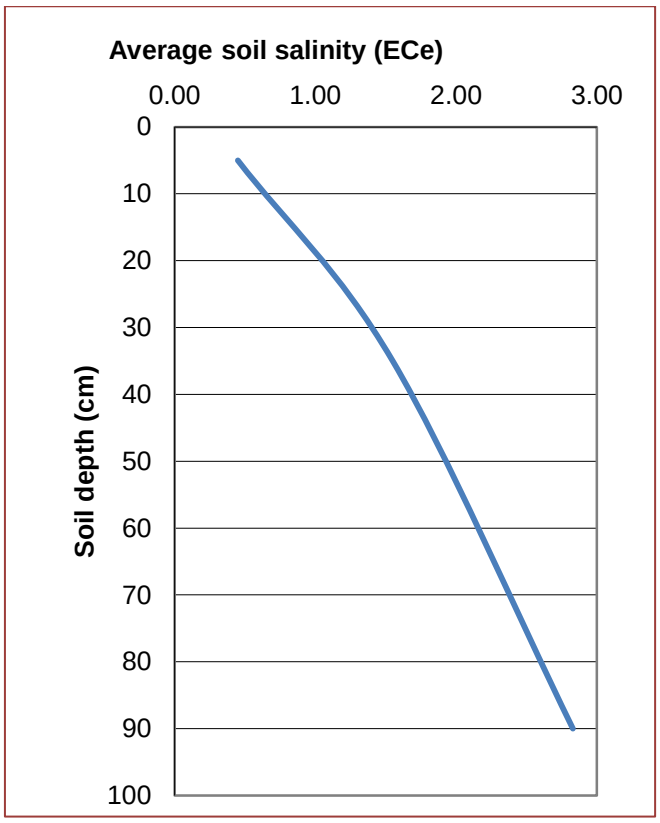


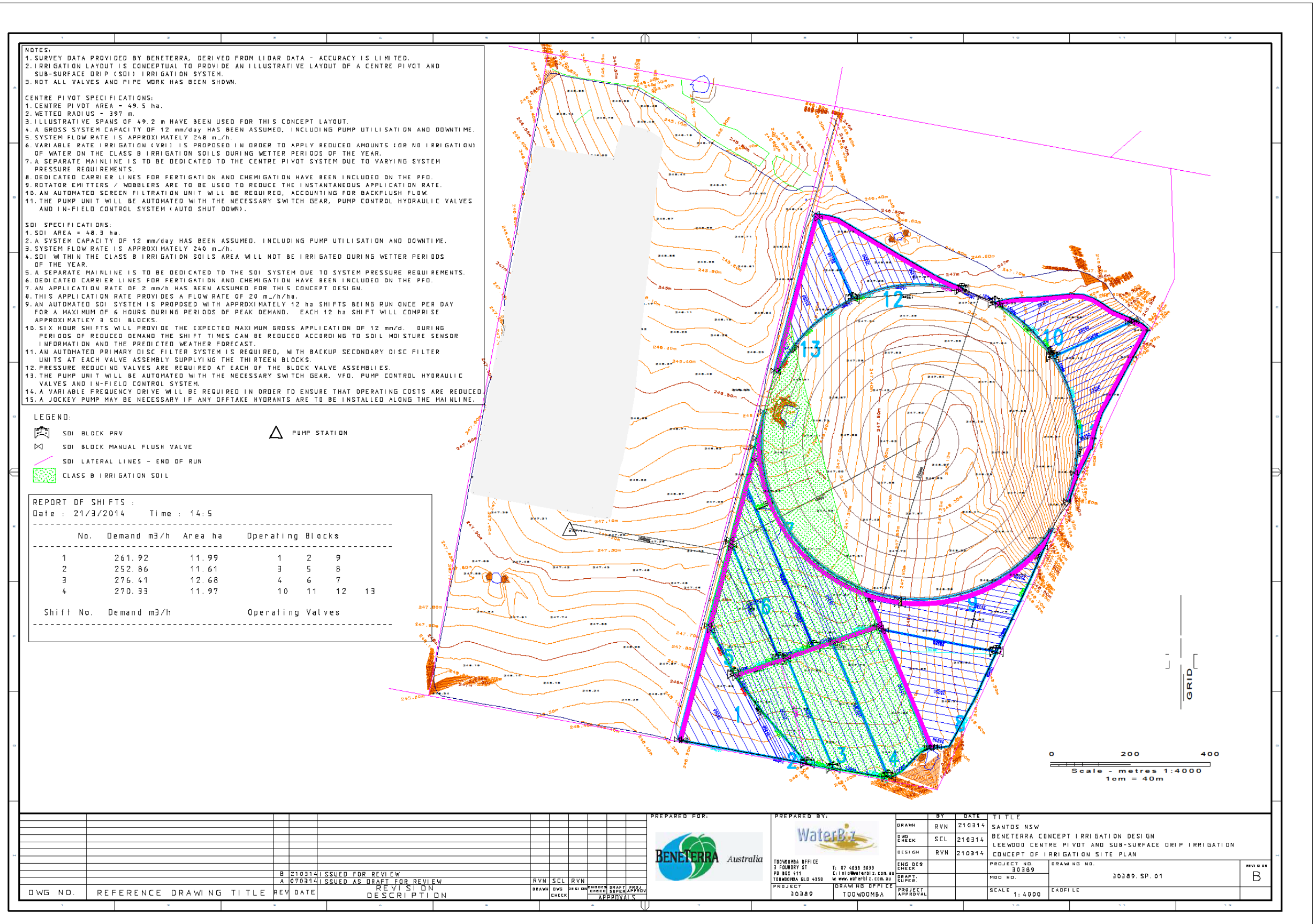
Figure 14 Average soil salinity by depth

Table 12 Total metals and total recoverable mercury

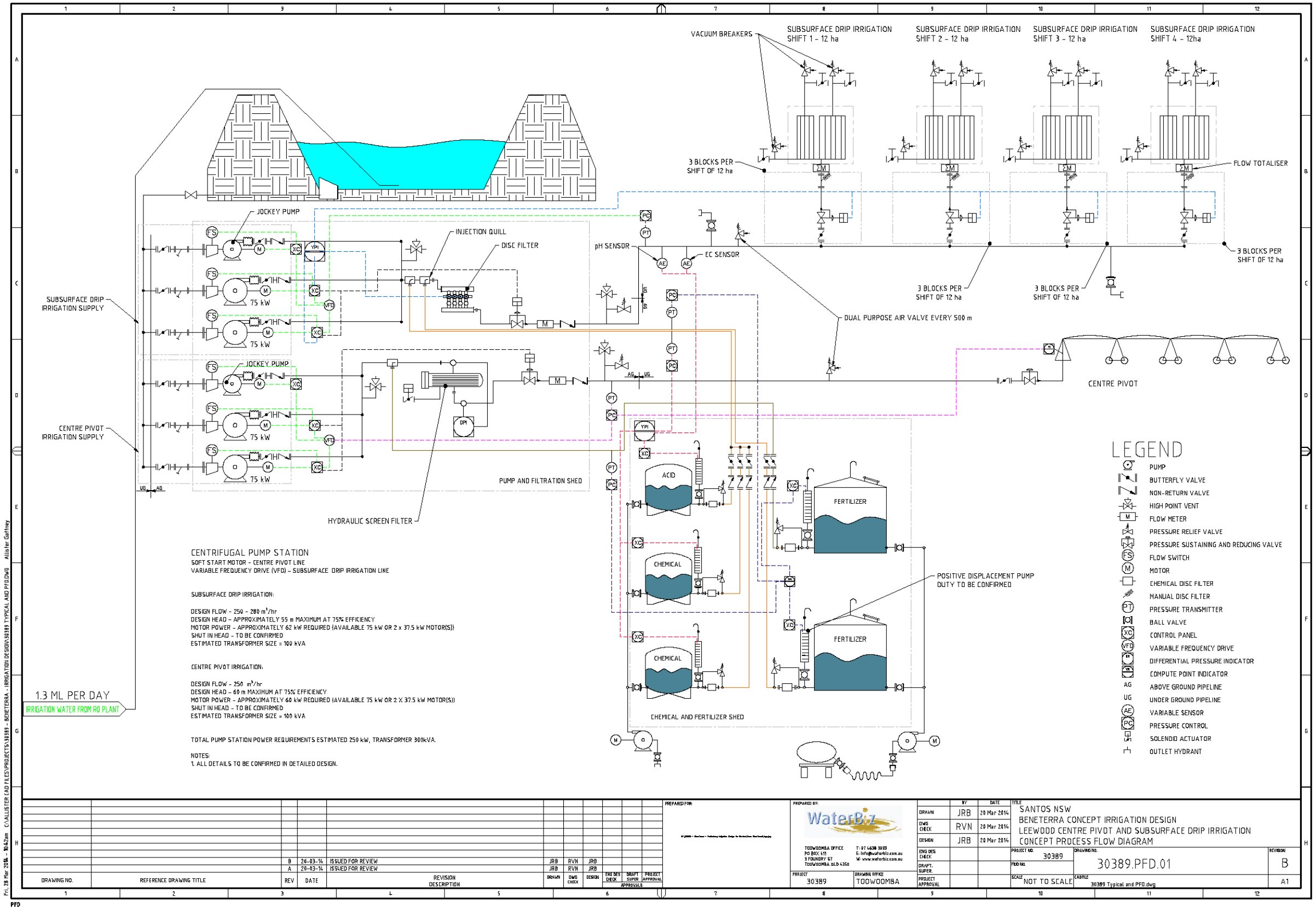
Sample ID	As mg/kg	Ba mg/kg	Be mg/kg	B mg/kg	Cd mg/kg	Cr mg/kg	Co mg/kg	Cu mg/kg	Pb mg/kg	Mn mg/kg	Ni mg/kg	Se mg/kg	V mg/kg	Zn mg/kg	U mg/kg	Hg mg/kg
L201-1	<5	60	<1	<50	<1	8	2	<5	6	111	3	<5	22	<5	0.4	<0.1
L201-2	<5	40	<1	<50	<1	8	<2	<5	6	<5	<2	<5	23	<5	0.4	<0.1
L201-3	<5	270	<1	<50	<1	12	4	<5	8	<5	4	<5	28	<5	0.6	<0.1
L201-4	<5	270	2	<50	<1	14	44	6	11	118	11	<5	33	8	0.6	<0.1
L203-1	<5	110	<1	<50	<1	11	4	<5	8	62	4	<5	48	7	0.4	<0.1
L203-2	<5	230	1	<50	<1	13	8	<5	10	6	5	<5	36	<5	0.5	<0.1
L203-3	<5	110	2	<50	<1	14	14	<5	10	<5	8	<5	33	6	0.3	<0.1
L203-4	<5	50	<1	<50	<1	13	6	<5	9	5	3	<5	36	6	0.7	<0.1
L206-2	<5	590	1	<50	<1	14	5	<5	10	11	7	<5	36	<5	0.5	<0.1
L206-4	<5	150	1	<50	<1	13	41	7	13	140	7	<5	47	8	0.4	<0.1
L208-1	<5	50	<1	<50	<1	11	2	<5	8	98	5	<5	29	<5	0.4	<0.1
L208-2	<5	280	1	<50	<1	14	5	<5	10	<5	6	<5	36	<5	0.7	<0.1
L208-3	<5	220	2	<50	<1	15	22	8	10	22	13	<5	32	8	0.8	<0.1
L208-4	<5	250	2	<50	<1	15	26	9	10	10	15	<5	38	10	0.6	<0.1
L210-1	<5	50	<1	<50	<1	6	<2	<5	<5	109	3	<5	18	<5	0.2	<0.1
L210-2	<5	220	<1	<50	<1	9	3	<5	7	59	4	<5	23	<5	0.5	<0.1
L210-3	<5	160	<1	<50	<1	10	4	<5	8	88	7	<5	23	<5	0.3	<0.1
L210-4	<5	110	<1	<50	<1	12	9	5	7	43	7	<5	25	5	0.3	<0.1
L211-1	<5	40	<1	<50	<1	8	2	<5	5	94	3	<5	23	<5	0.2	<0.1
L211-3	<5	250	1	<50	<1	11	13	<5	6	41	7	<5	36	<5	0.4	<0.1
L216-2	<5	270	1	<50	<1	17	30	6	9	73	10	<5	38	6	0.5	<0.1
L218-1	<5	40	<1	<50	<1	9	<2	<5	5	84	2	<5	23	5	0.3	<0.1
L218-2	<5	60	<1	<50	<1	9	<2	<5	6	8	2	<5	26	<5	0.3	<0.1
L218-3	<5	50	<1	<50	<1	13	14	<5	7	59	5	<5	32	7	0.4	<0.1
L218-4	<5	50	<1	<50	<1	14	10	7	8	115	7	<5	32	8	0.4	<0.1
L219-1	<5	130	<1	<50	<1	13	7	<5	8	197	5	<5	35	7	0.6	<0.1
Minimum	0	40	1	0	0	6	2	5	5	5	2	0	18	5	0.2	0
Maximum	0	590	2	0	0	17	44	9	13	197	15	0	48	10	0.8	0
Average	0.00	158.08	1.40	0.00	0.00	11.77	12.50	6.86	8.20	70.59	6.12	0.00	31.19	7.00	0.45	0.00

15 Appendix B – Concept irrigation design

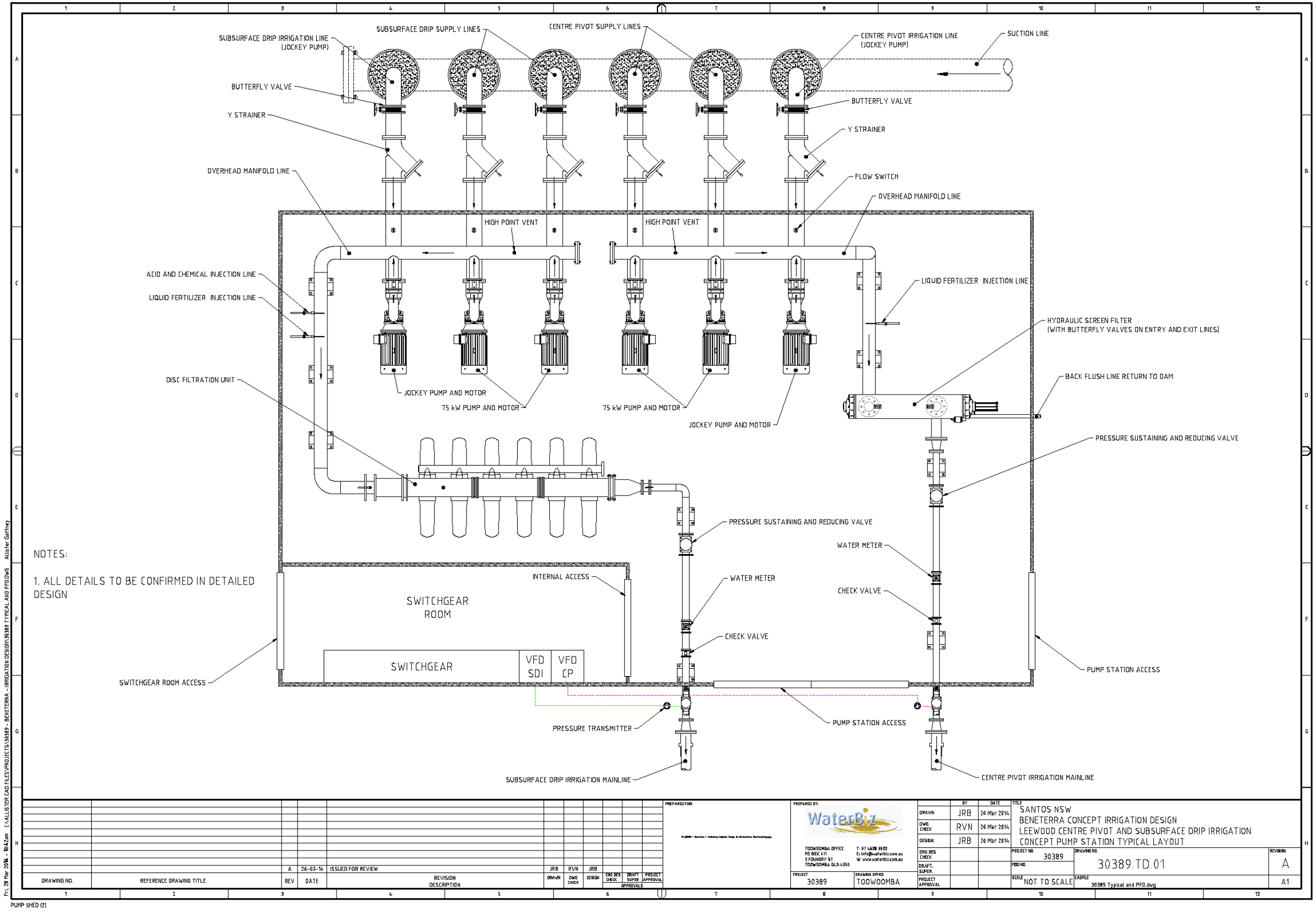
15.1 Concept irrigation design



15.2 Concept process flow diagram



15.3 Typical pump station layout



16 Appendix C - Anticipated Vehicle Movements

Anticipated Vehicle Movements

1. Land preparation (duration 60 days)
    a. Utility vehicles (3)
    b. Semi-float (1) for delivery of heavy equipment
    c. Excavator (1) for tree removal
    d. Bulldozer (1) for stick raking, deep ripping
    e. Tractor (1) for discing, harrowing, seeding
    f. ATV (1) for management, shuttling people, small equipment
2. Centre-pivot installation (duration 21 days)
    a. Semi – flatbed (1)
    b. Utility vehicles (3)
    c. ATV (1)
    d. Telehandler (1)
    e. Trencher or excavator (1)
3. Subsurface drip installation
    a. Semi – flatbed (2)
    b. Utility vehicles (3)
    c. ATV (1)
    d. Telehandler (1)
    e. Small excavator (1)
    f. Tractor with injection shank & spool carrier (1)
4. Pump station
    a. Telehandler (1)
    b. Transit mixer truck (1)
    c. Utility vehicles (4)
    d. Delivery trucks – s
        i. Semis (1)
        ii. Heavy rigid (1)
5. Operations and maintenance
    a. Utility vehicles (2)
    b. ATV (1)
    c. Tractor (1)
    d. Small excavator (1)
    e. Delivery trucks – heavy rigid (1)
    f. Aerial sprayer – helicopter or airplane (1)

Appendix 4

Transport Assessment (GTA Consultants)



Leewood Produced Water Treatment and Beneficial Reuse Project

Newell Highway, Narrabri

Transport Assessment

transportation planning, design and delivery

13S1042400 11/03/15

GTAconsultants

Leewood Produced Water Treatment and Beneficial Reuse Project

Newell Highway, Narrabri

Transport Assessment

Issue: D 11/03/15

Client: RPS Group
Reference: 13S1042400
GTA Consultants Office: NSW

Quality Record

Issue	Date	Description	Prepared By	Checked By	Approved By	Signed
A	15/04/14	Final report	Brigette Humphrey-Robinson	Rhys Hazell	Brett Maynard	Brett Maynard
B	30/06/14	Revised with relevant changes to proposed activity	Brigette Humphrey-Robinson	Rhys Hazell	Brett Maynard	Brett Maynard
C	07/07/14	Revised to include minor updates to project references	Brigette Humphrey-Robinson	Rhys Hazell	Brett Maynard	Brett Maynard
D	11/03/15	Updated to reflect minor design changes & proposed activity description	Brigette Humphrey-Robinson	Rhys Hazell	Brett Maynard	

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1. Introduction

1.1 Background

RPS Group on behalf of Santos NSW (Eastern) Pty Limited engaged GTA Consultants to prepare a transport assessment to determine the transport related impacts associated with the Leewood Produced Water Treatment and Beneficial Reuse Project (Leewood Project).

The primary objective of the proposed activity is to construct and operate a purpose built, centralised water treatment facility outside of the Pilliga State Forest, to treat, manage and beneficially reuse produced water stored within the ponds.

Santos NSW (Eastern) Pty Limited is the proponent for the proposed activity on behalf of the titleholders of PAL 2. The proposed activity will include:

- construction and operation of:
  - a water treatment plant (WTP), including pre-treatment and reverse osmosis (RO) plant
  - a brine treatment plant (BTP)
  - a brine distribution manifold and associated piping at Leewood, to allow water distribution into the water treatment plant and associated return flows to brine storage ponds
  - a treated water storage tank (5 megalitres capacity)
  - a managed irrigation system including a centre pivot and sub-surface drip irrigation system
  - other associated infrastructure, including a gas pipeline to fuel the generators
  - a small potable water treatment system for water extracted from the licensed bore.
- the construction of (and the ability to operate) a treated water pipeline extending to the Leewood property boundary to transfer water to another location for irrigation by a third party (if required)
- re-use of treated water for irrigation at the Leewood property and other uses both on and off site including dust suppression, drilling and construction and firefighting. Santos is investigating the option of providing treated water to third parties for agricultural irrigation, although this potential use of treated water does not form part of the proposed activity for the purposes of this REF and will be subject to separate assessment and approvals
- amelioration of soils within irrigation area by deep tillage, fertiliser, lime and gypsum in preparation for irrigation
- decommissioning and rehabilitation of the site, if the Narrabri Gas Project does not proceed.

Santos (or its assigned operator) will operate the proposed activity for up to five years. The WBTP will treat up to 1.5 megalitres per day of produced water from Santos' CSG exploration and appraisal activities within PEL 238, PAL 2 and PPL 3. The operational process is expected to involve, but is not limited to:

- pumping of produced water from the produced water pond to the water treatment plant

- treatment of produced water within the water treatment plant, including removal of solids by filter (pre-treatment), reverse osmosis to separate the water and brine streams (treatment), and chemical and pH dosing (post-treatment) to make the treated water appropriate for irrigation
- transfer of treated water to the treated water storage tank or directly to the on-site managed irrigation system for beneficial re-use
- beneficial re-use of treated water for irrigation, or other uses both on and off-site such as dust suppression, drilling and construction and firefighting
- transfer of brine to the brine treatment plant for concentration and further recovery of treated water
- storage of brine in the existing Leewood ponds.

1.2 Purpose of this Report

This report sets out an assessment of the anticipated transport implications of the project, as they relate to the construction and operation, including consideration of the following:

i existing traffic conditions surrounding the site
ii construction staging and associated traffic management
iii construction vehicle requirements
iv haul routes to and from each site
v site accesses during operation
vi the transport impact of the construction works and site operation on the surrounding road network.

1.3 References

In preparing this transport assessment, reference has been made to the following:

- several inspections of the site and its surrounds
- Leewood Project – Phase 1, Narrabri – Transport Assessment, Issue E, GTA Consultants, 02/10/13
- Leewood – Produced Water and Brine Management Ponds REF, RPS Australia, 17/12/12.
- Guide to Traffic Management, Part 2: Traffic Theory, Austroads, 2008
- Guide to Road Design, Part 4A: Unsignalised and Signalised Intersections, Austroads, 2010 2nd Edition
- 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
- traffic surveys undertaken by Narrabri Shire Council and Roads and Maritime Services as referenced in the context of this report
- plans for the proposed development prepared by Aurecon, Drawing Number 7058-040-GAR-0001 and 0003 to 0006, dated 17/06/14
- plans for the proposed development prepared by Aurecon, Drawing Number 7058-040-GAR-0002, dated 13/06/14
- plans for the proposed development prepared by Aurecon, Drawing Number 7058-040-DDR-0006 and 0007, dated 17/06/14

- plans for the proposed development prepared by Osmoflo, Drawing Number JB0605-2000-A (sheets 1 to 3))
- other documents and data as referenced in this report.

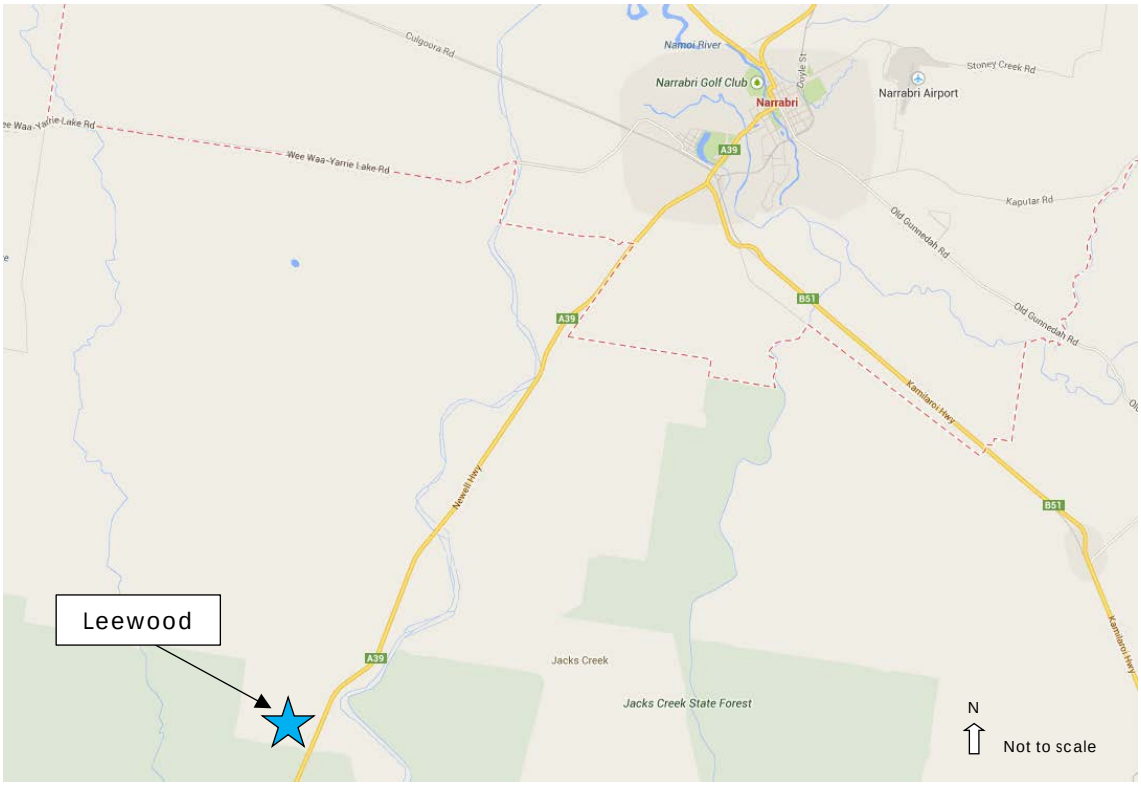
2. Existing Conditions

The Leewood site is located adjacent to the Newell Highway approximately 24km south of Narrabri and covers an area of approximately 246 hectares. It has frontages to the Newell Highway along the eastern boundary and Old Mill Road (also known as Dog Proof Fence Road) along the southern boundary.

The surrounding properties predominantly include rural land used primarily for farming purposes with Pilliga East State Forest located immediately to the south. There are currently six sensitive receivers within a 2km radius of the site, with the closest dwelling location approximately 360m to the east of the site. In addition, the closest dwelling to the construction works is located approximately 750m west of the site.

The location of Leewood and the surrounding environs is shown in Figure 2.1.

Figure 2.1: Subject Site and its Environs

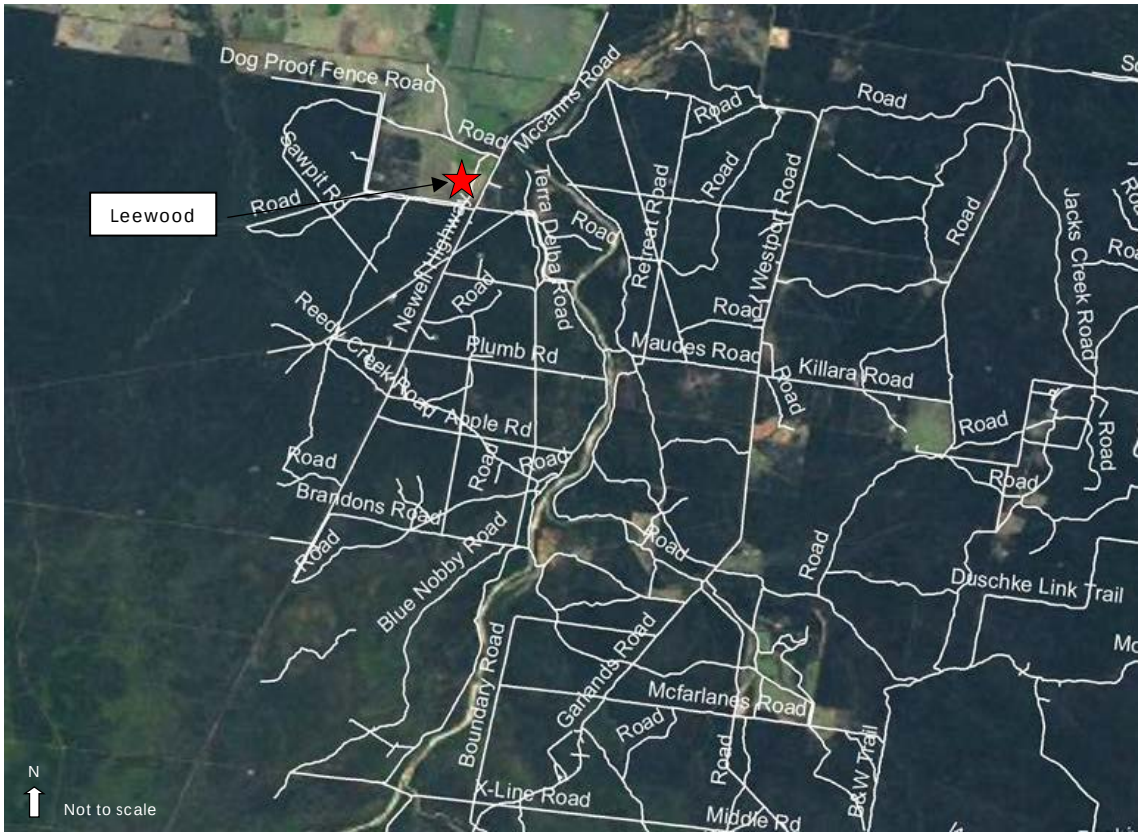


Basemap Source: Google Maps

2.1 Road Network

The road network within the vicinity of the sites is shown in Figure 2.2, with further identification of the key roads in the vicinity of each site.

Figure 2.2: Road Network



Basemap Source: Santos

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. Adjacent to the site, it is a two-way sealed rural highway configured with a 2-lane, 7 metre wide carriageway, with approximately 0.5m sealed shoulder. On-site observations indicate that the current pavement condition is good in the vicinity of Old Mill Road with no major defects. The posted speed limit is 110km/h.

The Newell Highway is shown in Figure 2.3 and carries approximately 1,860 vehicles per day[1].

Old Mill Road

Old Mill Road (also known as Dog Proof Fence Road) is an unsealed forestry road travelling in an east-west direction for approximately 35km along the northern boundary of Pilliga East State Forest. It is understood to be managed and maintained by Forestry Corporation of NSW, however on-site observations indicate that maintenance is infrequent and there is no posted speed limit.

1 Based on the tube counts undertaken by Narrabri Shire Council in September to November 2011

Old Mill Road connects with the Newell Highway at a priority controlled T-intersection. Old Mill Road is shown in Figure 2.4.

It is understood that Santos recently completed an upgrade of Old Mill Road between the Newell Highway and the site access as part of the water and brine storage ponds/ existing construction activities onsite. This upgrade ensures appropriate access for all vehicles including up to 25m long B-double trucks. The upgrade works included the following:

- drainage works
- installation of a clean gravel surface
- spray seal surface of Old Mill Road at the Newell Highway over a distance of approximately 30m
- installation of cattle grids to remove loose material from vehicles exiting the site.

Figure 2.3: Newell Highway (looking north)



Image Source: GTA Consultants

Figure 2.4: Old Mill Road



Image Source: Santos NSW (Eastern) Pty Limited

2.2 Traffic Volumes

The Roads and Maritime Services (RMS) has provided GTA Consultants with traffic volume data collected on the Newell Highway throughout April 2012. The data indicates that the average daily traffic along the Newell Highway was approximately 1,860 vehicles, with peak hourly flows of 169 vehicles. Further to this, traffic volume data provided by Narrabri Shire Council indicated that the proportion of heavy vehicles on the Newell Highway is approximately 40% of the average daily traffic.

2.3 Level of Service

Reference has been made to the Guide to Traffic Generating Developments (RMS, 2002) (The Guide) 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 169 vehicles in any peak hour, the LOS along the Newell Highway is, at worst LOS B.

3. Construction Traffic Management

3.1 Overall Principles of Traffic Management

The overall principles of traffic management during the construction activity include:

- maintain access to/ from adjacent properties
- restrict construction vehicle movements to designated haul routes to/ from the site via Old Mill Road and the Newell Highway
- manage and control construction vehicle activity in the vicinity of the site
- carry out construction activity in accordance with the approved hours of works as determined by the relevant authorities.

3.2 Staging Schedule and Truck Volumes

Construction works are anticipated to commence in Q2 of 2015, with a planned completion in early 2016; a period of up to 50 weeks. It is understood that construction will be undertaken through four key stages as detailed in Table 3.1, with construction activities generally occurring sequentially. It is noted that other activities (not detailed in Table 3.1) could occur throughout the construction period, which have been allowed for within the 50 week construction period.

Table 3.1: Works Stages and Scheduling

Stage	Activity	Description	Vehicle Types	Peak Construction Vehicle Trips (trips/day)	Estimated Duration
Stage 1	Mobilisation	Delivery of plant equipment including excavators, construction amenities and temporary services	• Standard flatbed trucks • 19m-25m articulated heavy vehicles • Low loader (minimal)	20	6-8 weeks
	Irrigation area	Land Preparation	• Standard flatbed trucks	10	
Stage 2	Earthworks	Excavation and trenching	• Tippers for spoil transportation	40	6-8 weeks
	Irrigation area	Land Preparation and Installation	• Standard flatbed trucks • Articulated vehicles Semi-trailers • Large Rigid Vehicles	10	
Stage 3	Concrete	Deliveries for foundation pours	• Concrete trucks	20	2 weeks
	Irrigation area	Installation	• Standard flatbed trucks • Semi-trailers • Large Rigid Vehicles	5	
Stage 4	Mechanical/ Electrical	Delivery and installation of WBTP plant and equipment	N/A	20	10-12 weeks
	Irrigation area	Installation	• Standard flatbed trucks • Semi-trailers • Large Rigid Vehicles	5	13 weeks

Based on Table 3.1, up to 50 external construction vehicle trips could be required on any given day over the 6-8 week long Stage 2 works. Up to 100 internal construction vehicle trips could also be required throughout Stage 2. Overall, a typical day would likely see no more than 20-30 external vehicle trips throughout all construction work stages. For the purposes of this assessment, a worst case scenario (assuming 50 trips per day) has been used.

All heavy plant and machinery will be delivered during mobilisation and will remain on-site for the duration of their use, with no impact on the external road network during this period. Any oversize vehicles required for transporting earthmoving equipment to site would be further addressed through specific permits and consultation with RMS.

It is noted that the Guide defines a vehicle trip as a one-way vehicular movement from one point to another excluding the return journey. This approach has been used throughout this report with a return trip regarded as two vehicle trips.

3.3 Hours of Operation

The standard construction hours will be as follows:

- 7:00am – 6:00pm Monday to Friday
- 8:00am – 1:00pm Saturdays
- No work Sundays and/ or public holidays.

Any associated heavy vehicle activity that passes through residential areas (including Narrabri town centre) are confined to the typical construction hours as stated above with the exception of Police, emergency service and/ or other authorised authorities.

Exceptions to the standard construction hours also include works that causes LAeq (15 minute) noise levels that are not more than 5dB above the rating background level of 30dB(A) at any residence not subject to a private negotiated agreement.

The works contractor was commissioned in late 2014 and will be responsible for instructing and controlling all subcontractors with respect to the hours of work. Any work outside the standard construction hours would be subject to specific prior approval by the relevant authorities.

3.4 Construction Worker Traffic

The number of workers would vary between each works stage and is anticipated to peak at 50 workers. Specific worker access arrangements will be developed in detail by the contractor. It is however understood that a combination of 12 seater shuttle buses and 4WD/ utility vehicles will transport workers between Narrabri worker accommodation and Leewood, via Old Mill Road, at the start and end of each shift. As such, the site will generate up to 20 trips each day for activity associated with worker transport. This equates to 10 shuttle bus trips in any peak hour (i.e. between 6-7am and 6-7pm to reflect the specified construction hours).

The shuttle bus service operating between Narrabri and Leewood at the start and end of each shift will reduce the overall construction vehicle activity and car parking requirement otherwise required, if each worker was to travel by private vehicle.

Further to the above, light vehicles (likely to be 4WD and utility vehicles) will transport a minimal number of workers between Narrabri and Leewood. It is estimated that a maximum of 10 vehicle trips will be generated each day by light vehicles, for the purpose of small deliveries. An additional 8 light vehicle trips would also be generated for irrigation works.

Combining the above construction worker traffic would result in a total of 38 vehicle trips per day.

3.5 Truck Routes

All trucks would be accommodated within the site throughout the construction period. Construction traffic will not be permitted to queue or park within Old Mill Road or along the Newell Highway at any time.

The majority of truck arrivals and departures will be via the north, to/ from Narrabri, with minor interstate deliveries expected to also 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.

3.6 Traffic Generation

As discussed above, all construction vehicles and worker vehicles will access Leewood via the Newell Highway and Old Mill Road. There would be a maximum of 88 trips generated on a peak day with 20-25 trips generated during a site activity peak hour throughout all construction work stages, including all worker vehicles, shuttle buses and trucks. Table 3.2 summarises this detail.

It is noted that the peak hour traffic generation is conservatively based on the construction generating peak hour (6:00am-7:00am), with base traffic along the Newell Highway based on its peak hour (10:00am-11:00am).

Table 3.2: Peak Construction Vehicle Activity

Period of Activity	Number of Trips			Total
	Trucks	Shuttle Buses	Worker Vehicles	
Daily	50	20	18	**88**
Hourly	5-10	10	5	**20-25** [1]

[1] A conservative estimate of 25 vehicles per hour has been used for the remainder of this assessment.

The traffic volumes detailed above equate to 60% of the projected peak daily traffic generation associated with the water and brine storage ponds/ existing construction activities onsite[2]. Given that the extent of traffic-related impacts would be less than that already approved and experienced on site, intersection upgrades would not be required in order to accommodate the proposed construction activity. However, the intersection arrangements have been assessed for completeness, as detailed in the following sections.

3.7 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.

The vehicle generation results in a 5-6% increase in two-way daily traffic flows and a 6-7% increase in truck movements on the Newell Highway. Given the existing traffic volumes along the Newell Highway, the anticipated increase in traffic would have a negligible impact on the operation of the Newell Highway and it would continue to operate at a LOS B or better.

2 Leewood Project – Phase 1, Narrabri – Transport Assessment, Issue E, GTA Consultants, 02/10/13

3.8 Existing and Future Developments

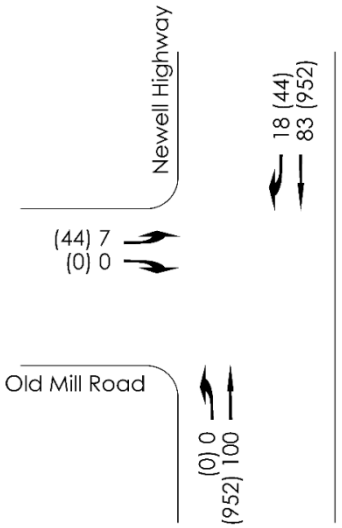
It is understood that there are currently no proposed land use developments within the immediate local area that would be adversely impacted by the construction works.

Santos has other approved exploration and appraisal activities in PEL 238 and PAL 2 in the vicinity of Leewood. Although yet to be determined, should Santos decide to proceed with Dewhurst 30 and Dewhurst 31, it is anticipated that there would be an overlap of construction activities. Traffic volumes associated with these works would generate up to 44 additional daily trips and approximately 14 hourly trips along the Newell Highway.

To assess the cumulative impacts associated with Santos exploration and appraisal activities in PEL 238 and PAL 2, the cumulative peak traffic generation has been added to the base traffic along the Newell Highway (169 vehicles per hour), to conservatively assess the turning movements at the intersection of the Newell Highway and Old Mill Road.

Overall, all activities may result in an additional 132 vehicle trips per day and 39 during any peak hour, with these volumes illustrated in Figure 3.1.

Figure 3.1: Newell Highway-Old Mill Road Construction Traffic



10 (10) = Peak Hourly Traffic (Daily Traffic)

Based on the above, the cumulative impact of the construction works associated with the Leewood Project and Dewhurst 31 and Dewhurst 32 results in a 7% increase in existing Newell Highway traffic. The Newell Highway has considerable spare capacity and would be capable of accommodating these additional peak traffic volumes.

3.9 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 Old Mill Road and its intersection 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[3]. 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 Old Mill Road along the Newell Highway every 15-20 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.

3.9.1 Austroads Warrants

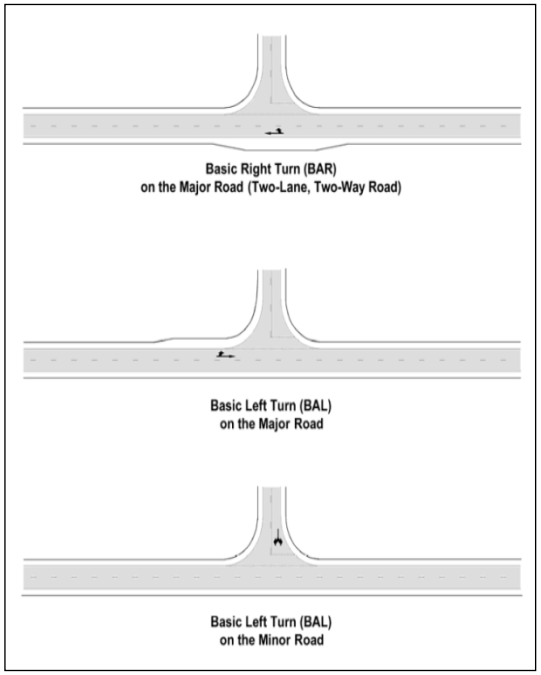
The Austroads *Guide to Road Design Part 4A: Unsignalised and Signalised Intersections* outlines standard intersection right turn treatments and warrants for urban and rural roads. The three basic road turn treatments are as follows and illustrated in Figure 3.2 and Figure 3.3.

- Basic Turn Treatments [BA]
- Channelised Turn Treatment Short [CH(s)]
- Channelised Turn Treatment [CH].

The current layouts at the Newell Highway and Old Mill Road provide basic turn treatments for the right turn in and left turn out of Old Mill Road.

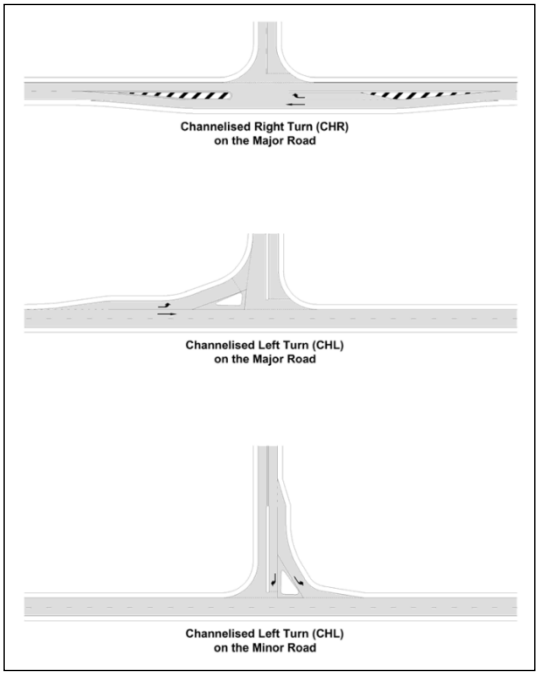
Warrants for each turn treatment are based on the measured safety performance of each treatment and a cost benefit ratio whereby the benefits of providing a higher level treatment are made equal to a proportion of the additional construction costs. The warrants are based on a ratio of through traffic volumes and turning vehicle volumes and are illustrated in Figure 3.4.

Figure 3.2: Basic Turn Treatments (BA)



Source: Austroads Guide to Road Design – Part 4A: Unsignalised and Signalised Intersections, Figure 4.1

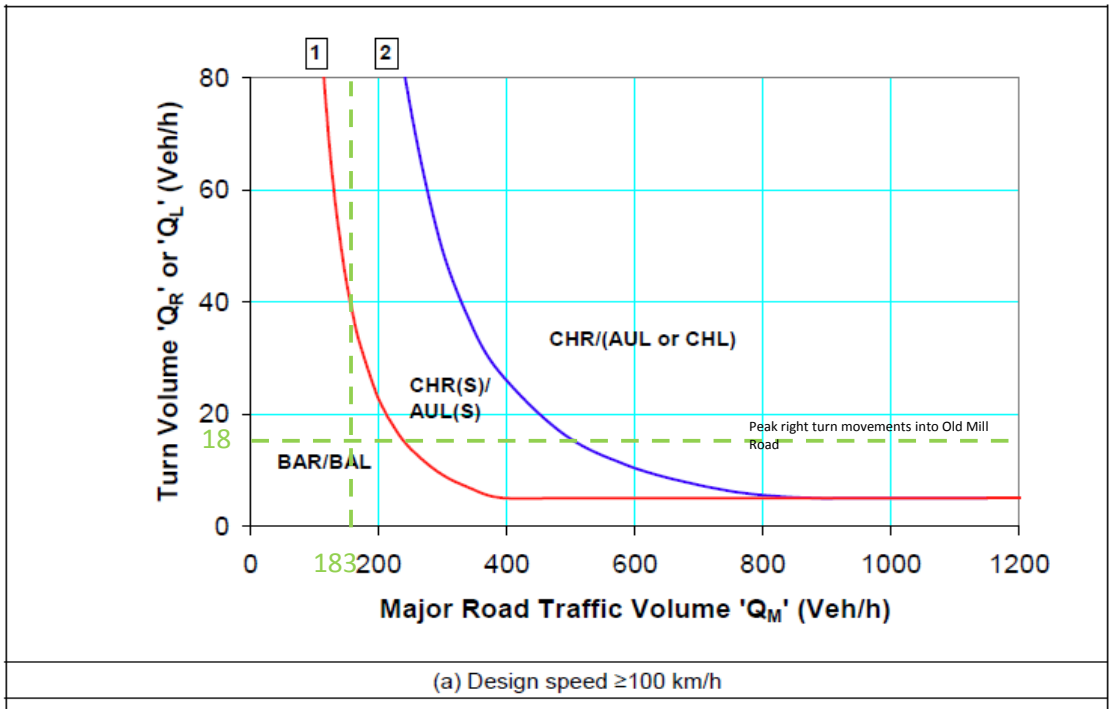
Figure 3.3: Channelised Turn Treatment (CH)



Source: Austroads Guide to Road Design – Part 4A: Unsignalised and Signalised Intersections, Figure 4.7

[3] Austroads Guide to Traffic Management Part 2: Traffic Theory, Section 5.5, Table 5.2, 2008

Figure 3.4: Warrants for Turn Treatments on Major Roads (Design Speed >100km/h)



Base Source: Austroads Guide to Road Design – Part 4A: Unsignalised and Signalised Intersections, Figure 4.9a

Based on the Newell Highway highest average peak hour of 183 vehicles (base traffic and Dewhurst traffic), Figure 3.4 determines a range for an appropriate right turn treatment based on the volumes of right turning vehicles and through vehicles as follows:

- 0-40 right turning vehicles per hour - Basic Right Turn Treatment
- 40+ right turning vehicles per hour - Channelised Turn Treatment Short.

More than 40 vehicles per hour turning right into the site on a regular/ semi-regular basis would trigger the requirement for installation of a channelised right turn treatment. Based on the estimate of 18 right turning vehicles, the proposed works do not trigger the requirement for a channelised turn treatment. Further to this, the works are short term and the maximum site generated traffic (typically 6am-7am) would not occur during the Newell Highway peak hours.

On the basis of the above, the cumulative construction vehicle volumes would have a negligible impact on the surrounding road network.

3.10 Traffic Movements in Adjoining Council Areas

No adverse effects are expected from the movement of heavy vehicles through adjacent council areas.

3.11 Site Access Plan

It is recommended that the 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 A.

As part of the water and brine storage ponds/ existing construction activities onsite, a site access plan was prepared by GTA Consultants, with signage implemented at the intersection of the

Newell Highway and Old Mill Road. It is recommended that the signage be re-instated for the proposed 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 B.

In addition to the above site access, the contractor would be responsible for implementing appropriate internal site traffic management measures, to safely accommodate the anticipated internal construction vehicle trips as identified in Section 3.2. This would include minimising any potential conflicts with the external construction vehicle trips.

4. Operational Traffic Management

4.1 Description

A small on-site staff presence is anticipated during the operational phase of the Leewood site.

Although the Leewood site would generate the majority of traffic activity during the construction stages, traffic would also be generated during the operational stages and generally, as a result of the following:

- staff travelling to and from the site at the start and end of the daytime shift
- deliveries, maintenance activities and visitors
- harvesting and crop management activities associated with the irrigation area.

4.2 Traffic Volumes

The Leewood site's operational workforce would function on a typical daytime shift basis and staff would typically travel to and from the site by car. The operational workforce is expected to be generally less than ten staff, increasing at times as a result of visitors and site meetings. The occupancy of vehicles carrying staff to and from work at comparable mine sites is typically 1.2 staff per vehicle, and it is assumed that the staff travel characteristics at Leewood would be similar. The shift times are assumed to be between 7:00am and 5:00pm weekdays, with administration personnel comprising the vast majority of site personnel. Operational deliveries and visitors would be minor and total less than five vehicles per week.

The workforce would be primarily drawn from the local area around Narrabri and the distribution of Leewood operational staff is assumed to be similar to that during the construction stages.

The worker traffic associated with the Leewood site would be minor, with less than 10 vehicle trips 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 Old Mill Road.

Further to the above, up to 10 trucks per day associated with irrigation, harvesting and crop management would be generated during operation. All brine will be stored on-site and will not generate any such vehicle activity during operation of the site.

The operational traffic impact of the Leewood site would be minor, with 10-15 vehicles arriving 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 Old Mill Road.

As discussed above, Santos has planned exploration and appraisal activities in PEL 238 and PAL 2, with an overlap of operational activities. These sites are also anticipated to operate with lower operational traffic volumes to those outlined in this report. On this basis, the cumulative traffic generation associated with the various Santos sites is expected to have a negligible impact on the Newell Highway during operation.

5. Conclusion

Based on the analysis and discussions presented within this report, the following conclusions are made:

i The Leewood Produced Water Treatment and Beneficial Reuse Project construction works are scheduled to commence in Q2 of 2015 and continue through to early 2016; a period of up to 50 weeks.

ii Construction works would be conducted in four sequential stages, with peak vehicle activity generated during Stage 2, while excavation, trenching and irrigation works occur.

iii It is anticipated that up to 50 external construction vehicle trips and up to 100 internal trips could be required on a given day during the 6-8 week long Stage 2 works.

iv Standard construction hours will be 7:00am-6:00pm Monday to Friday, 8:00am-1:00pm Saturdays with no work Sundays and/ or public holidays. Any exceptions to these hours are based on noise levels.

v Up to 50 workers are anticipated to be on-site at Leewood during peak construction activity. This equates to 38 vehicle trips per day, including 20 shuttle bus trips to transport workers to/ from the site via the Newell Highway.

vi Overall, Old Mill Road will carry a maximum of 88 vehicle trips (trucks and worker vehicles) per day, with 20-25 trips generated during a site activity peak hour throughout all construction work stages.

vii The Newell Highway will experience an increase in total traffic volumes of 5-6%, with an increase in truck volumes of 6-7%.

viii A cumulative assessment concludes that up to 132 vehicle trips per day and 39 vehicle trips per hour could occur where the proposed construction works may overlap with other activities associated with the existing and future exploration and appraisal activities within PEL 238 and PAL 2.

ix The Newell Highway will continue to operate at its existing Level of Service.

x The intersection of the Newell Highway and Old Mill Road is capable of accommodating the increase in traffic associated with the construction and operational phases of work.

xi A site access plan has been prepared and signage should be implemented along the Newell Highway to warn drivers of increased truck activity at Old Mill Road, with the contractor responsible for safely managing internal site traffic movements.

xii The operational workforce is expected to be less than 10 staff per day, generating less than 10 vehicle trips per hour, with additional visitors anticipated to be minor.

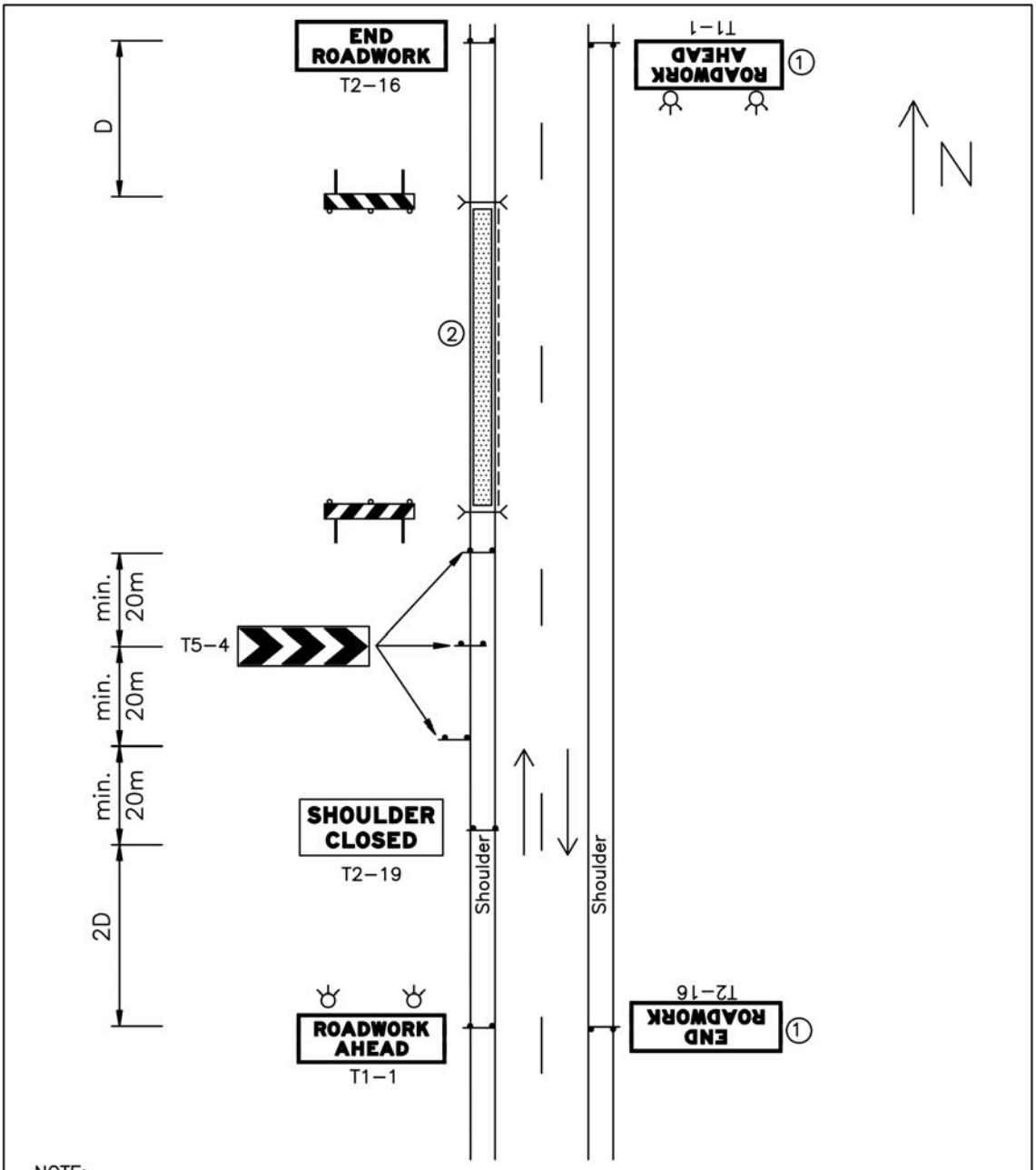
xiii It is anticipated that up to 10 trucks per day would be generated during operation as a result of irrigation, harvesting and crop management activity.

xiv The existing layout of the intersection of the Newell Highway with Old Mill Road is suitable for the proposed construction and operational traffic volumes.

xv The cumulative traffic generation associated with the operational phases of the different Santos projects proposed in the surrounding area will have a negligible impact on the Newell Highway.

Appendix A

Standard Traffic Control Plan (TCP)

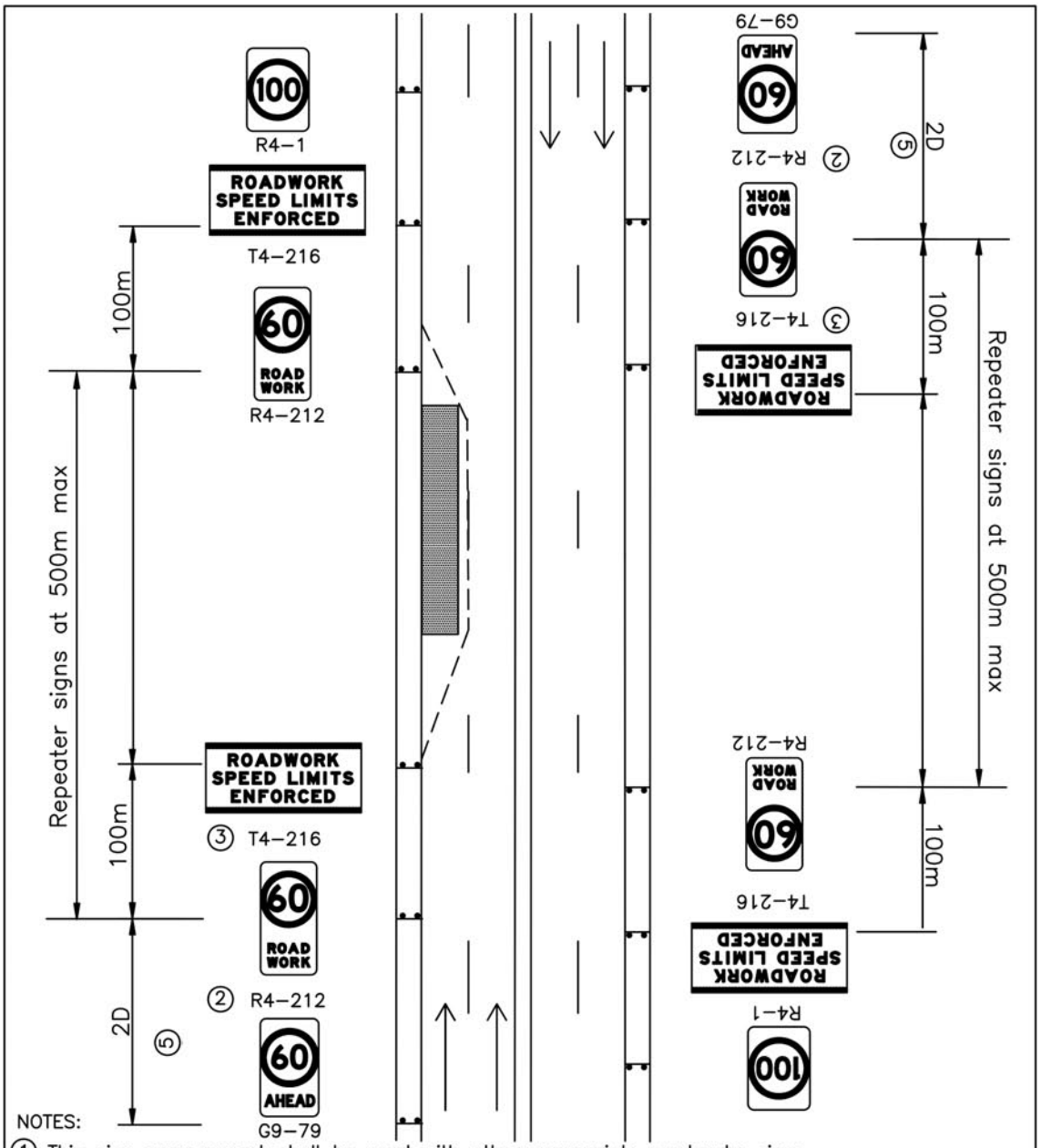


NOTE:
(1) Southbound T1–1 and T2–16 signs should be omitted on a one way carriageway.
(2) At night or when work has stopped, barriers may be erected along the work site at right angles to the traffic flow.

LONG TERM WORK
ALL ROADS
SHOULDER CLOSED

T000042

TCP 42



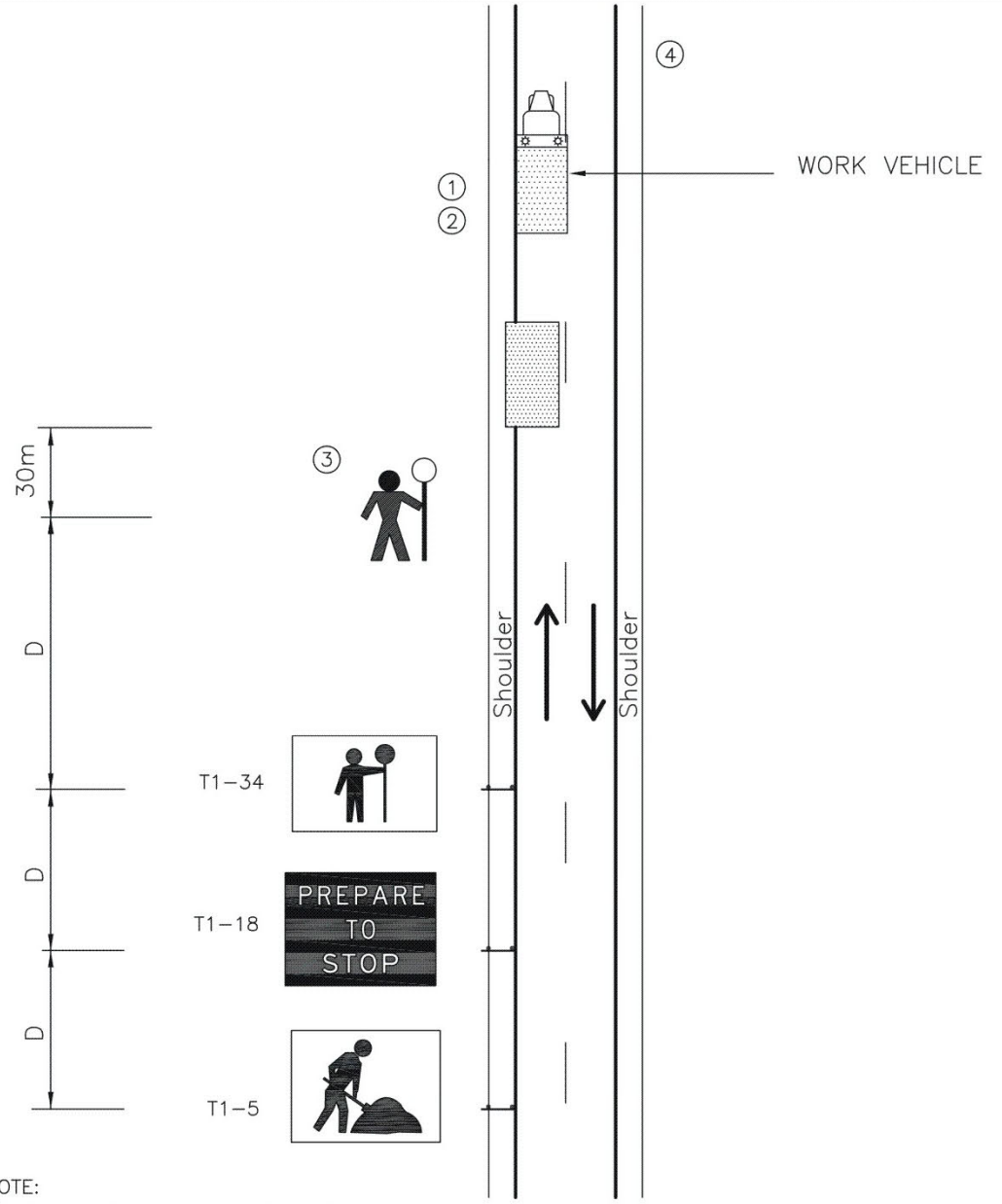
NOTES:

① This sign arrangement shall be used with other appropriate roadworks signs.
② The value of speed limits displayed shall match the speed zone approval.
③ ROADWORKS SPEED ZONES ENFORCED signs are required for works in excess fo 4 weeks or where speed zone compliance is a problem.
④ See Section 8.2 ***Roadwork (temporary) speed zones.***
⑤ The value of D shall be determined at the time of TCP selection/design and shown on the TCP.

ROADWORK SPEED LIMITS

T000057

TCP 57



NOTE:

① While setting up, park Work Vehicle on the shoulder and allow traffic to proceed.

② During work, park Work Vehicle in lane in front of the work to protect personnel from traffic in opposite direction.

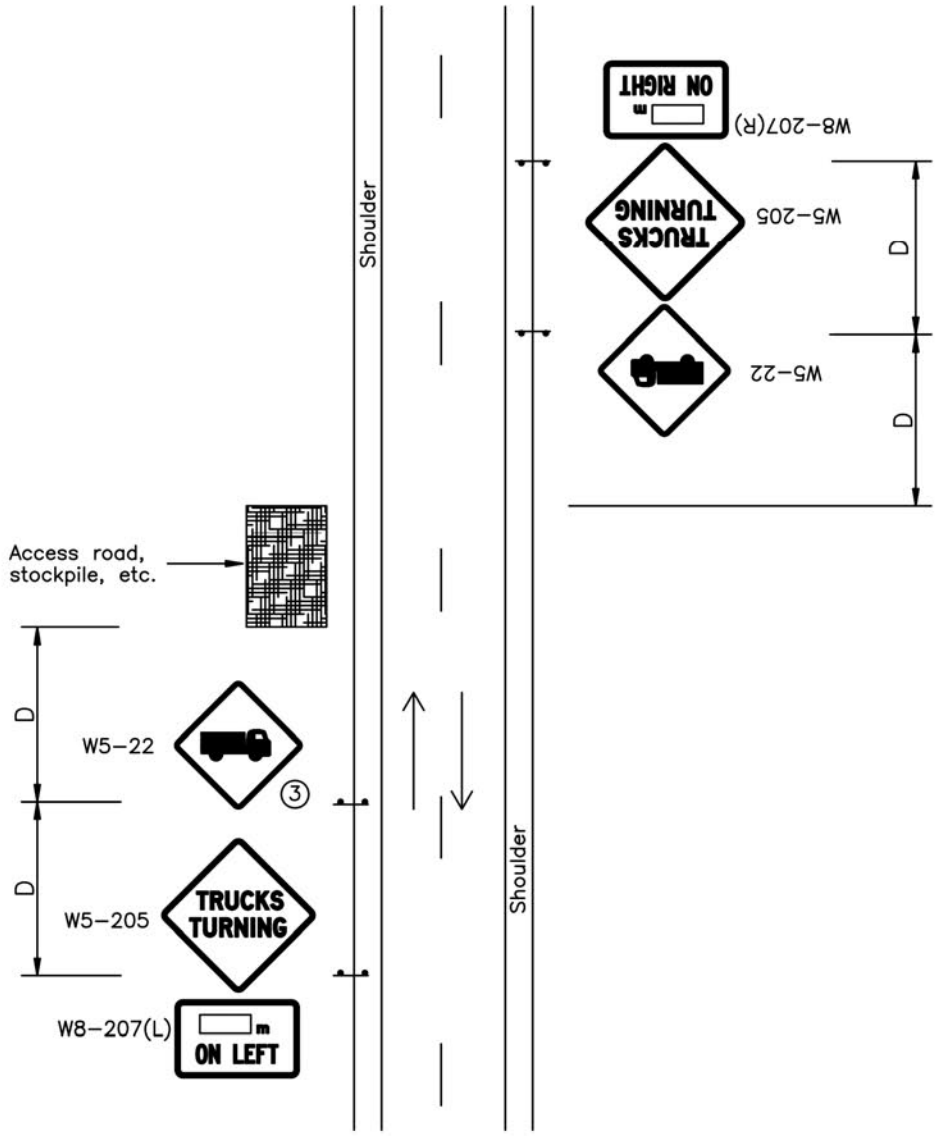
③ Traffic Controller to stop traffic for duration of work and then direct traffic through work area, once it has been cleared of personnel and the Work Vehicle.

④ Signs may be necessary facing the other direction of traffic.

SHORT TERM WORK (UP TO FIVE MINUTES)
2 LANE / 2 WAY (ADT ⩾ 3,000)
MINOR MANUAL WORK

T000077

TCP 77



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 B

Site Access Plan

NOTE:
TEMPORARY VARIABLE MESSAGE SIGNS (VMS) MAY ALSO BE LOCATED ON THE NEWELL HIGHWAY, APPROXIMATELY 250m FROM OLD MILL ROAD TO PROVIDE ADDITIONAL WARNING/ SAFETY DURING CONSTRUCTION ACTIVITY.

PROPOSED SITE ACCESS FROM OLD MILL ROAD

LEEWOOD

SITE

VMS LOCATION

OLD MILL ROAD

NEWELL HIGHWAY

Dog Fence Rd

Bohena Creek Rd

Newell Hwy

110

R1-2A GIVE WAY

W5-205 TRUCKS TURNING

W8-207(R) 220 m ON RIGHT

W5-22

W8-207(L) 220 m ON LEFT

OLD MILL ROAD

OLD MILL ROAD

N

PRELIMINARY PLAN

FOR DISCUSSION PURPOSES
ONLY SUBJECT TO CHANGE
WITHOUT NOTIFICATION

GTAconsultants
www.gta.com.au

LEEWOOD PROJECT
NEWELL HIGHWAY
SITE ACCESS PLAN

24 SEPTEMBER '12
NOT TO SCALE
13S1042000-01-01-P1

PLOTTED BY : Cameron Ward ON 24/09/2012 AT 7:40:29 PM

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Appendix 5

SEPP 33 hazard assessment (Sherpa Consulting)

SANTOS LEEWOOD PHASE 2

WATER AND BRINE TREATMENT PLANT

SEPP33

RPS AUSTRALIA EAST PTY LTD

PREPARED FOR: **Katharine Bond**
Environmental Scientist

DOCUMENT NO: **20823-RP-001**
REVISION: **6**
DATE: **13-Mar-2015**

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Title: **Santos Leewood Phase 2** **Water and Brine Treatment Plant** **SEPP33**	**QA verified:** **F. Wong** **Date: 13-Mar-2015**

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ABBREVIATIONS

ADG	Australian Dangerous Goods
CIP	Clean in Place
CSG	Coal Seam Gas
DG	Dangerous Goods
DoP	Department of Planning and Infrastructure
EDTA	Ethylenediaminetetraacetic acid
EPL	Environmental Protection Licence
ML	Mega Litre
NSW	New South Wales
PAL	Petroleum Assessment Lease
PEL	Petroleum Exploration License
PG	Packing Group
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
REF	Review of Environmental Factors
SDS	Safety Data Sheet
SEPP	State Environmental Planning Policy
WBTP	Water and Brine Treatment Plant

1. INTRODUCTION

1.1. Background

Santos NSW (Eastern) Pty Limited (Santos) (or its assigned contractor), for and on behalf of the titleholders of Petroleum Assessment Lease (PAL) 2, proposes to construct and operate a Water and Brine Treatment Plant (WBTP) and associated infrastructure, including a managed irrigation system, at a property known as 'Leewood' within PAL 2 (the proposed activity). Leewood is located on the Newell Highway approximately 24 kilometres south west of Narrabri, NSW.

The primary objective of the proposed activity is to construct and operate a purpose built, centralised water treatment facility outside of the Pilliga State Forest, to treat, manage and beneficially reuse produced water stored within the ponds.

Santos NSW (Eastern) Pty Limited is the proponent for the proposed activity on behalf of the titleholders of PAL 2. The proposed activity will include:

- construction and operation of:
  - a water treatment plant, including pre-treatment and reverse osmosis plant
  - a brine treatment plant
  - a brine distribution manifold and associated piping at Leewood, to allow water distribution into the water treatment plant and associated return flows to brine storage ponds
  - a treated water storage tank (five megalitre capacity)
  - a managed irrigation system including a centre pivot and sub-surface drip irrigation system
  - other associated infrastructure, including a gas pipeline to fuel the generators
  - a small potable water treatment system for water extracted from the licensed bore
- the construction of (and the ability to operate) a treated water pipeline extending to the Leewood property boundary to transfer water to another location for irrigation by a third party (if required)
- re-use of treated water for irrigation at the Leewood property and other uses both on and off site including dust suppression, drilling and construction and firefighting. Santos is investigating the option of providing treated water to third parties for agricultural irrigation, although this potential use of treated water does not form part of the proposed activity for the purposes of this REF and will be subject to separate assessment and approvals.
- amelioration of soils within irrigation area by deep tillage, fertiliser, lime and gypsum in preparation for irrigation.

- decommissioning and rehabilitation of the site, if the Narrabri Gas Project does not proceed.

Santos (or its assigned operator) will operate the proposed activity for up to five years. The WBTP will treat up to 1.5 megalitres per day of produced water from Santos' CSG exploration and appraisal activities within PEL 238, PAL 2 and PPL 3. The operational process is expected to involve, but is not limited to:

- pumping of produced water from the produced water pond to the water treatment plant
- treatment of produced water within the water treatment plant, including removal of solids by filter (pre-treatment), reverse osmosis to separate the water and brine streams (treatment), and chemical and pH dosing (post-treatment) to make the treated water appropriate for irrigation
- transfer of treated water to the treated water storage tank or directly to the on-site managed irrigation system for beneficial re-use
- beneficial re-use of treated water for irrigation, or other uses both on and off-site such as dust suppression, drilling and construction and firefighting
- transfer of brine to the brine treatment plant for concentration and further recovery of treated water
- storage of brine in the existing Leewood ponds.

RPS Australia East Pty Ltd (RPS) has engaged Sherpa Consulting Pty Ltd (Sherpa) to undertake a screening assessment review using the *State Environmental Planning Policy (SEPP) No. 33 – Hazardous and Offensive Development Application Guidelines* and if required, undertake a Preliminary Hazard Analysis (PHA) for the proposed WBTP. This document forms part of the Review of the Environmental Factors (REF).

1.2. SEPP33 applicability

State Environmental Planning Policy No. 33 – Hazardous and Offensive Development Application Guidelines (SEPP33) links the permissibility of an industrial development to its offsite safety and environmental risks. Developments that involve storage, handling or processing materials, which in the absence of locational, technical or operational controls may pose an offsite risk and offence to people, property or the environment are defined by SEPP33 as '*potentially hazardous industry*' or '*potentially offensive industry*'.

Development proposals that are classified as '*potentially hazardous industry*' must undergo a PHA to determine the risk to people, property and the environment. If the residual risk exceeds the acceptability criteria, the development is a '*hazardous industry*' and may not be permissible within NSW.

Developments that have the potential to emit contaminants to the environment and which require an Environmental Protection Licence (EPL) are '*potentially offensive*'.

1.3. Study objectives

The objectives of the study is to prepare a screening assessment in compliance with the SEPP33 to determine whether a Preliminary Hazard Analysis is required.

1.4. Study scope

The scope of the SEPP33 review includes the following:

- Leewood water and brine treatment plant (WBTP)
- chemical storage at the site associated with the WBTP.

1.5. Exclusions and limitations

The study excludes the following:

- Requirement for environmental licensing to assess whether the development is '*potentially offensive*' (as explained in Section 1.2) does not form part of this assessment.

2. SEPP33 ASSESSMENT

2.1. Methodology

The screening process published in the NSW Department of Planning (DoP) guideline *Hazardous & Offensive Development Application Guidelines – Applying SEPP33 (January 2011)* was used to establish whether the development is '*potentially hazardous*' or not.

SEPP33 defines '*potentially hazardous*' as follows:

> *'Potentially hazardous industry' means a development for the purposes of an industry which, if the development were to operate without employing any measures (including, for example, isolation from existing or likely future development on other land) to reduce or minimise its impact in the locality or on the existing or likely future development on other land, would pose a significant risk in relation to the locality:*
>
> *(a) to human health, life or property; or*
>
> *(b) to the biophysical environment, and:*
>
> *includes a hazardous industry and a hazardous storage establishment.*

To determine whether a proposed development is '*potentially hazardous'*, the screening in SEPP33 considers the type and quantity of hazardous materials to be stored on the site and the distance of the storage area to the nearest site boundary, as well as the expected number of transport movements.

'Hazardous materials' are defined within the *Applying SEPP33* guideline as substances that fall within the classification of the Australian Dangerous Goods (ADG) Code.

2.2. Dangerous goods

2.2.1. Types and quantities of DG

A list of expected types and quantities of Dangerous Goods (DG) to be stored or handled at the development, together with the relevant SEPP33 screening threshold is presented in Table 2.1.

The electrical power needs for the site will be met by on-site power generation turbines. Initially, diesel fuelled turbines will be used. However, once the site is operational, natural gas will be supplied to site via an offtake from the existing gas pipeline through the Leewood site, allowing gas powered turbines to be used. The diesel turbines and associated fuel storage will be retained as a backup for operational flexibility. Natural gas will not be stored on-site and was therefore excluded from Table 2.1.

2.2.2. Storage arrangements

Figure 2.1 is an indicative layout, showing the locations of the chemical and diesel storage within the WBTP.

Chemicals will be stored in a storage area located to the south of the WBTP.

Chemical storage systems will include bunding in accordance with Australian Standards. Each chemical type will be stored in a separate bunded area. Incompatible chemicals will be not be located in adjacent bunds unless a dividing wall is provided to prevent the chemicals mixing. Chemical storage tanks will be provided with appropriate signage including the chemical being stored and any hazardous material or dangerous goods ratings.

Bunds will be designed to minimise the need for entry (ie pumps and equipment shall be accessible from outside the bunded area to the maximum extent practicable). Chemical storage areas will be enclosed to prevent rain water filling the bunded area. Bunds will be provided with sumps to allow for submersible pumps to be manually placed in the bund to remove chemical in the event of a leak. Bunded areas will be provided with level switches to indicate when liquid is present in the bund sump. Bunded areas will be epoxy coated with a rough epoxy coating used for designated walkways. Appropriate personal protective equipment (PPE) will be located at the chemical storage area.

Chemical systems will be designed to minimise the level of manual handling required. Chemical unloading areas will be provided with a bund capable of holding the largest delivery truck volume available. Safety showers will be provided at each chemical storage bund and adjacent to the chemical unloading bund.

Chemical dosing lines will be provided with double containment. Containment lines will be pitched to a sump to allow for identification of leaks.

2.2.3. Transport

Overall vehicle movements to and from the site will be less than five vehicles per week, a fraction of which would involve Class 8 and 9 DG. Even if all vehicle movements were deliveries of Class 8 and 9 DG to and from the site, the overall weekly vehicle movements would still be below the SEPP33 screening threshold of 30 vehicle movements per week.

As the operational weekly vehicle movements are well below the SEPP33 transport screening threshold levels, the development is not '*potentially hazardous*' with respect to transportation and a route evaluation study is not required.

2.3. Conclusion

The following conclusions are made from Table 2.1.

- A total of approximately 3 tonnes of Class 9 Packing Group (PG) III material will be stored on the site. There is no threshold identified in SEPP33 for such goods.
- A total of approximately 5 tonnes of Class 8 PG II material will be stored on the site. This is below the SEPP33 threshold level of 25 tonnes for Class 8 Packing Group II materials.
- A total of approximately 7 tonnes of Class 8 PG III material will be stored on the site. This is below the SEPP33 threshold level of 50 tonnes for Class 8 Packing Group III materials.
    - A total of approximately 1 tonne of the Class 8 PG III material has a sub-class of 6.1. This is below the SEPP33 threshold level of 2.5 tonnes for Class 6.1 Packing Group III materials.
- Even if the Class 8 PG II and PG III material was stored in the same 'general location', the total would be approximately 12 tonnes, which is below the SEPP33 threshold level of 25 tonnes for the worst case PG.

Therefore, based on the screening thresholds for the dangerous goods listed above, the development is not '*potentially hazardous*' and a Preliminary Hazard Analysis (PHA) is not required.

As the operational weekly vehicle movements are well below the SEPP33 transport screening threshold levels, the development is not '*potentially hazardous*' with respect to transportation and a route evaluation study is not required.

Figure 2.1: Leewood water treatment– Detailed site layout showing WBTP and chemical storage location

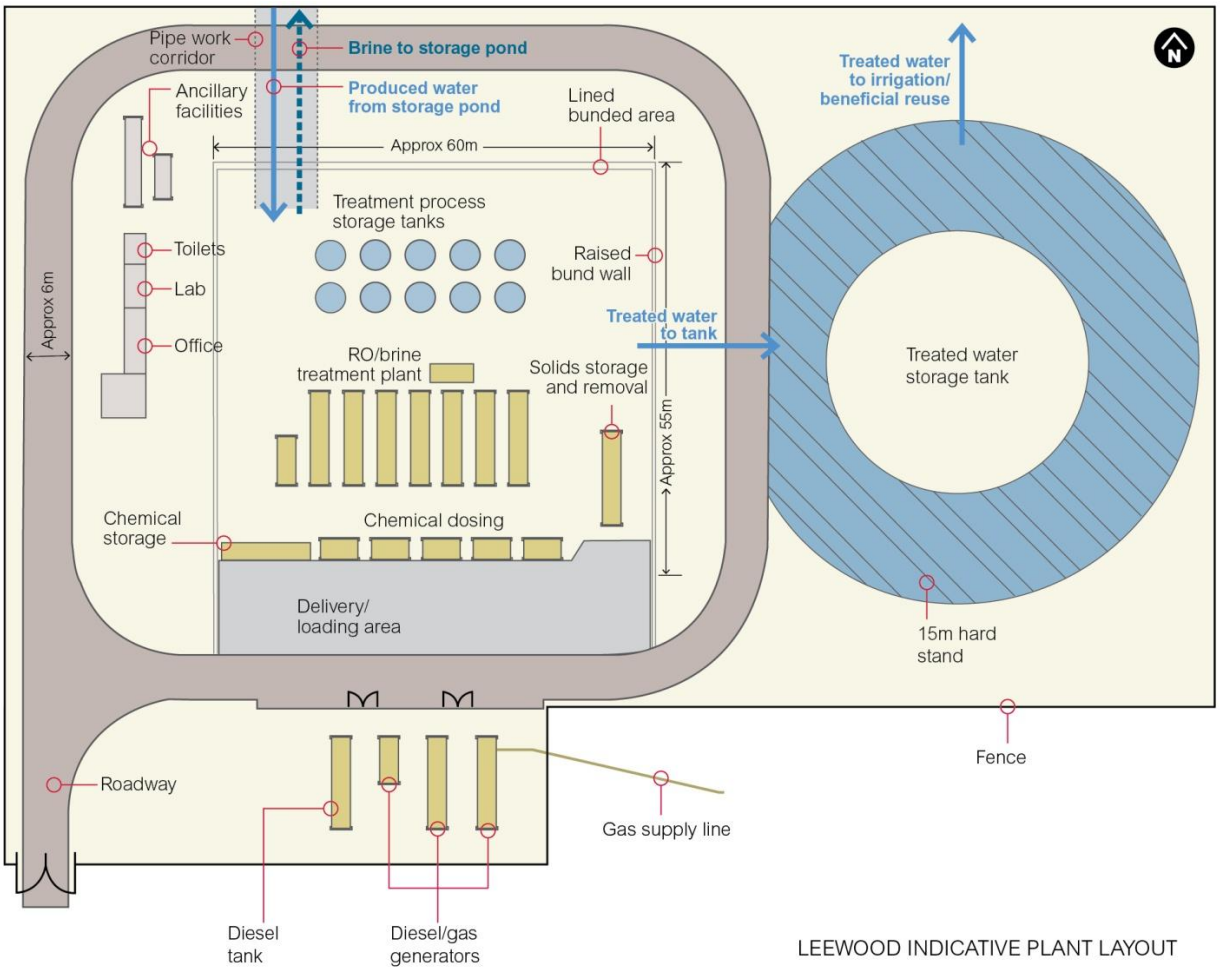

Table 2.1: SEPP33 hazardous material storage screening summary

Material	Purpose	UN No.	DG class [b]	Sub-class	Approximate quantity stored on site		SEPP33 threshold	SEPP33 determination
					m^3	tonnes [b]		
Hydrochloric acid (33% wt/wt)	Chemical Clean in Place (CIP) Resin Regeneration	1789	8 PG II[c]		1.55	1.8	Based on Table 3 in Ref 1: Screening threshold for Class 8 PG II is 25 tonnes.	Total Class 8 PG II storage does not exceed SEPP33 threshold.
Sulphuric acid (98% wt/wt)	Chemical Clean in Place (CIP) Resin Regeneration	1830	8 PG II		<1	1.8		
Caustic soda (30%wt/wt)	Neutralisation Resin Regeneration	1824	8 PG II[c]		<1	1.3		
				Total Class 8 PG II		*~4.9 tonnes*		
Sodium hypochlorite (10% wt/wt)	Chemical Clean in Place (CIP) Chloramination	1791	8 PG III[c]		1.9	2.2	Based on Table 3 in Ref 1: Screening threshold for Class 8 PG III is 50 tonnes. Screening threshold for Class 6.1 PG III is 2.5 tonnes.	Total Class 8 PG III storage does not exceed SEPP33 threshold. Total Class 6.1 PG III does not exceed SEPP33 threshold.
Aqueous ammonia (25% wt/wt)	Chloramination	2672	8 PG III		1.5	1.4		
Sodium bisulphite (33% wt/wt)	Dechlorination Neutralisation	2693	8 PG III		0.38	0.5		
Osmocide[d]	Biocide[e]	2922	8 PG III	6.1	N/A	1.0		
Kuriverter	Biocide[e]	3266	8 PG III		N/A	2.0		
				Total Class 6.1 PG III		*~1.0 tonnes*		
				Total Class 8 PG III		*~7.1 tonnes*		
				Total Class 8 (all packing groups)		**~12 tonnes**	Based on Table 3 in Ref 1: Screening threshold for Class 8 PG (all applicable PG) is 25 tonnes.	Total Class 8 PG (all PG) storage does not exceed SEPP33 threshold.
1,2 benzisothiazolin-3-one	Biocide[e]	3082	9 PG III		N/A	3.0	No threshold identified based on SEPP33.	Not applicable
				Total Class 9 PG III		*~3.0 tonnes*		
Citric acid (50% wt/wt)	Chemical Clean in Place (CIP) Resin Regeneration				N/A	1	No SEPP33 threshold requirements for non-DG.	Not applicable.
Anti scalant	Chemical Clean in Place (CIP)				N/A	0.3		
Calcium Chloride		-	Non-DG		N/A	1		
Ethylenediaminetetraacetic acid (EDTA)		-	Non-DG		N/A	0.5		
Polyaluminium Chloride		-	Non-DG		N/A	1.1		
Aluminium Chlorohydrate	Coagulant	-	Non-DG		N/A	1.2		
Diesel	Fuel for generator	-	Combustible C1		30	N/A	No threshold identified for Combustibles C1, based on SEPP33. (If diesel is stored in the same bund as gasoline (Class 3 PGII), total inventory of diesel would be classified as Class 3 PG II).	Not applicable.

Notes:

(a) Quantities of PG II and PG III, Class 8 chemicals require to be added together, unless they are in separate 'general locations'. Refer to Section 2.3 for more information.

(b) Details such as DG Class and density were obtained from chemical SDS. Details provided in Appendix A.

(c) The Australia Code of Dangerous Goods 7th Edition lists PG II and PG III for these chemicals. The PG class depends on the physical and chemical properties of the chemicals (eg concentration% which affects the level of danger and packing required). PG class was referenced from the Safety Data Sheet (Refer to Appendix A).

(d) Osmocide is categorised under DG Class 8 and sub-class 6.1 under PG III. The storage quantities of both classes were compared respectively against the corresponding thresholds based on SEPP33.

(e) These are optional disinfection chemicals, and the final choice will be made during process commissioning. Not all biocide chemicals will be stored on site at the same time.

APPENDIX A. SDS REFERENCES

Safety Data Sheets (SDSs) for the following dangerous goods (DG) were used for reference and are provided in this Appendix:

- Hydrochloric acid (33% wt/wt)
- Sulphuric acid (98% wt/wt)
- Caustic soda (30% wt/wt)
- Sodium hypochlorite (10% wt/wt)
- Aqueous ammonia (25% wt/wt)
- Sodium bisulphite (33% wt/wt).

SDS are provided by the suppliers of the DG. Hence, depending on the supplier, the actual SDS supplied to the site may not be identical to those included in this Appendix. However, the information contained in the SDS will be consistent in the context of this SEPP33 screening.

MATERIAL SAFETY DATA SHEET

Cleantec
A Campbell Brothers Limited Business

1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

PRODUCT NAME: **HYDROCHLORIC ACID 33%**

OTHER NAMES: **HYDROCHLORIC ACID, HYDRO ACID**

RECOMMENDED USE: **General chemical - Acid**

SUPPLIER NAME: **CAMPBELL CLEANTEC (ABN 92 009 657 489)**

ADDRESS: **32 PERIVALE STREET, DARRA, QLD, 4076**

TELEPHONE: **GENERAL ENQUIRIES:** **+ 61 7 3710 3200**

CUSTOMER SERVICE: **1800 077 240**

FAX: **GENERAL ENQUIRIES:** **+ 61 7 3710 3210**

CUSTOMER SERVICE: **+ 61 7 3710 3207**

EMERGENCY TELEPHONE NUMBER: **AUSTRALIA:** **1800 628 724 (ALL HOURS)**

INTERNATIONAL: **+ 61 7 3710 3184 (ALL HOURS)**

2. HAZARDS IDENTIFICATION

HAZARD CLASSIFICATION: Classified as **hazardous** according to the criteria of NOHSC.

Classified as a **dangerous good UN 1789** according to the criteria of ADG Code (see section 14).

Classified as **schedule 6** according to the criteria of SUSDP (see section 15).

HAZARD CATEGORY: C – Corrosive

Xi – Irritant

RISK PHRASES: R35 – Causes severe burns.

R37– Irritating to respiratory system.

R41 – Risk of serious eye damage.

SAFETY PHRASES: S1/2 – Keep locked up and out of the reach of children.

S7/9 – Keep container tightly closed and in a well-ventilated place.

S23 – Do not breathe fumes, vapour or spray.

S24/25 – Avoid contact with skin and eyes.

S26 – In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

S36/37/39 – Wear suitable protective clothing, gloves and eye/face protection.

S45 – In case of accident or if you feel unwell, seek medical advice immediately (show the label whenever possible).

The information contained in this MSDS is specific to the product when handled and used neat. This product when diluted may not require the same control measures as the neat product. Check with your technical representative if in doubt.

3. COMPOSITION / INFORMATION ON INGREDIENTS

INGREDIENT	CAS No.	PROPORTION (% w/w)
*The ingredients below are considered either **hazardous, dangerous goods or poison scheduled** according to the criteria of NOHSC, ADG Code and SUSDP (respectively) at the levels used in the product.*		
Hydrochloric Acid	7647-01-0	30 – 60%
*The ingredients below are **not** considered either **hazardous, dangerous goods or poison scheduled** according to the criteria of NOHSC, ADG Code and SUSDP (respectively) at the levels used in the product.*		
water		> 60%

4. FIRST AID MEASURES

INGESTION: For advice, contact a Poisons Information Centre (Phone Australia 131126, New Zealand 0800 764 766) or a doctor. If swallowed, do NOT induce vomiting.

EYE CONTACT: If in eyes, hold eyelids apart and flush the eye continuously with running water. Continue flushing until advised to stop by the Poisons Information Centre or a doctor, or for at least 15 minutes.

SKIN CONTACT: If skin or hair contact occurs, remove contaminated clothing and flush skin and hair with running water. Continue flushing until advised to stop by the Poisons Information Centre or a doctor.

INHALATION: Remove from source of exposure to fresh air. Seek medical assistance if the effects persist.

***** SHOW THIS SAFETY DATA SHEET TO A DOCTOR *****

FIRST AID FACILITIES: Potable water should be available to rinse eyes or skin. Provide eye baths and safety showers.

NOTES TO PHYSICIAN: Treat symptomatically and as for strongly acidic corrosive material. Can cause corneal burns.

5. FIRE FIGHTING METHODS

SUITABLE EXTINGUISHING MEDIA: Water spray, foam, carbon dioxide or dry chemical powder.

HAZARDS FROM COMBUSTION: The product is non-combustible; however, the packaging material may burn to emit noxious fumes. Contact with metals may liberate hydrogen gas which is extremely flammable.

PRECAUTIONS FOR FIRE FIGHTERS AND SPECIAL PROTECTIVE EQUIPMENT: Fire fighters should wear self-contained breathing apparatus and acid-resistant chemical splash unit to minimise risk of exposure.

HAZCHEM CODE: 2R

6. ACCIDENTAL RELEASE MEASURES

EMERGENCY PROCEDURES: Spillages are slippery. Ensure adequate ventilation, work up wind or increase ventilation. Keep spectators away – rope off the area. Avoid accidents, clean up immediately. Wear protective equipment to prevent skin and eye contamination and inhalation of vapours.

METHODS AND MATERIALS FOR CONTAINMENT AND CLEAN UP: Contain the spill and prevent run off into confined areas, drains and waterways. Vapour-suppressing foam may be used to control vapours.

Absorb with dry earth, sand or other non-combustible material. Neutralise with lime or soda ash. Use clean, non-sparking tools to collect and seal in properly labelled drums for disposal in an area approved by local authority by-laws. Wash area down with excess water to remove residual material.

Incineration of disposed material is not recommended, as it is unlikely to adequately burn.

7. HANDLING AND STORAGE

PRECAUTIONS FOR SAFE HANDLING: Keep containers closed at all times - check regularly for leaks or spills. Transport and store upright.

Addition to water releases heat which can result in violent boiling and splattering. Always add slowly and in small amounts. Never add water to acids - always add acids to water.

Avoid eye contact and repeated or prolonged skin contact and breathing in vapour, mists and aerosols. Do not eat, drink or smoke in contaminated areas. Always remove contaminated clothing and wash hands before eating, drinking, smoking or using the toilet. Wash contaminated clothing and other protective equipment before storage or re-use.

CONDITIONS FOR SAFE STORAGE: Store in the original container, in a cool, dry, well-ventilated area out of sunlight and away from incompatible materials and foodstuffs.

Keep containers closed when not in use to ensure contamination does not occur- check regularly for leaks. Do not combine part drums of the same product, as this may be a source of contamination. Do not mix with other chemicals.

This material is a Scheduled Poison S6 and must be stored, maintained and used in accordance with the relevant regulations.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

NATIONAL EXPOSURE STANDARDS: No value assigned for this specific material by NOHSC, however as published by NOHSC:
T.W.A. for Hydrochloric Acid = 7.5 mg/m^3 (5ppm) Peak Limitation

BIOLOGICAL LIMIT VALUES: No biological limit allocated.

ENGINEERING CONTROLS: Ensure ventilation is adequate to maintain air concentrations below Exposure Standards.
If inhalation risk exists then use with local exhaust ventilation or while wearing a suitable respirator. Keep containers closed when not in use.

PERSONAL PROTECTIVE EQUIPMENT:

Protective equipment must be worn at all times. Risk assessments should always be conducted to identify the hazards and in turn determine the appropriate personal protective equipment for the hazard.

Protective gloves: elbow-length laminate film, natural rubber, nitrile, neoprene, neoprene/natural rubber blend or PVC impervious gloves. Always check with the glove manufacturer or your personal protective equipment supplier regarding the correct type of glove to use. Consult AS/NZS 2161 for further information.

Eye protection: safety glasses/goggles with side shield protection and/or full-face shield. Consult AS/NZS 1336 and AS/NZS 1337 for further information.

Clothing and footwear: waterproof apron, coveralls, trousers, long sleeved shirt, closed in shoes and/or safety footwear. Consult AS/NZS 2210 and AS/NZS 2919 for further information.

Respiratory Protection: Avoid breathing mist, sprays or vapours. Where ventilation is not adequate, respiratory protection may be required. Any air-purifying respirator with an acid gas filters or any chemical cartridge respirator with an acid gas cartridge(s) providing protection against the compound of concern meeting the requirements of AS/NZS 1715 and AS/NZS 1716.

9. PHYSICAL AND CHEMICAL PROPERTIES:

APPEARANCE:	Clear, colourless, mobile, fuming liquid.
ODOUR:	Odour of Hydrogen Chloride Gas.
pH (NEAT):	<1
SPECIFIC GRAVITY OR DENSITY:	1.16
VAPOUR PRESSURE:	No information available.
PERCENT VOLATILES:	No information available.
BOILING POINT / RANGE:	No information available.
FREEZING / MELTING POINT:	No information available.
SOLUBILITY:	The product is water based and is fully soluble in water.
FLASH POINT:	No known fire hazard.
FLAMMABILITY LIMITS:	No information available.
IGNITION TEMPERATURE:	No information available.
SHELF LIFE:	2 years from manufacturing date (when stored as directed).
OTHER:	None.

10. STABILITY AND REACTIVITY

CHEMICAL STABILITY:	Stable under normal conditions of use. The shelf life is 2 years.
CONDITIONS TO AVOID:	Do not combine part drums of the same product, as this may be a source of contamination.
INCOMPATIBLE MATERIALS:	Chlorine containing products, alkalis, organic materials, aluminium, tin or zinc coated metals.
HAZARDOUS DECOMPOSITION PRODUCTS:	The packaging material may burn to emit noxious fumes.
HAZARDOUS REACTIONS:	Reacts violently with alkalis. Reacts exothermically on dilution with water. Reacts with chlorine products and oxidising agents liberating toxic chlorine gas. Corrosive to many metals with the liberation of extremely flammable hydrogen gas.

11. TOXICOLOGICAL INFORMATION

No adverse health effects expected if the product is handled in accordance with this Safety Data Sheet and the product label. Symptoms or effects that may arise if the product is mishandled and overexposure occurs are:

ACUTE EFFECTS

INGESTION:	Swallowing can result in nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract.
EYE CONTACT:	Highly corrosive to eyes; contact can cause corneal burns. Contamination of eyes can result in permanent injury.
SKIN CONTACT:	Highly corrosive to skin - may cause skin burns.
INHALATION:	Breathing in mists or aerosols may produce respiratory irritation.
LONG TERM EFFECTS:	No information available.

ACUTE TOXICITY / CHRONIC TOXICITY: No toxicity data for this specific product, however toxicity data for the hazardous ingredient is listed below.

TOXICITY DATA FOR HYDROCHLORIC ACID:
Oral LD_{50} (rat) 900 mg/kg
Inhalation LC_{50} (rat) 3124 ppm/1h Inhalation LC_{50} (mouse) 1108 ppm/1h

12. ECOLOGICAL INFORMATION

ECOTOXICITY: Avoid contaminating waterways. The product is highly acidic. If large spills occurred a water pH drop could be responsible for an environmental effect on aquatic organisms.

ECOTOXICITY DATA FOR HYDROCHLORIC ACID:
LC_{50} Mosquito fish (female) 282 mg/L/24hr
LC_{50} Shore Crab 240 mg/L/48hr LC_{50} Sand shrimp 260 mg/L/48hr

PERSISTENCE AND DEGRADABILITY: Not relevant.

MOBILITY: No information available.

OTHER: None.

13. DISPOSAL CONSIDERATIONS

DISPOSAL METHODS: Empty containers should be forwarded to an approved agent for recycling. Avoid unauthorised discharge to sewer.

SPECIAL PRECAUTIONS FOR LANDFILL OR INCINERATION: The product is suitable for disposal by landfill through an approved agent. Incineration of the product is not recommended, as it is unlikely to adequately burn.

14. TRANSPORT INFORMATION

ROAD AND RAIL TRANSPORT: Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for transport by Road and Rail.

UN NUMBER: 1789

UN PROPER SHIPPING NAME: HYDROCHLORIC ACID

CLASS AND SUBSIDIARY RISK(S): 8

PACKAGING GROUP: II

HAZCHEM CODE: 2R

INITIAL EMERGENCY RESPONSE GUIDE: Guide 40

SEGREGATION DANGEROUS GOODS: Not to be loaded with explosives (class 1), dangerous when wet substances (class 4.3), oxidising agents (class 5.1), organic peroxides (class 5.2), radioactive substances (class 7), corrosives (strong alkalis of class 8), foodstuffs and foodstuff empties, however exemptions may apply.

MARINE TRANSPORT: Classified as Dangerous Goods by the criteria of the International Maritime Dangerous Goods Code (IMDG Code) for transport by sea.

UN NUMBER: 1789

UN PROPER SHIPPING NAME: HYDROCHLORIC ACID

CLASS AND SUBSIDIARY RISK(S): 8

PACKAGING GROUP: II

STOWAGE AND SEGREGATION: Category C

AIR TRANSPORT: Classified as Dangerous Goods by the criteria of the International Air Transport Association (IATA) for transport by air.

UN NUMBER: 1789

UN PROPER SHIPPING NAME: HYDROCHLORIC ACID

CLASS AND SUBSIDIARY RISK(S): 8

PACKAGING GROUP: II

ERG CODE: 8L

15. REGULATORY INFORMATION

POISONS SCHEDULE (AUST.): 6

APVMA STATUS: Not relevant.

TGA STATUS: Not relevant.

AICS STATUS: All the constituents of this product are listed.

AQIS STATUS: Not relevant.

OTHER: None.

16. OTHER INFORMATION

GENERAL INFORMATION: The product is highly acidic. Use good industrial hygiene.

MSDS ISSUE NUMBER: 003

MSDS ISSUE DATE: 15 JUNE 2006

In any event, the review and, if necessary, the re-issue of a MSDS shall be no longer than 5 years after the last date of issue.

Electronic versions of the MSDS's in a PDF format are also available on our Website at www.cleantec.com.au/product.asp

REASON(S) FOR ISSUE: Update to conform to requirements of NOHSC:2011(2003); 16-header format.

THIS ISSUE NUMBER REPLACES ALL PREVIOUS ISSUES.

LITERARY REFERENCE:

SOURCES FOR DATA:

LEGEND:	
AICS	Australian Inventory of Chemical Substances
APVMA	Australian Pesticides and Veterinary Medicines Authority
AQIS	Australian Quarantine and Inspection Service
AS	Australian Standard (as issued by Standards Australia)
ERP Code	Emergency Response Drill Code as found in the ICAO (International Civil Aviation Organisation) Doc 9481
MSDS	Material Safety Data Sheet
NOHSC	National Occupational Health and Safety Commission
STEL	Short Term Exposure Limit - A 15 minute TWA exposure which should not be exceeded at any time during a working day even if the eight-hour TWA average is within the TWA exposure standard. Exposures at the STEL should not be longer than 15 minutes and should not be repeated more than four times per day. There should be at least 60 minutes between successive exposures at the STEL.
TGA	Therapeutic Goods Administration
TLV	Threshold Limit Value - TLV is a proprietary name registered by the American Conference of Governmental Industrial Hygienists (ACGIH) and refers to airborne concentrations of substances or levels of physical agents to which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect.
TWA	Time Weighted Average - The average airborne concentration of a particular substance when calculated over a normal eight-hour working day, for a five-day working week.

This MSDS has been prepared from current technical data and summarises at the date of issue our best knowledge of the health and safety information of the product, and in particular how to safely handle and use the product in the workplace.

If clarification or further information is needed to ensure that an appropriate assessment can be made, the user should contact this company.

Our responsibility for products sold is subject to our standard terms and conditions, a copy of which is sent to our customers and is also available upon request.

This MSDS may only be reproduced in full. Summaries or excerpts from this MSDS may not contain all the relevant information and thus are not permitted.

End of MSDS

ABN: 81 008 668 371

MATERIAL SAFETY DATA SHEET

Sulfuric Acid (98% Solution)

Section 1 – Identification of the Material and Supplier

Product Name

Sulfuric Acid (98% Solution)

Other names

Sulphuric acid, Oil of Vitriol. Company product 1010.

Recommended use

Fertiliser manufacture, battery acid, metal treatment, pH control, acid leaching.

Company name

CSBP Limited

Address	State	Postcode
Kwinana Beach Road, KWINANA	Western Australia	6167

Telephone number	Emergency telephone number
(08) 9411 8777 (Australia), +61 8 9411 8777 (Overseas)	1800 093 333 (Australia), +61 8 9411 8444

Section 2 – Hazard Identification

Hazard Classification, including a statement of overall hazardous nature

HAZARDOUS SUBSTANCE.

Sulfuric acid (98% solution) is classified as hazardous and specified in the NOHSC of Designated Hazardous Substances [NOHSC:1005(1999)].

DANGEROUS GOODS.

Sulfuric acid (98% solution) is classified for physicochemical hazards and specified as dangerous in the Australian Code for the Transport of Dangerous Goods by Road and Rail (ADG Code), 7th Edition, (FORS, 2007).

Risk Phrases

Sulfuric acid (98% solution) is classified as corrosive.

R23/25	Toxic by inhalation and if swallowed.
R35	Causes severe burns
R36/37/38	Irritating to eyes, respiratory system and skin.
R41	Risk of serious damage to the eyes.
R48	Danger of serious damage to health by prolonged exposure.
R49	May cause cancer by inhalation

Safety Phrases

Sulfuric acid (98% solution) is a hazardous substance.

S1/2	Keep locked and out of reach of children.
S21	When using do not smoke.
S23	Do not breathe fumes, vapour or mist
S24/25	Avoid contact with skin and eyes.
S26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S27	Take off immediately all contaminated clothing.
S28	After contact with skin, wash immediately with plenty of water.
S29	Do not empty into drains.
S30	Never add water to this product.
S36/37/39	Wear suitable protective clothing, gloves and eye/face protection.
S41	In case of fire and/or explosion do not breathe fumes.
S45	In case of accident or if you feel unwell seek medical attention immediately (show the label where possible).

S46/62/64	If swallowed, rinse mouth with water (only if the person is conscious), do not induce vomiting: seek medical advice immediately and show this label.
S50	Do not mix with hypochlorites, cyanides, strong alkalies, or organic and combustible materials.

Poison Schedule

SUSDP Poison Schedule 6

Section 3 – Composition/Information on Ingredients

Chemical identity of ingredients	Proportion of ingredients	CAS Number for ingredients
Sulfuric acid	98 % ($^{wt}/_{wt}$)	7664-93-9
Water	Remainder	

Section 4 – First Aid Measures

First Aid

SULFURIC ACID (98% SOLUTION) IS CORROSIVE ON CONTACT AND POISONOUS BY INGESTION AND INHALATION OF ITS VAPOUR. FIRST AID ATTENTION MUST BE GIVEN AS URGENTLY AS POSSIBLE AS OUTLINED BELOW. ALL SUSPECTED SULFURIC ACID (98% SOLUTION) BURNS SHOULD RECEIVE MEDICAL ATTENTION. TRAINING ON HANDLING SULFURIC ACID (98% SOLUTION) INCIDENTS USING THIS MSDS SHOULD BE PROVIDED BEFORE ANY SULFURIC ACID (98% SOLUTION) HANDLING OR USE COMMENCES.

First Aid Facilities

First aid procedures, equipment, medication and training for the treatment of burns with sulfuric acid (98% solution) should be in place BEFORE the use commences. Company physician, occupational health nurse and first aid personnel should be aware of the nearest hospitals which are familiar with the treatment of sulfuric acid (98% solution) burns.

Equipment and medication in place should be:

Safety shower and eyewash stations immediately accessible in the workplace;

Eye-wash bottle;

Personal protective equipment for use by first aid personnel;

Fresh, clean cool drinking water;

Oxygen;

“Space” or thermal blankets for treating patients for shock.

FIRST AID PROCEDURES FOR DEALING WITH THIS PRODUCT AND EXPOSURE TO IT

1. Personal Protection By First Aid Personnel

First aid personnel providing first aid treatment to a patient exposed to sulfuric acid (98% solution) should observe the following precautions for their own personal protection:

- Avoid contact with contaminated skin, clothing and equipment by wearing protective gloves to prevent contact of sulfuric acid (98% solution) with skin;
- Wear chemical goggles as a minimum level of eye protection to prevent splashes of sulfuric acid (98% solution) entering eyes;
- Avoid inhalation of sulfuric acid (98% solution) fumes or mist during rescue in contaminate areas by wearing suitable respiratory protection;
- Respiratory protection suggested is: an air supplied breathing apparatus, or positive pressure self-contained breathing apparatus.

2. Swallowed

Do not give anything by mouth if victim is losing consciousness, or is unconscious, or convulsing. If victim is conscious, rinse mouth thoroughly with water immediately and give water or milk to drink.

DO NOT induce vomiting.

Seek urgent medical assistance.

3. Eyes

Persons with potential eye exposure should not wear contact lenses. Immediately irrigate with copious quantities of water, while holding eyelids open, for at least 15 minutes.

Seek urgent medical assistance.

4. Skin

First aid personnel must avoid contact with this chemical. Wear protective gloves when assisting patient. DO NOT USE HOT WATER. Immediately wash affected areas with copious amounts of water. Remove all contaminated clothing and launder before re-use. DO NOT apply creams or ointments.

Seek urgent medical assistance.

5. Inhalation

Rescuer should wear appropriate personal protection to avoid skin contamination skin and breathing sulfuric acid (98% solution) fumes or mist. Remove affected persons from exposure. Allow affected person to assume most comfortable position and keep warm. Keep at rest until fully recovered. If breathing is laboured, or affected person is cyanotic (blue), ensure airways are clear and have a qualified person give oxygen through a face-mask. If breathing has stopped apply expired air resuscitation immediately. If the affected person suffers cardiac arrest commence cardio-pulmonary resuscitation immediately.

Seek urgent medical attention.

ADVICE TO DOCTOR.

Treatment for sulfuric acid (98% solution) burns to the eyes:

- Retract eyelids to ensure thorough irrigation of the conjunctival cul-de-sacs;
- Irrigate eyes with several litres of saline for at least 20 minutes;
- DO NOT use neutralising agents or any other additives;
- Cycloplegic drops, antibiotic drops, steroid drops, vasoconstrictive agents, or artificial tears should only be administered with the approval of a consulting ophthalmologist.

Treatment for sulfuric acid (98% solution) fume, or mist, inhalation:

- Pulmonary oedema may arise – symptoms may be delayed for several hours. Affected persons should not be left unattended during this period;
- Airway problems may arise from laryngeal oedema – symptoms may be delayed for several hours;
- Treat with 100% oxygen initially;
- Respiratory distress may require cricothyroidotomy if endotracheal intubation is constrained by excessive swelling;
- Intravenous lines should be established immediately in all cases where there is evidence of circulatory compromise;
- Sulfuric acid (98% solution)may produce a coagulation necrosis characterised by formation of a coagulum (eschar), which is the result of the desiccating action of the acid on proteins in specific tissues.

Treatment for sulfuric acid (98% solution) burns to skin:

- Skin lesions require copious saline irrigation;
- Treat acid burns as thermal burns with non-adherent gauze and wrapping;
- Deep second-degree burns may benefit from topical silver sulfadiazine.

Treatment for sulfuric acid (98% solution) ingestion:

- Severe burns from acid ingestion may be associated with life-threatening acute complications of oesophageal, gastric, or intestinal perforation. Oesophageal perforation is associated with chest pain, dyspnoea, fever, subcutaneous emphysema of the chest or neck, and a pleural rub;

- Initial management is primarily supportive. Particular attention should be directed to securing the airway, fluid resuscitation and provision of opioid analgesia;
- Immediate dilution (milk or water) within 30 minutes post ingestion is recommended;
- DO NOT attempt to neutralise the acid since exothermic reaction may extend the corrosive injury;
- A chest x-ray, upright abdominal film is recommended – this may show widening of the mediastinum, pleural effusions, pneumomediastinum, and pneumothorax. Perforation of the stomach or small intestine is associated with clinical features of chemical peritonitis: fever, abdominal tenderness, guarding and rebound, and ileus. Septic shock and multi-organ failure may complicate perforation;
- Be careful to avoid further vomit since re-exposure of the mucosa to the acid is harmful;
- Limit fluids to one or two glasses in an adult;
- Charcoal has NO place in acid management as it will interfere with endoscopic evaluation;
- The use of gastric lavage within 1 hour of ingestion is suggested;
- Symptomatic patients may need the following investigations:
    - Arterial blood gas analysis;
    - Coagulation profile;
    - Complete blood count;
    - ECG;
    - Electrolytes;
    - Glucose;
    - Liver and renal function;
    - Type and cross-match;
    - Upper gastrointestinal endoscopy, ideally at 6 to 24 hours following exposure. Upper gastrointestinal endoscopy should also be strongly considered for asymptomatic patients who have intentionally ingested a strong acid and children, where the history may be unreliable. The site, extent and severity of mucosal damage can be accurately assessed by modified endoscopic classification;
    - Contrast oesaphagography or thoracic CT is useful in the detection of perforation.
- Ongoing supportive care includes maintenance of adequate analgesia, fluid, electrolyte and pH balance, nutritional support, and monitoring for the development of complications. Parenteral nutrition is necessary in more severe cases;
- Subsequent management and prognosis is largely dictated by findings at upper gastrointestinal tract endoscopy;

There are two methods of treatment of oesophageal stenosis: first conservative treatment including dilatation, hydrocortisone and antibiotic therapy; and second surgical procedure.

Long Term Complications

Long term complications may include oesophageal, gastric or pyloric strictures or stenosis.
Tracheoesophageal fistulae may result from perforation of the anterior oesophageal wall. The fistula may extend to involve the aorta; both types are fatal complications.
Acid ingestions that cause deep ulceration will result in oesophageal strictures in 70% of patients. If full thickness necrosis occurs, strictures are highly likely. Strictures do not develop following superficial mucosal ulceration (the muscularis mucosa is intact).
Eighty percent of strictures will become symptomatic within two months. Strictures may also involve the stomach but only 40% become symptomatic. Strictures may rarely develop in the mouth and pharynx.

Further information about the treatment for exposure to this product can be obtained from the Poisons Information Centre on (08) 13 1126 (Australia only)

Section 5 – Fire Fighting Measures

Product flammability

Sulfuric acid (98% solution) is non-flammable and non-combustible. However, on contact with most metals, it will liberate hydrogen gas, which is flammable and (when confined) explosive. Sulfuric acid (98% solution) is an oxyacid with a good oxidizing ability – therefore, contact with cellulose based products (e.g., paper and cotton), organic solvents and other organic materials may lead to liberation of large quantities of heat.

Suitable extinguishing media

Water fog (or if unavailable, fine water spray), foam, dry chemical powder, or carbon dioxide.

Hazard from combustion products

Decomposes on heating producing toxic fumes of sulfur oxides.

Special protective precautions and equipment for fire fighters

Wear full body protective clothing with breathing apparatus. Prevent spillage from entering drains or waterways. Consider evacuation. Use water to control fire and cool adjacent area and fire exposed sulfuric acid (98% solution) storage containers. Avoid direct water impingement on strong acid since this creates heat increasing toxic fume evolution. Do not approach sulfuric acid (98% solution) containers suspected to be hot. If safe and practicable to do so remove sulfuric acid (98% solution) containers from path of fire. Equipment should be thoroughly decontaminated after use.

Wear self-contained breathing apparatus with a full-face piece operated in pressure-demand or positive pressure mode.

Hazchem Code

2P

Section 6 – Accidental Release Measures

Emergency procedures

The hazardous nature of sulfuric acid (98% solution) requires emergency and spill procedures to be effective to avoid both human and environmental exposure. Hazardous conditions may result if material is managed improperly. Make plans in advance to handle possible emergencies, including obtaining stocks of absorbent materials.

Always wear recommended personal protective equipment and respiratory protection. Good ventilation is necessary.

Sulfuric acid (98% solution) dissolves very readily in water, giving off large quantities of heat. Avoid direct water contact with sulfuric acid (98% solution) leaks.

Methods and Materials for containment and clean up

For ALL spills, evacuate unprotected personnel upwind and out of danger.

Shut off sulfuric acid (98% solution) supply, if safe to do so. Shut off all possible sources of ignition. Stay upwind of vapours. Restrict access to spill site.

Small Leaks

Sulfuric acid (98% solution) fumes: Increase ventilation and allow fumes to vent to a safe area

Sulfuric acid (98% solution) liquid: If possible contain the surface area of a spill by bunding with sand, earth or vermiculite. Do NOT use sawdust. Dilute spill with water, then neutralise with lime or soda ash to pH 6 to 10.

Prevent run-off into drains and waterways.

Large Leaks

Sulfuric acid (98% solution) fumes: Use water fog to dampen cloud of sulfuric acid (98% solution) fumes and reduce vapours. Do not spray water directly on the leak or sulfuric acid (98% solution) container.

Sulfuric acid (98% solution) liquid: If possible contain the surface area of a spill by bunding with sand, earth or vermiculite. Do NOT use sawdust. Use water fog to dampen sulfuric acid (98% solution) fumes and reduce vapours.

Prevent run-off into drains and waterways.

Dispose of all contained spill residues in accordance with the requirements of the Department of Environment Protection.

For the management of sulfuric acid (98% solution) emergencies during transport by road or rail, SAA/SNZ HB76: Dangerous Goods-Initial Response Guide, Guide 40 should be consulted. This Guide should be carried at all times when sulfuric acid (98% solution) is being transported.

Clean up personnel will need personal protection equipment and respiratory protection. Portable safety shower and eyewash facilities may also be needed for clean up personnel. Bags of lime or soda ash neutralising agent or chemical absorbent and substantial amounts of water will be required for large spill. A front-end loader may be required to scoop up neutralised acid/lime/soda ash residue.

Section 7 – Handling and Storage

Precautions for safe handling

Regulated dangerous goods as Class 8 Corrosive. Proper protective clothing must be worn that encapsulates the body including the face. A safety shower and eyewash should be available. Do not breathe vapour or mist. Avoid contact with skin, eyes and clothing.

Do not add water to sulfuric acid (98% solution) – this may generate spitting and splashing of acid. In dilution process, sulfuric acid (98% solution) should be added to plenty of water.

Do not smoke anywhere near the storage and handling of sulfuric acid (98% solution) or associated pipework and equipment.

Do not touch damaged containers or spilled material unless wearing appropriate personal protective equipment.

Change and wash clothing, and personal protective equipment if contaminated, or before storing and/or re-using. Wash hands and face thoroughly after handling and before work breaks, eating, drinking, smoking and using toilet facilities.

Conditions for safe storage, including any incompatibilities

Ensure sulfuric acid (98% solution) in bulk is stored and handled in accordance with Australian Standard AS 3780 *The storage and handling of corrosive substances*. Ensure adequate ventilation to keep airborne concentration below exposure standard. Where necessary, use local exhaust ventilation in conjunction with P2 canister respirator, or as appropriate, self contained breathing apparatus.

Store away from strong alkalis, hypochlorites, cyanides, organic and combustible materials.

Sulfuric acid (98% solution) is highly corrosive to most metals. Many plastics (except for Teflon - PTFE) do not resist sulfuric acid (98% solution).

Section 8 – Exposure Controls/Personal Protection

National exposure standards

ES-TWA	ES-STEL	ES-Peak
1 mg/m^3	3 mg/m^3	No data available

Biological limit values

No data available.

Engineering controls

Handle sulfuric acid (98% solution) within closed systems whenever possible. Provide adequate ventilation particularly at low level.

Personal protective equipment

Whenever the risk of exposure exists, such as tanker loading/unloading procedures, non-routine operations and emergency circumstances, the following personal protection measure are recommended:

Respiratory protection:

Supplied air or full face mask and filter respirator self contained breathing apparatus may be required if working with sulfuric acid (98% solution) or if decomposition fumes exits, for prolonged periods.

Hand protection:
PVC or butyl rubber gauntlet-type gloves.
Eye protection:
Chemical splash goggles (gas tight type preferred) and full face shield.
Skin protection:
PVC overalls or jacket and pants and butyl rubber Wellington boots.

Section 9 – Physical and Chemical Properties

Appearance (colour, physical form, shape)
Hygroscopic, viscous clear to brownish liquid.

Odour
No appreciable odour.

pH
10% solution < 1.

Vapour pressure
Approximately 0·011 kPa at 25°C.

Vapour density
3·4 at 20°C (Air =1).

Boiling point/range
335°C at 101·3 kPa.

Freezing/melting point
Melting point, approximately 10°C at 101·3 kPa.

Solubility
Miscible in water in all proportions, soluble in most organic solvents.

Specific gravity or density
Specific gravity = 1·84 at 20°C (water = 1 at 4°C).

Flash point and method of detecting flash point
Not applicable.

Upper and lower flammable (explosive) limits in air
Not applicable.

Ignition temperature
Not applicable.

Viscosity
24 mPa.s at 20°C and 101·3 kPa.

Section 10 – Stability and Reactivity

Chemical stability
Stable at ambient conditions of use and storage.

Conditions to avoid
Sulfuric acid (98% solution) reacts violently with water, alkalis and most organic materials to liberate large quantities of heat. Dilute acid on contact with most metals, will liberate hydrogen gas, which is flammable and (when confined) explosive.

Incompatible materials
Sulfuric acid (98% solution) can react with most metals generating flammable hydrogen gas. Most plastics do not resist concentrated sulfuric acid greater than 50 to 60% strength.

Hazardous decomposition products
Releases sulfur dioxide at extremely high temperatures.

Hazardous reactions

Sulfuric acid (98% solution) reacts vigorously, violently or explosively with many organic and inorganic chemicals including water, acrylonitrile, alkali solutions, carbides, chlorates, fulminates, nitrates, perchlorates, permanganates, picrates, metal acetylides or carbides, epichlorohydrin, aniline, ethylenediamine, alcohols with strong hydrogen peroxide, chlorosulfonic acid, cyclopentadiene, hydrofluoric acid, nitromethane, 4-nitrotoluene, phosphorus (iii) oxide, potassium, sodium, ethylene glycol, isoprene, styrene. Acetaldehyde and allyl chloride may polymerise violently in the presence of sulfuric acid (98% solution). Hazardous gases such as hydrogen cyanide, hydrogen sulfide, and acetylene, are evolved when sulfuric acid (98% solution) contacts cyanide, sulfides and carbides, respectively.

Section 11 – Toxicological Information

HEALTH EFFECTS

When handled in accordance with the guidelines in this material safety data sheet, sulfuric acid (98% solution) should not present any health effects. If this product is mishandled, symptoms that may arise are:

Acute:

Sulfuric acid (98% solution) is extremely corrosive, irritating and toxic leading to severe burns and rapid destruction of tissue.

Inhalation:

Sulfuric acid (98% solution) is not very volatile; hence workplace exposures are mainly due to mists and aerosols. The acid mists are very corrosive and can cause severe irritation and injury if inhaled. The degree and severity of respiratory effects are influenced by the size of the aerosol particulate, deposition site, concentration and humidity. Inhalation of acid mists may cause severe lung damage and life threatening pulmonary oedema (accumulation of fluid in lungs). Symptoms of pulmonary oedema include coughing and shortness of breath, and may be delayed until hours or days after exposure. Asthma can also be aggravated by exposure to sulfuric acid mists. LC_{50} (Rat) = 510 mg/m^3 2 hour exposure.

Carcinogenicity - The International Agency for Research on Cancer (IARC) has concluded that there is sufficient evidence that occupational exposure to strong inorganic mists containing sulfuric acid is carcinogenic to humans (Group 1)*. Many studies have reported an excess of cancer of larynx, and to a lesser extent, the lungs, in a variety of processes involving the use of strong inorganic acids including sulfuric acid. Throughout these studies, sulfuric acid mists were the most common exposure, and in two studies, the number of cancers increased as exposure increased.

Mutagenicity – There was a significant higher number of sister chromatoid exchanges, micronuclei and chromosomal aberrations in cultured lymphocytes (white blood cells) from workers exposed to sulfur dioxide in a sulfuric acid factory*.

** IARC Monographs On The Evolution Of Carcinogenic Risks To Humans, Vol. 54, IARC, 1992, pp 41-130.*

Skin:

Highly corrosive to skin. Causes severe burns leading to necrosis and scarring. The severity of injury depends on the concentration of sulfuric acid (98% solution) and the duration of exposure.

Eye:

Corrosive to eyes. Contact may cause corneal burns. Permanent eye damage including loss of sight may occur. Sulfuric acid (98% solution) mists and aerosols are expected to be very irritating.

Swallowed:

Can kill if swallowed. Will cause severe damage to the mucous membranes. May cause nausea, vomiting, abdominal pain and severe burns to the mouth, throat, stomach and gastrointestinal tract. LD_{50} (Oral, rat) = 2,140 mg/kg.

Chronic:

Chronic exposure to sulfuric acid (98% solution) may lead to teeth disorders (yellow discolouration and erosion of the dental enamel), dermatitis, and respiratory irritation such as bronchial hyperactivity.

Section 12 – Ecological Information

Ecotoxicity

Sulfuric acid (98% solution) is slightly to moderately toxic to aquatic life. Large discharges into the environment may contribute to lowering of water pH and be fatal to aquatic life and soil micro-organisms.

Persistence and degradability

Sulfuric acid (98% solution) is soluble in water and remains indefinitely in the environment as sulfate.

Mobility

Sulfuric acid (98% solution) is soluble in water and has high mobility in soil. During transport through the soil, sulfuric acid (98% solution) will dissolve some of the soil material; in particular, the carbonate based materials. The acid will be neutralised to some degree with adsorption of the proton also occurring on clay materials. However, significant amounts of acid are expected to remain for transport down towards the ground water table. Upon reaching the ground water table, the acid will continue to move, now in the direction of the ground water flow. Lime addition may be required to rectify low pH resulting from sulfuric acid (98% solution) spillages.

Environmental fate (exposure)

Large discharges may contribute to the acidification of effluent treatment systems and injure sewage treatment organisms.

96 hr LC_{50} (Bluegill sunfish): 10·5 ppm.

Bioaccumulative potential

Sulfuric acid (98% solution) has low potential for bioaccumulation.

Section 13 – Disposal Considerations

Disposal methods and containers

Due to its inherent properties, hazardous conditions may result if material is managed improperly. Dispose of all contained and neutralised spill residue in accordance with Department of the Environment requirements. As required under the ADG Code treat empty containers as filled containers.

Special precautions for landfill or incineration

No data available.

Section 14 – Transport Information

UN Number

1830

UN Proper shipping name

Sulfuric Acid.

Class and subsidiary risk

Class 8 Corrosive. No subsidiary risk.

Packing group

II

Special precautions for user

Not to be loaded with explosives (Class 1), dangerous when wet substances (Class 4.3), oxidizing agents (Class 5.1), organic peroxides (Class 5.2),toxic and infectious substances (Class 6) – where the Class 6 substance is a cyanide, radioactive substances (class 7) and foodstuffs and foodstuff empties.

Hazchem code

2P

Section 15 – Regulatory Information

Australian regulatory information

SUSDP POISON Schedule 6. Licensing is required for this chemical in some States and Territories.
Listed on the Australian Inventory of Chemical Substances (AICS).

Additional national and/or international regulatory information

OSHA: Hazardous by definition of Hazard Communication Standard (29CFR 1910.1200).

Section 16 – Other Information

Key / legend to abbreviations and acronyms used in the MSDS

NOHSC	National Occupational Health and Safety Commission
SUSDP	Standard for the Uniform Scheduling of Drugs and Poisons
ES-TWA	Exposure Standard – Time weighted average
ES-STEL	Exposure Standard – Short term exposure level
ES-Peak	Exposure Standard – Peak level
FORS	Federal Office of Road and Safety
LC_{50}:	Lethal concentration 50, median lethal concentration
LD_{50}	Lethal dose 50. The single dose of a substance that causes the death of 50% of an animal population from exposure to the substance by any route other than inhalation
$\%(^{wt}/_{wt})$	Percent amount on a weight per weight basis
$\%(^{wt}/_{vol})$	Percent amount on a weight per volume basis
PPM	Parts per million
Zone 1 Class 1	An area in which an explosive gas atmosphere can be expected to occur periodically or occasionally during normal operation. (More than 10 hours per year but less than 1000 hours per year)

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Poisons Act 1964, State Law Publisher, Western Australia, Reprinted 22 January 1999.

Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environmant, [NHSC:1003(1991)].

Hazardous Materials Handbook for Emergency Responders, Onguard Training for Life, J. Varela (Editor), Van Nostrand Reinhold, New York, 1996.

Chemwatch www.chemwatch.net

Guidance for the Compilation of Safety Data Sheets for Fertilizer Materials, European Fertilizer Manufacturers Association, online at www.efma.org/Publications/Guidance/Index.asp

Sources for data

Important Notes

1. To the best of our knowledge this document complies with the National Code of Practice for the Preparation of Material Safety Data Sheets 2nd Edition [NOHSC:2011 (2003)].
2. This material safety data sheet summarises our best knowledge of the health and safety hazard information of the product and how to safely handle and use the product in the workplace. Each user should read this material safety data sheet and consider the information in the context of how the product will be handled and used in the workplace, including in conjunction with other products.
3. If clarification or further information is needed to ensure that an appropriate risk assessment can be made, the user should contact the Safety and Emergency Services Department, CSBP Limited on (08) 9411 8777 (Australia), +61 8 9411 8777 (Overseas).
4. Our responsibility for products sold, is subject to our terms and conditions, a copy of which is sent to our customers, and is also available on request.
5. CSBP reserves the right to make change to material safety data sheets without notice.

Safety Data Sheet

1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

Product Name: **CAUSTIC SODA - LIQUID (5%-45%)**

Other name(s): Sodium hydroxide - liquid (20%-30%), Soda lye solution (20%-30%), Caustic soda solution (20%-30%), Sodium hydroxide solution (20%-30%), Liquid caustic soda (20%-30%), Caustic soda 10%, Caustic soda - liquid 17%, Caustic soda solution 17%, Liquid caustic soda 17%, Caustic soda 5%, Aluminux LL; Sodium hydroxide 2.4N

Recommended Use: Chemical and explosives manufacture; neutralising agent.

Supplier: Orica Australia Pty Ltd
ABN: 99 004 117 828
Street Address: 1 Nicholson Street,
Melbourne 3000
Australia
Telephone Number: +61 3 9665 7111
Facsimile: +61 3 9665 7937
Emergency Telephone: **1 800 033 111 (ALL HOURS)**

2. HAZARDS IDENTIFICATION

This material is hazardous according to criteria of Safe Work Australia; HAZARDOUS SUBSTANCE.

Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.

Risk Phrases: Causes severe burns. Risk of serious damage to eyes.

Safety Phrases: Avoid contact with skin and eyes. In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. Wear suitable protective clothing, gloves and eye/face protection. In case of accident or if you feel unwell, seek medical advice immediately (show the label whenever possible).

Poisons Schedule: S6 Poison.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Components	CAS Number	Proportion	Risk Phrases
Water	7732-18-5	55%-95%	-
Sodium hydroxide	1310-73-2	5%-45%	R35, R41

4. FIRST AID MEASURES

For advice, contact a Poisons Information Centre (e.g. phone Australia 131 126; New Zealand 0800 764 766) or a doctor.

Inhalation:
Remove victim from area of exposure - avoid becoming a casualty. Remove contaminated clothing and loosen remaining clothing. Allow patient to assume most comfortable position and keep warm. Keep at rest until fully recovered. For all but the most minor symptoms arrange for patient to be seen by a doctor as soon as possible, either on site or at the nearest hospital.

Skin Contact:
If spilt on large areas of skin or hair, immediately drench with running water and remove clothing. Continue to wash skin and hair with plenty of water (and soap if material is insoluble) until advised to stop by the Poisons Information Centre or a doctor.

Eye Contact:
If in eyes, hold eyelids apart and flush the eye continuously with running water. Continue flushing until advised to stop by a Poisons Information Centre or a doctor, or for at least 15 minutes.

Ingestion:
Immediately rinse mouth with water. If swallowed, do NOT induce vomiting. Give a glass of water. Seek immediate medical assistance.

Medical attention and special treatment:
Treat symptomatically. Can cause corneal burns.

5. FIRE FIGHTING MEASURES

Hazards from combustion products:
Non-combustible material.

Precautions for fire fighters and special protective equipment:
Contact with metals may liberate hydrogen gas which is extremely flammable. Fire fighters to wear self-contained breathing apparatus and suitable protective clothing if risk of exposure to products of decomposition.

Suitable Extinguishing Media:
Not combustible, however, if material is involved in a fire use: Fine water spray, normal foam, dry agent (carbon dioxide, dry chemical powder).

Hazchem Code: 2R

6. ACCIDENTAL RELEASE MEASURES

Emergency procedures:
Clear area of all unprotected personnel. If contamination of sewers or waterways has occurred advise local emergency services.

Methods and materials for containment and clean up:
Slippery when spilt. Avoid accidents, clean up immediately. Wear protective equipment to prevent skin and eye contact and breathing in vapours. Work up wind or increase ventilation. Contain - prevent run off into drains and waterways. Use absorbent (soil, sand or other inert material). Collect and seal in properly labelled containers or drums for disposal. Caution - heat may be evolved on contact with water.

7. HANDLING AND STORAGE

This material is a Scheduled Poison S6 and must be stored, maintained and used in accordance with the relevant regulations.

Conditions for safe storage:
Store in cool place and out of direct sunlight. Store away from incompatible materials described in Section 10. Store away from foodstuffs. Do not store in aluminium or galvanised containers nor use die-cast zinc or aluminium bungs; plastic bungs should be used. At temperatures greater than 40°C, tanks must be stress relieved. Keep containers closed when not in use - check regularly for leaks.

Precautions for safe handling:
Avoid skin and eye contact and breathing in vapour, mists and aerosols. Keep out of reach of children.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational Exposure Limits: No value assigned for this specific material by the National Occupational Health and Safety Commission. However, Exposure Standard(s) for constituent(s):

Sodium hydroxide: Peak Limitation = 2 mg/m^3

As published by the National Occupational Health and Safety Commission.

Peak Limitation - a ceiling concentration which should not be exceeded over a measurement period which should be as short as possible but not exceeding 15 minutes.

These Exposure Standards are guides to be used in the control of occupational health hazards. All atmospheric contamination should be kept to as low a level as is workable. These exposure standards should not be used as fine dividing lines between safe and dangerous concentrations of chemicals. They are not a measure of relative toxicity.

Engineering controls:
Ensure ventilation is adequate and that air concentrations of components are controlled below quoted Exposure Standards. If inhalation risk exists: Use with local exhaust ventilation or while wearing suitable mist respirator. Keep containers closed when not in use.

Personal Protective Equipment:
The selection of PPE is dependant on a detailed risk assessment. The risk assessment should consider the work situation, the physical form of the chemical, the handling methods, and environmental factors.

Orica Personal Protection Guide No. 1, 1998: D - OVERALLS, CHEMICAL GOGGLES, FACE SHIELD, GLOVES (Long), APRON, RUBBER BOOTS.



Wear overalls, chemical goggles, face shield, elbow-length impervious gloves, splash apron or equivalent chemical impervious outer garment, and rubber boots. Always wash hands before smoking, eating, drinking or using the toilet. Wash contaminated clothing and other protective equipment before storage or re-use.
If risk of inhalation exists, wear suitable mist respirator meeting the requirements of AS/NZS 1715 and AS/NZS 1716.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Liquid
Colour:	Water-white to Slightly Turbid
Odour:	No specific odour
Solubility:	Miscible with water.
Specific Gravity:	1.23-1.33 @20°C
Relative Vapour Density (air=1):	Not available
Vapour Pressure (20 °C):	Not available
Flash Point (°C):	Not applicable
Flammability Limits (%):	Not applicable
Autoignition Temperature (°C):	Not applicable
Boiling Point/Range (°C):	119 (25%)
pH:	>10.5 (1% sol.)

10. STABILITY AND REACTIVITY

Chemical stability: Stable under normal conditions. Absorbs carbon dioxide from the air.

Conditions to avoid: Avoid contact with foodstuffs.

Incompatible materials: Incompatible with acids , ammonium salts , aluminium , tin , and zinc .

Hazardous decomposition products: None known.

Hazardous reactions: Corrosive to aluminium, tin, and zinc, liberating flammable hydrogen gas. Reacts violently with acids. Reacts with ammonium salts liberating ammonia gas. Reacts exothermically on dilution with water.

11. TOXICOLOGICAL INFORMATION

No adverse health effects expected if the product is handled in accordance with this Safety Data Sheet and the product label. Symptoms or effects that may arise if the product is mishandled and overexposure occurs are:

Ingestion: Swallowing can result in nausea, vomiting, diarrhoea, abdominal pain and chemical burns to the gastrointestinal tract.

Eye contact: A severe eye irritant. Corrosive to eyes; contact can cause corneal burns. Contamination of eyes can result in permanent injury.

Skin contact: Contact with skin will result in severe irritation. Corrosive to skin - may cause skin burns.

Inhalation: Breathing in mists or aerosols may produce respiratory irritation.

Long Term Effects:
No information available for the product.

Toxicological Data: No LD50 data available for the product. For the constituent Sodium hydroxide :
SKIN: Severe irritant (rabbit).

12. ECOLOGICAL INFORMATION

Ecotoxicity Avoid contaminating waterways.

13. DISPOSAL CONSIDERATIONS

Disposal methods:
Refer to local government authority for disposal recommendations. Dispose of material through a licensed waste contractor. Decontamination and destruction of containers should be considered.

14. TRANSPORT INFORMATION

Road and Rail Transport
Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail; DANGEROUS GOODS.



UN No:	1824
Class-primary	8 Corrosive
Packing Group:	II
Proper Shipping Name:	SODIUM HYDROXIDE SOLUTION
Hazchem Code:	2R

Marine Transport
Classified as Dangerous Goods by the criteria of the International Maritime Dangerous Goods Code (IMDG Code) for transport by sea; DANGEROUS GOODS.

UN No:	1824
Class-primary:	8 Corrosive
Packing Group:	II
Proper Shipping Name:	SODIUM HYDROXIDE SOLUTION
IMDG EMS Fire:	F-A
IMDG EMS Spill:	S-B

Air Transport
Classified as Dangerous Goods by the criteria of the International Air Transport Association (IATA) Dangerous Goods Regulations for transport by air; DANGEROUS GOODS.

UN No:	1824
Class-primary:	8 Corrosive
Packing Group:	II
Proper Shipping Name:	SODIUM HYDROXIDE SOLUTION

15. REGULATORY INFORMATION

Classification:	This material is hazardous according to criteria of Safe Work Australia; HAZARDOUS SUBSTANCE.
Hazard Category:	C: Corrosive
Risk Phrase(s):	R35: Causes severe burns. R41: Risk of serious damage to eyes.

Safety Phrase(s): S24/25: Avoid contact with skin and eyes.
S26: In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S36/37/39: Wear suitable protective clothing, gloves and eye/face protection.
S45: In case of accident or if you feel unwell, seek medical advice immediately (show the label whenever possible).

Poisons Schedule: S6 Poison.

All the constituents of this material are listed on the Australian Inventory of Chemical Substances (AICS).

16. OTHER INFORMATION

`Registry of Toxic Effects of Chemical Substances'. Ed. D. Sweet, US Dept. of Health & Human Services: Cincinatti, 2011.

This safety data sheet has been prepared by Orica SDS Services.

Reason(s) for Issue:
5 Yearly Revised Primary SDS

This SDS summarises to our best knowledge at the date of issue, the chemical health and safety hazards of the material and general guidance on how to safely handle the material in the workplace. Since Orica Limited cannot anticipate or control the conditions under which the product may be used, each user must, prior to usage, assess and control the risks arising from its use of the material.

If clarification or further information is needed, the user should contact their Orica representative or Orica Limited at the contact details on page 1.

Orica Limited's responsibility for the material as sold is subject to the terms and conditions of sale, a copy of which is available upon request.

MSDS

MATERIAL SAFETY DATA SHEET

24 Hour Emergency Telephone Number CHEMTREC 1-800-424-9300

SUNBELT CHEMICALS 71 HARGROVE GRADE PALM COAST, FLORIDA 32137

All non-emergency questions should be directed to Customer Service **(1-386-446-4595)** for assistance.

10% SODIUM HYPOCHLORITE SOLUTION

1. Product Identification

Synonyms: chlorinating solution, swimming pool chlorine, a solution of chlorine in alkaline water.

CAS Number: 7681-52-9
Product Name: AQUA CHEM Liquid Chlorinizor
Part Number: 3004
UPC Code: 017926030042
Supplier GLN: 00179264004142
GTIN: 00179260030048

2. Composition/Information on Ingredients

Ingredient	CAS Number	Percent	Hazardous
Sodium Hypochlorite (NaOCl)	7681-52-9	10%	yes
Water	7732-18-5	90%	no

3. Hazards Information

Emergency Overview

WARNING, HARMFUL IF SWALLOWED OR INHALED. CAUSES IRRITATION TO EYES AND RESPIRATORY TRACT. CAUSES SUBSTANTIAL, BUT TEMPORARY EYE INJURY.

Potential Health Effects

Inhalation: May cause irritation to the nose, throat and respiratory tract. Symptoms may include coughing and sore throat.

Ingestion: May cause nausea, vomiting and upset stomach.

Skin Contact: May irritate intact skin. May cause severe irritation to mucus membranes and broken skin.

Eye Contact: Eye contact may cause severe irritation and damage, especially at higher concentrations.

Chronic Exposure: A constant irritant to the eyes and throat. Low potential for sensitization after exaggerated exposure to broken skin or mucus membranes.

Aggravation of Pre-existing Conditions: Persons with impaired respiratory function, or heart disorders (or disease) may be more susceptible to the effects of hypochlorite solutions.

Note to Physician: Consider oral administration of sodium thiosulfate solutions if sodium hypochlorite is ingested. Do not administer neutralizing agents, exothermic reaction may result and cause further damage.

4. First Aid Measures

Inhalation: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Seek immediate medical attention.

Ingestion: If swallowed DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. Seek immediate medical attention.

Skin Contact: In case of contact with liquid, immediately flush with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Seek immediate medical attention.

Eye Contact: Immediately flush eyes with plenty of flowing water for at least 15 minutes, while lifting upper and lower eyelids. Seek immediate medical attention.

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5. Fire Fighting Measures

NFPA ratings: Health **2** Flammability **0** Reactivity **0**

Fire: Not considered to be a fire hazard. Releases oxygen when heated, causing increased severity of an existing fire.

Explosion: Not considered to be an explosion hazard.

Fire Extinguishing Media: Water or water spray to cool fire exposed containers. Use any means to extinguish surrounding fire.

Special Information: In the event of fire, wear full protective clothing and NIOSH approved self-contained breathing apparatus (SCBA), with full face shield, operated in positive pressure mode. Stay away from ends of tanks. Cool tanks and drums with water spray until well after fire is out.

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6. Accidental Release Measures

Adequately ventilate area of leak or spill. Wear appropriate personal protective equipment (PPE), as specified in Section 8. Isolate area to keep unprotected personnel from entering. Stop the leak if possible. Contain and recover liquid when possible. Absorb spilled liquid with an inert material, such as vermiculite, sand, or earth and place recovered material in an approved, compatible chemical waste container. Do not use combustible materials such as cardboard or saw dust as an absorbent. EPA regulations require reporting spills and releases to the soil, air and water, in excess of the reportable quantity (103.4 gallons of solution), to the National Response Center, telephone number 1-800-424-8802. Reporting to the State Emergency Response Commission (SERC) warning point and local authorities (911) is also required. Notify CHEMTREC, for specific information, in the event of any transportation related spills or leaks. (1-800-424-9300). See Section 13 of this MSDS for more information.

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7. Handling and Storage

Store in a cool, dry, ventilated storage area with good drainage. Protect from physical damage. Keep out of sunlight, away from direct heat, water and incompatible materials. Do not wash out container and use it for other purposes. Observe all warnings and precautions stated on the container label. Wear personal protective equipment when handling, opening containers and using hypochlorite solutions.

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8. Exposure Control and Personal Protection

Airborne Exposure Limits:

OSHA Permissible Exposure Limit (PEL)	0.5 ppm (TWA)	1 ppm (STEL) as chlorine
NIOSH Relative Exposure Level (REL)	unavailable	
ACGIH Threshold Limit Value (TLV)	1 ppm (TWA)	3 ppm (STEL) as chlorine
NIOSH Immediately Dangerous Level (IDLH)	unavailable	

Ventilation: A system of local and/or general exhaust is recommended to keep exposure below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion into occupied areas.

Personal Respirators (NIOSH Approved): If exposure limits are exceeded and engineering controls are not feasible, a full face respirator, with an acid gas cartridge, may be worn up to 50 times the permissible exposure limit (PEL). For emergencies or instances where the exposure levels are not known, use full face, positive pressure, air supplied respirator. WARNING, Air purifying respirators do not provide protection in oxygen deficient atmospheres.

Skin Protection: Rubber or neoprene gloves and additional protection including impervious boots, apron, or coveralls, as needed in areas of unusual exposure to prevent skin contact.

Eye Protection: Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick drench facilities (safety shower) in work areas.

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9. Physical and Chemical Properties

Appearance: Clear to yellowish liquid.

Odor: Bleach like odor.

Solubility: Infinitely soluble in water.

Specific Gravity: 1.15 – 1.16

Percent Volatile: >90%

Boiling Point: 180 ^{O}F decomposes slightly

Vapor Density: unavailable

Vapor Pressure: 17.5 @ 68 ^{O}F (hypochlorite)

Evaporation Rate: < 1 (butyl acetate = 1)

pH: < 11.5

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10. Stability and Reactivity

Stability: Slowly decomposes on contact with air. Decomposition rate increases with concentration and temperature. Exposure to sunlight accelerates decomposition. Sodium hypochlorite solutions become less toxic with age.

Hazardous Decomposition Products: When heated to decomposition, emits toxic chlorine fumes and will react with water or steam to produce heat and toxic, corrosive fumes. Thermal decomposition results in the emission of chlorine oxides.

Hazardous Polymerization: Will not occur.

Incompatibilities: Ammonia (chloramines gas may evolve), amines, ammonium salts, acids, methanol, cellulose, reducing agents, oxidizable metals, and bisulfates.

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11. Toxicological Information

Lethal ingested dose (LD50) in rats: 8.91 g/kg
Not listed on the OSHA, NTP or IARC list of carcinogens.

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12. Ecological Information

Environmental Fate: Decomposes in air and light to release chlorine gas, oxygen and sodium chloride solution (salt water).

Environmental Toxicity: Highly toxic to aquatic organisms.

13. Disposal Considerations

In case of a spill, flood area with large quantities of water. Small quantities of spilled or unusable product should be diluted with water before disposal to a sanitary sewer (through toilet).

State and local disposal regulations may slightly differ from Federal regulations. Dispose of waste in a facility permitted for non-hazardous waste.

Do not reuse empty container. Triple rinse container and place into trash or recycle bin where facilities accept pigmented white HDPE bottles.

Do not allow product to enter storm drains, lakes, streams or other bodies of water. Not harmful to septic systems.

14. Transportation Information

Proper Shipping Name: 1.3 gallons, or less, is classified in accordance with DOT regulation 49 CFR 173.154, as; ORM-D, CONSUMER COMMODITY

Full Shipping Description: HYPOCHLORITE SOLUTIONS, 8, UN1791, PGIII (> 1.3 gal)

15. Regulatory Information

Regulated Ingredient: Sodium Hypochlorite (CAS # 7681-52-9)

TSCA Inventory Listed: No **CERCLA RQ:** 100 lbs of sodium hypochlorite (103.4 gals of solution)

SARA Title III, Section 302: Not listed **TPQ:** NA

SARA Title III, Section 312: Subject to Toxic Chemical Inventory Reporting

Acute: Yes **Chronic:** No **Fire:** No **Pressure:** No **Reactivity:** No

SARA Title III, Section 313: Not subject to Toxic Chemical Release Inventory Reporting

RCRA Hazardous Waste: Not a listed Hazardous Waste.

Clean Air Act: Not a Listed Hazardous Air Pollutant (HAP)

16. Other Information

Label Hazard Warning:
WARNING, HARMFUL IF SWALLOWED OR INHALED. CAUSES IRRITATION TO EYES AND RESPIRATORY TRACT. CAUSES SUBSTANTIAL, BUT TEMPORARY EYE INJURY.

Label Precautions: Do not get in eyes, on skin, or on clothing. Avoid breathing vapor or mist. Keep container closed when not in use. Use with adequate ventilation. Wash thoroughly after handling. KEEP OUT OF REACH OF CHILDREN.

Label First Aid: If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact, immediately flush eyes or skin with plenty of water, for at least 15 minutes. Remove contaminated clothing and shoes. Wash clothing before reuse. SEEK MEDICAL ATTENTION.

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1. Product identifier

Product trade name: Ammonia solution 25%
Product identification code: 2601056
Designation: processing/nonprocessing aid, intermediate
Product type: mixture

1.2. Relevant identified uses of the substance or mixture and uses advised against

Relevant identified uses: Industrial uses as an intermediate (chemical synthesis); Industrial end-uses as processing and nonprocessing aids, auxiliary agent, manufacture of food products.
Uses advised against: Not known.

1.3. Details of the supplier of the safety data sheet

Manufacturer: Petrokemija d.d., Aleja Vukovar 4, HR-44320 Kutina, Croatia
Telephone number: 00 385 44 647 122, e-mail: tmg@petrokemija.hr
EU supplier (*Only representative*): Petrokemija d.o.o., Ljubljanska Cesta 8, SI-8000 Novo Mesto, Slovenia.
Telephone number: 00 386 5 9074 190, e-mail: damir.pirsic@petrokemija.si

1.4. Emergency telephone numbers

Emergency (EU, Croatia): 112
Emergency health response (Croatia): 00 385 (0)1 2348 342

SECTION 2: Hazards identification

2.1. Classification of the substance or mixture

2.1.1. Classification according to Regulation (EC) No 1272/2008 [CLP/GHS]

Hazard classes and Hazard categories	Hazard Statements	Full text of Hazard Statements	Additional information
Skin Corr. 1B	H314	Causes severe skin burns and eye damage.	Conc: ≥ 5%
STOT Single Exp. 3			
Aquatic Acute 1	H400	Very toxic to aquatic life.	M-factor: 1 Conc: ≥ 25%

2.1.2. Classification according to Directive 67/548/EEC [DSD]

Classification	R phrases	Full text of R phrases	Additional information
C; R34 Corrosive	R34	Causes burns.	Conc: ≥ 10%
N; R50 Dangerous for the environment	R50	Very toxic to aquatic organisms	

2.2. Label elements

Labelling according to Regulation (EC) No 1272/2008 [CLP/GHS]

Hazard pictograms:



GHS05



GHS09

Signal word: Danger

Hazard statements:
H314 Causes severe skin burns and eye damage.
H400 Very toxic to aquatic life.

Precautionary statements:
P260: Do not breathe gas/vapours/spray.
P273: Avoid release to the environment.
P280: Wear protective gloves/protective clothing/eye protection/face protection.
P403+P233: Store in a well-ventilated place. Keep container tightly closed.

Additional labelling requirements (CLP supplemental hazard statement):
None

2.3. Other hazards

None.

SECTION 3: Composition/information on ingredients

3.2. Mixture

Substance name	EC No /CAS No	Index No.	Weight content	Classification		Registration reference number
				Directive 67/548/EEC	Regulation EC No 1272/2008	
ammonia, anhydrous	231-635-3 7664-41-7	007-001-00-5	25%	F; R10 T; R23 C; R34 N; R50	Flam. Gas 2 H221 Compressed gas H280 Acute Tox. 3 H331 Skin Corr. 1B H314 Aquatic Acute 1 H400	01-2119488876-14-0073

Description of the mixture: ammonia aqueous solution, 5-25%.

SECTION 4: First aid measures

4.1. Description of first aid measures

General notes: Remove affected person from further exposure. Always call a doctor to the site of the accident.

Ingestion:
- rinse the mouth and spit the fluids out,
- lay the casualty down and protect against hypothermia,
- if the patient remains conscious give casualty slowly sip a glass of water,
- conduct further measures as for inhalation.

Skin contact:
- remove contaminated clothing while protecting yourself,
- rinse the affected skin areas for 10 minutes under running water,
- seek medical treatment.

Eye contact:
- immediately rinse the affected eye with widely spread lids for 10 minutes under running water whilst protecting the unimpaired eye. Direct a gentle stream of water into the eyes in order to dilute or remove the alkaline solution as quickly as possible. Immediate rinsing can prevent serious eye damage,
- immediately transport the casualty to an eye doctor or to hospital. Continue rinsing during transport.

Inhalation:
- lay the casualty down and protect him against hypothermia,
- repeatedly have the casualty deeply breathe a glucocorticoid inhalation spray in or in the case of breathing difficulties have the casualty inhale oxygen and take up a semi-upright position,
- if the casualty is unconscious but breathing lay him in a stable manner on his side,
- if the casualty has stopped breathing give mouth to nose resuscitation or if this is not possible use mouth to mouth resuscitation,
- in the case of cardiac arrest (lack of heart beat or pulse) immediately apply heart lung resuscitation,
- the protection of the vital functions (heartbeat and respiration without assistance) takes priority over every other activity.

Advice to first aid responders:
- if ammonia comes into contact with the eyes thorough specialist care is required after initial first aid (rinsing, treatment of pain) is completed,
- water is the preferred medium for rinsing the eyes since immediate availability is the deciding criterion. If available, physiological saline solution or - better - ringer lactate solution or - even better - BSS (Balanced Salt Solution) may be used for further rinsing. These tear isotonic hypertonic rinsing solutions are assumed to be effective in preventing edema and epithelial damage. However, for this purpose they must be used immediately and in reliably sterile form (pay attention to the expiration date),
- in most cases treatment of the effects of inhalation will be of primary importance,
- following massive inhalation the administration of glucocorticoids (inhalative, i.v.) and oxygen are indicated,
- codeine may be administered to treat irritative cough,
- under no circumstances should vomiting be induced,
- do not administer active charcoal.

4.2. Most important symptoms and effects, both acute and delayed

Ingestion: painful corrosion of the mouth/throat/esophagus/ stomach/intestines (danger of perforation, peritonitis!), acute risk also through effects on the respiratory system (spasm, edema, see above) and cardiovascular reactions (collapse, shock).

Skin: irritation through to corrosion (after exposure to 20 - 25% solution after only a few minutes).

Eyes: the extent of the damage may be apparent only after a latency period: corneal edema, corneal epithelial damage (often loss of the epithelium), iritis, glaucoma, fixed pupils, cataract, opacity of the cornea, further irreversible damage (scarring);

Inhalation: irritation to the nose and throat, cough, breathing difficulties, hyperpnea, nausea, later inflammation of the respiratory passages, possibly asthma-like symptoms; following massive inhalation danger of glottic edema, laryngo/bronchospasm, reflexive respiratory/cardiac arrest, pulmonary edema, pneumonia (also as sequela).

4.3. Indication of any immediate medical attention and special treatment needed

Following contact with the eyes/skin: Following large-scale corrosion, treatment for shock, tetanus prophylaxis and further treatment in hospital may be necessary.

Following massive inhalation: Monitor cardiopulmonary functions and hospitalize the casualty as soon as possible for further observation and treatment.

Following ingestion of small amounts of the solution: In cases of hypotension, the infusion of full electrolyte solution and horizontal positioning of the patient are recommended in the first phase. Carry out prophylaxis for glottic edema with glucocorticoids as soon as possible, also in cases of ingestion; if necessary intubate via the nose. Hospitalize the patient as soon as possible for further treatment. In hospital, priority should be given to securing vital functions, treatment of pain, inspection and treatment of corrosive damage to tissues.
The sucking off of stomach contents by means of a thin flexible gastric tube inserted under sight conditions is indicated only in isolated cases (possibly after ingestion of large quantities of extremely dilute solution, if risk of perforation can be excluded.
Dilution therapy following ingestion of large amounts is controversial (slight change in pH values, increased nausea, increased damage to the tissues due to volume of fluid).

SECTION 5: Firefighting measures

5.1. Extinguishing media

Suitable extinguishing media: Substance is incombustible, select fire fighting measures according to the surrounding conditions.

5.2. Special hazards arising from the substance or mixture

Ambient fire may liberate hazardous vapours or decomposition products.

5.3. Advice for firefighters

Fire fighting:

- in case of ambient fire: cool surrounding containers with water spray.
- contains vapours with water spray; stay on upwind side,
- do not allow runoff to get into the sewage system.

Special protective equipment for firefighters: Wear self-contained breathing apparatus. In case of violent hazardous effect wear a special tightly sealed suit.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

6.1.1. For non-emergency personnel

Protective equipment: Wear respiratory protection, eye protection, hand protection and body protection. (see chapter Personal Protection).

Emergency procedures: Evacuate area. Warn affected surroundings. The hazardous area may only be entered once suitable protective measures are implemented. Only then can the hazardous situation be removed. Afterwards ventilate area. Stay on upwind side.

6.1.2. For emergency responders

Use personal protection equipment and respiratory protection. Wear self-contained breathing apparatus.

6.2. Environmental precautions

Avoid escape into water, drainage, sewer, or the ground. A hazard for drinking water sources when larger quantities get into groundwater. Inform the responsible authorities.
Maybe a hazard to the surrounding atmosphere if larger quantities of the substance escape. Inform the authorities (see subsection 1.4.).

6.3. Methods and material for containment and cleaning up

6.3.1 For containment

Absorb any spilt liquid with an absorbent (e.g. diatomite, vermiculite, sand).

6.3.2 For cleaning up

Bases and alcoholates are dilute, if necessary, by stirring cautiously in water. Then are neutralized with hydrochloric acid, check the pH value.
Place in collecting containers for salt solutions, adjust for a pH value of 6 - 8, or place in collecting containers for toxic inorganic residues as well as heavy-metal salts and their solutions.
Do not put/place waste into sink or dust bin.
Collection vessels must be clearly labelled with a systematic description of their contents. Store the vessels in a well-ventilated location. Entrust them to the appropriate authorities for disposal.

6.3.3 Other information

Afterwards ventilate area and wash spill site.

6.4 Reference to other sections

For protective equipment see section *8.2 Exposure controls*.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Protective measures:
- the floor must be alkaline resistant.
- for the additional information see section *8.2.1. Key details of workers exposure control.*

Measures to prevent fire: Keep away from incompatible substances.

Advice on general occupational hygiene:
- take care to maintain clean working place, do not permit smoking in the storage area,
- avoid contact with clothing. Contaminated clothes must be exchanged and cleaned carefully. Before cleaning clothes rinse thoroughly first in water.
- the skin must be washed with soap and water before breaks and at the end of work; apply fatty skin-care products after washing.
- food, beverages and other articles of consumption must not be consumed at the work areas. Suitable areas are to be designated for these purposes.

Reference to other sections: For protective equipment see *Section 8.2. Exposure controls.*

7.2. Conditions for safe storage, including any incompatibilities

Technical measures and storage conditions: Store in the original container as much as possible. Containers have to be labelled clearly and permanently. Keep container tightly closed. Keep container in a well-ventilated place. Recommended storage at room temperature. Do not store in escape routes, work rooms, or in direct proximity to them. For the storage and manipulation larger amounts install an audible alarm for the surrounding area.

Packaging materials: see section *10.5 Incompatible materials*

Requirements for storage rooms and vessels:
The floor must be alkaline resistant. Ammonia can escape at room temperature. Use closures with aeration valve. Preferably use unbreakable containers rather than glass containers. Place fragile vessels in break-proof outer vessels. Store smaller vessels in cabinets with collecting tubs.

Further information on storage conditions:
- Non-combustible corrosive substance
- Collocated storage with the following substances is prohibited: pharmaceuticals, foods, and animal feeds including additives, infectious, radioactive and explosive materials, other explosive substances of storage class 4.1, flammable solid substances or desensitized substances of storage class 4.1, spontaneously flammable substances, substances liberating flammable gases in contact with water, strongly oxidizing substances of storage class 5.1 , organic peroxides and self reactive substances.

7.3. Specific end use(s)

None.

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

8.1.1. Occupational exposure limits

	Limit value - Eight hours		Limit value - Short term		Legal basis
	ppm	mg/m³	ppm	mg/m³	
European Union	20	14	50	36	Directives 91/322/EEC, 2000/39/EC, 2006/15/EC

8.1.2. DNEL/PNEC values

DNELs for workers – ammonia anhydrous, EC No 231-635-3				
Route of exposure	**Accute effects - local**	**Accute effects - systemic**	**Chronic effects - local**	**Chronic effects - systemic**
Inhalation	36 mg/m³	47,6 mg/m³	14 mg/m³	47,6 mg/m³
Dermal	No-threshold effect and/or no dose response information available	6,8 mg/kg bw/d (100% dermal absorption: corrosive concentrations)	No-threshold effect and/or no dose response information available	6,8 mg/kg bw/d (100% dermal absorption: corrosive concentrations)

DNELs for the general population - ammonia anhydrous, EC No 231-635-3				
Route of exposure	**Accute effects - local**	**Accute effects - systemic**	**Chronic effects - local**	**Chronic effects - systemic**
Oral	No-threshold effect	6,8 mg/kg bw/d	No-threshold effect	6,8 mg/kg bw/d
Inhalation	7,2 mg/m³	23,8 mg/m³	2,8 mg/m³	23,8 mg/m³
Dermal	No-threshold effect and/or no dose-response information available	68 mg/kg bw/d (10% dermal absorption: non-corrosive concentrations)	No-threshold effect and/or no dose-response information available.	68 mg/kg bw/d (10% dermal absorption: non-corrosive concentrations)

PNEC values - ammonia anhydrous, EC No 231-635-3		
PNEC exposure route – environmental protection target	**Value**	**Remarks/Justification**
Fresh water	0,0011 mg/L	Extrapolation method, AF=20.
Freshwater sediment	No data available	Ammonia does not accumulate in sediments
Marine water	0,0011 mg/L	Extrapolation method, AF=20.
Marine sediments	No data available	Bioaccumulation is not considered important - PNEC for sediment is not required.
Food chain	No data available	There is no evidence that ammonia bioaccumulates, as the log Kow value is 0.23. Since the trigger of BCF >100 (log Kow >3) is not met, the derivation of PNECs to protect against secondary poisoning is not required.
Microorganisms in sediment treatment	No data available	Derivation of PNEC STP is not required.
Soil (agricultural)	No data available	Toxicity to soil microorganisms is unlikely: ammonia is an intrinsic part of the nitrate cycle.
Air	No data available	No data are required.

8.2. Exposure controls

8.2.1. Key details of workers exposure control

- provision of ventilation in the working area,
- vapour/air mixtures are heavier than air. Adequate ventilation at the floor area must be ensured as well.
- avoid any contact when handling the substance.
- eye bath required (these locations must be signposted clearly),
- When handling excessive amounts of the substance an emergency shower is required.
- Washing facility at the workplace required.
- avoid inhalation of vapours/aerosols ,
- change clothing that has been in contact with ammonia aqueous solution.

Skin protection:

- wear protective gloves (EN:388, EN:374).
- wear a tight, long apron and boots or suitable chemical protection clothing. The protection clothing should be alkali resistant.

Respiratory protection:

- In an emergency (e.g.: unintentional release of the substance, exceeding the occupational exposure limit value) respiratory protection must be worn. Consider the maximum period for wear.
- gas filter K (EN:14387), colour code green.
- use insulating device for concentrations above the usage limits for filter devices, (EN:145), for oxygen concentrations below 17% volume, or in circumstances which are unclear.

Eye protection:

- wear chemical safety goggles, (EN:166),
- If vapours or aerosols that may injure the eyes arise, wear a full mask (EN:136).

Hand protection (ammonia solution 25%):

- gloves should be well cleaned before being removed, then stored in a well ventilated location. Pay attention to skin care.
- The following materials are suitable for protective gloves (Permeation time >= 8 hours):
  - Butyl rubber - Butyl (0,5 mm)
  - Fluoro carbon rubber - FKM (0,4 mm)
- Protective gloves of the following materials should not be worn longer than 4 hours continually (Permeation time >= 4 hours): Nitrile rubber/Nitrile latex - NBR (0,35 mm)
- textile or leather gloves are completely unsuitable.
- Following materials are unsuitable for protective gloves because of degradation, severe swelling or low permeation time:
  - Natural rubber/Natural latex - NR
  - Polyvinyl chloride - PVC

8.2.2. Environmental exposure controls

Avoid escape into water, drainage, sewer, or the ground. A hazard for drinking water sources when larger quantities get into groundwater. Inform the responsible authorities. Hazard to the surrounding atmosphere if larger quantities of the substance escape. Inform the authorities.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Property	Unit	Value	Reference conditions
Appearance		Colourless liquid	20 °C and 1013 hPa
Odour		Pungent	
Odour threshold	ppm	No data available	
pH		≈ 11	
Melting point / freezing point	°C	-69,2	28% solution
Initial boiling point and boiling range	°C	36	30% solution
Flash point	°C	Aqueous solutions of ammonia of various concentrations did not show any flash point	
Evaporation rate		No data available	
Flammability		Not flammable	
Upper/lower flammability or explosive limits	%	Lower/upper explosion limit: 16/25. (Ammonia anhydrous)	
Vapour pressure	Pa	41690	23% solution, 20 °C.
Vapour density		Study scientifically unjustified for inorganic gas	
Relative density	g/cm^3	0,91	28% solution, 20°C.
Solubility(ies)	g/L	510-531	in water at 20 °C.

Partition coefficient: n-octanol/water		0,23 (Ammonia anhydrous)	20 °C.
Auto-ignition temperature	°C	651(Ammonia anhydrous)	
Decomposition temperature	°C	Study scientifically unjustified for inorganic gas. (Ammonia anhydrous)	
Viscosity	mPa s	1,1	26% solution, 27 °C
Explosive properties	vol. %	Non explosive.	
Oxidising properties		No.	

9.2. Other information

Dissociation constant: pKa = 4,77 at 25 °C.

SECTION 10: Stability and reactivity

10.1. Reactivity

Freely soluble in water. Aqueous solution reacts alkaline.

10.2. Chemical stability

Ammonia is thermally stable. The danger of ignition exists, but only localised and under certain conditions. Little dissociation above 840 °C and 100 kPa.

10.3. Posibility of hazardous reactions

Risk of explosion in contact with: strong acids; iodine

10.4. Conditions to avoid

The substance should not be stored with substances with which hazardous chemical reactions are possible.

10.5. Incompatible materials

The substance can react dangerously with strong bases.

10.6. Hazardous decomposition products

Nitrogen, hydrogen.

SECTION 11: Toxicological information

11.1. Information on toxicological effects

11.1.1 Acute toxicity

Ammonia aqueous solution is not classified under the CLP Regulation with Acute Tox. 3.

11.1.2 Skin corrosion/irritation

Ammonia aqueous solution is listed on Annex VI of CLP regulation and is classified as Skin Corr. 1B (Hazard statement: H314: Causes severe skin burns and eye damage).

Skin corrosion/irritation – Ammonia anhydrous, EC No 231-635-3			
Routes of exposure	**Method/species**	**Effective dose**	**Results**
Respiratory tract	Human inhalation data (review of literature)	400 ppm (= 278 mg/m³; in air) = Immediate throat irritation 700 ppm (= 487 mg/m³; in air) = Eye irritation 1700 ppm (= 1182 mg/m³; in air) = Coughing 2500 - 6500 ppm (= 1738-4519 mg/m³; in air) = Life threatening after 0.5 hour 5000 - 10000 ppm (= 348-6953 mg/m³; in air) = Mortality	irritating
Skin	study scientifically unjustified	No data available	Classification: Corrosive

11.1.3 Serious eye damage/irritation

Ammonia is classified as Skin Corr. 1B (Hazard statement: H314: Causes severe skin burns and eye damage) under the CLP Regulation. This classification is consistent with the data available. No change to this classification is proposed.

Serious eye damage/irritation			
Routes of exposure	**Method/species**	**Effective dose**	**Results**
Eye	study scientifically unjustified	No data available	Highly irritating (Classification: Corrosive)

11.1.4 Respiratory or skin sensitization

No classification is proposed for skin sensitisation or respiratory sensitisation.

Respiratory or skin sensitization - Ammonia anhydrous, EC No 231-635-3			
Routes of exposure	**Method/species**	**Effective dose**	**Results**
Skin	study scientifically unjustified	No data available	Not sensitising. The local dermal effects of anhydrous ammonia will be dominated by irritation/corrosion and sensitisation is considered to be unlikely.
Inhalation	No data available	No data available	The local respiratory tract effects of the substance will be dominated by irritation. There are no reports of occupational asthma attributable to ammonia exposure.

11.1.5 Germ cell mutagenicity

No classification is proposed for anhydrous ammonia. : there is no evidence for genotoxicity in studies performed *in vitro* or *in vivo*.

Germ cell mutagenicity - Ammonia anhydrous, EC No 231-635-3			
Routes of exposure	**Method/species**	**Effective dose**	**Results**
Oral	AMES - test equivalent or similar to OECD471 (Bacterial Reverse Mutation Assay)	—	Genetic toxicity: negative

11.1.6 Carcinogenicity

No classification for carcinogenicity is proposed.

Carcinogenicity- Ammonia anhydrous, EC No EC No 231-635-3			
Routes of exposure	**Method/species**	**Effective dose**	**Results**
Oral	Equivalent or similar to OECD Guideline 453 (Combined Chronic Toxicity / Carcinogenicity Studies) / rat (Fischer 344/DuCrj) male/female	Read across (ammonium sulphate): NOAEL = 67 mg/kg bw/d	There is no evidence that the substance is carcinogenic.

11.1.7 Reproductive toxicity

The available data do not indicate that ammonia is a reproductive or developmental toxin: no classification is proposed.

Reproductive toxicity - Ammonia anhydrous, EC No 231-635-3			
Routes of exposure	**Method/species**	**Effective dose**	**Results**
Inhalation	inhalation: vapour (whole body) 7±1 and 35±3 ppm (analytical conc.) / pig	NOAEC: 25 mg/m³	No evidence of any reproductive effects was seen in studies with ammonium salts. The physiological role of ammonia indicates that it is unlikely to be a reproductive toxin at relevant exposure levels.
Oral	OECD 414 rabbit (New Zealand White) Test material (EC name): Ammonium perchlorate	Read across: NOAEL: 100 mg/kg bw/d	

11.1.8 STOT-single exposure

Reason for no classification: conclusive but not sufficient for classification

11.1.9 STOT-repeated exposure

Reason for no classification: conclusive but not sufficient for classification

11.1.10 Aspiration hazard

Reason for no classification: conclusive but not sufficient for classification

11.2 Symptoms

See subsection 4.2.

SECTION 12: Ecological information

12.1. Toxicity

12.1.1. Toxicity to aquatic organisms

Classification: Hazards to the aquatic environment: Aquatic Acute 1, Hazard statement: Very toxic to aquatic life.

Acute (short-term) toxicity - Ammonia anhydrous, EC No 231-635-3				
	Effect dose (Exposure time) / Test material	**Species / Method**	**Evaluation**	**Results**
Fish	LC50 (96h): 0.89 mg/L un-ionised ammonia	*Oncorhyncus mykiss.*	The toxicity of ammonia to fish is attributable mainly to the un-ionised NH_3 molecule. The proportion of un-ionised ammonia increases with increasing temperature and pH, but decreases with increasing salinity.	The toxicity of ammonia is dependent on pH, as pH will influence the proportion of total ammonia present as the unionised form.
Aquatic invertebrate toxicity	EC50/LC50 for (48 h) = 101 mg/L unionised ammonia (meas. (not specified)) based on: mortality	*Daphnia magna* freshwater static,equivalent or similar to ASTM E729-80		The 48 hour LC50 value for freshwater invertebrates was determined to be 101 mg/L .
Algae toxicity	EC50 (18 d): 2700 mg/L based on: cell number . Test material (EC name):ammonium sulphate	*Chlorella vulgaris* (algae) Freshwater Static	Read-across: ammonium sulphate (structural analogue or surrogate)	Algae appear to be of lower sensitivity to the toxicity of ammonia compared to other aquatic organisms including fish, consistent with the fact that ammonia represents a nitrogen source for algae.
Sediment organisms			study scientifically unjustified	Ammonia does not accumulate in sediments

Chronic (long-term) toxicity - Ammonia anhydrous, EC No 231-635-3				
	Effect dose (Exposure time) / Test material	**Species / Method**	**Evaluation**	**Results**
Fish	LOEC (73 d): 0.022 mg/L ammonia	Oncorhynchus mykiss (Salmo gairdneri) /Toxicity to eggs after fertilisation	Growth and development of rainbow trout sac fry are inhibited by long-term exposures to concentrations of ammonia as low as 0.05 mg NH_3-N/L	The lowest concentration of unionised ammonia at which long-term effects were found is 0.022 mg/L (NH_3) when a cumulative mortality of 71% was observed for eggs, larvae and fry of rainbow trout (*Oncorhynchus mykiss*) over 73 days exposure.
Aquatic invertebrates	NOEC for freshwater invertebrates: 0.79 mg/L Test material: Ammonium chloride	*Daphnia magna* / EPA OPPTS 850.1300	read-across : ammonium chloride (structural analogue or surrogate)	EC10/LC10 or NOEC for freshwater invertebrates: 0.79 mg/L

12.1.2 Toxicity to terrestrial organisms

Ammonia applied directly to the soil is rapidly converted to other forms by bacteria in the nitrate cycle. Exposure of soil macro-organisms is therefore not predicted. Exposure of terrestrial arthropods is therefore not predicted. Ammonia is used as a component of fertilisers; therefore toxicity to terrestrial plants is not predicted.

12.1.3 Toxicity to aquatic micro-organisms in sewage treatment systems

Non-toxic.

Toxicity to aquatic micro-organisms - Ammonia anhydrous, EC No 231-635-3				
	Effect dose (Exposure time) / Test material	**Species / Method**	**Evaluation**	**Results**
Activated sludge - freshwater	--	study scientifically unjustified	Ammonia is used as a source of nitrogen by microorganisms and is also produced by bacteria from other nitrogenous compounds. A waiver is therefore proposed for this endpoint as testing is not relevant.	Non-toxic

12.2. Persistence and degradability

Abiotic degradation – hydrolisis: In aqueous solution, ammonia is in equilibrium with the ammonium ion. At environmentally relevant pH values of 5- 8, the predominant form will be NH_4^+. Hydrolysis is not predicted.

Biodegradation in water: readily biodegradable.

Biodegradation in soil: Ammonia is rapidly biodegraded in soil by the process of ammonification or mineralisation.

Phototransformation/photolysis: Photolytic degradation and reaction with photolytically produced hydroxyl radicals (·OH) in the troposphere are major pathways for the removal of atmospheric ammonia.

12.3. Bioaccumulative potential

The accumulation of ammonia in biota is not considered of importance in the environment as it does not accumulate in lipid-rich tissues in the same manner as organic chemicals, even though levels of ammonia in the blood of exposed animals may increase following exposures.

12.4. Mobility in soil

Ammonia is rapidly biodegraded in soil by the process of ammonification or mineralisation.

12.5. Results of PBT and vPvB assessment

PBT and vPvB assessment is not relevant and is not required for inorganic substances. Ammonia is neither a PBT nor a vPvB substance. Accordingly, an Emission Characterisation under Section 4.2 of Annex I of REACH Regulation is not required.

12.6. Other adverse effects

Not known.

SECTION 13: Disposal considerations

13.1. Waste treatment methods

13.1.1 Product/ packaging disposal

Hazardous waste according to Waste Catalogue. If there is no way of recycling it must be disposed of in compliance with the respective national and local regulations.

Waste code/waste designations according to LoW: 06 02 03* Ammonia (Waste alkaline solutions)

13.1.2. Waste treatment-relevant information

See section 13.1.1.

13.1.3. Sewage disposal-relevant information

Do not discharge into drains or sewage system. Do not put/place waste into sink or dust bin.

13.1.4. Other disposal recommendations

None.

SECTION 14: Transport information

14.1. UN number

2672

14.2. UN proper shipping name

AMMONIA, SOLUTION

14.3. Transport hazard class(es)

ADR/RID/ADN/ICAO/IATA: 8
IMDG: 8

14.4. Packing group

ADR/RID/AND/IMDG/ICAO/IATA: III

14.5. Environmental hazards

ADR, RID, ADN, ICAO/IATA: Hazardous to the aquatic environment.
IMDG: Marine pollutant.

14.6. Special precautions for user

ADR Transport category: 3 Vehicle for tank carriage: AT Tank Code: L4BN Tunnel restriction code: E Label: 8 Classification code: C5 Hazard identification No: 80 Special provisions: 543	**RID** Transport category: 3 Tank Code: L4BN Label: 8 Classification code: C5 Hazard identification No: 80 Special provisions: 543
ADN Label: 8 Additional requirements/Remarks: 34 Dangers: 8+N1 Equipment required: PP, EP Classification code: C5 Carriage permitted: T Type of tank vessel: N Anti-explosion protection required: No Maximum degree of filling in %: 97	**IMDG** Subsidiary risk: No data. Ship stowage and segregation category: Category A. UNDER DECK IN A MECHANICALLY VENTILATED SPACE. Clear of living quarters. “Separated from” acids. Special provisions: No data. EmS: F-A, S-B. Segregation group: Alkalis

ICAO
Label: 8
Cargo IMP Code: RCM
Passenger and Cargo Aircraft:
- EQ: E1; Ltd Qty: 1 l/Pkg; Pkg Inst: Y841
- Max Net Qty/Pkg: 5 l; Pkg Inst: 852

Cargo Aircraft only:
- Pkg Inst: 856; Max Net Qty/Pkg: 60 l

ERG Code: 8L

14.7. Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

Product name: Ammonia aqueous (28% or less)
Pollution Category (according to MARPOL Annex II): Y
Ship type (according to IBC Code): 2
Specific and operational requirements (according to IBC Code): 15.19.6

SECTION 15: Regulatory information

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

Regulation (EC) No 1907/2006; Commission regulation (EU) No 453/2010, Annex I, amending Regulation (EC) No 1907/2006; Council Directive 67/548/EEC; Regulation (EC) No 1272/2008; Commission directive 2006/15/EC, Council directive 91/689/EEC; Directive 2008/98/EC; Directive 98/24/EC; Recommendations on the transport of dangerous goods, Model Regulations; ADR, ADN, RID, IMDG, ICAO/IATA.

15.2. Chemical safety assessment

In accordance with Article 14 of Regulation EC No 1907/2006 a Chemical Safety Assessment has been carried out for ammonia anhydrous.

SECTION 16: Other information

16.1. Indication of changes to the previous revision

First issue.

16.2. Abbreviations and acronyms

ADR - Accord européen sur le transport des marchandises dangereuses par Route (European Agreement concerning the International Carriage of Dangerous Goods by Road)
CAS No - Chemical abstract registry number
CLP - Calssification labelling and packaging
CSA - Chemical safety assessment
DMEL - Derived minimal effect level
DNEL - Derived no effect level
EEC - European Economic Community
EC - European **C**ommission
EC No - European **C**ommission number

GHS - Globally harmonized system of classification and labelling of chemicals
IMDG - International maritime code for dangerous goods
IATA - International Air Transport Association
ICAO - International Civil Aviation Organization
IOEL - Indicative occupational exposure limit
LC50 - Median lethal concentration
LD50 - Median lethal dose
NOAEC - No observed adverse effect concentration
NOAEL - No observed adverse effect level.
NOEC - No observed effect concentration
OEL - Occupational exposure limit
PBT - Persistent bioaccumulative and toxic
PNEC - Predicted no effect concentration
PPE - Personal protective equipment
REACH - Registration, evaluation authorisation and restriction of chemicals
RID - Règlement international concernant le transport des marchandises dangereuses par chemin de fer (Regulations Concerning the International Transport of Dangerous Goods by Rail)
STOT - Specific target organ toxicity
vPvB - Very persistent and very bioaccumulative
IUPAC – The International union of pure and applied chemistry

16.3. Further information

Safety phrases relevant to ammonia:
S1/2 - keep locked up and out of reach of children
S9 - keep container in a well-ventilated place
S26 - in case of contact with eyes, rinse immediately with plenty of water and seek medical advice
S36/37/39 - wear suitable protective clothing, gloves and eye/face protection
S45 - in case of accident or if you feel unwell, seek medical advice immediately (show the label where possible)
S61 - avoid release to the environment. refer to special instructions/safety data sheets

Note:
The data given here is based on current knowledge and experience. The purpose of this Safety Data Sheet is to describe the product in terms of their safety precautions. However, it shall not constitute or imply a guarantee concerning composition, properties of performance, and shall not establish a legally valid contractual relationship.

Material Safety Data Sheet

Revision Issued: 3/02/2010 Supercedes: 4/19/2005 First Issued: 10/03/1996

Section I - Chemical Product And Company Identification

Product Name: Sodium Bisulfite

CAS Number: 7631-90-5 HBCC MSDS No. CS05200

HILL BROTHERS Chemical Co.
1675 NORTH MAIN STREET • ORANGE, CALIFORNIA 92867-3499
(714) 998-8800 • FAX: (714) 998-6310
http://hillbrothers.com

1675 No. Main Street, Orange, California 92867
Telephone No: 714-998-8800 | Chemtrec: 800-424-9300

Section II - Composition/Information On Ingredients

Chemical Name	CAS Number	%
Sodium Bisulfite	7631-90-5	28-43

See Section VIII for exposure guidelines

Section III - Hazard Identification

Routes of Exposure: Eyes, skin, inhalation, and ingestion
Summary of Acute Health Hazards
Ingestion: This product may cause irritation to the gastro-intestinal tract. Large doses may cause diarrhea, Central Nervous System Depression colic and death. May also cause severe allergic reaction in some asthmatics and sulfite sensitive individuals.
Inhalation: If mists or sprays of this solution are inhaled, this product may cause irritation to respiratory tract. May cause allergic reaction in sensitive individuals. If mixed with acids, sodium bisulfite will release large amounts of sulfur dioxide gas. This gas can cause severe irritation of the nose and throat. Exposure to high levels of sulfur dioxide gas may result in severe lung damage.
Skin: Can cause burns and severe irritation to the skin and mucous membranes.
Eyes: Can cause severe irritation to the eyes.
Summary of Chronic Health Hazards: N/A
Signs and Symptoms of Exposure: Acute: This material is an irritant to eyes, skin, and mucous membranes. Inhalation of mist may cause irritation to respiratory tract. Ingestion may cause irritation to the gastrointestinal tract. Large doses may cause diarrhea, depression, colic and death. May also cause severe allergic reaction in some asthmatics and sulfite sensitive individuals. **Chronic:** Repeated skin contact with this product may result in dermatitis (inflammation and reddening of the skin). The effects of long-term, low level exposures to this product have not been determined. Safe handling of this material on a long-term basis should emphasize the avoidance of acute exposures.
Effects of Overexposure: N/A
Medical Conditions Generally Aggravated by Exposure: May also cause severe

allergic reaction in some asthmatics and sulfite sensitive individuals.
Note to Physicians: N/A

Section IV - First Aid Measures

Ingestion: If this product is swallowed, call a poison control center or doctor immediately for treatment advice. Do not induce vomiting unless told to do so by a poison control center or doctor. Have person drink several glasses of water if able to swallow. Never induce vomiting or give diluents (milk or water) to someone who is unconscious, having convulsions, or unable to swallow. If spontaneous vomiting occurs, have victim lean forward with head down to avoid breathing in of vomitus, rinse mouth and administer more water. Victims of chemical exposure must be taken for medical attention. Rescuers should be taken for medical attention if necessary. Take a copy of label and MSDS to health professional with victim.
Inhalation: If vapors, mists, or sprays of this product are inhaled, remove victim to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferable mouth-to-mouth if possible. Remove or cover gross contamination to avoid exposure to rescuers. Do not give anything by mouth to an unconscious person.
Skin: If the product contaminates the skin, rinse skin immediately with plenty of water for 15 minutes. Take off contaminated clothing, taking care not to contaminate eyes. Victim must seek medical attention. Call a poison control center or doctor for treatment advice.
Eyes: If this product enters the eyes, open victim's eyes while under gentle running water. Use sufficient force to open eyelids. Have victim "roll" eyes. Minimum flushing is for 15 minutes. Remove contact lenses, if present after the first 5 minutes, then continue rinsing eye. Do not attempt to neutralize. Oils or ointments should not be used at this time. Call a poison control center or doctor for treatment advice. Victim must seek immediate medical attention.

Section V - Fire Fighting Measures

Flash Point: Non-flammable **Autoignition Temperature:** N/A

Lower Explosive Limit: N/A **Upper Explosive Limit:** N/A

Unusual Fire and Explosion Hazards: Not considered flammable or combustible. This material, when heated, may release sulfur dioxide gas. Run-off from fire control may cause pollution. Keep fire-exposed containers cool with water spray to prevent rupture due to excessive heat. High pressure water hose may spread product from broken containers increasing contamination. If involved in a fire, this product may decompose to produce a variety of compounds, i.e. sulfur dioxide, sodium oxide, oxygen), Emergency responders must wear the proper personal protective equipment suitable for this situation to which they are responding. Products of combustion are irritating to the respiratory tract and may cause breathing difficulty.

Extinguishing Media: Carbon dioxide, dry chemical, foam, halon, or water spray.

Special Firefighting Procedures: Incipient fire responders should wear eye protection. Structural fire fighters must wear Self-Contained Breathing Apparatus and full protective equipment. Move fire-exposed containers, if it can be done without risk to firefighters. If possible, prevent run-off water from entering storm drains, bodies of water, or other environmentally sensitive areas. If necessary, discard or decontaminate fire response equipment using before returning such equipment to service.

Section VI - Accidental Release Measures

Uncontrolled releases should be responded to by trained personnel using pre-planned procedures. Proper protective equipment should be used. In case of a spill, clear the affected area, protect people, and respond with trained personnel. The proper personal protective equipment for incidental releases (e.g. –1 L of the product released in a well-ventilated area) use impermeable gloves, specific for the material handled, goggles, face shield, and appropriate body protection. In the event of a large release, use impermeable gloves, specific for the material handled, chemically resistant suit and boots, and hard-hat. Self-Contained Breathing Apparatus or respirator may be required where engineering controls are not adequate or conditions for potential exposure exist. When respirators are required, select NIOSH/MSHA approved based on actual or potential airborne concentrations in accordance with latest OSHA and/or ANSI recommendations. Absorb spilled liquid with polypads or other suitable absorbent materials. Neutralize residue with sodium bicarbonate and water rinse. Decontaminate the area thoroughly. Test area with litmus paper to confirm neutralization. Place all spill residue in a suitable container.

Section VII - Handling and Storage

Avoid all bodily contact. Do not take internally. Wash thoroughly after handling. Avoid breathing mist. Store away from acids and oxidizers. Open containers carefully.

Section VIII - Exposure Controls/Personal Protection

Exposure Controls

Engineering Controls: Use ventilation to maintain TLV below 5 mg/m^3. If required use a corrosion-resistant ventilation system separate from other exhaust ventilation systems to ensure that there is no potential for overexposure to sprays, mists of this product.

Work/Hygienic Practices: Wash hands thoroughly with soap and water before eating, drinking, smoking or using toilet facilities. Do NOT place food, coffee or other drinks in the area where dusting or splashing of solutions is possible.

Exposure Guidelines: Sodium Bisulfite: CAS Number 7631-90-5, 28-43%, Exposure Limits (TWAs) in Air: ACGIH TLV: 5 ppm as SO_2; OSHA PEL: 5 ppm as SO_2; STEL: N/A

Personal Protection

Personal Protection Equipment (PPE): None normally required. (Respirator if TLV above 5 mg/m^3) If adequate ventilation is not available or if there is potential for airborne exposure above the exposure limits (listed in Section II) a respirator may be worn up to respirator exposure limitations, check with respirator equipment manufacturer's recommendation/limitations. For a higher level of protection use positive pressure supplied air respiration protection or Self-Contained Breathing Apparatus or if oxygen levels are below 19.5% or are unknown.

Protective Clothing: Rubber gloves, rubber boots, and rubber apron.

Eye Protection: Chemical safety goggles.

Section IX - Physical and Chemical Properties

Physical State: Liquid **pH:** 4.8 – 5.2

Melting Point/Range: N/A **Boiling Point/Range (F):** 210 - 220

Appearance/Color/Odor: Yellow liquid with a slightly sulfurous odor.

Solubility in Water: Complete
Specific Gravity (Water=1): 1.1 - 1.4
Vapor Density (Air=1): 10.26
How to detect this compound:
Because it is a weak acid, litmus paper will maintain almost original brown paper bag color upon contact with this solution.

Vapor Pressure (mmHg @ 20ºC): 2 - 9
Molecular Weight: N/A
% Volatiles: 57-72

Freezing Point: 6ºC (43ºF)

Section X - Stability and Reactivity

Stability: Stable **Hazardous Polymerization:** Will Not Occur

Conditions to Avoid: Temperature at or near boiling causes evolution of toxic and corrosive sulfur dioxide gas. Sulfur dioxide is also evolved slowly at ambient temperatures.

Materials to Avoid: Sodium nitrite, aluminum powder, acids, and oxidizing agents

Hazardous Decomposition Products: Sulfur Dioxide Gas

Section XI - Toxicological Information

Mildly Toxic (LD [Human] = 10G)
This product is irritating to contaminated tissue.
Sodium Bisulfite may also cause severe allergic reaction in some asthmatics and sulfite sensitive individuals.

Section XII - Ecological Information

N/A

Section XIII - Disposal Considerations

If collected material can be dissolved, it may be discharged to an industrial waste water collection system. Consult local, state or federal regulatory agencies before disposing of any material.

Section XIV - Transport Information

DOT Proper Shipping Name	
% Sodium Bisulfite in Solution	
28	Bisulfites, aqueous solutions, n.o.s. (contains Sodium Bisulfite 28%)
40	Bisulfites, aqueous solutions, n.o.s. (contains Sodium Bisulfite 40%)
43	Bisulfites, aqueous solutions, n.o.s. (contains Sodium Bisulfite 43%)

DOT Hazard Class/ I.D. No.: 8, UN 2693, III
DOT Label(s) Required: Corrosive

Section XV - Regulatory Information

Reportable Quantity (CERCLA): 5000 Lbs.
NFPA Rating: Health - 2; Flammability - 0; Instability - 1
0=Insignificant 1=Slight 2=Moderate 3=High 4=Extreme
Carcinogenicity Lists: No **NTP:** No **IARC Monograph:** No **OSHA Regulated:** No

Section XVI - Other Information

Synonyms/Common Names: Sodium Acid Sulfite, Sodium Hydrogen Sulfite
Chemical Family/Type: Inorganic Salt
Sections changed since last revision: II, III, VIII, IX, XI, XIV, XV

IMPORTANT! Read this MSDS before use or disposal of this product. Pass along the information to employees and any other persons who could be exposed to the product to be sure that they are aware of the information before use or other exposure. This MSDS has been prepared according to the OSHA Hazard Communication Standard [29 CFR 1910.1200]. The MSDS information is based on sources believed to be reliable. However, since data, safety standards, and government regulations are subject to change and the conditions of handling and use, or misuse are beyond our control, **Hill Brothers Chemical Company** makes no warranty, either expressed or implied, with respect to the completeness or continuing accuracy of the information contained herein and disclaims all liability for reliance thereon. Also, additional information may be necessary or helpful for specific conditions and circumstances of use. It is the user's responsibility to determine the suitability of this product and to evaluate risks prior to use, and then to exercise appropriate precautions for protection of employees and others.

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OSMOFLO Pty Ltd A.C.N. 050 952 175

MATERIAL SAFETY DATA SHEET

Product : OSMOCIDE 20%

Classified as a hazardous according to criteria of NOHSC/ASCC
Classified as a Dangerous Good according to the Australian Dangerous Goods Code

Emergency Response No:1800 039 008

1 IDENTIFICATION

IDENTIFICATION

Product Code:	P00227; P00350; P01092
Product Name:	OSMOCIDE 20%
Product use:	Microbiocide for Water systems
Packaging Size:	15 Kg Drum, 200 kg Plastic Drums; 400 Kg IBC

COMPANY DETAILS

Company:	OSMOFLO Pty Ltd
ACN Number:	050 952 175
Address:	382 Diment Road BURTON SA 5110
Telephone Number:	(08) 8282 9700
Facsimile Number:	(08) 8280 3015
Emergency Telephone Number:	1800 039 008

Other Information: This information summarises our best knowledge on the health and safety hazard information of the product and how to safely handle and use the product in the workplace. Each user should read this MSDS and consider the information in the context of how the product will be handled and used in the workplace including in conjunction with other products.

2 HAZARD IDENTIFICATION

Hazard Classification: Hazardous according to the criteria of NOHSC Australia.

C, Corrosive.



T, Toxic.



Risk Phrases:

R23/24/25	Toxic by inhalation, in contact with skin and if swallowed.
R34	Causes burns.
R36/37/38	Irritating to eyes, respiratory system and skin.
R41	Risk of serious eye damage.
R42/43	May cause sensitization by inhalation and skin contact.
R51	Toxic to aquatic organisms.
R53	May cause long term effects in the aquatic environment.

Safety Phrases:

S3/9/14	Keep in a cool, well ventilated place away from strong alkalis and oxidizing agents.
S24/25	Avoid contact with skin and eyes.
S29	Do Not empty into drains.
S36/37/39	Wear suitable protective clothing, gloves and eye/face protection.
S45	In case of accident or if you feel unwell, seek medical advice immediately (show label where possible)
S46	If swallowed, seek medical advice immediately and show this container or label.

Poisons Schedule: S6.

3 COMPOSITION

Ingredients

Chemical Entity	CAS Number	Proportion	Risk Phrases
2,2 Di Bromo 3 Nitrilopropionamide	10222-01-2	20%	
Poly Ethylene Glycol	25322-68-3	30-60%	
Water	7732-18-5	10-30%	

4 FIRST AID MEASURES

Eyes: Any contamination of eyes should be washed away with copious quantities of clean water. Eyelids to be held open. Seek urgent medical advice. Irritating to eyes. Will cause pain and visual problems.

Particularly, if left untreated, may cause permanent damage to the eye.

Skin: Any contamination of the skin should be immediately washed away with copious quantities of water. Remove any contaminated clothing (including footwear). If irritation occurs, seek medical advice. DO NOT reuse clothing. Discard clothing.

Inhalation: Remove victim to fresh air. Remove any contaminated clothing. Do not use mouth-to-mouth method. Induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer oxygen if breathing is difficult. Seek immediate medical attention. May Cause chemical burns to the respiratory tract.

Ingestion: Do Not induce vomiting. If victim conscious give 2-4 cups of milk or water to dilute stomach contents. Never give anything orally to an unconscious person. Wash mouth with water and seek medical advice urgently. May Cause gastrointestinal tract burns

.5 FIRE FIGHTING MEASURES

Suitable Extinguishing Media: CO_2, Foam, Dry Powder, Water Fog.
Hazards from combustion: When heated to decomposition (above 70 Deg C), may release poisonous and corrosive fumes of bromine gas, hydrogen bromide, and nitrogen oxides.
Special Fire Fighting Procedures: Fire fighters should wear self-contained breathing apparatus and protective fire-fighting clothing. Keep away from drains and stormwater.
Hazchem Code: •2Z

6 ACCIDENTAL RELEASE MEASURES

Emergency Procedures: Keep non-essential personnel away from the spill. Isolate hazard area and restrict entry. Stay upwind. Wear appropriate eye, skin and respiratory protection as outlined in this MSDS. Keep spills and cleaning runoff out of municipal sewers and streams, lakes or ponds.

Clean Up Procedures: Contain spills immediately with sand or vermiculite and place in closed container for disposal. Decontaminate spill area with a solution of 10% sodium bicarbonate in water. Absorb decontaminated solution with sand or vermiculite. Sweep up and place in a suitable container and hold for waste disposal. Ventilate area and wash spill site after material pickup is complete.

LARGE SPILLS: Notify Emergency Services (Police/ Fire Brigade/ Ambulance). Inform them of the exact location and quantity of the release. Be prepared to answer any other questions they may have. Block access to drains, particularly storm water drains. Trained personnel should wear personal protective equipment as indicated in this MSDS.

7 HANDLING AND STORAGE

Precautions for safe handling: Keep containers tightly closed. Avoid bodily contact. Wear correct PPE. Handle in accordance with good industrial hygiene practice and any legal requirements.

Conditions for safe storage: Store in a dry, cool, well-ventilated and shaded area away from heat source and strong alkalis and oxidizing agents. Check containers for leaks regularly. Store in original packages as approved by manufacturer. Suitable materials for product handling are glass, PVC, polypropylene, polyethylene and glass reinforced plastic. Do NOT store in steel, aluminium or other metals.

8 EXPOSURE CONTROL / PERSONAL PROTECTION

National exposure standards: TLV-TWA Not established.
Biological limit values: BEI's Not established.
Engineering controls: Local exhaust or natural ventilation should be adequate under normal use conditions. Normal safety showers and eyewash facilities should be nearby.
Personal protective equipment:
RESPIRATORY PROTECTION: A respiratory protection program meeting OSHA 1910.134 and ANSI Z88.2 requirements must be followed whenever workplace conditions warrant a respirator's use. Not required under normal operating conditions. Where misting may occur, wear a MSHA/NIOSH approved (or equivalent) full-face, dust/mist air-purifying respirator. Air-purifying respirators should be equipped with MSHA/NIOSH approved (or equivalent) filters for protection against dusts and mists.
EYE PROTECTION: Use chemical splash goggles or face shield with safety glasses (ANSI Z87.1 or approved equivalent). Eye protection worn must be compatible with respiratory protection system employed.

HAND PROTECTION: Material is a possible skin sensitizer. Use rubber gloves to protect against permeation. Gloves should be removed or replaced immediately if there is any indication of degradation or chemical breakthrough. Rinse and remove gloves immediately after use. Wash hands with soap and water.
OTHER PROTECTION: Use chemically resistant apron or other impervious clothing to avoid prolonged or repeated skin contact. If entering spaces where the airborne concentration of a contaminant is unknown then the use of a Selfcontained breathing apparatus (SCBA) with positive pressure air supply complying with AS/NZS 1715 / 1716, or any other acceptable International Standard is recommended. In these circumstances, the use of a fully encapsulating gas-tight suit is also recommended.

9 PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	Clear yellow solution.
Odour:	No Odour
pH (25ºC):	3.0 – 5.50.
Vapour Density:	No data
Boiling Point/Range:	No data.
Freezing/Melting Point:	No data.
Solubility in Water:	Soluble in water.
Specific Gravity @25ºC:	1.22 – 1.26.
Flash Point:	Not applicable.

10 STABILITY AND REACTIVITY

Chemical Stability: Stable under normal conditions of use.

Conditions to avoid: Heat and incompatibilities.

Incompatible materials: Corrosive to aluminium, tin, zinc in the presence of moisture. Reacts with ammonium Salts to evolve ammonia gas. Can react violently if in contact with alkalis acids and Chlorinated hydrocarbons. HIGHLY reactive with aluminium, zinc, lead, tin, and alloys of these metals producing flammable hydrogen gas.

Hazardous decomposition products: Poisonous and corrosive fumes of bromine gas, hydrogen bromide, and nitrogen oxides.

Hazardous reactions: Polymerization will not occur.

11 TOXICOLOGICAL INFORMATION

Acute and chronic health effects:

ORAL LD50	308 mg/kg (rat)
INHALATION LD50	0.32 mg/1/4hr (rat)
EYE IRRITATION	Corrosive (rabbit)
DERMAL IRRITATION	Moderate irritant (rabbit)
DERMAL SENSITIZATION	Weak sensitizer (guinea pig)
SUB-CHRONIC TOXICI	NOEL: 5 mg/kg/day (13 weeks oral, rat)

Possible routes of exposure: Eyes, skin, inhalation, ingestion.

Range of effects following exposure: May cause severe irritation to eyes, skin, respiratory and digestive tracts.

Dose, concentration or conditions of exposure likely to cause injury:

ORAL LD50	308 mg/kg (rat)
INHALATION LD50	0.32 mg/1/4hr (rat)
EYE IRRITATION	Corrosive (rabbit)
DERMAL IRRITATION	Moderate irritant (rabbit)
DERMAL SENSITIZATION	Weak sensitizer (guinea pig)
SUB-CHRONIC TOXICITY	NOEL: 5 mg/kg/day (13 weeks oral, rat)

Delayed effects: No data.

Relevant negative data: Not a likely carcinogen

12 ECOLOGICAL INFORMATION

Ecotoxicity:
AQUATIC TOXICITY

Rainbow trout (96-hour LC50)	2.3 mg/l
Sheepshead minnow (96-hour LC50)	3.4 mg/l

Bluegill sunfish (96-hour LC50)	2.3 mg/l
Mysid shrimp (96-hour LC50)	0.72 mg/l
Eastern oyster (96-hour LC50)	0.37 mg/l
Daphnia magna (48-hour EC50)	0.86 mg/l

AVIAN TOXICITY

Bobwhite quail (acute oral LD50)	354 mg/kg
Mallard duck (dietary LC50)	5620 ppm
Bobwhite quail (dietary LC50)	>5620 ppm

The environmental toxicity data mentioned are from studies conducted on active ingredient 2,2-Dibromo-3-nitrilopropionamide.

Persistence and degradability: No data.

Mobility: Avoid contaminating waterways.

13 DISPOSAL CONSIDERATIONS

Disposal Methods: Dispose of in accordance with local, state and federal regulations utilizing a licensed contactor.

14 TRANSPORT INFORMATION

Land Transport

UN Number	2922
Shipping Name	Corrosive Liquid, Toxic, N.O.S.
Dangerous Goods Class	8 Corrosive Substance
Subsidiary Risk	6.1 Toxic
Pack Group	III
Precaution for User	CORROSIVE and TOXIC
Hazchem Code	2Z



Sea Transport

UN Number	2922
Shipping Name	Corrosive Liquid, Toxic, N.O.S.
Dangerous Goods Class	8 Corrosive Substance
Subsidiary Risk	6.1 Toxic
Pack Group	III
Precaution for User	CORROSIVE and TOXIC
Hazchem Code	2Z

15 REGULATORY INFORMATION

Poisons Schedule	6
EPG	37
AICS Name	2,2 Di Bromo 3 Nitrilopropionamide

16 OTHER INFORMATION

Literature References No data available.

Sources for Data No data available.

Legend to Abbreviations and Acronyms

<	less than
>	greater than
AICS	Australian Inventory of Chemical Substances
CAS	Chemical Abstracts Service (Registry Number)
cm^2	square centimetres
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
deg C (°C)	degrees Celsius
ERMA	Environmental Risk Management Authority
G	gram
g/cm^3	grams per cubic centimetre
g/l	grams per litre
HSNO	Hazardous Substance and New Organism
IDLH	Immediately Dangerous to Life and Health
Immiscible	liquids are insoluble in each other
Kg	kilogram
kg/m^3	kilograms per cubic metre
LC50	LC stands for lethal concentration. LC50 is the concentration of a material in air which causes the death of 50% (one half) of a group of test animals. The material is inhaled over a set period of time, usually 1 or 4 hours.

LD50	LD stands for Lethal Dose. LD50 is the amount of a material, given all at once, which causes the death of 50% (one half) of a group of test animals
Ltr	Litre
m^3	cubic metre
mbar	millibar
mg	milligram
mg/24H	milligrams per 24 hours
mg/kg	milligrams per kilogram
mg/m^3	milligrams per cubic metre
Misc	miscible
Miscible	liquids form one homogeneous liquid phase regardless of the amount of either component present
mm	millimetre
mPa.s	milli Pascal per second
N/A	Not Applicable
NOHSC	National Occupational Health and Safety Commission
OECD	Organization for Economic Co-operation and Development
PEL	Permissible Exposure Limit
ppb	parts per billion
ppm	parts per million
ppm/2h	parts per million per 2 hours
ppm/6h	parts per million per 6 hours
RCP	Reciprocal Calculation Procedure
STEL	Short Term Exposure Limit
TLV	Threshold Limit Value
tne	tonne
TWA	Time Weighted Average
ug/24H	micrograms per 24 hours
UN	United Nations (number)
Wt	weight

Certified System Quality ISO 9001

Certified System Health & Safety AS 4801

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Material Safety Data Sheet

acc. to ISO/DIS 11014

Printing date 02/11/2011 Reviewed on 02/11/2011

1 Identification of the substance/mixture and of the company/undertaking

· **Product identifier**

· **Trade name: ACTICIDE BW 20**
· **Relevant identified uses of the substance or mixture and uses advised against**
· **Application of the substance / the preparation** Biocide for industrial and/or commercial use.

· **Details of the supplier of the safety data sheet**
· **Supplier:**
Thor Specialties, Inc.
56 Quarry Road
Trumbull, CT 06611
USA
Phone: +1 203 3656530
Fax: +1 203 3656537

· **Competent person responsible for the Material Safety Data Sheet :**
Regulatory Affairs Department: Lynn P. Tordo, E-Mail: ltordo@thorsp.com
· **Emergency telephone number:**
Emergency phone number (worldwide 24 hrs service): +49 6 21 60-4 33 33
USA: In case of emergency call CHEMTREC 24 Hours at 800/424-9300 or international: +1-703-527-3887

2 Composition/information on ingredients

· **Chemical characterization: Mixtures**
· **Description:** Microbiocide based on isothiazolinones.

· **Dangerous components:**		
2634-33-5	1,2-benzisothiazol-3(2H)-one H318; H400; H302; H315; H317	20%

*

3 Hazards identification

· **Classification of the substance or mixture**


GHS05 Corrosion

H318 Causes serious eye damage.


GHS09 Environment

H400 Very toxic to aquatic life.


GHS07

H315 Causes skin irritation.
H317 May cause an allergic skin reaction.

· **Classification according to Directive 67/548/EEC or Directive 1999/45/EC**


Irritant

Irritating to skin. Risk of serious damage to eyes. May cause sensitization by skin contact.


Dangerous for the environment

(Contd. on page 2)

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Trade name: ACTICIDE BW 20

(Contd. of page 1)

Very toxic to aquatic organisms.

· **Classification system:**
The health and environmental hazards of this preparation have been assessed by the conventional method described in annex II and III of the Dangerous Preparations Directive 1999/45 EC.

· **Label elements**
· **GHS label elements**
The product is classified and labelled according to the Globally Harmonized System (GHS).
· **Hazard pictograms**



GHS05 GHS07 GHS09

· **Signal word** Danger

· **Hazard-determining components of labelling:**
1,2-benzisothiazol-3(2H)-one
· **Hazard statements**
Causes skin irritation.
Causes serious eye damage.
May cause an allergic skin reaction.
Very toxic to aquatic life.
· **Precautionary statements**
Avoid release to the environment.
Wear protective gloves/protective clothing/eye protection/face protection.
IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower.
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
If eye irritation persists: Get medical advice/attention.
If skin irritation or rash occurs: Get medical advice/attention.

· **Classification system:**
· **NFPA ratings (scale 0 - 4)**



Health = 2
Fire = 0
Reactivity = 0

· **HMIS-ratings (scale 0 - 4)**



Health = 3
Fire = 0
Reactivity = 0

· **Other hazards**
· **Results of PBT and vPvB assessment**
· **PBT:** This mixture does not contain substances that meet the PBT criteria of REACH, annex XIII.
· **vPvB:** This mixture does not contain substances that meet the vPvB criteria of REACH, annex XIII.

(Contd. on page 3)

Material Safety Data Sheet

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Printing date 02/11/2011 Reviewed on 02/11/2011

Trade name: ACTICIDE BW 20

(Contd. of page 2)

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4 First aid measures

· **Description of first aid measures**
· **General information:**
In case of emergency call toll free (800) 424-9300. Have the product container or label with you when you call a Poison Control Center or doctor or going for treatment.
· **If inhaled:**
Move person to fresh air.
If person is not breathing, call 911 or an ambulance, then give artificial respiraton, preferably mouth-to-mouth if possible.
Call a Poison Control Center or doctor for treatment advice.
Supply fresh air; consult doctor in case of symptoms.
· **If on skin or clothing:**
IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower.
Call a Poison Control Center or a doctor for treatment advice.
If skin irritation or rash occurs: Get medical advice/attention.
· **If in eyes:**
Hold eyes open and rinse slowly and gently with water for 15 to 20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eyes. Call a Poison Control Center or doctor for treatment advice.
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
If eye irritation persists: Get medical advice/attention.
· **If swallowed:**
IF SWALLOWED: rinse mouth. Do NOT induce vomiting.
IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell.
Call a Poison Control Center or doctor immediately for treatment advice.

· **Note to physician:** Probable mucosal damage may contraindicate the use of gastric lavage.

5 Firefighting measures

· **Extinguishing media**
· **Suitable extinguishing agents:** Water spray jet, extinguishing powder, CO2, foam.
· **For safety reasons unsuitable extinguishing agents:** None
· **Special hazards arising from the substance or mixture**
In certain fire conditions, traces of other toxic gases cannot be excluded, e.g.:
Nitrogen oxides (NOx)
Carbon monoxide (CO)
Sulphur dioxide (SO2)
· **Advice for firefighters**

· **Protective equipment:** Wear protective clothing and self-contained respiratory protective device.
· **Additional information**
Collect contaminated fire fighting water separately. It must not enter the sewage system.

*

6 Accidental release measures

· **Personal precautions, protective equipment and emergency procedures**
Wear protective clothing.
Keep unprotected persons away.

(Contd. on page 4)

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acc. to ISO/DIS 11014

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Trade name: ACTICIDE BW 20

(Contd. of page 3)

When selecting the protective suit it has to be paid attention to a complete and safe protection of skin and mucous membrane. Impermeable protective clothes, protective boots made of neoprene, complete face protection, nitrile-rubber-gloves with long tops.

· **Environmental precautions:**
Prevent from spreading (e. g. by enclosing with a ring of chemical absorbent).
As the product is hazardous for the aquatic environment, it must be prevented from reaching surface water.
Inform respective authorities in case of seepage into water course or sewage system.

· **Methods and material for containment and cleaning up:**
Collect large amounts in suitable container. Cover the rest with absorbent, mix intensively and collect mechanically.
Suitable binder: multi-purpose absorbent.
Dispose of contaminated binding material in accordance with local, state and federal regulations.

· **Reference to other sections** None

7 Handling and storage

· **Handling:**
· **Precautions for safe handling**
Ensure good ventilation/exhaustion at the workplace.
Handle product in closed systems preferably.
Load carefully, avoid splashes.
Compliance with the minimum requirements designed to guarantee a better standard of safety and health at work is essential to ensure the safety and health of workers.

· **Information about protection against explosions and fires:** No special measures required.

· **Conditions for safe storage, including any incompatibilities**
· **Storage:**
· **Requirements to be met by storerooms and receptacles:** Keep containers tightly sealed.
· **Information about storage in one common storage facility:** None
· **Further information about storage conditions:**
Prevent release to the environment by adequate secondary containment design and use of appropriate spill control procedures.

8 Exposure controls/personal protection

· **Additional information about design of technical systems:** No further data; see item 7.

· **Control parameters**
· **Components with limit values that require monitoring at the workplace:** Not required.

· **Additional information:** The lists that were valid during the creation were used as basis.

· **Exposure controls**
· **Personal protective equipment:**
· **General protective and hygienic measures:**
Avoid contact with the eyes and skin.
Wash hands thoroughly before breaks and at the end of work.
Provide skin protection plan.

· **Breathing equipment:** Not required under normal conditions and adequate ventilation.

(Contd. on page 5)

Material Safety Data Sheet

acc. to ISO/DIS 11014

Printing date 02/11/2011 Reviewed on 02/11/2011

Trade name: ACTICIDE BW 20

(Contd. of page 4)

· **Protection of hands:**



Chemical protective gloves according to DIN EN 374 with CE-labelling.

Before use check protective gloves for any damages like holes, cuts or tears.
Do not wear protective gloves longer than necessary.

· **Material of gloves** Nitrile rubber, NBR

· **Penetration time of glove material**
Penetration time depends on different criteria and may be determined by the manufacturer according to the standard DIN EN 374-3.

· **Not suitable are gloves made of the following materials:**
Gloves for mechanical protection do not provide protection against chemicals.

· **Eye protection:**



Goggles or face shield

· **Body protection:** Protective work clothing

9 Physical and chemical properties

· **Information on basic physical and chemical properties**
· **General Information**
· **Appearance:**

Form:	Dispersion
Color:	beige
· **Odor:**	Mild
· **pH-value at 20°C (68 °F):**	5.5-8.5
· **Change in condition**	
Melting point/Melting range:	Undetermined.
Boiling point/Boiling range:	ca. 100°C (ca. 212 °F)
· **Flash point:**	Not applicable
· **Auto igniting:**	Product is not selfigniting.
· **Danger of explosion:**	Product does not present an explosion hazard.
· **Vapor pressure at 20°C (68 °F):**	23 mbar
· **Density at 20°C (68 °F):**	1.04-1.10 g/cm3
· **Solubility in / Miscibility with**	
Water:	Dispersible.

10 Stability and reactivity

· **Reactivity**
· **Chemical stability**
· **Thermal decomposition / conditions to be avoided:**
Before handling, the product should not be diluted or mixed with other chemicals, in order to avoid any negative influences on the active ingredient(s).

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Material Safety Data Sheet
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Trade name: ACTICIDE BW 20

(Contd. of page 5)

· **Minimum shelf life:** 12 months from production date, if stored at a temperature of about 20°C
· **Possibility of hazardous reactions** No dangerous reactions known.
· **Hazardous decomposition products:** None expected during normal storage, handling and use.

*
11 Toxicological information

· **Information on toxicological effects**
· **Acute toxicity:**

· **LD/LC50 values that are relevant for classification:**		
Oral	ATE mix	454 mg/kg (rat)
Dermal	ATE mix	> 2000 mg/kg (rat)

· **Primary irritant effect:**
· **Target Organism - skin:** Irritant to skin and mucous membranes.
· **Target Organism - eye:** Strong irritant with the danger of severe eye injury.

· **Sensitization:** Sensitization possible through skin contact.

· **Subacute to chronic toxicity:**
Non mutagenic (Ames-test OECD 471: In vitro genmutation study in bacteria).

*
12 Ecological information

· **Toxicity**

· **Acquatic toxicity:**	
L(E)C 50 mix, alg	0.3 mg/l (Scenedesmus subspicatus) (calculated acc. to Annex I, item 4.1.3.5.2 CLP)
L(E)C 50 mix, dap	15 mg/l (Daphnia) (calculated acc. to Annex I, item 4.1.3.5.2 CLP)
L(E)C 50 mix, fish	11 mg/l (rainbow trout) (calculated acc. to Annex I, item 4.1.3.5.2 CLP)

· **Persistence and degradability**
· **Method:** OECD 302B (Zahn-Wellens-Test), 28 d
· **Analyzing method:** BIT-Elimination
· **Degree of elimination:**
ca. 90 %
The product ingredients can be readily eliminated in the sewage system.
· **Other information:** The active ingredient(s) is (are) biodegradable up to the MIC for bacteria.

· **Behavior in environmental systems:**
· **Components:**
The active substance BIT proved to be biodegradable in the Aerobic Sewage Treatment Simulation Test (OECD 303 A). Primary degradation is above 90%.
· **Bioaccumulative potential**
Due to the distribution coefficient n-octanol/water an accumulation in organisms is not expected.
log Kow 0.4; BIT

· **Ecotoxical effects:**

· **Behavior in sewage processing plants:**	
2634-33-5 1,2-benzisothiazol-3(2H)-one	
EC50 / 16 h	0.4 mg/l (Pseudomonas putida) Noack, BPZ59991

(Contd. on page 7)

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· **Remark:**
Toxic effect on activated sludge organisms depending on concentration possible. The continuous addtion of waste water that contains up to 10 ppm BIT into an adapted biological sewage plant is tolerated by the activated sludge organisms.
· **Additional ecological information:**
· **AOX-indication:**
The product does not contain substances, which can influence the AOX of waste water.
· **According to the formulation contains the following heavy metals and compounds from the EU guideline NO. 2006/11 EC:**
None

· **General notes:**
The product contains materials that are harmful to the environment.
Avoid transfer into the environment.
· **Results of PBT and vPvB assessment**
· **PBT:** This mixture does not contain substances that meet the PBT criteria of REACH, annex XIII.
· **vPvB:** This mixture does not contain substances that meet the vPvB criteria of REACH, annex XIII.

13 Disposal considerations

· **Waste treatment methods**
· **Recommendation:**
Biocide or Pesticide wastes are acutely hazardous. Improper disposal or excess product or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Biocide/Pesticide or Environmental Control Agency, or the Hazardous Waste representative at your nearest EPA Regulation Office for guidance.

· **Uncleaned packagings:**
· **Recommendation:** In accordance with label and federal and local regulations.

14 Transport information

· **US DOT Ground Transport Hazard Class:** 9
· **Identification number:** UN3082
· **Packing group:** III
· **Proper shipping name (technical name):** ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (1,2-benzisothiazol-3(2H)-one)
· **Label** 9

· **Land transport ADR/RID (cross-border):**



· **ADR/RID class:** 9 (M6) Miscellaneous dangerous substances and articles
· **Danger code (Kemler):** 90
· **UN-Number:** 3082
· **Packaging group:** III
· **Special marking:** Symbol (fish and tree)

(Contd. on page 8)

Material Safety Data Sheet

acc. to ISO/DIS 11014

Printing date 02/11/2011 Reviewed on 02/11/2011

Trade name: ACTICIDE BW 20

(Contd. of page 7)

· **UN proper shipping name:** 3082 ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (1,2-benzisothiazol-3(2H)-one)

· **Maritime transport IMDG:**



· **IMDG Class:** 9
· **UN Number:** 3082
· **Label** 9
· **Packaging group:** III
· **EMS Number:** F-A,S-F
· **Marine pollutant:** Yes
Symbol (fish and tree)
· **Propper shipping name:** ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (1,2-benzisothiazol-3(2H)-one)

· **Air transport ICAO-TI and IATA-DGR:**



· **ICAO/IATA Class:** 9
· **UN/ID Number:** 3082
· **Label** 9
· **Special marking:** Symbol (fish and tree)
· **Packaging group:** III
· **Propper shipping name:** ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (1,2-benzisothiazol-3(2H)-one)
· **Remarks:** Packing Instructions / max. net weight: Passenger aircraft: 964 / 450 L; Cargo aircraft: 964 / 450 L

· **UN "Model Regulation":**
UN3082, ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S., 9, III
· **Special precautions for user** Warning: Miscellaneous dangerous substances and articles

· **Transport/Additional information:**
Single packagings and combination packagings containing inner packagings with contents of 5 l or less for liquids, or contents of 5 kg or less for solids need not be marked with the environmentally hazardous substance mark (fish and tree).

*

15 Regulatory information

· **Safety, health and environmental regulations/legislation specific for the substance or mixture**

· **EPA-Registration number:** 67071-23

· **Canada Pest Control Act Registration Number:** 28126
· **SARA**

· **Section 302 (extremely hazardous substances):**
None of the ingredient is listed.

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(Contd. of page 8)

· **Section 313 (Specific toxic chemical listings):**
None of the ingredients is listed.

· **TSCA (Toxic Substances Control Act):**
All ingredients are listed.

· **Canadian Domestic Substances List (DSL):**
All ingredients are listed.

· **Canadian Non Domestic Substance List (NDSL):**
None of the ingredients is listed.

· **WHMIS:** Class: D1

· **Carcinogenic categories**

· **EPA (Environmental Protection Agency)**
None of the ingredients is listed.

· **IARC (International Agency for Research on Cancer)**
None of the ingredients is listed.

· **NTP (National Toxicology Program)**
None of the ingredients is listed.

· **TLV (Threshold Limit Value established by ACGIH)**
None of the ingredients is listed.

· **NIOSH (National Institute for Occupational Safety and Health)**
None of the ingredients is listed.

· **OSHA (Occupational Safety & Health Administration)**
None of the ingredients is listed.

· **GHS label elements**
The product is classified and labelled according to the Globally Harmonized System (GHS).

· **Hazard pictograms**



GHS05 GHS07 GHS09

· **Signal word** Danger

· **Hazard-determining components of labelling:**
1,2-benzisothiazol-3(2H)-one

· **Hazard statements**
Causes skin irritation.
Causes serious eye damage.
May cause an allergic skin reaction.
Very toxic to aquatic life.

· **Precautionary statements**
Avoid release to the environment.
Wear protective gloves/protective clothing/eye protection/face protection.
IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower.
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
If eye irritation persists: Get medical advice/attention.
If skin irritation or rash occurs: Get medical advice/attention.

(Contd. on page 10)

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acc. to ISO/DIS 11014

Printing date 02/11/2011 Reviewed on 02/11/2011

Trade name: ACTICIDE BW 20

(Contd. of page 9)

· **Chemical safety assessment:** A Chemical Safety Assessment has not been carried out.

*

16 Other information

This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.

· **Training hints**
US: Use only in accordance with EPA-approved label. Canada: Use only in accordance with PMRA-approved label.
Further information under the regulations of use can be taken from the Product Data Sheet and label.

· **Contact for technical information:** Biocides: info@ThorSp.com

· **Abbreviations and acronyms:**
ADR: Accord européen sur le transport des marchandises dangereuses par Route (European Agreement concerning the International Carriage of Dangerous Goods by Road)
RID: Règlement international concernant le transport des marchandises dangereuses par chemin de fer (Regulations Concerning the International Transport of Dangerous Goods by Rail)
IMDG: International Maritime Code for Dangerous Goods
IATA: International Air Transport Association
IATA-DGR: Dangerous Goods Regulations by the "International Air Transport Association" (IATA)
ICAO: International Civil Aviation Organization
ICAO-TI: Technical Instructions by the "International Civil Aviation Organization" (ICAO)
ACGIH: American Conference of Governmental Industrial Hygienists
NFPA: National Fire Protection Association (USA)
HMIS: Hazardous Materials Identification System (USA)
LC50: Lethal concentration, 50 percent
LD50: Lethal dose, 50 percent

· *** Data compared to the previous version altered.**

S A F E T Y D A T A S H E E T GHS1209181

1 IDENTIFICATION (PRODUCT AND COMPANY INFORMATION)

PRODUCT NAME : K U R I V E R T E R I K－１１０

USAGE : Slime-control chemical for R.O.menbrane units

COMPANY NAME : KURITA WATER INDUSTRIES LTD.
DEPARTMENT : QUALITY ASSURANCE DEPT.
ADDRESS : 10-1 NAKANO 4-CHOME, NAKANO-KU, TOKYO
164-0001, JAPAN
PHONE : 03-6743-5020
FACSIMILE : 03-3319-2013

EMERGENCY COMMUNICATION :
Phone:

DATE OF ISSUE : September 19 , 2012
DATE OF REPLACED :

---

2 HAZARDOUS IDENTIFICATION

HAZARDOUS INFORMATION : Corrosive substance

GHS CLASSIFICATION

SKIN CORROSION/IRRITATION : Category 1(A ,B,C)
EYE DAMAGE/IRRITATION : Category 1
SPECIFIC TARGET ORGAN TOXICITY(SINGLE EXPOSURE): Category 2

Labeling

Symbol :



Signal Word : Danger

Hazard statements : Causes severe burns and eye damage
Causes serious eye damage
May cause damage to organs

Precautionary statement

Prevention : Do not eat, drink or smoke when using this product.
Do not breathe dusts or mist.
Wear protective gloves.
Wear eye protection/face protection.

Response : IF ON SKIN : Wash plenty of soap and water.
If skin irritation occurs : Get medical advice/attention.
Take off contaminated clothing and wash before use.
IF IN EYES : Rinse cautiously with water for several minutes.
Remove contact lenses, if present and easy to do.

Storage : Store locked up.

Disposal : Dispose of contents/container to follow the regional regulation.

---

3 COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE OR MIXTURE : Mixture

GENERAL NAMES	CHEMICAL COMPOSITION	CONTENT(%)
Sodium hydroxide	NaOH	1 ～ 5
Inorganic acid salt		
Combined chlorine compound		

GENERAL NAMES	MITI No.	CAS No.	MHLW No.
Sodium hydroxide	1-410	1310-73-2	Published
Inorganic acid salt			
Combined chlorine compound			

HAZARDOUS INPURITIES

TOTAL MERCURY: Less than 0.01mg/kgHg CYANOGEN:Less than 0.1mg/kgCN
ARSENIC :Less than 0.1mg/kgAs2O3 TOTAL CHROMIUM:Less than 0.5mg/kgCr
LEAD :Less than 0.05mg/kgPb CADMIUM :Less than 0.01mg/kgCd

4 FIRST-AID MEASURES

A INHALATION

May cause severe irritation. Remove from exposed area immediately to fresh air. Keep warm and at rest. Take care for medical treatment.

B SKIN CONTACT

May cause burns. Wash the affected area with plenty of water Take off immediately contaminated clothing. Wash it with plenty of water. If burns occur, cover affected area securely with sterile, dry, loose- fitting dressing. Get medical attention.

C EYE CONTACT

May cause severe corneal or conjunctival ulceration, possibly resulting in blindness. Wash eyes immediately with large amount of water for more than 15 minutes. Get medical attention immediately.

D INGESTION

May cause severe irritation and injury to the mouth and throat, distention of the esophagus and stomach, and internal bleeding. Give large amount of water or milk immediately. Do not induce vomiting. Get medical attention immediately.

5 FIRE-FIGHTING MEASURES

Keep away from the source of fire or cool containers with water in case of difficult transportation.

6 ACCIDENTAL RELEASE MEASURES

Wear protective clothing. Stop leak. For small powder leaks, flush area with flooding amount of water. For large spills, recover the powder to bags ,and thoroughly rinse affected ground with plenty of water.

7 HANDLING AND STORAGE

Operate with filter respirator, chemical safety goggles, working clothes with long sleeve and rubber globes to avoid inhalation, eye and skin contact. Do not use empty containers for drinking water supply, etc.

Store product in tightly closed containers in the cool, dry and well-ventilated indoor
Area. Store separating from acids, bases, oxidizers, reducers and flammables.

8 EXPOSURE CONTROLS/PERASONAL PROTECTION

OCCUPATIONAL EXPOSURE LIMIT : Sodium hydroxide
Japan Society for Occupational health(2005) 2 mg/m3
ACGIH(2005) TLV-STEL 2 mg/m3

PROTECTING EQUIPMENTS :Filter respirator, chemical safety goggles, working clothes with long sleeve and synthetic rubber globes.

9 PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE : Slightly yellowish to Brownish liquid
pH : More than 13.0 (20℃)
SPECIFIC GRAVITY : 1.20 ～ 1.40 (20℃)
WATER SOLUBILITY : Miscible at any ratio
FLASH POINT : None
FREEZING POINT : Less than -16℃
COD_{Mn} : 1.4 %
Total nitrogen : 2.6 % Total phosphorus : 0 %

10 STABILITY AND REACTIVITY

STABILITY : Stable on normal usage and handling.

11 TOXICOLOGICAL INFORMATION

ACUTE TOXICITY : Oral rat LD50 : More than 2000 mg/kg
NOEL 100 mg/kg
SKIN CORROSION/IRRITATION : Strong irritation when product contact skin.
EYE CORROSION/IRRITATION : May cause severe corneal or conjunctival ulceration, possibly resulting blindness.

MUTAGENECITY : Ames test : Negative

12 ECOLOGICAL INFORMATION

FISH TOXICITY : ＬＣ50 : Killifish （24hrs） : More than 320 mg / l

13 DISPOSAL CONDITIONS

PRODUCT : Never draw chemical directly to waste water line.
Request treatment to licensed industrial waste-treatment company as " Special controlled industrial waste (Waste Alkaline)".

PACKAGE : Empty used containers completely, dispose containers.

14 TRANSPORT INFORMATION

UN Class : 8 UN No. 3266

Prevent destruction by keeping away from water and careless dealing.

15 REGULATORY INFORMATION

The poisonous and deleterious substances control Act : Not Applicable
Act on the Prohibition of Chemical Weapons and the Regulation of Specific Chemicals : Not Applicable
Export trade control order : Not Applicable
Industrial safety and health Act : Applicable
Sodium hydroxide
:Article 57-2 Substance which MSDS should be informed.
:Reg. 326 Corrosive liquid
Fire and disaster management act : Not Applicable
Ship safety act : Applicable
Sodium hydroxide : Corrosive substance
Civil aeronautic act : Applicable
Sodium hydroxide : Corrosive substance
Act on port regulation : Applicable
Sodium hydroxide : Corrosive substance
PRTR law[1] : Not Applicable

[1] Act on Confirmation, etc. of Release Amounts of Specific Chemical Substances in the Environment and Promotion of Improvements to the Management Thereof

*According to the law regulated in Japan

16 OTHER INFORMATION

*The information herein may be revised by the newest knowledge.

*The information herein be only translated from MSDS written in Japanese language and nothing should be assured.

E.O.D.

Appendix 6

Survey plan

Gleeson Surveying

Registered Surveyors

1 Bowen Street, P.O. Box 1,
Narrabri N.S.W. 2390.
Phone: 02-67922720 Facs.: 02-67923660
E-mail: gleesurv@bigpond.net.au

"LEEWOOD"

LOT 1 DP771141

Client: SANTOS LIMITED

File Name:	Sheets:	Ref. No.:
8419□DET.dwg	1 OF 2	8419

Drawing Description:

DETAIL SURVEY

Issue	Date	Revision Type	Dr. By	Ch. By
A	02-08-12	Org□□□e	L.B.	R.G.

Datum: AHD

Orientation: MGA

Registered Surveyor

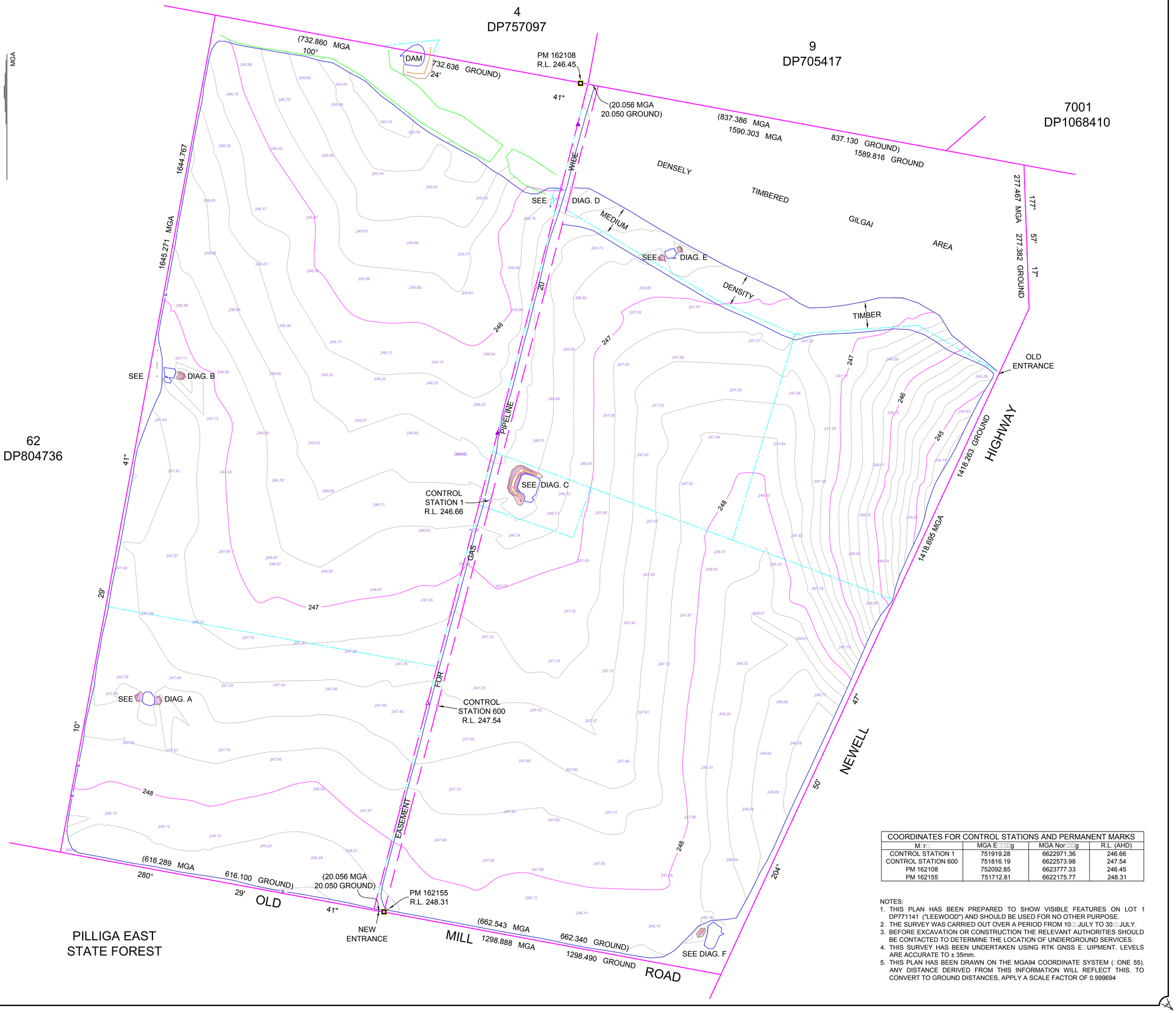
Ross Gleeson

Date : .....

Scale: 1 : 3,500 @ A1

Legend:

- BOUNDARY
- EASEMENT, PEG
- FENCE, POST
- TREE LINE
- EDGE OF DAM
- TOP OF BATTER
- BOTTOM OF BATTER
- CENTRELINE OF TRACK
- 247 CONTOUR MAJOR (1□)
- CONTOUR MINOR (0.2□)
- 246.87 NATURAL SURFACE LEVEL
- ▲ SANTOS GAS PIPELINE SIGN



COORDINATES FOR CONTROL STATIONS AND PERMANENT MARKS			
M□r□	MGA E□□□g	MGA Nor□□□g	R.L. (AHD)
CONTROL STATION 1	751919.28	6622971.36	246.66
CONTROL STATION 600	751816.19	6622573.98	247.54
PM 162108	752092.85	6623777.33	246.45
PM 162155	751712.81	6622175.77	248.31

NOTES:

1. THIS PLAN HAS BEEN PREPARED TO SHOW VISIBLE FEATURES ON LOT 1 DP771141 ("LEEWOOD") AND SHOULD BE USED FOR NO OTHER PURPOSE.
2. THE SURVEY WAS CARRIED OUT OVER A PERIOD FROM 10□□ JULY TO 30□□ JULY.
3. BEFORE EXCAVATION OR CONSTRUCTION THE RELEVANT AUTHORITIES SHOULD BE CONTACTED TO DETERMINE THE LOCATION OF UNDERGROUND SERVICES.
4. THIS SURVEY HAS BEEN UNDERTAKEN USING RTK GNSS E□UIPMENT. LEVELS ARE ACCURATE TO ± 35mm.
5. THIS PLAN HAS BEEN DRAWN ON THE MGA94 COORDINATE SYSTEM (□ONE 55). ANY DISTANCE DERIVED FROM THIS INFORMATION WILL REFLECT THIS. TO CONVERT TO GROUND DISTANCES, APPLY A SCALE FACTOR OF 0.999694

Appendix 7

Agricultural Impact Statement

Leewood Produced Water Treatment and Beneficial Reuse Project

Agricultural Impact Statement

Prepared by:

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Report Number: PR121521-1
Version / Date: January 2015 / Rev 2

Prepared for:

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Document Status

Version	Purpose of Document	Orig	Review	Review Date
A	Draft report for internal review	BH/JC	DF	18/03/2014
B	Draft for external review		KB/JC	04/04/2014
0	Final for release		CH/JC	30/06/2014
1	Final for external review		KB/JC	08/07/2014
2	Final for release	SD	JH	22/01/2015
3	Final w/ update of activity description ONLY	KMD	JH	12/03/2015

Approval for Issue

Signature	Date
	12/03/2015

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Summary

An agricultural impact statement (AIS) has been prepared for the proposed Leewood Produced Water and Beneficial Reuse Project. 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 short-term activities are considered to have low to medium risk on agricultural resources and industries. The proposed irrigation regime will in fact increase the net productivity of the area from the current low productivity pasture. In short, improvements in soil properties associated with gypsum and lime application and management of an irrigated perennial pasture such as lucerne improves productivity, albeit from a low base. 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 will not impact on any mapped 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; and
- Processing facilities.

The proposed works will result in minor increases in traffic along the Newell Highway and Old Mill 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 negligible disruption to agricultural rail networks as the proposed works are not located in the vicinity of any such infrastructure.

1.0 Introduction

The Strategic Regional Land Use Plan New England North West (SRLUP) from the Department of Planning and Infrastructure (DP&I, 2012a) identifies more than two million hectares of strategic agricultural land and valuable water resources and aims to provide greater certainty for companies wanting to invest in mining and coal seam gas (CSG) projects in regional NSW.

As a result of this NSW overarching Strategic Regional Land Use Policy, an Agricultural Impact Statement (AIS) is required for exploration activities subject to further approval under the *Mining Act 1992* or *Petroleum (Onshore) Act 1991* and submission of a Review of Environmental Factors (REF) assessment under Part 5 of the *Environmental Planning and Assessment Act 1979*. The AIS is to form part of the REF for assessment.

Santos NSW (Eastern) Pty Limited (Santos) (or its assigned contractor), for and on behalf of the titleholders of Petroleum Assessment Lease (PAL) 2, proposes to construct and operate a Water and Brine Treatment Plant (WBTP) and associated infrastructure, including a managed irrigation system, at a property known as "Leewood" within PAL 2 (the proposed activity).

The proposed activity is designed to treat produced water stored at Leewood from Santos' CSG exploration and appraisal activities, and beneficially reuse the treated water for irrigation, dust suppression, construction and drilling uses, and emergency firefighting purposes.

The primary purpose of the proposed activity is to enable Santos to continue its CSG exploration and appraisal activities within PAL 2 and PEL 238. The WBTP will initially be temporary in nature and will operate for up to five years. The further development of the CSG field will necessitate a larger water treatment facility. This will be subject to further assessment and regulatory approvals as part of the Narrabri gas development project. A request for Director-General's environmental assessment requirements for the Narrabri gas development project was submitted to NSW Planning and Infrastructure (now referred to as NSW Planning and Environment) on 31 March 2014.

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 REF (RPS 2015) and should be read in conjunction with the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015) and the Leewood – Concept Irrigation Design (BeneTerra 2014).

2.0 Existing Environment

2.1 Location

This AIS relates to the land formally described as Lot 1 on DP771141, referred to as "Leewood", located approximately 24 kilometres south-east of the Narrabri township, New South Wales ("the site"). The site is situated in the northern extent of (PAL) 2 which lies within the larger Petroleum Exploration Lease (PEL) 238 (**Figure 2.1**). PAL 2 covers an area of approximately 265 square kilometres and is contained within the Narrabri Shire Local Government Area (LGA).

2.2 Site Description

The site is bounded by the Pilliga East State Forest to the south and the Newell Highway to the east. The properties located to the north and west of the site contain paddocks with both cleared areas and vegetation. An unsealed road (Old Mill Road) provides access from the Newell Highway and runs along the southern boundary of the site. An existing gas flow line traverses the study site on a north-south alignment, connecting gas compression facilities at Bibblewindi to the Wilga Park Power Station. The site has been previously cleared for cattle grazing and currently comprises grassy paddocks with minimal scattered tree cover. A stand of dense vegetation is located in the far north-eastern corner. There is no intent to disturb this vegetation.

2.3 Vegetation

The property is primarily covered with low quality pasture grasses and scattered remnant trees. The dominant tree species is *Eucalyptus pilligaensis* (Pilliga box), with occasional *E. crebra* (narrow leaved ironbark). Approximately 200 medium to large woodland trees occur within the proposed irrigation area of approximately 97.8 ha.

A total of six weed species were identified on-site, two of which are declared noxious species (Tiger Pear and Prickly Pear). Under the provisions of the *Noxious Weeds Act 1993*, these species are classified as Class 4 weeds.

2.4 Proposed Activities

2.4.1 Construction and Operational Phases

Santos NSW (Eastern) Pty Limited is the proponent for the proposed activity on behalf of the titleholders of PAL 2. The proposed activity will include:

- construction and operation of:
  - a water treatment plant, including pre-treatment and reverse osmosis plant
  - a brine treatment plant
  - a brine distribution manifold and associated piping at Leewood, to allow water distribution into the water treatment plant and associated return flows to brine storage ponds
  - a treated water storage tank (five megalitre capacity)
  - a managed irrigation system including a centre pivot and sub-surface drip irrigation system
  - other associated infrastructure, including a gas pipeline to fuel the generators
  - a small potable water treatment system for water extracted from the licensed bore

- the construction of (and the ability to operate) a treated water pipeline extending to the Leewood property boundary to transfer water to another location for irrigation by a third party (if required)
- re-use of treated water for irrigation at the Leewood property and other uses both on and off site including dust suppression, drilling and construction and firefighting . Santos is investigating the option of providing treated water to third parties for agricultural irrigation, although this potential use of treated water does not form part of the proposed activity for the purposes of this REF and will be subject to separate assessment and approvals.
- amelioration of soils within irrigation area by deep tillage, fertiliser, lime and gypsum in preparation for irrigation.
- decommissioning and rehabilitation of the site, if the Narrabri Gas Project does not proceed.

Santos (or its assigned operator) will operate the proposed activity for up to five years. The WBTP will treat up to 1.5 megalitres per day of produced water from Santos' CSG exploration and appraisal activities within PEL 238, PAL 2 and PPL 3. The operational process is expected to involve, but is not limited to:

- pumping of produced water from the produced water pond to the water treatment plant
- treatment of produced water within the water treatment plant, including removal of solids by filter (pre-treatment), reverse osmosis to separate the water and brine streams (treatment), and chemical and pH dosing (post-treatment) to make the treated water appropriate for irrigation
- transfer of treated water to the treated water storage tank or directly to the on-site managed irrigation system for beneficial re-use
- beneficial re-use of treated water for irrigation, or other uses both on and off-site such as dust suppression, drilling and construction and firefighting
- transfer of brine to the brine treatment plant for concentration and further recovery of treated water
- storage of brine in the existing Leewood ponds.

An overview of the operational phase of the proposed activity is outlined in Figure 2.2. A detailed description of the construction and operation phases of the proposed activity is provided in Section 2.0 of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015), while the irrigation design is discussed in full in Section 7.0 of the Leewood - Conceptual Irrigation Design (BeneTerra 2014).

The total area of potential disturbance from the proposed activity is approximately 99.6 hectares. This includes the:

- irrigation area – 97.8 hectares
- WBTP, treated water storage tank and associated infrastructure – 1.8 hectares.

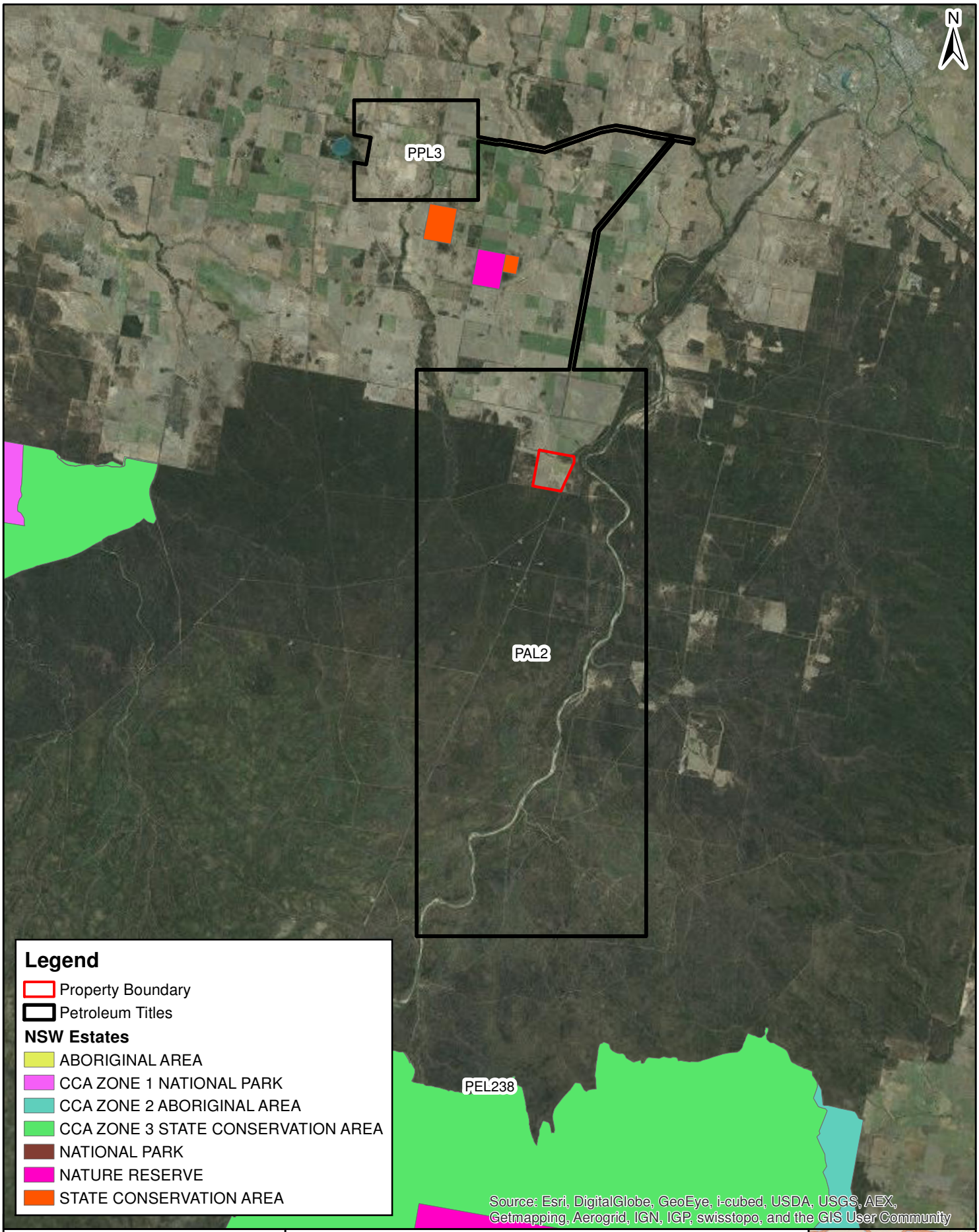
While the disturbance footprint for the proposed activity is 99.6 hectares a total of 143 hectares will be quarantined for the proposed project and approved water and brine storage ponds.

2.4.2 Decommissioning and Rehabilitation

Once construction of the proposed activity is completed, disturbed areas of the site will be stabilised in accordance with *Managing Urban Stormwater: Soils and Construction - Volume 1* (the Blue Book).

The proposed activity will operate for up to five years to support Santos' exploration and appraisal activities. Any operation beyond this would be subject to further environmental assessment and approval. Should this not occur, the proposed activity would be decommissioned and the site rehabilitated in accordance with the conditions of PAL 2.

Decommissioning and rehabilitation of the produced water and brine ponds currently under construction was considered under the Leewood – Produced Water and Brine Management Ponds REF (RPS, 2012). These ponds would likely be rehabilitated at the same time as the proposed activity. The decommissioning of this Project and rehabilitation of the site are detailed in **Section 2.0** of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015).



Client:	Santos
Compiled by:	SD
Date:	04/07/2014
Approved by:	JC
Date:	04/07/2014

0 2.25 4.5 9 km

Datum: GDA94
Scalre 1:225,000 @ A4

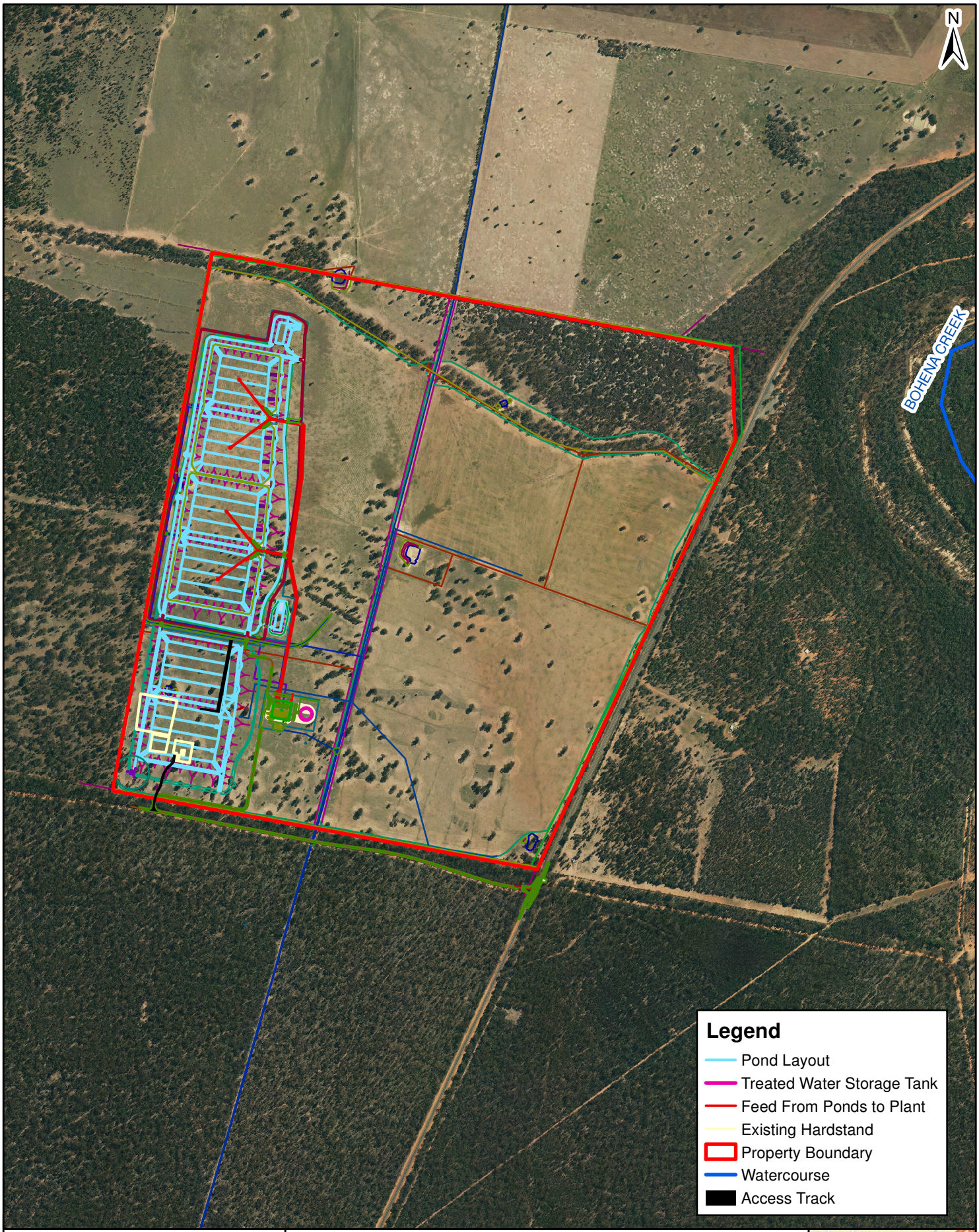
RPS

NSW Estates and Petroleum Titles

Figure 2.1

Project: Leewood Produced Water Treatment and Beneficial Reuse Project

Source: Imagery from Santos 2012
Infrastructure from Santos 2013
Other data supplied from OEH 2012



Client: Santos

Compiled by: SD | Date: 22/01/2015

Approved by: JH | Date: 22/01/2015

0 0.15 0.3 0.6 km

Datum: GDA94
Scalre 1:15,000 @ A4

RPS

Site Layout

Figure 2.2

Project: Leewood Produced Water Treatment and Beneficial Reuse Project

Source: Imagery from Santos 2012
Infrastructure from Santos 2013
Other data supplied from OEH 2012

3.0 Project Design Review / Alternatives

The justification for the proposed activity and analysis of alternatives are discussed in **Sections 2.5** and **2.6** of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015), respectively.

4.0 Agricultural Enterprise and Resources

The site was previously used for low intensity grazing. There is no specific agricultural production statistics for the site, therefore the following section identifies the agricultural enterprises and production value that exist within the surrounding Narrabri Shire LGA.

4.1 Agricultural Enterprise

In the Northern Plains of NSW, grain and cotton are the most significant crops, while beef and sheep grazing are also important agricultural enterprises. 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 hectares 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 4.1** and **Figure 4.1**). 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. Timber harvesting / forestry within the Pilliga Scrub has been reduced largely due to conservation efforts; therefore such forestry enterprises are not considered significant in the Narrabri LGA.

Table 4.1: Land use statistics for the Namoi catchment (source: NSW Department of Environment and Climate Change, 2011)

Land Use	Extent (ha)	Proportion of Catchment (%)
Wetland	2,153	<0.1
River/drainage	61,100	1
Transport/corridor	27,032	1
Urban	35,726	1
Cropping	848,769	20
Irrigation (cotton, fodder crop, pastures)	80,188	2
Grazing	2,132,230	51
Horticulture	1,217	<0.1
Intensive Animal Production	1,422	<0.1
Conservation Area	628,999	15
Tree and Shrub Cover	369,950	9
Mining/Quarrying	1,923	<0.1
Power Generation	99	<0.1
Farm Infrastructure	2,917	<0.1
Native Landscapes (cliffs / rock outcrop, crown reserve)	4,637	0.1

There are approximately 3,195 registered beekeepers in the state of NSW. Amateur beekeepers account for 77% of registrations in NSW. The 148 beekeepers that own over 500 hives may be termed professional beekeepers and constitute 4.6% of total apiary registrations in NSW (RIRDC, 2007). Current estimates within

the Narrabri and Gunnedah LGAs indicate that a total of 7 people are employed as beekeepers (ABS, 2010). The Pilliga East State Forest provides areas for beekeepers to carry out apiary activities. No artificial nesting hives were identified at defined Santos project sites in the Pilliga Scrub.

4.1.1 Agricultural Production Value

Agriculture and agribusiness is worth $1.8 billion per annum to the New England - North West regional economy (Australian Bureau of Statistics (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).

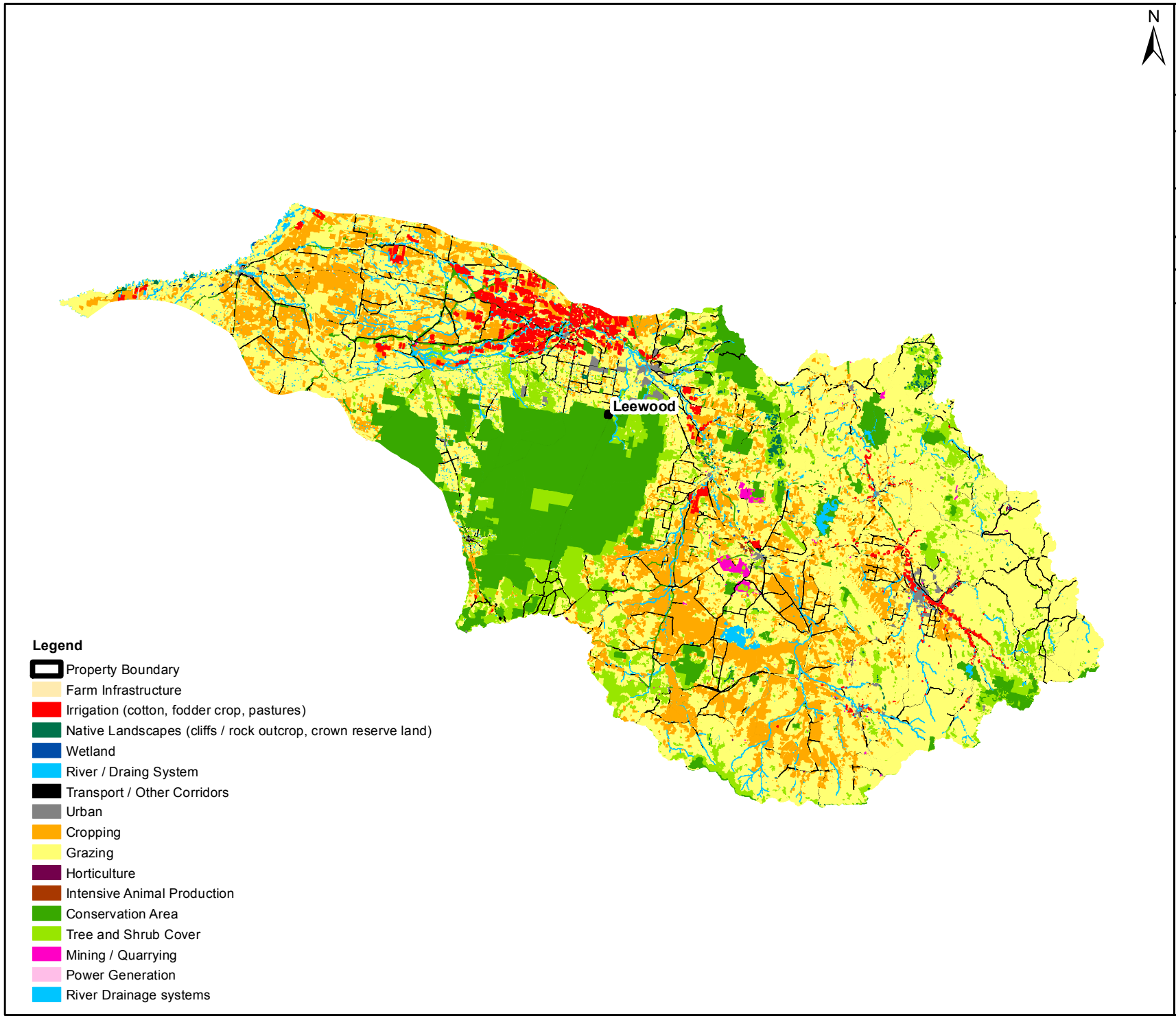
In 2009 / 2010 the Narrabri Shire recorded a Gross Regional Product (GRP) of $730 million, with agriculture, forestry and fishing contributing $115.3 million (15.8%) of total GRP (AEC, 2011). This sector is the second largest contributor to GRP in Narrabri Shire, behind the mining sector.

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.

4.1.2 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 4.2**). The data demonstrates that the largest agricultural enterprises in the region are cotton and grain industries, which employ approximately 47% of the agricultural workforce.



Namoi Catchment Land Use

Figure 4.1

Project:
Leewood Produced Water Treatment and Beneficial Reuse Project

Client:
Santos

Compiled by:	SD	Date:	04/07/2014
Approved by:	JC	Date:	04/07/2014

Source: Imagery from Bing Maps 2012
Infrastructure from Santos 2013
other data from OEH2012 and DECC 2011

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Datum: GDA94

RPS



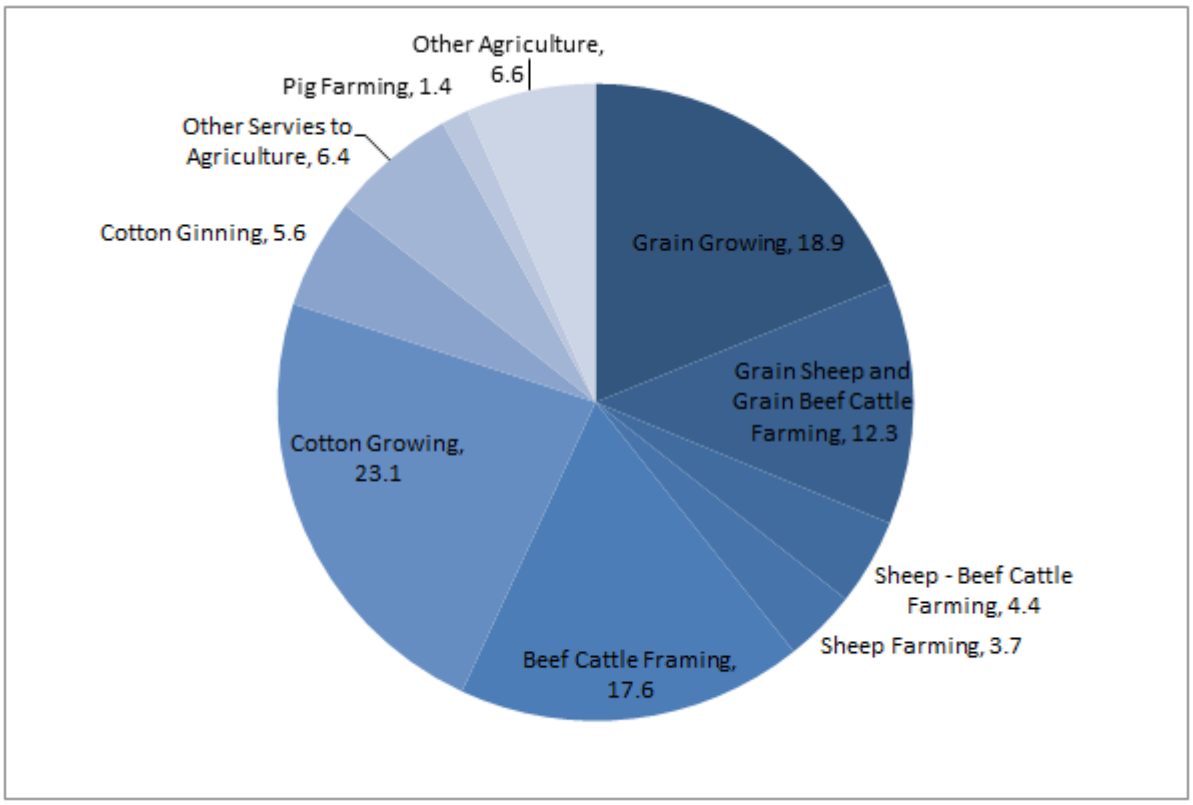


Figure 4.2: Agricultural Employment by Place of Work (Reproduced from AEC, 2011)

4.2 Agricultural Support Information

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 (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 Cargill Oilseeds plant in Narrabri processes approximately 250,000 tonnes of cottonseed each year. The Canzac Pulse Processors plant in Narrabri produces high quality pulse seeds for export. Other processing plants in the LGA include seed grading, mixing and packaging operations.

Research establishments are located in the Narrabri district; the I.A Watson Grains Research Centre (operated by the University of Sydney); and the Australian Cotton Research Institute (ACRI). The Cotton Research and Development Corporation is also located in Narrabri, which is funded by the Federal Government and industry to select and fund suitable research projects.

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). Existing traffic volumes along the Newell Highway are typically in the order of 1,860 vehicles per day with a 40% proportion

of heavy vehicles (GTA 2013). NSW Rail services part of north-western New South Wales. Opened in 1908, a line 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 adjacent to the site or within the immediate surrounds. The nearest railway line is located approximately 20 kilometres to the north-east of the site. The Newell Highway Narrabri-Coonabarabran travelling stock route is located adjacent along the north-east corner of the Leewood property.

4.3 Tourism

Tourism in the Narrabri shire is led by its natural attractions. The Pilliga 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. This impact assessment has not identified any tourism opportunities within the site or surrounding areas on which agricultural enterprises are reliant.

4.4 Agricultural Resources

4.4.1 Climate

The closest operational weather station is located north east of the site at Narrabri West (Station 53030). Climate in this area is regarded as semi-arid, due to hot summers and mild winters with evaporation potential exceeding rainfall in all months. Average (1900 - 2014) monthly maximum temperatures range from 18°C (July) to 34.4°C (Jan) (**Table 4.2**). Maximum daily temperatures often exceeded 40°C in summer months. Frost can occur in all low lying parts of the region between June and August though can begin as early as May.

Average annual rainfall at Narrabri West is 650 mm. Pan evaporation exceeds rainfall throughout the year (**Figure 4.3**), indicating the regions reliance on irrigation and soil water storage during fallows.

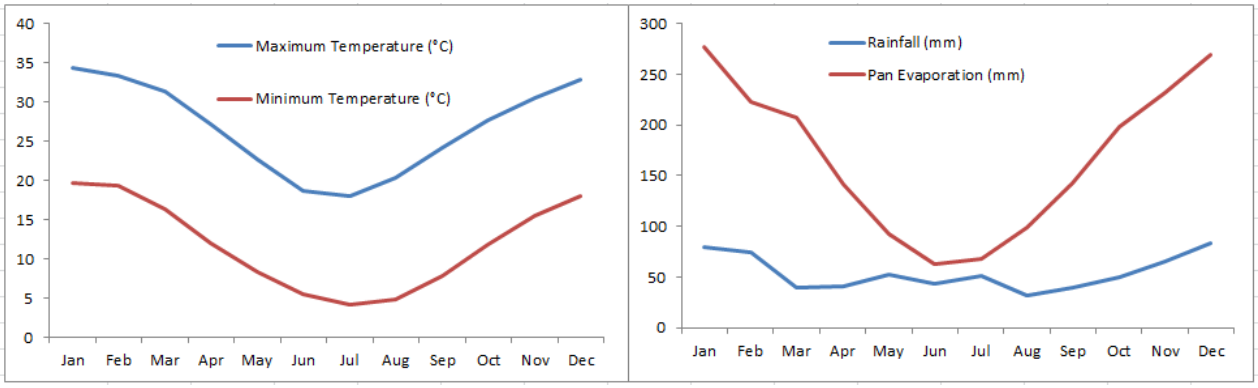


Figure 4.3: Mean maximum and minimum monthly temperatures (°C), rainfall (mm) and pan evaporation (mm) at Narrabri West (station no: 53030) (1900 to January 2014) (Australian climate www.australianclimate.net.au)

Table 4.2: Climate statistics Narrabri West for years 1900 to 2014, weather station 53030 (SILO 2014)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum Temperature (°C)	34.4	33.4	31.4	27.2	22.7	18.7	18	20.3	24.2	27.7	30.5	32.9
Minimum Temperature (°C)	19.7	19.4	16.3	12	8.3	5.5	4.2	4.8	7.9	11.9	15.6	18
Rainfall (mm)	79.7	74.1	39	40.2	52.2	42.7	51.4	32	39.8	49.8	65.5	82.9
Pan Evaporation (mm)	277	223	207	141	91.9	63.2	67.9	99.4	143	198	232	270

4.4.2 Surface Geology

Detailed surface geology mapping indicates that the study site is underlain by two geological formations (Qrhs3 and Qfps2) .The lithological descriptions are provided in **Table 4.3**.

Table 4.3 : Geological Formations (source: Geosciences Australia 2011)

Formation Name	Map Symbol	Age	Dominant Lithology	Lithological Description
Unnamed	Qrhs3	Cainozoic–Quaternary	Alluvium	Clayey alluvium often gilgaied
Unnamed	Qfps2	Cainozoic–Quaternary	Sand	Texture contrast soils with sand Predominating at the surface

4.4.3 Topography

The site is located on a very gently undulating plain at approximately 250 m AHD elevation. A prominent feature of the property is a broad drainage area that can be intermittently inundated during above average rainfall periods. The site generally slopes towards a drainage feature which grades downwards through the site from its south east corner in a north westerly direction. A small portion of the site drains to the north east into the Bohena Creek.

The median slope of the proposed irrigation area is 0.4%, while the minimum and maximum slopes are 0.2% and 1.2%, respectively. All slopes on the site adhere to the landform requirements for effluent irrigation systems (DECCW 2010). A stock dam is located centrally on the property within the predominant drainage line.

Native vegetation is located sporadically and sparsely across the site. The dominant native tree species is Pilliga Box (*Eucalyptus pilligaensis*). The presence of Pilliga box typically indicates soil characteristics as being texture contrast, low permeability soils with seasonal waterlogging.

4.4.4 Soils

4.4.4.1 Desktop Assessment

Namoi Catchment Management Authority (NCMA 2009) Mapping

RPS (2013) undertook a review of the NCMA report (2009) to identify soil boundaries and key soil limitations, which could impede site establishment and rehabilitation of the approved water and brine storage ponds. It was concluded that the site is located in the Flat Pilliga Outwash Land Management Unit (LMU) which is dominated by deep Sodosols (sodic soils) with sandy to loamy Tenosols (shallow sandy soils) (Namoi CMA, 2009a).

The Namoi CMA fact sheet for this LMU points out several factors to consider when using these soils, including:

- Soils tend to be relatively shallow and have low fertility;

- Soils tend to have poor soil structure and low water holding capacity;
- Much of this area is prone to erosion and severe scalding;
- Soils can set hard and can be prone to wind erosion;
- Soils are highly erodible and are easily degraded if overused;
- Runoff can be high when soils are degraded;
- Effective ground cover can be hard to maintain; and
- Salinity is found within this LMU.

4.4.4.2 Field Assessment

Golder Associates

Soil profile data for the subject site was compiled by Golder Associates (2012) as part of geotechnical investigations at the site. Borehole logs indicated that soils were deep textured contrast soils (Sodosols). Soil profile at the site typically include a light textured A horizon to 0.5 m depth over a heavier textured silty clay B horizon typically to 1.8 to 2.0m.

Soil chemistry data indicated that topsoil at the subject site is strongly (pH 5.4) to slightly acidic (pH 6.2). The optimum range for plant establishment is pH 6 to pH 7, however most crops or pasture/forage will tolerate a range between pH 5.5 to pH 7.0 (Hazelton and Murphy, 2009).

BeneTerra

BeneTerra (2013; 2014) undertook a soil investigation of the property to determine the prospects for irrigation of various soil units. A total of 34 soil pits were excavated to a depth of 1.5 m and were described in terms of:

- Soil horizon depths;
- Soil structure (macropores, cracks and aggregates);
- Plant rooting depth;
- Soil texture;
- Soil colour;
- Consistency Observations;
- Field pH and presence of carbonates; and
- Laboratory chemical analyses (pH, elements of soil salinity, base saturation, fertility and metals).

As per the NCMA (2009), BeneTerra (2014) identified that the site largely consisted of “Magnesic Mesonatric Grey or Brown Sodosols; medium, non-gravelly, clay loamy/clayed, deep”, while the north-west region of the property was identified as a “Mottled, Mesotrophic Brown or Red Chromosol; medium or thick, non-gravelly, loamy/clay loam, deep.” Within these two ASCs five different soil management units (SMU) were defined by BeneTerra (2014) (**Figure 4.4**). The BeneTerra SMUs are described in **Table 4.5**.

Table 4.4: Identified SMUs and associated descriptions (BeneTerra 2013) of the site.

SMU	Description
1	Red Chromosols - A friable brown loam over a friable red clay loam. Well drained, and chemically and physically amenable to root growth. Approximate 1 ha in area.
2	Brown Chromosol – A friable brown loam over a hard brown clay loam. Well drained, and chemically and physically amenable to root growth. Approximately 4 ha in area.

SMU	Description
3	Transitional Brown Sodosol – This unit is very similar to the Brown Sodosol unit for most of its properties (see description below). The soils of this unit were shallower than the other Sodosol units, with a sandstone parent material encountered at around 120 cm. The soils of this unit also exhibited a very slightly brighter surface colour than the other Sodosol units. Additionally, boundaries derived from the EM38 scan and the surface topography appear to correlate with this unit. Approximately 6 ha in area.
4	Brown Sodosols - A hardsetting brown clay loam over a very hard columnar reddish brown clay. Well drained in the 20 cm or so of loam at the surface, changing sharply to much lower porosity clay upon which water perches for extended periods following heavy rainfall (several days to a week). Root growth extends to the full depth excavated, but is restricted by the coarse soil structure and moderate salinity of the subsoil, particularly below 1 m. Approximately 58 hectares.
5	Grey/Brown Sodosol - Similar to Brown Sodosol unit, but with the following distinctions. Often a thicker surface soil, possibly built up from erosion off the up-slope soils, usually with a distinctly bleached subsurface horizon above the coarsely structured subsoil. The subsoil is grey or grey brown, indicating poorer drainage than the other soil units. However, it appears this is due just to landscape induced inundation i.e. due to drainage line flooding, rather than to lower internal permeability of the soil. Root development and clay structure are similar to the other Sodosols, indicating that the landscape effect is more important than differences in soil morphology. These cover approximately 31 ha in area.

For the purposes of this irrigation design, the soils on this site were grouped into two irrigation management classes – A and B. These were differentiated primarily due to their landscape position and include:

- Class A soils - Chromosols and Brown Sodosols – more upland soils; and
- Class B soils – Grey/Brown Sodosols – lower lying soils.

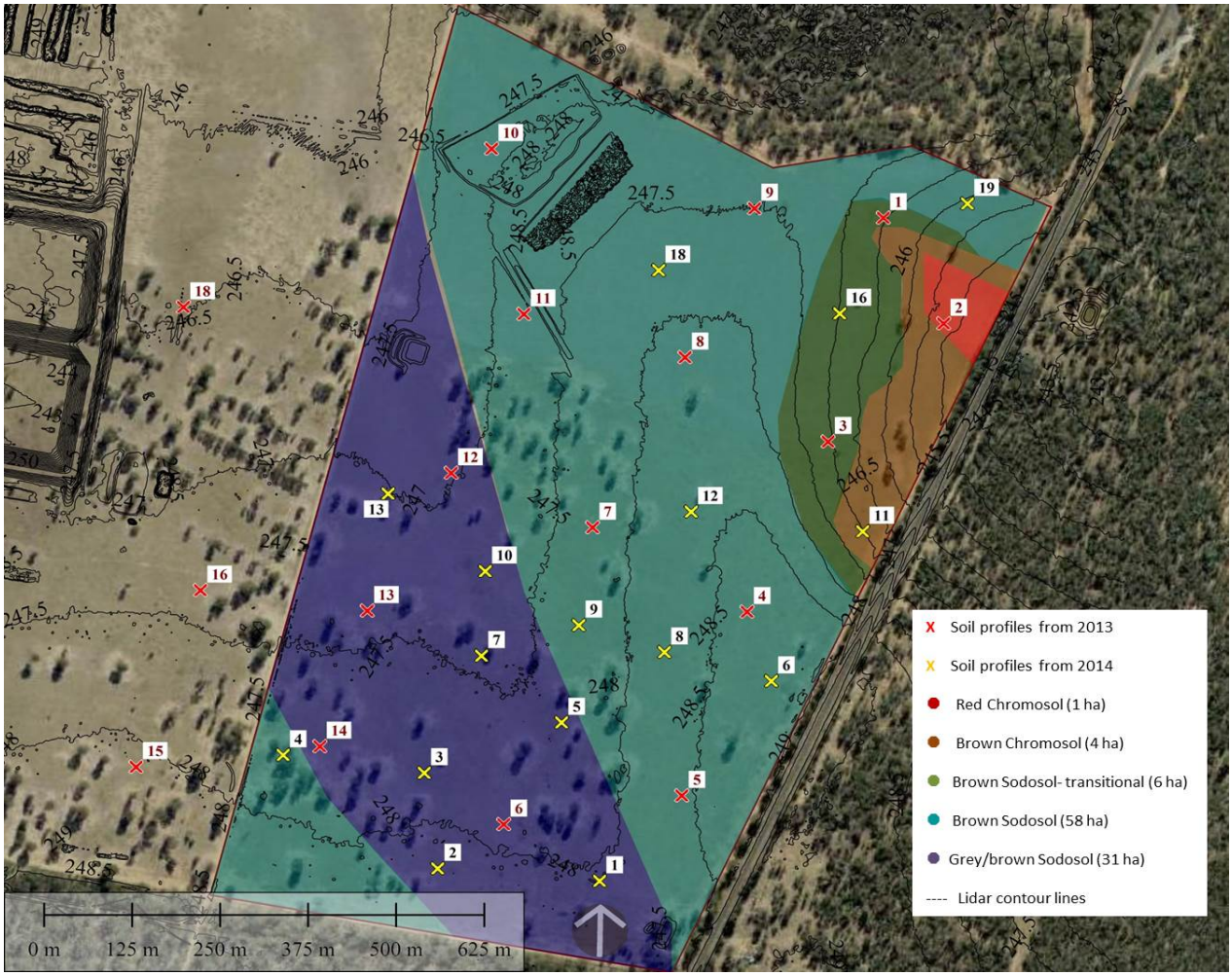


Figure 4.4: Soil profile locations and types as Identified by BeneTerra (2014).

4.4.4.3 Soil Limitations

BeneTerra (2014) identified the following soil limitations for the site:

- Surface acidity;
- Dispersive soils as a result of sodicity;
- Low saturated hydraulic conductivity and/or impeded drainage of the subsoil; and
- Soil compaction.

Application of lime, gypsum and organic material will improve soil permeability, reduce runoff and compaction and in turn increase productivity of selected species for irrigation. Deep ripping will also improve drainage at the site. A summary of current limitation ratings and potential limitation ratings post amendment are defined in **Table 4.5**. In general, identified limitations change from severe to moderate and/or negligible after soil amendment.

Further information regarding identified soils and associated limitations can be found in **Sections 5.3**, **5.4** and **Appendix A** of the Leewood - Conceptual Irrigation Design (BeneTerra 2014).

Table 4.5: Range of soil qualities from all described units found at Leewood site and expected effect of amendment (shaded) in reference to Table 2.2 NSW effluent guide (BeneTerra 2014).

Parameter	Minimum	Maximum	Mean	Limitation rating
ESP (0-40 cm)	10	25	18	severe
ESP (0-40 cm) - amended	**3**	**10**	**8**	**moderate**
ESP (40-100 cm)	20	35	28	severe
ESP (40-100 cm) - amended			**na**	**na**
ECe (0-70 cm) dS/m	0.5	1.0	0.8	nil
ECe (70-100 cm) dS/m	3.5	5.5	4.8	slight /moderate
Water table depth	>5 m		na	nil
Depth to C horizon	>1.5 m		na	nil
SHC top 1m (mm/hr)	1	20	na	severe
SHC top 1m (mm/hr) - amended	**5**	**30**	**na**	**moderate**
PAWC (mm/m)	110	110	110	nil
pH surface	5.2	5.9	5.5	moderate
pH surface - amended	**7.0**	**7.0**	**7.0**	**nil**
CEC (0-40)	10	16	12	moderate
Dispersion	1	1	1	severe
Dispersion - amended	**4**	**4**	**4**	**nil**
P buffer	high	high	high	nil

To characterise the contamination potential, the highest reported value for each metal measured by BeneTerra (2014) was assessed against the Health Based Investigation Levels for residential with garden / accessible soil (NEPC 1999) and Ecological Investigation Levels for National Parks and areas with a high

conservation area (NEPC 1999). While the land use selected does not appropriately describe Leewood, the investigation levels were still applied as they are the most conservative outlined by the NEPC (1999).

As no ambient background concentrations were obtained from reference locations as part of the original works undertaken by BeneTerra (2014), no site specific EILs were able to be calculated. However, generic EIL limits for chromium and lead were obtained using the most conservative reported values for cation exchange capacity, pH and organic carbon content (%). EIL limits for chromium and lead were calculated using the EIL Calculation Spreadsheet (NEPC 1999).

There were no detectable concentrations of arsenic, boron, cadmium, selenium and mercury reported for any analysed sample. All metals were below HIL A and EILs. **Appendix A** of the Leewood - Concept Irrigation Design (BeneTerra 2014) details metal concentrations for selected sites at various depths

4.4.5 Land Designations and Capability

4.4.5.1 BSAL and CIC

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: CICs 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 (DP&I, 2012a).

According to the Strategic Agricultural Land mapping (DP&I, 2012a), the site and surrounds are not located on BSAL of the New England - North West region. The nearest BSAL is located approximately 25 kilometres east of the site as shown in **Figure 4.5**. No CICs have been identified in the New England North West Region (DP&I, 2012a).

4.4.5.2 Land and Soil Capability

In NSW, land and soil capability classes (LSC Classes) have been mapped for the New England - North West region (OEH, 2012c). The mapping is based on an eight class system with values ranging between 1 and 8 which represent a decreasing capability of the land to sustain land use. 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 3 and 5 (**Figure 4.6**). Lands in LSC Class 3 are described as having moderate limitations and are capable of sustaining high impact land uses using more intensive, readily available and accepted management practices. 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.



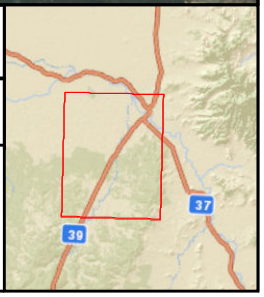
Client: Santos	**Strategic Agricultural Land**
Compiled by: SD — Date: 04/07/2014	
Approved by: JC — Date: 04/07/2014	**Figure 4.5** — Project: Leewood Produced Water Treatment and Beneficial Reuse Project

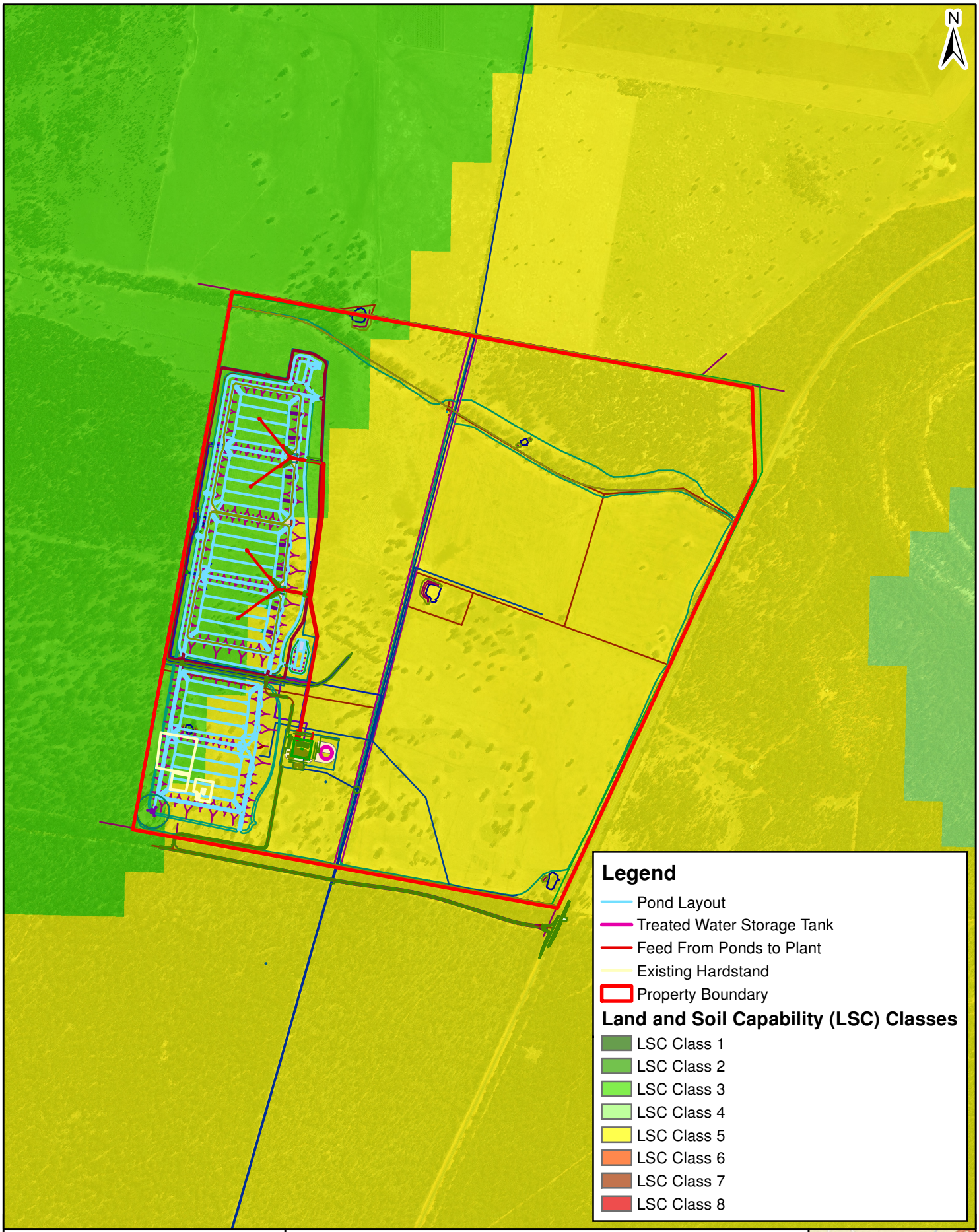
0 2 4 8 km

RPS

Datum: GDA94
Scalre 1:15,000 @ A4

Source: Imagery from Santos 2012
Infrastructure from Santos 2013
Other data supplied from OEH 2012





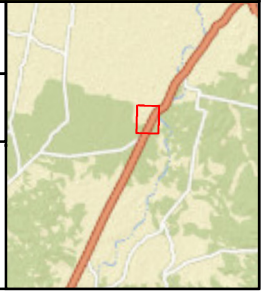
Client: Santos		**Land and Soil Capability**	
Compiled by: SD	Date: 21/01/2015	**Figure 4.6**	Project: Leewood Produced Water Treatment and Beneficial Reuse Project
Approved by: JH	Date: 21/01/2015		

0 0.15 0.3 0.6 km

Datum: GDA94
Scalre 1:20,000 @ A4

RPS

Source: Imagery from Santos 2012
Infrastructure from Santos 2013
Other data supplied from OEH 2012



4.4.6 Water Resources

4.4.6.1 Water Supply for Irrigation

At peak production it is anticipated that 1.5 ML/day of produced water will be treated via the water and brine treatment plant, resulting in approximately 1 ML/day of treated water.

The expected water quality (temperature dependant) for irrigation was determined by BeneTerra (2014) and is provided in **Table 4.6**. To avoid damage to irrigation infrastructure additional amendment may be required. The expected water quality would encourage aggregation of soil particle and therefore improve soil permeability. The added calcium may also alleviate the need for any future gypsum additions to soil; however calcium carbonate precipitates may block subsurface drip irrigation system, therefore sulphuric acid amendments will reduce the likelihood of carbonate deposits in the subsurface drip irrigation system and potential negative effects of bicarbonates in soil (BeneTerra 2014).

According to DEC (2004) the expected water quality is categorised as “medium strength effluent” due to the expected total dissolved solids (TDS concentrations). The expected electrical conductivity (EC) is suitable for moderate sensitive crops (DEC 2004) and is appropriate for the intended soil and would serve to maintain or improve soil structure stability (BeneTerra 2014).

Nitrogen as ammonium will be 3 mg/L, Boron (0.8 mg/L) will be safe for selected forage species and Fluoride concentrations will be (0.1 mg/L) (BeneTerra 2014). No metals or sources of nutrients are expected within the treated water.

Table 4.6: Expected irrigation water quality (BeneTerra 2014)

Parameter	Expected permeate (25°C)	Expected permeate (30°C)
NH_4-N (mg/L)	2.2	2.9
K (mg/L)	1.1	1.4
Na (mg/L)	117	151
Mg (mg/L)	0	0
Ca (mg/L)	65	170
Sr (mg/L)	0	0
Ba (mg/L)	0.1	0.1
CO_3 (mg/L)	0	0
HCO_3 (mg/L)	59	50
NO_3 (mg/L)	0	0
Cl (mg/L)	119	181
F (mg/L)	0.1	0.1
SO_4 (mg/L)	200	211
SiO_2 (mg/L)	0.6	0.8
B (mg/L)	0.7	0.8
SAR	4.0	5.0
pH	8.0	8.0
TDS (mg/L)	659	801
EC (mS/cm)	1.03	1.25

*Permeate to be amended prior to entering the irrigation system

4.4.6.2 Surface Water

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 to the east, the Liverpool Ranges and Warrumbungle Ranges to 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, 2012).

Overall trends indicate a decline in surface water quantity and quality in the Namoi catchment. The Namoi River catchment has one of the largest irrigated areas in the northern Murray-Darling Basin (MDB), 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 Gigalitres) of this water being used. The high demand on surface water resources is attributed to surface water diversions (260 Gigalitres/year) and stream flow losses as a result of losses to groundwater (99 Gigalitres/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 high nutrient loads, salinity and turbidity.

The site is located at the junction of the Bohena sub-catchment and the Bundock sub-catchment of the Namoi River catchment. The Bohena sub-catchment covers an area of approximately 830 square kilometres and is located south of Narrabri. The sub-catchment is the northern extension of the Borah sub-catchment (NCMA, 2013a). The Bundock Creek sub-catchment is located 10km south-east of Wee Waa and covers an area of approximately 548 square kilometres. The sub-catchment drains from within the Pilliga Forest north-west towards the Namoi River (NCMA, 2013b).

A headwater tributary of Mollee Creek dissects the property with a stock dam located in the centre of the site. The tributary is ephemeral and not well defined at the location of the proposed works. The feature captures the most of the overland flow on the property, which drains to the north-west towards the Namoi River. A small portion of the property drains to the north-east under the Newell Highway into Bohena Creek, approximately 500 metres to the east of the site.

A water balance model (HowLeaky v.5.47.00) was used by BeneTerra (2014) to estimate runoff volumes and water quality from the proposed WBTP. Four irrigation scenarios were investigated:

- Scenario 1 - Current dryland pasture (existing scenario) under natural rainfall. This was simulated to compare the natural erosion, deep drainage and runoff from the site;
- Scenario 2 – Even irrigation of all 98 hectares, simulation based on an average year with 1 megalitre/day permeate supply;
- Scenario 3 - Even irrigation of all 98 hectares, simulation based on an average year with unlimited treated water supply; and
- Scenario 4 – Irrigation was split between Class A and B soils, with priority given to watering the Class B soil from October to May and no irrigation of Class B soils from June to September. 1 megalitre/day treated water supply.

The following parameters were incorporated into the water balance model:

- Soil attributes – 140 mm plant available water capacity, 1.5-1.6 cm^3 bulk density; 0.5% slope, 0.3 mm/day drainage beyond the root zone;
- Permeate production rate of 1.0 ML/day for scenario 2 and 4;
- 5 ML treated water storage tank;

- For irrigated scenarios a 12 mm per day or 0.012 ML/ha/day of treated RO water would be applied when soil water deficit reached 50 mm; and
- Lucerne was selected as the preferred species for modelling purposes. While it is anticipated that lucerne will be sown across Class A soil areas, the additional pasture species (blend of fescue, white clover and lucerne) allocated to the Class B soil area was not incorporated into the modelling simulation as they all have similar water use patterns (BeneTerra 2014). Lucerne will be harvested 5 times per year.

For further information relating to model parameterisation view **Section 8** of the Leewood - Concept Irrigation Design (BeneTerra 2014). It should be noted that Scenario 3 is a hypothetical case and has been added as a point of reference to understand water balance under a lucerne crop with unlimited irrigation water, while the most likely selected irrigation regime is expected to be Scenario 4.

HowLeaky estimated that runoff in Scenarios 2 and 4 (irrigation scenarios) would be similar to the current land use (Scenario 1). While there are additional inputs into the water balance by irrigation, transpiration by lucerne is greater than the current pasture scenario, resulting in little additional runoff. Scenario 3 estimated that a total of 902 ML/yr could be applied and utilised by a lucerne crop across the 98 hectares (BeneTerra 2014). HowLeaky estimated that Scenarios 2 and 4 would utilise approximately 62% and 87%, respectively of the available treated water. As Scenario 4 is the most likely selected irrigation scheme, the unutilised water will be beneficially used on and off site for dust suppression, drilling and construction, agriculture/third party irrigation and emergency firefighting.

Sediment losses were predicted to be low, with estimates for each scenario to be less than 80 kg/ha annually. Proposed and existing land uses are estimated to result in similar erosion rates (**Table 4.7**). For further information regarding irrigation optimisation view **Section 8** of the Leewood – Conceptual Irrigation Design (BeneTerra 2014).

Table 4.7: Annual average hydrology and water quality under each scenario at Leewood (BeneTerra 2014)

Water balance and sediment loss	Scenario 1	Scenario 2	Scenario 3	Scenario 4 – Class A	Scenario 4 – Class B
Rainfall (mm/yr)	644	644	644	644	644
Irrigation (mm/yr)	-	230	920	240	510
Runoff (mm/yr)	14.2	13.5	39.6	14.6	17.6
Deep drainage (mm/yr)	4.0	3.9	16.9	4.3	5.7
Erosion (t/ha/yr)	0.22	0.22	0.7	0.24	0.30

4.4.6.3 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 (Upper and Lower Namoi Alluvium).

The porous rock groundwater sources of the Great Artesian Basin (GAB) Surat Pilliga Sandstone underlie the Upper and Lower Namoi groundwater sources. Water associated with this formation is more saline than the Lower and Upper Namoi and is generally used for stock purposes rather than irrigation. 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, 2012). Groundwater use is approximately 261 gigalitres, 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).

Three sets of nested groundwater monitoring bores (CH2MHILL 2012) were drilled to 36 metres below ground level (bgl) on the Leewood property. Static water levels ranged from 20.1 to 28.9 metres bgl. BeneTerra (2013) estimated a gradient running from south-east to north-west. CH2MHILL (2012) undertook slug tests to identify lateral hydraulic conductivity. Average lateral hydraulic conductivity ranged from 2.3 x 10^{-5} to 6.81 x 10^{-4}, which is considered slow and unproductive (BeneTerra 2013). Total dissolved solids (TDS in groundwater ranged from 631 mg/L at LWD-3 to 1272 mg/L at LWD-1. Due to TDS concentrations within groundwater, use for irrigation would be more suited for moderately salt sensitive to salt tolerant crops (NRW 2007).

Deep drainage estimates by HowLeaky for Scenarios 2 and 4 conditions are low and slightly more than current conditions (**Table 4.6**). Since deep drainage is minimally influenced by the proposed irrigation development, there is little likelihood of impacts on groundwater or salt movement in the landscape. The predicted salt concentrations (total dissolved solids (TDS) of 651 to 801 mg/L) indicates that the leachate would not impact groundwater quality as it would similar to the highest quality groundwater (631 mg/L TDS) found on the site (BeneTerra 2013). Metals in soils were identified as low (BeneTerra 2014) and below regulation thresholds. The pH of applied treated water is expected to be neutral and therefore not anticipated to result in any additional dissolution of heavy metal ions into the vadose zone and ultimately to groundwater. BeneTerra (2014) indicated that some salts may accumulate in the rootzone which will be managed via leaching. Potentially higher salt concentrations may result in some additional release of ions to the soil solution with the input of irrigation water.

In balance, with similar drainage rates associated with more vigorous vegetation under intensively managed irrigation, and good quality water being applied to the land, the risk of heavy metal movement to groundwater must be regarded as unlikely.

4.4.6.4 Licensed Water Use

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 licenses (WALs) and water management and activity approvals. There are four water sharing plans in force for the project area:

- Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources;
- Water Sharing Plan for the NSW Great Artesian Basin Groundwater Source (Southern Recharge);
- Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources; and
- Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Source.

5.0 Agricultural Risk Assessment

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 5.1**). The risk ranking system includes probability of the event occurring and the associated consequence of the event. Descriptions of probabilities are provided in **Table 5.2**, while descriptions of consequences are provided in **Table 5.3**.

Table 5.1 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 DP&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 CSG pilot testing.

Table 5.1: Agricultural Impact Risk Ranking Matrix (DP&I 2012c)

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 5.2: Agricultural Impact Risk Ranking – probability descriptors (DP&I 2012c)

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 5.3: Agricultural Impact Risk Ranking – consequence descriptors (DP&I 2012c)

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.

5.1 Leewood Produced Water Treatment and Beneficial Reuse Project Related Impacts

Table 5.5 details the nature of risk, likelihood and consequence of potential impacts on agricultural resources and industries. **Table 5.5** also summarises the mitigation measures for the identified potential impacts. In short, based on the Agricultural Impact Risk Ranking System, the proposed activity has been classified as a low to medium risk activity due to the following:

- The proposed activity is not located on or near BSAL or CIC;
- The proposed activity is located on land with a current low value commercial agricultural land use;
- The proposed irrigation regime will increase the net productivity of the area from the current low productivity pasture (**Table 5.4**);
- All surface disturbance areas will be fully rehabilitated to the pre-existing land condition. There will be no permanent land capability reduction of agricultural resources; and
- There are no significant impacts anticipated on surface or ground water resources.

The proposed mitigation, management and monitoring systems will reduce the likelihood of any impacts to agricultural resources or industries. These are described in brief below, while the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015) 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 5.4: Annual agricultural productivity impact of the proposed Leewood irrigation area

Land use	$/ha	Area Quarantined	Predicted gross margin
Current - low intensity grazing	230	97.8	22,540
Proposed - Irrigated lucerne (5 cuts per year, 15 tonnes per cut)	1,393	97.8	136,514
Total benefit per year			**113,974**

Table 5.5: Agricultural Impact Risk Ranking of the Proposed Activities

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Mitigation Measures
Socio-Economic Impacts					
Agricultural Support Infrastructure	▪ Pressure on transport infrastructure. ▪ Impact on agricultural support industries (e.g. processing facilities, travelling stock routes etc.).	E (Rare)	4 (Minor)	E4 (Low)	▪ The site is not located on or within the surrounding area of any mapped CICs. ▪ The minor increase of traffic along the Newell Highway and Old Mill Road can be accommodated by the existing road network. Santos has upgraded the Old Mill Road / Newell Highway intersection to allow for construction traffic access. Further, a traffic management plan will be installed to mitigate any pressures on the local road network. ▪ Further mitigation measures for the potential disruption on transport infrastructure are outlined in **Section 6.3.2** of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015) ▪ Lucerne will be cut and bailed approximately five times per year. As the irrigation area is only 97 hectares and the irrigation scheme will run for approximately three years the removal of agricultural support infrastructure is considered minimal.
Employment and Economic Development	▪ Reduction of current or future agricultural employment opportunities. ▪ Competition of labour resources ▪ Removal of agricultural related positions ▪ Adverse impact to local tourism industry (wineries, bed and breakfast, etc.)	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 site. The proposed irrigation scheme will improve agricultural employment and economic development due to the conversion of low to high intensity agricultural activities. ▪ Negligible impacts on labour resources within the local area as specialised skills are required to complete the proposed activity during construction. Approximately 50 staff are required during construction which will be sourced externally (outside of Narrabri Shire) due to specialist skill requirements. During operation only 10 staff will be employed. Due to the small number of staff and short term nature of the project competition of labour resources is considered minimal. ▪ During operation of the irrigation scheme the employment opportunities for agricultural related skills will increase in the local area due to the required skills for the management of the irrigation scheme. ▪ Negligible consequence on agricultural related tourism as there are no agricultural-related tourism (e.g. wineries, farm stays etc.) on the site or surrounds. ▪ No mitigation measures required.

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Mitigation Measures
Agricultural Resources					
Loss of land from agricultural use	▪ Alienation of land for agricultural uses ▪ Interference with mapped BSAL ▪ Removal of target honey tree (impact to apiary industry)	E (Rare)	5 (Negligible)	E5 (Low)	▪ The proposed activity is located on land with low potential for commercial agricultural use. The Leewood property is approximately 149 ha, with 51.2 ha alienated from low intensity grazing. The remaining 97.8 hectares (irrigation area) will be amended for high intensity agricultural activities, thus improving the productivity of this area from low intensity grazing to high intensity agricultural activities ▪ The site is not located on any mapped BSAL. The nearest mapped BSAL is located approximately 25 kilometres from the site. ▪ The site is predominantly cleared of vegetation and hence does not harbour significant populations of target honey trees. Furthermore, the area that contains dense vegetation in the north eastern extent of the site will remain intact throughout construction and operation. Therefore, the proposed activity is anticipated to have negligible impact on the apiary industry. ▪ The disturbed area will be fully rehabilitated once the works are completed.
Soil	▪ Soil erosion ▪ Soil compaction ▪ Soil salinity ▪ Crop failure ▪ Nutrient deficiencies ▪ High sodium absorption ratio and pH of applied water ▪ Waterlogging ▪ Contamination from generated waste during the construction and operational phases ▪ Contamination due to fuel/oil spill during	D (Unlikely)	4 (Minor)	D4 (Low)	▪ To break down the hard, coarse subsoils deep ripping will occur to a minimum depth of 60 cm with tyne spacing of less than 100 cm (BeneTerra 2014). If required deeper ripping will also occur to a depth of 100 cm (BeneTerra 2014). ▪ Following deep ripping the irrigation area will have offset discs run across the area to produce a tilth suitable for sowing (BeneTerra 2014). ▪ To stabilise the soil and displace the majority of sodium within the upper root zone approximately 20 t/ha of gypsum will be applied, with 15 t/ha prior to any tillage operations and 5 t/ha following discing to reduce the risk of surface crusting (BeneTerra 2014). ▪ BeneTerra (2014) identified that some salts will accumulate in the rootzone. Accumulated salts in the root zone will be managed through leaching. ▪ Due to the high soil pH, lime will be applied at 8 t/ha during final dressing. The addition of calcium will also ameliorate sodium, which has been subtracted from the gypsum application requirements (BeneTerra 2014). ▪ The irrigation water will be amended to decrease the sodium absorption ration to between 4 and 5 (temperature dependant) and raise the EC to

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Mitigation Measures
	construction				between 1.03 to 1.25 mS/cm (temperature dependant) (BeneTerra 2014). The irrigation water may also be neutralised when required depending on the alkalinity of the permeate water. A disinfectant will also be injected into the water entering the drip irrigation system to prevent biofouling and emitter plugging (BeneTerra 2014). Further water amendment measures are outlined in **Section 10.1.1** of the Leewood – Concept Irrigation Design (BeneTerra 2014). ▪ Traffic across the irrigation area will be limited and managed to reduce soil compaction. Soils will be dried out prior to harvest and bales will be stored in a place that encourages careful traffic management (BeneTerra 2014). ▪ Phosphorous as monoammonium phosphate will be applied prior to ripping at a rate of 100 kg/ha (BeneTerra 2014). Nitrogen that the lucerne crop will require over time will come from the legume itself (BeneTerra 2014). Soil and leaf tissue monitoring will inform ongoing application rates. ▪ An irrigation event will be triggered once the soil water deficit reaches 50 mm or 36% of the 140 mm plant available water capacity (PAWC) of the soil. Climatic and soil moisture monitoring will assist in the determination of appropriate irrigation scheduling. 12 mm per event will be applied or 0.012 ML/ha/day to prohibit waterlogging; however other extenuating factors may override this (BeneTerra 2014). Irrigation scheduling is discussed in full in **Section 10.2.2** of the Leewood – Concept Irrigation Design (BeneTerra 2014). ▪ A lucerne variety or other crop suited to the local conditions and heavy soils will be selected. Seeds will be coated with an insecticide and fungicide to ensure viability. The crop will be checked for insect and mite damage. Should damage occur an appropriate insecticide will be applied. Further a pre and post-emergent herbicide may be applied should weed infestation be imminent. Appropriate crop establishment and management throughout the life of the project will be guided by a suitably qualified agronomist. Sowing details are discussed in full in **Section 9.4.2** of the Leewood – Concept Irrigation Design (BeneTerra 2014). ▪ The proposed land use is not expected to significantly increase erosion when compared to the current low intensity grazing scenario (BeneTerra 2014). ▪ Due to the presence of sodic subsoils, adequate groundcover will be

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Mitigation Measures
					maintained during rehabilitation on the existing landscape and reformed landscapes after the rehabilitation works are carried out. This will prevent erosion and allow for successful rehabilitation. ▪ No generated waste will be disposed of onsite or on other agricultural enterprises. Management of generated waste is detailed in **Section 6.1.6** of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015). ▪ Generate brine will be stored on site in suitable brine ponds. Generate brine will be disposed to a licenced landfill. ▪ Chemical and hazardous substances will be managed and disposed of following the regulatory requirements including the *Work Health and Safety Act 2011* and the *Dangerous Goods (Road and Rail Transport) Act 2008*. ▪ Further mitigation measures for the protection of soil resources are detailed in **Section 6.1.1**of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015), while **Sections 9** and **10** of the Leewood – Conceptual Irrigation Design (BeneTerra 2014) details the land preparation and crop management strategies for the site.
Surface water	▪ Sedimentation of waterways. ▪ Impacts to water quality from sediment laden runoff. ▪ Change in local surface water discharge volumes due to changes in surface runoff ▪ Contamination from generated waste during the construction and operational phases ▪ Contamination due to spills, fuels or	D (Unlikely)	3 (Moderate)	D3 (Medium)	▪ Erosion and sediment controls will be implemented during site preparation activities in accordance with best management practices (such as the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008)). These controls will be maintained until disturbed areas of the site are stabilised. ▪ Construction activities will require approximately 100 megalitres of water, which will be sourced from the water supply bore already on the Leewood property or an alternative appropriately licenced water supply bore. In addition, approximately 0.01 megalitres per day of potable water will be required for facilities during construction. This will be sourced from Narrabri's town water supply and not from agricultural supplies. ▪ No surface waters will be lifted from the local drainage system for the construction, operational or rehabilitation phases of the proposed activities. ▪ Under the expected irrigation scenario runoff does not significantly increase when compared to the current land use (BeneTerra 2014). ▪ Predicted sediment losses would be similar under the expected

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Mitigation Measures
	chemicals ▪ Removal from agricultural related uses				irrigation scenario (BeneTerra 2014), thus the amount of sediment carried into the local drainage system would not significantly increase under the proposed land use. ▪ BeneTerra (2014) estimated that Scenarios 2 and 4 would utilise approximately 62% and 87%, respectively of the available treated water. As Scenario 4 is the most likely selected irrigation scheme, the unutilised water will be beneficially used on and off site for dust suppression, drilling and construction, agriculture/third party irrigation and emergency firefighting. ▪ Management of generated waste will prohibit contamination to surface water resources. Waste disposal management measures are detailed in **Section 6.1.6** of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015). ▪ Chemical and hazardous substances will be managed and disposed of following the regulatory requirements including the *Work Health and Safety Act 2011* and the *Dangerous Goods (Road and Rail Transport) Act 2008*. Further mitigation measures for the potential contamination of surface water resources are detailed in **Section 6.1.7** of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015). ▪ Further mitigation measures for the protection of surface water resources are detailed in **Section 6.1.3** of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015).
Groundwater	▪ Changes to groundwater recharge volumes posed by irrigation ▪ Salt and metal movement ▪ Contamination from generated waste during the construction and operational phases ▪ Contamination due to spills, fuels or chemicals.	D (Unlikely)	3 (Moderate)	D3 (Medium)	▪ Under either irrigation scenario deep drainage does not significantly increase when compared to the current land use. The predicted salt concentrations (total dissolved solids (TDS) of 651 to 801 mg/L indicates that the leachate would not impact groundwater quality as it would similar to the highest quality groundwater (631 mg/L TDS) found on the site (BeneTerra 2013). BeneTerra (2014) indicated that some salts may accumulate in the rootzone which will be managed via leaching. ▪ In balance, with similar drainage rates associated with more vigorous vegetation under intensively managed irrigation, and good quality water being applied to the land, the risk of heavy metal movement to groundwater must be regarded as unlikely. ▪ Management of generated waste will prohibit contamination to groundwater resources. Waste disposal management measures are

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Mitigation Measures
	▪ Removal from agricultural related uses				detailed in **Section 6.1.6** of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015). ▪ Chemical and hazardous substances will be managed and disposed of following the regulatory requirements including the *Work Health and Safety Act 2011* and the *Dangerous Goods (Road and Rail Transport) Act 2008*. ▪ No groundwater will be lifted for either the construction, operational or rehabilitation phases of the proposed activities. ▪ Further mitigation measures for the protection of groundwater resources are detailed in **Section 6.1.2** of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015).
Air and Noise	▪ Reduced productivity of surrounding cropping areas due to dust generation and settlement ▪ Unfavourable conditions for livestock due to the following: - Exhaust emissions from, vehicle movements and plant and machinery operations; and - Noise generation above agricultural background level of 30 dB(A).	C (Possible)	4 (Minor)	C4 (Low)	▪ Minor or short term impact on grazing stock near the site given the short duration of the construction phase (primary air and noise polluting period) (approximately 40 weeks). ▪ Where the predicted or measured noise level is greater than the noise affected level, all reasonable and feasible work practices should be applied to meet the noise affected level. All potentially impacted residents will be informed of the nature of works to be carried out, the expected noise levels and duration, as well as contact details. ▪ Potential air impacts will be mitigated by the measures outlined in **Section 6.1.4** of Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015). ▪ Further mitigation measures to manage potential noise pollution are detailed in **Section 6.1.6** of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015).
Biological (Weeds and Biosecurity)	▪ Introduction of weeds to area or	D (Unlikely)	4 (Minor)	D4 (Low)	▪ Identified noxious weeds (Tiger Pear /Prickly Pear) will be readily managed and their spread mitigated in accordance with local and state

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Mitigation Measures
	spread of current weeds on site ▪ Land degradation ▪ Reduced agricultural productivity ▪ Spread of *Phytophthora cinnamomi*				guidelines. ▪ Post emergent herbicides may be applied as weeds compete with young seedlings. Application and handling will be in accordance with specifications outlined on the herbicide label. ▪ The spread of weeds and *Phytophthora* within and surrounding the will be managed via vehicle wash downs.

6.0 Cumulative Impacts

Santos plans to continue exploration, appraisal and evaluation of the CSG hydrocarbon potential in PEL 238 and PAL 2 through Santos' existing and future exploration and appraisal activities within PEL 238 and PAL 2.

Santos' existing and future exploration and appraisal activities within PEL 238 and PAL 2 will be conducted over the next two to three years in stages and is currently proposed to include, subject to obtaining the necessary approvals:

- Operation of the existing Dewhurst 13-18H Pilot and the construction, drilling and operation of additional lateral wells from well casing within Dewhurst 16H-18H;
- Construction, drilling and operation of the Dewhurst 26-29 Pilot and the expansion of the pilot by adding two wells, Dewhurst 30 and 31, and operating the combined six well set;
- Construction, drilling and operation of the Dewhurst 22-25 Pilot;
- Construction, drilling and operation of the Dewhurst 32-37 Four-Spot Pilot;
- Construction and drilling of the Bibblewindi 34 corehole;
- 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;
- Operation of the existing Bibblewindi West Pilot;
- Operation of the existing Tintsfield 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 and Brine Plant and ancillary infrastructure; and
- Gas and water management during operation of Santos' existing and future exploration and appraisal activities within PEL 238 and PAL 2.

The construction and operation of the above wells and associated infrastructure has and will be subject to separate assessment and approval as the detail and specific locations of the wells and infrastructure is developed.

The proposed activity forms part of Santos' existing and future exploration and appraisal activities within PEL 238 and PAL 2; however cumulative impacts to agricultural resources and industries are not expected to be significant as discussed below.

6.1 Agricultural Land Use Disturbance

Approximately 90 existing exploration wells are located within PEL 238 and PAL 2. 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 182 hectares, which includes 28 hectares of existing infrastructure and well sites to be retained and 153 hectares of proposed infrastructure and well sites. This is approximately 0.014% 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 hectares. At this stage two proposed sites (low intensity grazing onsite) are located on land with a current or previous agricultural land use within PEL 238 and PAL 2 (in terms of major agricultural industries identified in PEL 238 and PAL 2 e.g. cropping, grazing, horticulture and plantations) totalling in 53.4 hectares of disturbance. Therefore, approximately 0.007% of agricultural land will be disturbed in PEL 238 and PAL 2. 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 Scrub 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 no current or planned exploration activities are located on any intensive agricultural enterprises. It should be noted that 97.8 hectares (planned irrigation area) of low potential for commercial agricultural land use will be improved to sustain high intensity agricultural activities. Further, the majority of land disturbances would be fully rehabilitated following the completion of activities.

Based on the nominated gross margins (GM) published by the DPI (2012a,b,c) 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 program has the capacity to generate an estimated annual gross margin of approximately $8,328 and $25,248 per annum, respectively (**Table 6.1**). The amounts are based on the DPI agricultural productivity data for agricultural enterprises suitable for each of the LSC 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, rather than the more likely land use outcome (forestry).

Table 6.1: Annual agricultural productivity of the Santos PEL 238 and PAL 2 exploration project.

LSC Class	$/ha	Area Quarantined (ha)	Gross margin based on the potential agricultural land use ($)	Gross margin based on site with a current agricultural enterprise ($)
Existing infrastructure and well sites to be retained within each LSC Class				
2	418	-	-	-
3		9.0	3,762	-
4	230	3.29	757	-
5		16.56	3,809	-
Total		**28.85**	**8,328**	**-**
Proposed disturbance within each LSC Class				
2	418	-	-	-
3		-	-	-
4	230	37.02	8,515	-
5		72.75	16,733	12,282
Total		**109.75**	**25,248**	**12,282**

*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 the DPI.

*The area quarantined in each LSC Class is based on knowledge and understanding at the time of writing (March 2014).

* Only 51.2 hectares was used for the Leewood disturbance footprint as the 97.8 hectares proposed for irrigation will improve the agricultural productivity of this selected area, upgrading it from low intensity grazing to high intensity agricultural activities.

6.1.1 Apiary Industries

The most utilised beekeeping region in Australia is the temperate land stretching from southern Queensland to central Victoria. This area contains about 80% of the nation's hives and its beekeepers. Beekeepers in NSW depend on a combination of both public and private land. The Pilliga State Forest provides areas for beekeepers to carry out apiary activities. No artificial nesting hives were identified at the site or within the Pilliga Scrub at current or proposed activity locations; however both the site and Pilliga Scrub contain Pilliga Box and Narrow Leaved Ironbark species which may yield honey from time to time. Trees will be removed onsite to install irrigation infrastructure while the larger Santos existing and future exploration and appraisal activities within PEL 238 and PAL 2 will also remove Narrow Leaved Ironbark, Yellow Box and Pilliga Box for defined project sites in the Pilliga Scrub; Narrow leaved Ironbark are considered dominant within the defined project sites in the Pilliga Scrub, while Yellow Box and Pilliga Box have smaller distributions (**Table 6.2**). Narrow-leaved Ironbark communities account for 198,219 hectares of the Pilliga Scrub. Projected disturbance footprints for defined projects accounts for approximately 0.02% of Narrow-leaved Ironbark in the Pilliga Scrub. No such calculations could be made for the Yellow Box and Pilliga Box species however disturbance footprints of these species are minimal and are not considered significant.

Due to the minimal disturbance of potential honey trees within the Pilliga Scrub, a low to negligible impact is anticipated on the apiary industry.

Table 6.2: Impacted honey-yielding vegetation communities across the program

Species	Impact across all proposed activities
Narrow-leaved Ironbark	Dominant species across 25 - 30 ha
Pilliga Box	Potential to impact upon approximately 130 trees
Yellow Box	Occurs at very low densities across less than 1 ha

6.2 Water Resources

6.2.1 Surface Water

No surface water will be extracted from local creeks or wetlands for any of the Santos existing and future exploration and appraisal activities within PEL 238 and PAL 2. Potential impacts posed by soil erosion and contamination will be managed and mitigated with the measures outlined in **Sections 6.1.3** (surface water), **6.1.7** (waste) and **6.1.8** (chemicals and hazardous substances) of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015).

6.2.2 Groundwater

No significant cumulative impacts to groundwater are anticipated a due to the following:

- No significant change to deep drainage rates;
- Low risk of potential waste and chemical hazardous substance through management per **Sections 6.1.7** and **6.1.8**, respectively; and
- The risk of heavy metal movement to groundwater is regarded as unlikely.

6.3 Additional Risks to Agriculture

Additional risks to agricultural enterprises posed by the program 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 6.1.4** (Air) and **6.1.6** (Noise) of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015). Weeds and Biosecurity risks will be managed as defined in **Table 5.4**.

7.0 Trigger Response Plan and Monitoring Program

7.1 Trigger Response Plan

The primary trigger response plans are highlighted in **Table 7.1**. Due to the low impact nature and relative short duration of the proposed activity, no significant impact to agricultural resources or supporting infrastructure are anticipated.

Table 7.1: Trigger Response Plans

Trigger	Response
Transfer of water from treated water storage tank to produced water pond due to potential of overtopping in low irrigation requirement periods	Triggered at 95% tank capacity
Spill of chemicals or fuels to land	Immediate application of spill kit and disposal of any contaminated material
Complaints of significant noise and air pollution	Source of the noise or air pollution will be investigated. Where necessary, Santos will offer to conduct noise monitoring from the proposed activity at the affected receivers house. If it is determined that noise levels are unacceptable, further feasible and reasonable work practices or mitigation measures will be implemented.

7.2 Monitoring and Management Programs

7.2.1 Irrigation Infrastructure

Installation, operation and maintenance guidelines are described in **Sections 9** and **10** of the Leewood – Conceptual Irrigation Design (BeneTerra 2014).

As per the Leewood – Concept Irrigation Design (BeneTerra 2014) records regarding environmental reporting, troubleshooting and hand-over between employees should be documented, reviewed and stored.

7.2.2 Climatic Data

An automated weather station will be installed to recorded rainfall, ambient air temperature, wind speed, wind direction, solar radiation and barometric pressure. Soil moisture data and collected climatic data will be used to calculate evapotranspiration in real time.

7.2.3 Agronomy

A healthy and active growing crop is essential to utilise the produced water. Should the crop fail, water balance across the site would be disrupted and could result in unnecessary removal from site. As per **Section 10.2** of the Leewood – Conceptual Irrigation Design (BeneTerra 2014) the health of the crop should be managed and monitored for key indicators to ensure crop failure does not occur.

7.2.4 Soil and Vadose Monitoring

Irrigation using treated coal seam water will be carried out in such a manner that:

- Soil erosion and soil structure damage is avoided;
- There is no surface ponding;
- There is little increase in runoff off-site compared to the existing scenario; and

- Percolation of treated coal seam water beyond the plant root zone is minimised where possible.

The recommended soil and vadose monitoring program and methodology is detailed in **Section 11.3** of the Leewood – Concept Irrigation Design (BeneTerra 2014).

7.2.5 Water

7.2.5.1 Treated Coal Seam Water

Quantity and quality of water delivered to the treated water storage tank should be monitored continuously to establish salt loads and concentration of input water.

The treated water storage tank level should be monitored continuously to provide a broad picture of the total water resource in relation to inputs from the water producer. Ideally, the effectiveness of the produced water would be monitored quarterly to confirm suitability for irrigation.

A representative sample of water from the processing plant should be analysed for all ions on a quarterly basis during pumping periods. A representative sample from the treated water storage tank should be collected and electrical conductivity, and SAR measured on a monthly basis during the irrigation season.

7.2.5.2 Ground and Surface Water

Ground and surface water monitoring is important in predicting and measuring the 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 ground and surface water sampling plan for Santos within the Narrabri Region. The sampling program commenced in February 2012, with approximately 30 groundwater and 30 surface water sampling locations continually monitored. The groundwater monitoring sites include shallow aquifer monitoring bores (SAMBS), in-stream monitoring bores and groundwater supply bores. Additionally 53 landholder bores proximal to current and proposed pilots have also been sampled intermittently. The above mentioned surface water monitoring sites are considered to be 'regular' monitoring sites throughout the monitoring program period to date. **Table 7.2** details the assessed parameters.

The three nested groundwater bores located on site will be assessed for groundwater elevation and quality. BeneTerra (2014) also recommended the installation of two additional monitoring wells as per **Figure 7.1** to assess the effects of irrigation system upon groundwater. The site groundwater monitoring is discussed in **Section 11.1** of the Leewood – Concept Irrigation Design report (BeneTerra 2014).

The nearest surface water monitoring locations are located 2.5 and 6.4 kilometres north-east of the site. These are located along the Bohena Creek, the major receiving environment of the site. The surface water monitoring includes the monitoring of water flow and quality. Surface water will be monitored downstream and upstream of the irrigation area to identify any significant impacts to surface water quality posed by the land use change.

Ground and surface water samples will be obtained using sampling technique defined by the AS/NZS 5667.1:1998 and 5667.6.1998, and with consideration of *ANZECC Guidelines and Water Quality Objectives in NSW*. All laboratory analyses are undertaken by a National Association of Testing Authorities (NATA) accredited laboratory.

It is anticipated that ground and surface water sampling programs will continue for the life of the CSG program to meet requirements of future regulation and environmental assessment.

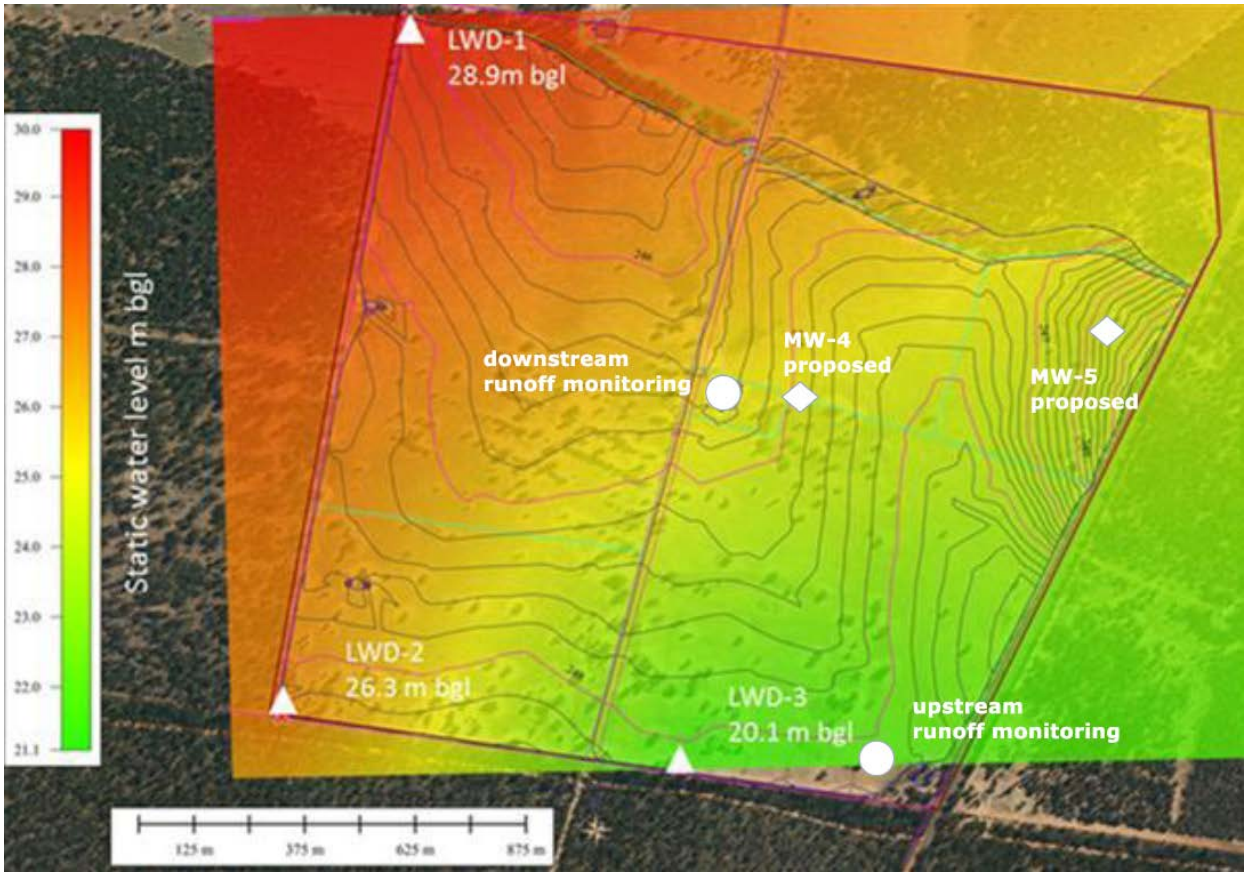


Figure 7.1: Existing (triangle) and proposed (diamond) monitoring well locations. Runoff monitoring locations are described by the circles (BeneTerra 2014).

Table 7.2: Proposed ground and surface water monitoring parameters.

Analyte	Unit	Groundwater	Surface Water
Physicochemical			
pH	pH Unit	Y	Y
Electrical Conductivity	µS/cm	Y	Y
Total Dissolved Solids @ 180°C	mg/L	Y	Y
Dissolved Anions			
Hydroxide alkalinity as $CaCO_3$	mg/L	Y	Y
Carbonate alkalinity as $CaCO_3$	mg/L	Y	Y
Bicarbonate alkalinity as $CaCO_3$	mg/L	Y	Y
Total alkalinity as $CaCO_3$	mg/L	Y	Y
Residual alkalinity	meq/L	Y	Y
Chloride	mg/L	Y	Y
Sulphate as SO4 2-	mg/L	Y	Y
Fluoride	mg/L	Y	Y
Dissolved Cations			
Calcium Magnesium	mg/L	Y	Y
Sodium	mg/L	Y	Y
Potassium	mg/L	Y	Y

Analyte	Unit	Groundwater	Surface Water
Total hardness as $CaCO_3$	mg/L	Y	Y
Sodium absorption ratio (calc)	-	Y	Y
Ionic balance	%	Y	Y
Dissolved Metals			
Aluminium	mg/L	Y	Y
Arsenic	mg/L	Y	Y
Barium	mg/L	Y	Y
Beryllium	mg/L	Y	Y
Boron	mg/L	Y	Y
Cadmium	mg/L	Y	Y
Chromium	mg/L	Y	Y
Cobalt	mg/L	Y	Y
Copper	mg/L	Y	Y
Iron	mg/L	Y	Y
Lead	mg/L	Y	Y
Lithium	mg/L	Y	Y
Manganese	mg/L	Y	Y
Mercury	mg/L	Y	Y
Molybdenum	mg/L	Y	Y
Nickel	mg/L	Y	Y
Selenium	mg/L	Y	Y
Strontium	mg/L	Y	Y
Tin	mg/L	Y	Y
Uranium	mg/L	Y	Y
Vanadium	mg/L	Y	Y
Zinc	mg/L	Y	Y
Total Metals			
Aluminium	mg/L	-	Y
Arsenic	mg/L	-	Y
Barium	mg/L	-	Y
Beryllium	mg/L	-	Y
Boron	mg/L	-	Y
Cadmium	mg/L	-	Y
Chromium	mg/L	-	Y
Cobalt	mg/L	-	Y
Copper	mg/L	-	Y
Iron	mg/L	-	Y
Lead	mg/L	-	Y
Lithium	mg/L	-	Y
Manganese	mg/L	-	Y
Mercury	mg/L	-	Y
Molybdenum	mg/L	-	Y

Analyte	Unit	Groundwater	Surface Water
Nickel	mg/L	-	Y
Selenium	mg/L	-	Y
Strontium	mg/L	-	Y
Tin	mg/L	-	Y
Uranium	mg/L	-	Y
Vanadium	mg/L	-	Y
Zinc	mg/L	-	Y

Y: Yes

-: No

7.2.5.3 Runoff Monitoring

The HowLeaky water balance assessment indicated that runoff and sediment loss would be similar in the proposed irrigation scenario. BeneTerra (2014) recommended that runoff be monitored down and upstream of the irrigation area (**Figure 7.1**) using stormwater sampling devices to identify runoff volumes and water quality (nutrients and total suspended solids) leaving the site.

8.0 Consultation

Santos undertakes consultation activities with relevant stakeholders and the community in the areas within which they work. This includes consultation with landowners and adjacent landowners, Council, Local 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 is provided in **Section 2.3** of the Leewood Produced Water Treatment and Beneficial Reuse Project REF (RPS 2015).

9.0 Conclusion

Santos is proposing to design, construct and operate a WBTP at a property known as "Leewood" together with associated infrastructure within PAL 2. Santos is proposing to operate the WBTP for up to three years, complementing Santos' existing and future exploration and appraisal activities within PEL 238 and PAL 2 by managing produced water and brine. The proposed activity is located on low intensity grazing land adjacent to the Pilliga East State Forest, approximately 24 kilometres south-east of the Narrabri. The total area of potential disturbance assessed in this AIS is 108 hectares. This includes the proposed irrigation area and remaining land occupied by the WBTP, treated water storage tank and associated infrastructure.

The proposed activity is considered low to medium 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:

- The site area is characterised by Chromosols and Sodosols, which are not well suited to intensive agricultural production without significant soil amelioration inputs;
- There are no intensive agricultural enterprises at the site or adjoining lands. The proposed irrigation regime and improvements in soil properties associated with gypsum, nutrient and lime application will increase the net productivity of the area from the current low productivity pasture. It is likely that after the irrigation proposal is implemented, there will be some residual benefits in soil properties;
- The site is not located on or within two kilometres of BSAL and/or a CIC;
- Runoff and deep drainage volumes are anticipated to be similar under the proposed scenario compare to the current land use at the site. Further, contamination to ground and surface waters is considered unlikely. Therefore no significant impact is anticipated on surface water and groundwater resources;
- The proposed activity is considered to be short to medium term in duration; and
- The proposed mitigation, management and monitoring systems will reduce the likelihood of any impacts to agricultural resources or industries in the surrounding areas.

The cumulative impacts and likelihood risks are not anticipated to be significant, provided that mitigation measures are followed and applied according to current best practice.

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Appendix 8

Ecological assessment (Eco Logical Australia)

Leewood Phase 2 Water Processing Facilities

Ecological Assessment

Prepared for
Santos NSW (Eastern) Pty Ltd

July 2014



DOCUMENT TRACKING

Item	Detail
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Abbreviations

Abbreviation	Description
BTP	Brine Treatment Plant
DRE	NSW Department of Resources and Energy
EEC	Endangered Ecological Community
ELA	Eco Logical Australia
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
ha	Hectares
km	Kilometres

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Abbreviation	Description
LGA	Local Government Area
ML	Megalitre
MNES	Matters of National Environmental Significance
NW Act	NSW *Noxious Weeds Act 1993*
PAL 2	Petroleum Assessment Lease 2
PEL 238	Petroleum Exploration Licence 238
REF	Review of Environmental Factors
RO	Reverse Osmosis
SEPP 44	State Environmental Planning Policy No 44 – Koala Habitat Protection
TSC Act	NSW *Threatened Species Conservation Act 1995*
WBTP	Water and Brine Treatment Plant
WTP	Water Treatment Plant

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Executive summary

Eco Logical Australia (ELA) was engaged by Santos NSW (Eastern) Pty Ltd (Santos) to undertake an Ecological Assessment of the works associated with water processing facilities at 'Leewood' to manage pilot production water from Santos' exploration and appraisal activities. These works form Phase 2 for the development of the water processing facility (the proposed activity), with Phase 1 being the construction of produced water and brine storage ponds, which was approved by the Division of Resources and Energy (DRE) within the Department of Trade and Investment Regional Infrastructure and Services (DTIRIS) (now Office of Coal Seam Gas) on 19 March 2013.

The 246 ha study area is located approximately 24 kilometres (km) south west of Narrabri NSW on the Santos owned 'Leewood' property.

This report summarises the ecological survey undertaken by RPS in 2012 in relation to the Phase 1 approvals and provides a desktop assessment of the impacts from the proposed Phase 2 works. This report has been prepared as an addendum to the Phase 1 ecological assessment prepared by RPS.

Three vegetation communities occur in the study area; *Pilliga Box – White Cypress Pine Grassy Open Woodland on Alluvial loams, Darling Riverine Plains and Brigalow Belt South; Derived Grasslands of the Pilliga Box – White Cypress Pine Grassy Open Woodland on Alluvial loams, Darling Riverine Plains and Brigalow Belt South; and Brigalow Woodland*. Of these communities, only the *Derived Grassland* will be directly impacted by the proposed activity with the other two vegetation communities being retained.

A total of 25 listed fauna including 13 threatened birds, nine threatened mammals and three migratory birds have been assessed as potentially, likely or known to occur in the study area and that have the potential to be impacted by the proposed activity. Assessments of Significance for these species under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) have been undertaken where applicable.

The removal of 102.6 hectares (ha) of *Derived Grassland* for the proposed activity is not considered likely to have a significant impact on ecological values listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) or EPBC Act or on the environment more broadly, provided the measures described in **Section 5** are adhered to.

Avoidance, minimisation and mitigation measures have been addressed in order to reduce the impact of the proposed activity on ecological values and the environment.

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1 Introduction

Santos engaged ELA to undertake an ecological assessment of land near Narrabri as part of a Review of Environmental Factors (REF) being prepared for works associated with water processing facilities at 'Leewood' to manage pilot production water from Santos' exploration and appraisal activities.

1.1 Structure of assessment

This report has been prepared as an addendum to the ecological assessment previously prepared for Leewood Phase 1 (RPS 2012). This first phase involved the construction of two 300 megalitre (ML) ponds for produced water and brine which was approved in March 2013.

The Leewood Phase 1 ecological assessment (RPS 2012) involved flora and fauna surveys throughout the area covered by the Leewood Phase 2 proposed activity. This current ecological assessment draws on the survey work undertaken previously and as a result must be read in conjunction with the Leewood Phase 1 ecological assessment (RPS 2012).

This current report takes the form of a desktop assessment and no additional field surveys have been undertaken. It provides a brief description of the works proposed and an assessment of the ecological impact based on the survey work carried out previously for Leewood Phase 1.

The database searches within RPS (2012) were undertaken in April 2012. As a result of the age of these searches and the additional work that has been recently carried out in the Pilliga, newer database searches associated with the ecological assessment for the Dewhurst Expansion (ELA 2013a) and the likelihood table therein has been used to determine the species with potential to be impacted by this proposed activity.

The 'study area' for the purposes of this assessment is the 'Leewood' property and the 'study region' encompasses the whole of the Petroleum Exploration Licence (PEL 238) area which incorporates Petroleum Assessment Lease (PAL) 2.

1.2 Study area

The study area is located within PAL 2 which in turn is incorporated within PEL 238 (the study region) approximately 24 km south west of Narrabri, NSW along the Newell Highway in the Narrabri LGA. The study site totals approximately 246 ha and was previously part of a private grazing enterprise. The north eastern portion of the site is vegetated with the remainder largely cleared paddock with some paddock trees. The site is surrounded by Pilliga East State Forest to the west, south and east (**Figure 1**).

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2 Project description

The Leewood Phase 2 proposed activity consists of the construction of a Water and Brine Treatment Plant (WBTP) to manage the water production from Santos' exploration and appraisal activities. The construction of two 300 ML storage ponds is currently underway as part of the Leewood Phase 1 approval.

The remaining activities will form part of the overall WBTP. The proposed activity involves the design, construction, operation and maintenance of the combined Water Treatment Plant (WTP) and Brine Treatment Plant (BTP) on the Santos-owned 'Leewood' property.

The scope of the proposed activity includes:

- a water treatment plant, including pre-treatment and reverse osmosis (RO) plant
- brine treatment plant,
- brine distribution manifold and associated piping, to allow water distribution into the water treatment plant and associated return flows to brine storage ponds
- a treated water storage tank
- other associated infrastructure.

The treated water will be beneficially re-used for irrigation at the Leewood property through a managed irrigation system and for other uses both on and off site including dust suppression, drilling and construction, agriculture/third party irrigation and emergency firefighting.

Santos (or its assigned operator) will operate the proposed activity for up to five years. The WBTP will treat 1.5 ML/day of produced water from Santos' CSG exploration and appraisal activities within PEL 238 and PAL 2.

It will be located adjacent to the 'Leewood' produced water and brine storage ponds (Leewood Phase 1), which were approved by DRE on 19 March 2013 and are currently under construction.

During operation, water from the produced water ponds will be pumped to the water treatment plant where it will undergo the removal of solids, RO to separate the water and brine streams, and chemical and pH adjustment. The treated water will then be available for beneficial use with the treated water storage tank providing a water balance buffer. The remaining brine will be transferred to the brine treatment plant for concentration and further recovery of treated water.

The footprint of these activities is provided on **Figure 1**.

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Figure 1: Location of site and proposed activities

3 Summary of ecological values

A review of RPS (2012) was undertaken to understand the vegetation communities, flora, fauna and habitat components of the study area. The following section provides a summary of the ecological values on the site to provide a background for the impact assessment.

3.1 Vegetation

Two vegetation communities were identified on site by RPS (2012) and have been mapped in **Figure 2**.

Pilliga Box – White Cypress Pine Grassy Open Woodland on Alluvial loams, Darling Riverine Plains and Brigalow Belt South

There were two condition classes of this community described in RPS (2012). The 'moderate condition' had some impact from stock but retained high species diversity and covered an area of 17.4 ha. Dominated by *Eucalyptus pilligaensis* (Pilliga Box) with other canopy species such as *Callitris glaucophylla* (White Cypress Pine) and *Eucalyptus crebra* (Narrow-leaved Ironbark). *Allocasuarina luehmannii* (Bulloak) and *Acacia deanei* (Deane's wattle) dominated the sub-canopy layer and the ground cover consisted mostly of native grasses including *Chloris ventricosa* (Tall Chloris), *Eragrostis setifolia* (Bristly Lovegrass), *Eragrostis lacunaria* (Purple Lovegrass), *Panicum effusum* (Hairy Panic) and *Austrostipa verticillata* (Slender Bamboo).

This community corresponds to the Benson *et al* (2006) vegetation type of *Pilliga Box - White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion.*

The 'poor condition' areas of this community were identified as the paddock areas where a few scattered paddock trees remain. These areas are strongly influenced by stock grazing and consequently the shrub layer was almost non-existent and the ground layer was largely a monoculture of a few grass species. This community has been identified as *Derived Grassland* and was the largest by area community on site covering 210 ha.

Brigalow Woodland

This community is commensurate with the Endangered Ecological Community (EEC) '*Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions'* under the TSC Act and 'Brigalow (*Acacia harpophylla* dominant and co-dominant)' under the EPBC Act.

This community was in a moderate-poor condition, with impacts such as soil compaction from stock. The woodland covered 19.1 ha of the site and was dominated by a dense canopy of *Acacia harpophylla* (Brigalow). Occasionally *Eucalyptus pilligaensis* (Pilliga Box) and *Casuarina cristata* (Belah) occur on the edges of this community. The shrub and ground layers were sparse and included species such as *Eremophila* spp., *Sclerolaena* spp., *Maireana microphylla* (Small-leaf Bluebush), *Marsilea hirsuta* (Nardoo) and *Chamaesyce drummondii* (Caustic Weed).

This community corresponds to the Benson *et al* (2006) vegetation type of *Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion.*

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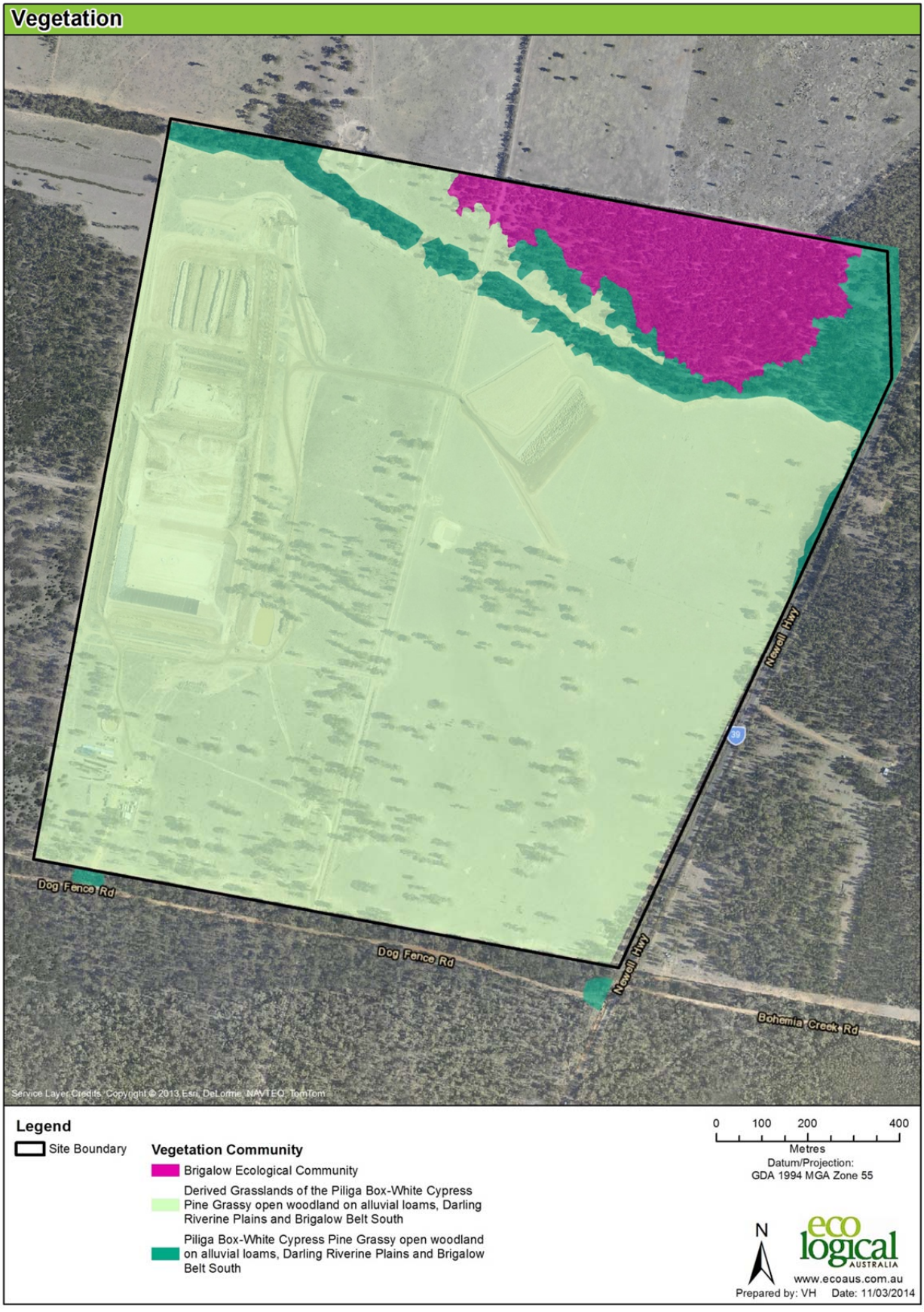

Figure 2: Vegetation as mapped in RPS (2012)

3.2 Flora

In total 59 flora species were recorded on the site, including six weed species. No threatened flora species were observed, although it is noted that surveys were undertaken outside of the survey period for some cryptic threatened flora species. However in regard to this, habitat within the disturbed Derived Grassland vegetation community, the focus of the proposed impacts, is not considered to be suitable habitat for any threatened flora species predicted in the area.

3.3 Fauna

Fauna were surveyed using a wide range of techniques including bird surveys, arboreal and terrestrial mammal trapping, hair funnels, herpetological searches, ultrasonic call recording for microchiropteran bats, spotlighting, call playback and searches for secondary or indirect evidence.

Fifty three fauna species were recorded on the site including 40 birds, nine mammals, two microchiropteran bats and two amphibians. One threatened bird was observed on the site, *Pomatostomus temporalis temporalis* (Grey-crowned Babbler), listed as vulnerable on the TSC Act.

3.4 Habitat

Three habitat types were identified on the site which ranged from moderate to poor condition. Cattle have had access to the entire site and present one of the major impacts to the communities present.

The predominantly cleared Pilliga Box – White Cypress vegetation community has had the most impact from cattle grazing and as a result has high levels of soil compaction and vegetation degradation. This community has very few habitat components such as mature canopy trees, tree hollows, logs, rocks or understorey vegetation. Feral species including the fox, pig, goat and rabbit were all recorded in this habitat type. Several small farm dams, heavily impacted by stock access are present within this community.

The moderate condition Pilliga Box – White Cypress community in the north east of the site provides the best habitat on the site. This community contained variably sized logs and stumps, understorey vegetation, albeit with a low diversity. There were numerous hollow-bearing trees with various hollow sizes suitable for small birds, bats and mammals.

The moderate-poor condition Brigalow Woodland community in the north east of the site contained only marginal habitat components. Few mature canopy trees were present and no hollow-bearing trees were recorded. Understorey vegetation was sparse and there was a paucity of logs. Significant damage by cattle grazing was evident.

The remnant vegetation on the site is highly connected with the Pilliga State Forest, with largely unrestricted movement between these areas. However, there is an existing dog proof fence along the southern and western boundaries of the property which will inhibit the movement of some ground dwelling fauna. As the Pilliga State Forest contains commensurate and superior habitat, the site is considered to form a small degraded patch of habitat for local flora and fauna.

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4 Impact assessment

Based on searches of the Atlas of NSW Wildlife (OEH 2013), review of relevant literature, vegetation mapping, results of flora and fauna surveys, presence of suitable habitat and professional judgement, a number of threatened species and ecological communities listed under the TSC Act and/or EPBC Act have been identified as having the potential to be impacted by the proposed activity.

The likelihood of presence or absence of threatened species, populations and ecological communities has been assessed with full details provided in **Appendix A**.

Twenty eight bird species, twelve mammals and four plants which are listed under the TSC Act and/or EPBC Act are determined to have a likelihood of occurrence of 'known', 'likely', or 'potential' to occur within the study area (**Table 2** & **Table 3**).

A discussion of the impacts on ecological values is provided below along with the avoidance and minimisation strategies recommended as part of the Leewood Phase 1 approvals (RPS 2012). These strategies have been taken into consideration in the assessment of impact to flora and fauna on the site.

4.1 Description of impacts

4.1.1 Direct impacts

The proposed construction of a water processing facility at 'Leewood' will include a number of different elements. The impacts are by in large restricted to the highly disturbed Pilliga Box – White Cypress derived grassland vegetation community (**Figure 3**). For the plant, equipment and infrastructure proposed the impact will result in the complete removal of vegetation and habitat. The area identified for irrigation will not result in the clearance of all vegetation but nonetheless will be assessed as such due to the indirect impacts from the addition of treated water to the land surface. The total area of direct impact from the proposed activity is 102.6 ha across the highly disturbed Pilliga Box – White Cypress derived grassland vegetation community.

4.1.2 Indirect impacts

Other impacts likely to result from the water processing facility at Leewood are associated with the treated (deionised and reverse osmosis) permeate water available for irrigation. Potential indirect impacts may arise from the irrigation process including spray drift, run-off, deep drainage and erosion. The treated water would classify as 'medium strength effluent' according to Table 3.1 of the NSW effluent guidelines, because it will rank as medium in Total Dissolved Solids (TDS) concentration of 792mg/L (medium range 600-1000mg/L). The treated water would rank as low strength effluent in the other categories listed, nitrogen, phosphorous, biochemical oxygen demand (BOD) and other potential contaminants (BeneTerra 2014).

Impacts to native vegetation including the listed Brigalow Ecological Community may arise from the impurities contained in the treated permeate water and may threaten the survival of the native vegetation *in situ*. Limited information on the sensitivity of the surrounding native vegetation is available, as such, a conservative approach has been applied and all native vegetation is assumed sensitive. Although, it is noted that *Acacia harpophylla* (Brigalow) and *Casuarina cristata* (Belah) are tolerant of saline conditions (van der Moezel et al. 1989; Reichman et al. 2006; DoE 2013), which are common in the soils on which they grow (DoE 2013).

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To limit the impact of spray drift into the adjoining vegetation, several mitigation techniques have been proposed. Two engineering controls will be employed including; use of low pressure drop nozzles operating at approximately 100 cm above the ground; and, variable rate irrigation systems allowing for the shutdown of various spans or individual nozzles in susceptible areas. In addition to these engineering controls two management controls will also be employed; regular visual inspections along the boundary of the sprinkler system; and, an automated control system linked to an anemometer to shut down the system in unfavourable wind speeds and directions.

The BeneTerra report (2014) quantified three parameters other than spray drift as having potential environmental impacts including runoff, deep drainage and erosion using their model approach (**Table 1**).

Table 1: Water losses from irrigation schedule with potential for environmental impacts (Amended Table 7 from BeneTerra 2014).

Water loss mechanism	Modelled scenario 4 Class A soils	Modelled scenario 4 Class B soils
Runoff (mm/yr)	14.6	17.6
Deep drainage (mm/yr)	4.3	5.7
Erosion and site sediment loss (t/ha-yr)	0.24	0.30

It is expected that given the high soil water deficit schedule being applied that runoff and deep drainage will be predominantly driven by rainfall, and will not be highly altered from conditions under a dryland pasture regime (BeneTerra 2014). The BeneTerra (2014) model suggests there will be small amounts of deep drainage beyond the root zone under irrigation as with the current pasture condition. Although the slopes are gentle and perennial cover will be maintained, it is expected that some water will run off the irrigated paddock.

An additional 0.2 ha of the Pilliga Box – White Cypress Pine Grassy Open Woodland community may be indirectly impacted because of the proposed irrigation activities.

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Figure 3: Impact footprint of the proposed activity

4.1.3 Avoidance measures

The following measures were recommended to avoid impacts as part of the Leewood Phase 1 approvals (RPS 2012). These strategies have been taken into consideration in the assessment of impact to flora and fauna on the site:

- No clearing within the remnant vegetation in the north of the site containing the Brigalow Woodland EEC and known Grey-crowned Babbler nesting sites.
- Access to the remnant vegetation in the north of the site is prohibited during the construction phase to maintain the ecological integrity of this habitat. During operation, the existing access track through this vegetation may be utilised by small vehicles, however no additional clearing is to occur.

4.1.4 Minimising impacts

The following measures were recommended to minimise potential impacts as part of the Leewood Phase 1 approvals (RPS 212). These strategies have been taken into consideration in the assessment of impact to flora and fauna on the site:

- Prevention of the spread of weed species by ensuring no seeds or plant material is removed from site and all vehicles and personnel are not accidently spreading weeds.
- Appropriate measures should be employed to ensure that machinery utilised on site are free of materials (soils etc.) such that they do not infect vegetation within the study area with *Phytophthora cinnamomi*, or cause the distribution of weed species.
- Vehicle speed should be minimised at all times on site to reduce the risk of fauna strike.
- An access track is required to intersect vegetation between Dog Proof Fence Road and the Leewood property boundary. Several areas provide a suitable width for the access track that will result in the clearing of *Callitris glaucophylla* and *Allocasuarina luehmannii* only. Clearing of large Eucalypts and hollowing bearing trees will be avoided.

4.2 Assessed species

The Pilliga region is a highly biodiverse region and a large number of threatened species are known to occur. The site is generally disturbed with only small areas of intact vegetation and important habitat features for threatened species. The highest value areas on the site are within the exclusion area and are not proposed to be impacted (**Figure 3**) and avoidance and minimisation strategies are in place to further reduce any potential impacts (**Section 5**).

The species listed below in **Table 2** and **Table 3** were either recorded on site or considered likely to occur on the site (see likelihood of occurrence table in **Appendix A**). As areas of the site will not be impacted and avoidance and minimisation strategies have been developed, some of the species that have potential to occur on the site will not be impacted by the proposed activity. As a result the full list of potential species has been divided into those that have potential to occur but not considered to be impacted (**Table 2**) and those that have the potential to occur or are known to occur and have the potential to be impacted (**Table 3**).

4.2.1 Species and communities not considered to be impacted

The species in **Table 2** have potential to occur but are not considered to be impacted due to the location of habitat on site and the avoidance and mitigation measures in place. Their potential to occur has been classed into one of the following circumstances (see **Appendix A**):

- Suitable habitat only within the Pilliga Box or Brigalow communities in the north of the site. There will be no disturbance to this habitat (beyond the irrigation) and no impacts are predicted.

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- Species likely to only overfly the study area and not utilise the habitat on site. As a result no impacts are predicted on this species.
- The study area is situated outside of the regular range of this species. This species is unlikely to be reliant on the habitat in the study area and there is a low potential for impact by the proposed activity.

As such, these species have not been further assessed as part of this proposed activity.

Table 2: Species and communities with potential to occur but not considered to be impacted by the proposed activity

Scientific name	Common name	TSC Act	EPBC Act
ECOLOGICAL COMMUNITIES			
Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions		E	
Brigalow (*Acacia harpophylla* dominant and co-dominant)			E
FLORA			
Diuris tricolor	Painted Diuris	V	~
Polygala linariifolia	Native Milkwort	E1	~
Pterostylis cobarensis	Greenhood Orchid	V	~
Tylophora linearis	-	V	E
FAUNA			
Aepyprymnus rufescens	Rufous Bettong	V	~
Apus pacificus	Fork-tailed Swift	-	M, Mar
Burhinus grallarius	Bush Stone-curlew	E1	~
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	~
Daphoenositta chrysoptera	Varied Sittella	V	~
Dasyurus maculatus	Spotted-tailed Quoll	V	E
Grantiella picta	Painted Honeyeater	V	~
Haliaeetus leucogaster	White-bellied Sea-Eagle	~	M, Mar
Hirundapus caudacutus	White-throated Needletail	-	M, Mar
Lophochroa leadbeateri (*Cacatua leadbeateri*)	Major Mitchell's Cockatoo / Pink Cockatoo	V	~
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	~
Neophema pulchella	Turquoise Parrot	V	~
Pachycephala inornata	Gilbert's Whistler	V	~
Petaurus norfolcensis	Squirrel Glider	V	~
Petroica boodang	Scarlet Robin	V	~
Polytelis swainsonii	Superb Parrot	V	V

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4.2.2 Species with potential to be impacted

The species in **Table 3** have potential or are known to occur on the site and have potential to be impacted by the proposed activity (see **Appendix A:**). An assessment of significance has been undertaken for these species.

Table 3: Species and communities considered potential, likely or known to occur on the site with potential to be impacted

Scientific name	Common name	TSC Act	EPBC Act
Anthochaera phrygia	Regent Honeyeater	CE	E, M
Ardea alba	Great Egret, White Egret	~	M, Mar
Ardea ibis	Cattle Egret	~	M, Mar
Chalinolobus dwyeri	Large-eared Pied Bat	V	V
Chalinolobus picatus	Little Pied Bat	V	~
Chthonicola sagittata	Speckled Warbler	V	~
Circus assimilis	Spotted Harrier	V	~
Glossopsitta pusilla	Little Lorikeet	V	~
Hamirostra melanosternon	Black-breasted Buzzard	V	~
Hieraaetus morphnoides	Little Eagle	V	~
Lathamus discolor	Swift Parrot	E1	E, Mar
Macropus dorsalis	Black-striped Wallaby	E1	~
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V	~
Merops ornatus	Rainbow Bee-eater	~	M, Mar
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	~
Ninox connivens	Barking Owl	V	~
Nyctophilus corbeni (syn. *Nyctophilus timoriensis* (South-eastern form))	South-eastern Long eared Bat / Corben's Long-eared Bat	V	V
Phascolarctos cinereus	Koala	V	V
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	~
Pteropus poliocephalus	Grey-headed Flying-fox	V	V
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	~
Stagonopleura guttata	Diamond Firetail	V	~
Tyto novaehollandiae	Masked Owl	V	~
Vespadelus troughtoni	Eastern Cave Bat	V	~

The following section provides an overview of the assessment process of the potential significance of the impacts from the proposed activity on ecological values considered to be impacted on site. A

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separate assessment of significance is required for entities listed under both the TSC Act and the EPBC Act.

The assessment of significances for species listed under the TSC Act in some instances have been grouped for the assessment process with species that contain similar characteristics and are likely to be impacted in a similar manner. These groupings include:

Birds

- Regent Honeyeater
- Owls:
  - Barking Owl and Masked Owl
- Parrots:
  - Little Lorikeet and Swift Parrot
- Birds of prey:
  - Spotted Harrier, Black-breasted Buzzard and Little Eagle
- Woodland birds – ground and mid-storey foraging (passerines):
  - Grey-crowned Babbler, Diamond Firetail, Speckled Warbler and Hooded Robin

Mammals

- Koala
- Grey-headed Flying-fox
- Black-striped Wallaby
- Predominantly tree-roosting bats:
  - Yellow-bellied Sheathtail-bat and South-eastern Long-eared Bat
- Predominantly cave-roosting bats:
  - Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat and Little Pied Bat

Specific 'Significant Impact Criteria' are provided for each Matter of National Environmental Significance (MNES) under the EPBC Act. The fauna have been assessed separately under their appropriate significant impact criteria, namely:

Critically endangered or endangered species

- Regent Honeyeater and Swift Parrot

Vulnerable species

- Koala, Large-eared Pied bat, South-eastern Long-eared Bat and Grey-headed Flying-fox

Migratory species

- Great Egret, Cattle Egret and Rainbow Bee-eater

4.3 Impacts to vegetation communities

A total of 0.2 ha of *White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion* has potential to be impacted by the proposed activity based on indicative impact footprints provided (**Table 4**). Much of this overlap of the proposed footprint on this vegetation

community is an artefact of the vegetation mapping resulting from an overhanging canopy. However, this impact will be restricted to the margins of the irrigation activity and will not result in any clearing. No impacts to any fauna or flora with potential to occur within this community are expected from the irrigation activities. As a result, it has been assumed for the purposes of this report that none of this community will be impacted.

The remaining impact will be on the Derived Grassland vegetation community, totalling 102.6 ha. This encompasses approximately 155 out of 250 individual trees of unknown age, but described as having very few mature canopy trees present. Approximately 158,384 ha of this vegetation type has been mapped in the study region and therefore the removal of 102.6 ha constitutes a 0.06% reduction of this vegetation community in the study region.

Table 4: Area of impact to vegetation communities on site

Impact	Vegetation community (RPS 2012)	Vegetation community (Benson et al 2006)	Area (ha)
Irrigation	Pilliga Box – White Cypress Pine Grassy Open Woodland	Pilliga Box - White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion	0.2 ha*
	Derived Grassland from Pilliga Box – White Cypress Pine Grassy Open Woodland	Derived Grassland	97.8 ha
Other site infrastructure	Derived Grassland from Pilliga Box – White Cypress Pine Grassy Open Woodland	Derived Grassland	4.8 ha

* Impact restricted to indirect impacts, no clearing or direct impact to this community

4.4 Impacts to threatened flora

No impacts to threatened flora are expected from this proposed activity.

4.5 Impacts to fauna habitat

There will be a direct loss of up to approximately 4.8 ha of fauna habitat as a result of the construction of water storage and associated plant and equipment along with construction of pipelines and road infrastructure. The remaining impact will be associated with the irrigation activities, which will remove the existing 97.8 ha of vegetation for the installation of irrigation infrastructure and the establishment of a suitable crop such as lucerne.

The total amount of potential foraging, breeding and roosting/sheltering habitat has been calculated for the disturbance areas within the study site to inform the significant impact assessments of the proposed activities (**Table 5**). The amount of loss of potential habitat in relation to the vegetation present within the study region has also been calculated.

Determination of the different types of habitat (foraging, breeding, roosting/sheltering) for individual threatened fauna species was made by first allocating vegetation types that would be used for foraging, breeding, and roosting/sheltering to individual species. The areas impacted were then summed for all vegetation types representing the type of habitat used by individual species within the study region.

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Table 5: Direct impact areas to potential threatened fauna habitat (no breeding or roosting habitat on site for any species)

Species	Foraging (ha) loss within study site / Loss in study region (%)[##]	Breeding (ha) loss within study site / loss in study region (%)[##]	Roosting (ha) loss within study site / Loss in study region (%)[##]
Regent Honeyeater	102.6 ha / 0.03 %	N/A[#]	-
Large-eared Pied Bat	102.6 ha / 0.02 %	N/A[#]	N/A[#]
Little Pied Bat	102.6 ha / 0.02 %	-	-
Speckled Warbler	102.6 ha / 0.02 %	-	-
Spotted Harrier	102.6 ha / 0.59 %	-	-
Little Lorikeet	102.6 ha / 0.03 %	-	-
Black-breasted Buzzard	102.6 ha / 0.59 %	-	-
Little Eagle	102.6 ha / 0.03 %	-	-
Swift Parrot	102.6 ha / 0.03 %	N/A[#]	-
Black-striped Wallaby	102.6 ha / 0.02 %	-	-
Hooded Robin (south-eastern form)	102.6 ha / 0.02 %	-	-
Eastern Bentwing-bat	102.6 ha / 0.02 %	N/A[#]	N/A[#]
Barking Owl	102.6 ha / 0.02 %	-	-
South-eastern Long eared Bat / Corben's Long-eared Bat	102.6 ha / 0.02 %	-	-
Koala	102.6 ha / 0.03 %	-	-
Grey-crowned Babbler (eastern subspecies)	102.6 ha / 0.02 %	-	-
Grey-headed Flying-fox	102.6 ha / 0.03 %	N/A[#]	N/A[#]
Yellow-bellied Sheathtail-bat	102.6 ha / 0.02 %	-	-
Diamond Firetail	102.6 ha / 0.02 %	-	-
Masked Owl	102.6 ha / 0.03 %	N/A[#]	N/A[#]
Eastern Cave Bat	102.6 ha / 0.02 %	N/A[#]	N/A[#]

[#] Breeding and/or roosting habitat has not been impacted or is not present for these species within the study region

[##] The regional vegetation class data utilised in this report is derived from a regional scale map that contains a proportion of modelling. Other datasets utilised are of varying scales and accuracies.

4.6 Indirect impacts

The proposed activity has potential to indirectly impact on vegetation communities and flora and fauna species present in the study area through habitat fragmentation, dust creation, introducing increased moisture, encouraging weed invasion and increases in noise and traffic.

Habitat fragmentation is considered to be minimal and connectivity will not be impacted. The site is currently largely cleared and disturbed, with only marginal habitat contained within the site boundary. The areas of habitat in the central portion of the site that will not be impacted by the proposed activity will still be connected to habitat to the south of the site. The proposed activity will not increase fragmentation with the surrounding vegetation being highly connected. No patches of habitat would be isolated as a result of the proposed activity.

The removal of vegetation would have an increased risk of dust formation. This is not expected to adversely impact on fauna on the site and this issue is addressed in the mitigation measures in **Section 5** to reduce the risk of this indirect impact.

The increase in soil moisture as a result of the irrigation has the potential to impact on the flora and fauna habitats within the site. The main influence will be in the north where the irrigation area adjoins the exclusion area. The increase in moisture content may benefit some local weed and pasture species and further increase their presence within the native vegetation communities. Mitigation measures in **Section 5** have been proposed to reduce the risk of this indirect impact.

Increases in noise during construction and operation of the proposed activity have potential to indirectly impact fauna both within the site and the adjacent habitat. Mitigation measures addressing behaviour of construction teams have been presented in **Section 5** to address this indirect impact. Noise during operation would largely be kept to a constant drone of infrastructure, rather than the intermittent and often times loud construction noise which is considered to be less of an impact on fauna.

4.7 Cumulative impacts

Cumulative impacts for Santos' defined exploration and appraisal activities have been assessed under the TSC Act (ELA 2013b) and the EPBC Act (ELA 2013c). These assessments address the removal of vegetation communities and habitat for threatened species at two different scales. The TSC Act assessment (ELA 2013b) had a broader focus and addressed the cumulative impact associated with all existing and proposed exploration and production appraisal activities associated within PEL 238 and PAL 2 (study region defined in this assessment). For the purposes of this assessment, the cumulative impacts are reported against the same study region included in the TSC Act assessment (ELA 2013b).

The cumulative impact assessed within this report include all activities from 2002 to the present including all proposed and planned activities.

At the date of this report, a total of 74.89 ha of *Derived Grassland* has been removed for exploration activities from the study region since 2002. From 2013 onwards, the 102.6 ha assessed within this report is the only additional area of this vegetation community to be removed at this stage. Importantly, the *Derived Grassland* on the site is of a much lower conservation value than remnant vegetation within the study region. This equates to a cumulative total of 177.49 ha of removal of this vegetation type. The study region has approximately 158,384 ha of this vegetation type remaining and hence removal of 177.49 ha equates to 0.11 % removal of this vegetation type in the study region.

A total of 11.77 ha of *Pilliga Box - White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion* has been removed for exploration activities from the study region since 2002. No additional areas of this community have been proposed to be removed at this stage, equating to cumulative total of 11.77 ha of removal of this vegetation type. The study region has approximately 37,418 ha of this vegetation type remaining and hence removal of 11.77 ha equates to 0.03 % removal of this vegetation type in the study region. The potential indirect impacts to 0.2 ha of this vegetation from irrigation activities has not been added to this cumulative total as the vegetation will not be removed and potential impacts are considered minimal.

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Cumulative impacts on threatened fauna addressed in this ecological assessment are presented in **Table 6**. These values include the 102.6 ha of vegetation impact for the proposed activity addressed in this ecological assessment.

Table 6: Cumulative direct impact areas to potential threatened fauna habitat from 2002

Species	Foraging (ha) loss within study region / Loss in study region (%)[##]	Breeding (ha) loss within study region / Loss in study region (%)[##]	Roosting (ha) loss within study region / Loss in study region (%)[##]
Regent Honeyeater	347.3 ha/0.11 %	N/A[#]	169.8 ha/0.06 %
Large-eared Pied Bat	349.7 ha/0.07 %	N/A[#]	N/A[#]
Little Pied Bat	349.7 ha/0.07 %	169.8 ha/0.03 %	169.8 ha/0.03 %
Speckled Warbler	349.7 ha/0.07 %	169.8 ha/0.06 %	169.8 ha/0.06 %
Spotted Harrier	213.5 ha/1.18 %	36 ha/0.2 %	36 ha/0.2 %
Little Lorikeet	349.7 ha/0.11 %	159.9 ha/0.05 %	169.8 ha/0.06 %
Black-breasted Buzzard	216.1 ha/1.19 %	0 ha/0%	12.3 ha/0.09 %
Little Eagle	349.7 ha/0.11 %	169.8 ha/0.06 %	169.8 ha/0.06 %
Swift Parrot	349.7 ha/0.11 %	N/A[#]	169.8 ha/0.06 %
Black-striped Wallaby	337.3 ha/0.07 %	157.4 ha/0.03 %	157.4 ha/0.03 %
Hooded Robin (south-eastern form)	349.7 ha/0.07 %	169.8 ha/0.06 %	169.8 ha/0.06 %
Eastern Bentwing-bat	349.7 ha/0.07 %	N/A[#]	N/A[#]
Barking Owl	349.7 ha/0.07 %	169.8 ha/0.06 %	169.8 ha/0.06 %
South-eastern Long eared Bat / Corben's Long-eared Bat	349.7 ha/0.07 %	169.8 ha/0.03 %	169.8 ha/0.03 %
Koala	347.3 ha/0.11 %	169.8 ha/0.06 %	169.8 ha/0.06 %
Grey-crowned Babbler (eastern subspecies)	349.7 ha/0.07 %	169.8 ha/0.03 %	169.8 ha/0.03 %
Grey-headed Flying-fox	347.3 ha/0.11 %	N/A[#]	N/A[#]
Yellow-bellied Sheathtail-bat	349.7 ha/0.07 %	169.8 ha/0.03 %	169.8 ha/0.03 %
Diamond Firetail	349.7 ha/0.07 %	169.8 ha/0.03 %	169.8 ha/0.03 %
Masked Owl	349.7 ha/0.11 %	36.2 ha/0.13 %	36.2 ha/0.13 %
Eastern Cave Bat	349.7 ha/0.07 %	N/A[#]	N/A[#]

Shaded Cells: no impact as part of this proposed activity, therefore no increase in cumulative impact

[#] Breeding and/or roosting habitat has not been impacted or is not present for these species within the study region

[##] The regional vegetation class data utilised in this report is derived from a regional scale map that contains a proportion of modelling. Other datasets utilised are of varying scales and accuracies.

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4.8 Conclusion of EP&A Act 7-part test

An Assessment of Significance under Section 5A of the EP&A Act (**Appendix B:**) was undertaken for those species with the potential to be impacted by the proposed activity (**Section 4.2.2**). The outcome of this assessment has determined that the proposed activity is *'unlikely'* to have a *'significant effect'* on the species within **Table 3** provided that the recommendations outlined in **Section 5** are fully adopted.

The proposed activity requires the removal of 102.6 ha of disturbed Derived Grassland. By in large the impact is concentrated on foraging habitat for the majority of the species to be impacted. Some impact to marginal roosting habitat for the Yellow-bellied Sheathtail-bat and South-eastern Long-eared Bat within the isolated paddock trees is expected. Additional sheltering habitat for the Black-striped Wallaby is found within the exclusion zone which will not be substantially impacted by the proposed activity.

The extent of habitat to be removed is considered a negligible impact in the context of the available resources in the remaining vegetation in the broader study region. The removal of the vegetation on the site will not affect habitat connectivity nor increase fragmentation of the remnants in the study area.

Recommendations have been provided in **Section 5** to further ameliorate any potential impacts on the site.

4.9 Conclusion of EPBC Act assessment

This section provides an overview of the assessment process of potential significance of impacts from the proposed activity on MNES. The EPBC Act Administrative Guidelines on Significance set out 'Significant Impact Criteria' that are to be used to assist in determining whether a proposed action is likely to have a significant impact on MNES (DoE 2013).

The assessment of impact (**Appendix C:**) was undertaken for those species with the potential to be impacted by the proposed activity (**Section 4.2.2**). The outcome of this assessment was that it is unlikely that the proposed activity would significantly impact on those threatened or migratory species assessed. The site provides only minor foraging habitat for the assessed species and additionally some marginal roosting habitat for the South-eastern Long-eared Bat. The level of habitat removal will be negligible in the context of the available habitat in the locality. As such, Referral to the Commonwealth under the EPBC Act is not recommended.

Recommendations have been provided in **Section 5** to further ameliorate the potential impacts on site.

4.10 SEPP 44 Koala assessment

The proposed activity is being assessed under Part 5 of the EP&A Act and as such an assessment under SEPP 44 is not technically required. However, due to the important nature of the Koala population in the Pilliga region an assessment has still been undertaken. As Narrabri LGA is listed on Schedule 1 of the SEPP and the site is greater than 1 ha, the following questions apply:

Step 1: Is the land potential Koala habitat?

The study area does not support any tree species which are listed in Schedule 2 as feed tree species. Therefore, the study area does not constitute potential Koala habitat. No further assessment is required.

5 Recommendations

Measures to mitigate the potential impacts of the proposed activity on ecological values have been provided below. These measures have been drawn from specifications for Leewood Phase 1 where possible to ensure consistency with current management practices.

5.1 Construction and maintenance of infrastructure

- The site boundary should be clearly marked in the field to ensure all clearing and construction activities occur within the approved footprint. Specifically, vegetation to be retained and part of the exclusion area in the north should be fenced off using 'fauna friendly' exclusion fencing (without barbed wire) in accordance with Santos policies.
- Regular scheduled weed inspections and appropriate control actions are required for the irrigation area and immediately surrounding vegetation. A weed management plan would be appropriate to regulate this.
- Appropriate sediment and erosion control measures should be installed and maintained as specified in the REF.
- Dust suppression during construction and use of access roads.
- All access during the pre-construction, construction, operational and rehabilitation phases should be through existing roads and designated access tracks.
- Removal of hollow-bearing trees should be undertaken with the supervision of an ecologist and following the clearing procedure developed by ELA and Santos, although no HBTs have been reported by RPS (2012) within the impact area.
- All personnel should be informed of their responsibilities whilst working on site in relation to ecological values, particularly in relation to the exclusion zone.
- Weed control measures should be in place during pre-construction, construction, operational and rehabilitation phases. These should include:
    - The establishment of wash down points for vehicles to prevent the transportation of seeds and soil.
    - Inspections of all equipment (machinery, tools, vehicles) brought on site to ensure that all equipment is free of materials where practicable (such as soils and seeds).
    - Documentation and records that detail the use of wash down points and inspections.
- Declared Noxious weeds (including *Opuntia* spp. Prickly Pear/ Tiger Pear) shall be managed in accordance with local and state guidelines. In the absence of these reference shall be made to the NSW *Noxious Weeds Act 1993* (NW Act).
- All areas disturbed during construction but outside of the final impact footprint should be progressively rehabilitated as soon as practicable following best practice guidelines.
- 40 km/h speed limits will be implemented at the site (i.e. construction and operational areas and access tracks constructed for the activity). Otherwise the posted speed limit will apply.

5.2 Irrigation of treated permeate water

- To control potential runoff and spray drift, the following controls are to be implemented within the centre-pivot sprinkler system as per the BeneTerra (2014) report and associated correspondence:
    - Low pressure drop nozzles operating 100 cm above the ground.
    - Variable rate irrigation system to allow automated shutdown of nozzles in susceptible areas.
    - Regular visual inspections along the boundaries of the system

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- Automated control system linked to an anemometer indicating wind speed and direction to allow programmed shut down of the system.

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6 Conclusion

Three vegetation communities were identified in the study area; *Pilliga Box – White Cypress Pine Grassy Open Woodland on Alluvial loams, Darling Riverine Plains and Brigalow Belt South; Derived Grasslands of the Pilliga Box – White Cypress Pine Grassy Open Woodland on Alluvial loams, Darling Riverine Plains and Brigalow Belt South; and Brigalow Woodland*. Of these communities, only the *Derived Grassland* will be impacted by the proposed activity, with the other two vegetation communities being contained within an exclusion area. The main important habitat components of the study area are contained within this exclusion zone.

A total of 25 listed fauna including 13 threatened birds, nine threatened mammals and three migratory birds were assessed as potentially, likely or known to occur in the study area and that were considered likely to be impacted by the proposed activity. The field surveys undertaken by RPS in 2012 identified only one threatened species; namely the Grey-crowned Babbler, listed as vulnerable under the TSC Act.

The proposed activity involving the removal of 102.6 ha of *Derived Grassland* is not considered likely to have a significant impact on ecological values listed under the TSC Act or EPBC Act or on the environment more broadly, provided the measures described in **Section 5** are adhered to.

Avoidance, minimisation and mitigation measures have been addressed in order to reduce the impact of the proposed activity on ecological values and the environment.

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Appendix A: Likelihood of occurrence table

The database searches within RPS (2012) were undertaken in April 2012. As a result of the age of these searches and the additional work that has been recently carried out in the Pilliga, newer database searches associated with the ecological assessment for the Dewhurst Expansion (ELA 2013) and the likelihood table therein have been used to determine the species with potential to be impacted by this proposed activity.

Provided below are the likelihood tables for threatened species listed under the TSC Act and EPBC Act. Threatened species, populations and communities considered to have the potential to occur are highlighted in yellow, those likely to occur are highlighted in brown, and those which are known occur are highlighted in green.

The analysis of the likelihood of occurrence table included previous reports conducted by ELA and RPS.

Key to the table:

- TSC Status = Listing under the NSW *Threatened Species Conservation Act 1995*
- EPBC Status = Listing under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
- CE = Critically Endangered
- E = Endangered (EPBC Act)
- E1 = Endangered (TSC Act)
- E2 = Endangered Population (TSC Act)
- E4 = Extinct (TSC Act)
- V = Vulnerable
- M = Migratory (EPBC Act)
- Mar = Marine (EPBC Act)

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east Pilliga forest	Likelihood of occurrence in the north-east Pilliga forest	Availability of habitat in the study area	RPS 2012 Likelihood	Likelihood of occurrence & impact in study area
FLORA										
Acacia jucunda	Yetman Wattle	E1	~	The Yetman Wattle is found in the Yetman district near the Queensland border on the North West Slopes of NSW. It also occurs in Queensland where it is reasonably common (OEH 2013b).	The Yetman Wattle is mainly restricted to the dry eucalypt forests or woodlands on sandy to sandy-loam soils. It is associated with other species in NSW including, *Acacia polybotrya* (Western Silver Wattle) and *Callitris endlicheri* (Black Cypress Pine). The species is known to occur within the Border Rivers – Gwydir CMA area but mostly restricted to the Yetman area.	Low	Unlikely	Low	–	Unlikely
Bertya opponens	Coolabah Bertya	V	V	Known from scattered sites in NSW including Coolabah, south of Narrabri on the North West Slopes (including Jacks Creek State Forest), Cobar and the North Coast.	Ranges from stony mallee ridges and cypress pine forest on red soils.	Moderate	Known	Low	Unlikely	Unlikely

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Boronia granitica	Granite Boronia	V	E	Granite Boronia is known from scattered localities on the New England Tablelands and North West Slopes north from the Armidale area to the Stanthorpe district in southern Queensland	Granite Boronia grows amongst granite outcrops, often in rock crevices, north from Inverell district.	No habitat	No	No habitat	–	Unlikely
Bothriochloa biloba	Lobed Blue-grass	~	V	Woodlands and grasslands on the western slopes and plains of NSW and QLD	Commonly found on clay soils	Low	Unlikely	Low	–	Unlikely
Cadellia pentastylis	Ooline	V	V	This species occurs along the western edge of the North West Slopes from north of Gunnedah to west of Tenterfield with some records from in Queensland. The natural range of Ooline is from 24ºS to 30ºS in the 500 to 750 mm per annum rainfall belt.	Ooline occurs in low- to medium-nutrient soils of sandy clay or clayey consistencies, with a typical soil profile having a sandy loam surface layer, grading from a light clay to a medium clay with depth.	Low	Unlikely	Low	Unlikely	Unlikely

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Cyperus conicus	A sedge	E1	~	This species occurs rarely in the Pilliga area of NSW and is also found in Victoria, Qld, the NT and WA	The species grows in open woodland on sandy soil. In central Australia, it grows near waterholes and on the banks of streams in sandy soils. In Qld the species is usually found on heavy soils. It has been recorded from Callitris forest in the Pilliga area, growing in sandy soil with *Cyperus gracilis*, *C. squarrosus* and *C. fulvus*.	Moderate	Potential	Low	–	Unlikely
Desmodium campylocaulon	Creeping Tick-Trefoil	E1	~	Occurs chiefly in the Collarenebri and Moree districts in the north-western plains of NSW. Also occurs in the NT and Darling Downs district of south-eastern Queensland (OEH 2013b)	In NSW the species grows on cracking black soils in the Narrabri, Moree and Walgett local government areas. It is associated with other species including *Acacia harpophylla, Astrebla pectinata* and *Sorghum, Dichanthium* and *Panicum* species. It flowers summer and autumn (OEH 2013b)	Low	Unlikely	No habitat	–	No potential

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Dichanthium setosum	Bluegrass	V	V	New England Tablelands, North West Slopes and Plains and the Central Western Slopes of NSW, as well as in Queensland and Western Australia.	Associated with heavy basaltic black soils. Often found in moderately disturbed areas such as cleared woodland, grassy roadside remnants and highly disturbed pasture.	Low	Unlikely	Low	–	Unlikely
Digitaria porrecta	Finger Panic Grass	E1	E	Occurs in NSW and Queensland. In NSW it is found on the North West Slopes and Plains, from near Moree south to Tambar Springs and from Tamworth to Coonabarabran.	Habitat includes native grassland, woodlands or open forest with a grassy understorey, on richer soils.	Low	Unlikely	Low	–	Unlikely
Diuris tricolor	Painted Diuris	V	~	Sporadically distributed on the western slopes of NSW, extending from south of Narrandera all the way to the far north of NSW.	Grows in sclerophyll forest among grass, often with native Cypress Pine (*Callitris spp.*). It is found in sandy soils, either on flats or small rises. Also recorded from a red earth soil in a Bimble Box community in western NSW. Disturbance regimes are not known, although the species is usually recorded from disturbed habitats.	High	Likely	Moderate	–	Potential Suitable habitat within the Pilliga Box or Brigalow communities in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted. No AoS has been undertaken.

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Haloragis exalata subsp. *velutina*	Tall Velvet Sea-berry	V	V	Disjunctly distributed in the central coast, south coast and north-western slopes botanical subdivisions of NSW	Protected and shaded damp situations in riparian habitats.	Low	Unlikely	Low	–	Unlikely
Homopholis belsonii	Belson's Panic	E1	V	North from the Warialda district and into Queensland	Habitat and ecology poorly known. Grows in dry woodland (e.g. Belah) on poor soils.	Low	Potential	Low	–	Unlikely
Lepidium aschersonii	Spiny Peppercress	V	V	Not widespread, occurring in the marginal central-western slopes and north-western plains regions of NSW (and potentially the south western plains). A several populations recorded at Narrabri. Also known from the West Wyalong, Barmedman and Temora areas.	Found on ridges of gilgai clays dominated by *Acacia harpophylla* (Brigalow), with *Austrodanthonia* and/or *Austrostipa* species in the understorey. The species grows as a component of the ground flora, in grey loamy clays. Vegetation structure varies from open to dense Brigalow, with sparse grassy understorey and occasional heavy litter.	Low	Potential	Low	Unlikely	Unlikely

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Lepidium monoplocoides	Winged Peppercress	E1	E	Widespread in the semi-arid western plains region of NSW. Recorded in previous ELA survey in Western Pilliga.	Known to occur on seasonally moist to waterlogged sites, on heavy fertile soils. In W Pilliga, it was found in White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion vegetation and associated with gilgais.	Moderate	Known	Low	–	Unlikely
Monotaxis macrophylla	Large-leafed Monotaxis	E1	~	Large-leaf Monotaxis is recorded from several highly disjunct populations in NSW: eastern edge of Deua NP (west of Moruya), Bemboka portion of South East Forests National Park, Cobar area (Hermitage Plains), the Tenterfield area, and Woodenbong (near the Queensland border). It is also in Queensland.	Grows on rocky ridges and hillsides. There is a great diversity in the associated vegetation within NSW (less though in Queensland), encompassing coastal heath, arid shrubland, forests and montane heath from almost sea level to 1300 m altitude.	Moderate	Potential	Low	–	Unlikely

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Myriophyllum implicatum		CE	~	This species was previously thought to be extinct in NSW; however the plant was recently discovered in the Pilliga National Park, south of Narrabri. It is known from QLD and is listed as 'Least Concern' under that States Nature Conservation Act (1992) (OEH 2013b).	The species occurs in moist situations, extending away from fresh water. A recent population was found in NSW in a large open partly inundated gilgai depression on cracking clay soil (OEH 2013b).	Low	Unlikely	Low	–	Unlikely
Philotheca ericifolia		~	V	Upper Hunter Valley and Pilliga to Peak Hill district	Grows chiefly in dry sclerophyll forest and heath on damp sandy flats and gullies	Low	Unlikely	Low	Unlikely	Unlikely
Platyzoma microphyllum	Braid Fern	E1	~	Species records exist in NSW only in the Yetman district. However, the species is widespread across northern Australia, from WA to the NT, eastern Qld and just into central-northern NSW (OEH 2013b).	It grows in sandy or swampy soils, or in clay soils adjacent to streams and lagoons and subject to periodic flooding. It has been recorded in NSW at Bruxner Highway growing as one localised patch in deep sandy soil, with *Leptospermum* species, *Brachyloma daphnoides* and *Lomandra* species (OEH 2013b).	Low	Unlikely	Low	–	Unlikely

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Polygala linariifolia	Native Milkwort	E1	~	Found north from Copeton Dam and the Warialda area to southern QLD; also found on the NSW north coast near Casino and Kyogle, and there is an isolated population in far western NSW near Weebah Gate, west of Hungerford. This species also occurs in Western Australia.	Occurs in sandy soils in dry eucalypt forest and woodland with a sparse understorey. The species has been recorded from the Inverell and Torrington districts growing in dark sandy loam on granite in shrubby forest of *Eucalyptus caleyi, Eucalyptus dealbata* and *Callitris*, and in yellow podsolic soil on granite in layered open forest.	High	Known	High	–	Potential Suitable habitat within the Pilliga Box or Brigalow communities in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted. No AoS has been undertaken.
Pomaderris queenslandica	Scant Pomaderris	E1	~	Records are widely scattered, but not common in north-east NSW and in Queensland. It is only known from a few locations on the New England Tablelands and North West Slopes, including near Torrington and Coolatai, and also from several locations on the NSW north coast.	The species is found in moist eucalypt forest or sheltered woodlands with a shrubby understorey, and occasionally along creeks.	Moderate	Known	Low	–	Unlikely

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Prasophyllum sp. *Wybong* (C.Phelps ORG 5269)	a leek-orchid	~	CE	Endemic to NSW. It is known from seven populations in eastern NSW near Ilford, Premer, Muswellbrook, Wybong, Yeoval, Inverell and Tenterfield	Known to occur in open eucalypt woodland and grassland	Low	Unlikely	Low	–	Unlikely
Pterostylis cobarensis	Greenhood Orchid	V	`	It is known chiefly from the Nyngan-Cobar-Bourke district in the far western plains of New South Wales. Recorded districts include Narrabri, Nyngan, Cobar, Nymagee, Mt Gundabooka, Mt Grenfell and Mutawintji National Park. There are also records from the Darling Downs district of Queensland.	The Greenhood Orchid is found in Eucalypt woodlands, open mallee or *Callitris* shrublands on low stony ridges and slopes in skeletal sandy-loam soils.	High	Known	High	Potential	Potential Marginal habitat within the Pilliga Box or Brigalow communities in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted. No AoS has been undertaken.
Pultenaea setulosa	Stony Bush-pea	~	V	Slopes and tablelands of NSW	Dry sclerophyll forest	Low	Unlikely	Low	–	Unlikely

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Rulingia procumbens		V	V	The species is endemic to NSW and mainly confined to the Dubbo-Mendooran-Gilgandra region, but also in the Pilliga and Nymagee areas.	It grows in sandy sites, often along roadsides. Recorded in *Eucalyptus dealbata* and *E. sideroxylon* communities, *Melaleuca uncinata* scrub, under mallee eucalypts with a *Calytrix tetragona* understorey, and in a recently burnt Ironbark and *Callitris* area. It also occurs in *E. fibrosa* subsp. *nubila, E. dealbata, E. albens* and *Callitris glaucophylla* woodlands north of Dubbo.	High	Known	Low	Potential	Unlikely Typically on sandy soils and areas with dense low shrubs. Habitat not described on site.
Sida rohlenae	Shrub Sida	E1	~	It has a limited distribution in QLD, the NT, SA and WA. In NSW it has been recorded south of Enngonia, south of Bourke and north-west of Coonamble	It occurs in flood-out areas, creek banks and at the base of rocky hills. NSW specimens have been found along roadsides in hard red loam to sandy-loam soils.	Low	Unlikely	Low	–	Unlikely

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Swainsona murrayana	Slender Darling Pea	V	V	The species is found throughout NSW. It has been recorded in the Jerilderie and Deniliquin areas of the southern Riverine plain, the Hay plain as far north as Willandra National Park, near Broken Hill and in various localities between Dubbo and Moree.	The species has been collected from clay-based soils, ranging from grey, red and brown cracking clays to red-brown earths and loams. It grows in a variety of vegetation types including bladder saltbush, black box and grassland communities on level plains, floodplains and depressions and is often found with Maireana species.	Low	Unlikely	Low	–	Unlikely
Thesium australe	Austral Toadflax	V	V	Small populations are scattered across eastern NSW, along the coast, and from the Northern to Southern Tablelands. It is also found in Tasmania and Queensland and in eastern Asia.	Austral Toadflax occurs in grassland or grassy woodland and often found in damp sites in association with *Themeda australis* (Kangaroo Grass).	Low	Unlikely	Low	–	Unlikely

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Tylophora linearis	-	V	E	The species is found in the Barraba, Mendooran, Temora and West Wyalong districts in the northern and central western slopes of NSW.	It grows in dry scrub and open forest. Recorded from low-altitude sedimentary flats in dry woodlands of *Eucalyptus fibrosa*, *E. sideroxylon*, *E. albens*, *Callitris endlicheri*, *C. glaucophylla* and *Allocasuarina luehmannii*.	High	Known	High	Potential	Potential Suitable habitat within the Pilliga Box or Brigalow communities in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted. No AoS has been undertaken.

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FAUNA										
Aepyprymnus rufescens	Rufous Bettong	V	~	The original range from Coen in north Queensland to central Victoria has been reduced to a patchy distribution from Cooktown, Queensland, to north-eastern NSW as far south as Mt Royal National Park. In NSW it has largely vanished from inland areas but there are sporadic, unconfirmed records from the Pilliga and Torrington districts. (OEH 2013b)	Prefer forests with a grassy to sparse understorey including coastal forest, tall wet sclerophyll forest and dry forests west of GDR (OEH 2013b). It is most commonly found on sites derived from sedimentary rock and in north eastern NSW in forests characterised by *Corymbia maculata* (Spotted Gum) and *C. henryi* (OEH 2013b). It has been known to feed on introduced pasture species (OEH 2013b).	Moderate	Potential	Moderate	–	Potential Suitable habitat within the Pilliga Box community in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted. No AoS has been undertaken.
Alectura lathami	Australian Brush-turkey	E2	~	The Australian Brush-turkey has a largely coastal distribution from Cape York south as far as the Illawarra in NSW. A population of the Australian Brush-turkey is known from the Nandewar and Brigalow Belt South Bioregions. Recent records for the species show the	It occurs in forested and wooded areas of tropical and warm-temperate districts, particularly above 300 m to at least 1200 m altitude. In NSW the inland vegetation type preferred by the Australian Brush-turkey is a dry rainforest community that is found within the Semi-evergreen Vine Thicket in the Brigalow Belt South and	No habitat	No	No habitat	–	No potential

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				population to range from north east of Warialda, to Narrabri, approximately 115 km to the south-west, and occur within the local government areas of Yallaroi, Bingara, Narrabri, Barraba and Moree Plains. (OEH 2013b)	Nandewar Bioregions Endangered Ecological Community (OEH 2013b)					
Anomalopus mackayi	Five-clawed Worm-skink	E1	V	Patchy distribution on the North West Slopes and Plains of north-east NSW and south-east Queensland, from the Ashford area west to Mungindi and Walgett in NSW and north to Dalby in Queensland (OEH 2013b)	Close to or on the lower slopes of slight rises in grassy White Box woodland on moist black soils, and River Red Gum-Coolibah-Bimble Box woodland on deep cracking loose clay soils. May also occur in grassland areas and open paddocks with scattered trees. Live in permanent deep tunnel-like burrows and deep soil cracks, coming close to the surface under fallen timber and litter, especially partially buried logs (OEH 2013b)	Low	Unlikely	Low	–	Unlikely
Anseranas semipalmata	Magpie Goose	V	~	The Magpie Goose is still relatively common in the Australian northern tropics, but had disappeared from south-east Australia	Activities centred on terrestrial sedge-dominated wetlands; mainly those on floodplains of rivers (Marchant & Higgins 1993 Simpson & Day 1999).	Low	Unlikely	No habitat	–	No potential

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				by 1920 due to drainage and overgrazing of reed swamps used for breeding. Since the 1980s there have been an increasing number of records in central and northern NSW. Vagrants can follow food sources to south-eastern NSW (OEH 2013b)						
Anthochaera phrygia	Regent Honeyeater	CE	E, M	The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. Once recorded between Adelaide and the central coast of Queensland, its range has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland (OEH 2013b)	Associated with temperate eucalypt woodland and open forest including forest edges, wooded farmland and urban areas with mature eucalypts, and riparian forests of *Casuarina cunninghamiana* (River Oak) (Garnett 1993). Areas containing *Eucalyptus robusta* (Swamp Mahogany) in coastal areas have been observed to be utilised. The Regent Honeyeater primarily feeds on nectar from box and ironbark eucalypts and occasionally from banksias and mistletoes (NPWS 1995). As such it is reliant on locally abundant nectar sources with different	High	Potential	Moderate	Unlikely	Potential Study area provides foraging habitat when *E. crebra* is in flower. Study area is unlikely to provide a reliable or abundant foraging habitat. However, it is possible that this species may use the study area on occasion.

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					flowering times to provide reliable supply of nectar (Environment Australia 2000).					
Aprasia parapulchella	Pink-tailed Legless Lizard	V	V	It is known only to occur in the Central and Southern Tablelands and South Western Slopes of NSW. Populations have been recorded in the Queanbeyan/Canberra district, Cooma, Yass, Bathurst, Albury and West Wyalong areas (DECC 2007)	It inhabits open woodland that has a predominately native grass understorey that is situated on sloping, well-drained soils with rocky outcrops or scattered partially buried rocks present. Burrows are formed beneath small, partially embedded rocks that are often inhabited by small black ants and termites. The Pink-tailed Worm-lizard feeds on the larvae and eggs of the ants with which it shares its burrows. In the summer months 2 eggs are laid inside the ant nests with the young first appearing in March. (DECC 2007)	Low	Unlikely	Low	–	Unlikely
Apus pacificus	Fork-tailed Swift	-	M Mar	The Fork-tailed Swift is a non-breeding visitor to all states and territories of Australia. In NSW, the Fork-tailed Swift is recorded in all regions. Many records occur east of the Great Divide,	Sometimes travels with Needletails. Varied habitat with a possible tendency to more arid areas but also over coasts and urban areas (Simpson & Day 1999).	High	Known	High	Potential	Potential Species likely to only overfly the study area and not utilise the habitat on site. As a result no impacts are predicted on

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				however, a few populations have been found west of the Great Divide. These are widespread but scattered further west of the line joining Bourke and Dareton. Sightings have been recorded at Milparinka, the Bulloo River and Thurloo Downs (DoE 2013b)						this species. No AoS has been undertaken.
Ardea alba	Great Egret, White Egret	~	M, Mar	Eastern Great Egrets are widespread in Australia. They occur in all states/territories of mainland Australia and in Tasmania. They have also been recorded as vagrants on Lord Howe, Norfolk and Macquarie Islands (DoE 2013b)	The Great Egret is common and widespread in Australia (McKilligan 2005). It forages in a wide range of wet and dry habitats including permanent and ephemeral freshwaters, wet pasture and estuarine mangroves and mudflats (McKilligan 2005).	Moderate	Likely	Moderate	Potential	Potential Suitable habitat features such as dams on the site
Ardea ibis	Cattle Egret	~	M, Mar	The Cattle Egret is widespread and common according to migration movements and breeding localities surveys. Two major distributions have been located; from north-east Western Australia to the Top End of the Northern	Cattle Egrets forage on pasture, marsh, grassy road verges, rain puddles and croplands, but not usually in the open water of streams or lakes and they avoid marine environments (McKilligan 2005). Some individuals stay close to the natal heronry from one nesting season to the next,	Moderate	Likely	Moderate	Potential	Potential Suitable habitat features such as dams on the site

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				Territory and around south-east Australia. In Western Australia and the Northern Territory, the Cattle Egret is located from Wyndham to Arnhem Land. In south-east Australia it is found from Bundaberg, inland to Roma, Thargominda, and then down through Inverell, Walgett, Nyngan, Cobar, Ivanhoe, Balranald to Swan Hill, and then west to Pinnaroo and Port Augusta (DoE 2013b)	but the majority leave the district in autumn and return the next spring. Cattle Egrets are likely to spend the winter dispersed along the coastal plain and only a small number have been recovered west of the Great Dividing Range (McKilligan 2005).					
Ardeotis australis	Australian Bustard	E1	~	The Australian Bustard mainly occurs in inland Australia and is now scarce or absent from southern and south-eastern Australia. In NSW, they are mainly found in the north-west corner and less often recorded in the lower western and central west plains regions. Occasional vagrants are still seen as far east as the western	Mainly inhabits tussock and hummock grasslands, though prefers tussock grasses to hummock grasses; also occurs in low shrublands and low open grassy woodlands; occasionally seen in pastoral and cropping country, golf courses and near dams (OEH 2013b)	High	Potential	Moderate	–	Unlikely Some grassland habitat but highly disturbed from grazing and little surrounding habitat

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				slopes and Riverine plain. Breeding now only occurs in the north-west region of NSW (OEH 2013b)						
Botaurus poiciloptilus	Australasian Bittern	E1	E	Australasian Bitterns are widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west (OEH 2013b)	Terrestrial wetlands with tall dense vegetation, occasionally estuarine habitats (Marchant & Higgins 1993). Reedbeds, swamps, streams, estuaries (Simpson & Day 1999).	Low	Unlikely	Low	–	Unlikely
Burhinus grallarius	Bush Stone-curlew	E1	~	The Bush Stone-curlew is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is it still common however and in the south-east it is either rare or extinct throughout its former range.	Associated with dry open woodland with grassy areas, dune scrubs, in savanna areas, the fringes of mangroves, golf courses and open forest / farmland (Pittwater Council 2000; Marchant & Higgins 1993). Forages in areas with fallen timber, leaf litter, little undergrowth and where the grass is short and patchy (Environment Australia 2000; Marchant & Higgins 1993). Is thought to require large tracts of habitat to support breeding, in which there is a preference for relatively undisturbed to lightly	High	Known	Moderate	–	Potential The study area has areas of open woodland with fallen timber and little undergrowth although this is restricted to the Pilliga Box communities in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted. No AoS has

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					disturbed					been undertaken.
Calyptorhynchus banksii (inland subspecies)	Red-tailed Black-Cockatoo	V	~	The Red-tailed Black-Cockatoo is the most widespread of the Black-Cockatoos, ranging broadly across much of northern and western Australia as well as western Victoria. In NSW, one population occurs on the north-western slopes and plains but another small isolated population is found in the coastal north-east. (OEH 2013b).	Occurs in coastal forests and woodlands or inland open shrubland near water (Simpson & Day 1999). This species is noted to feed mainly on seeds, especially of eucalypts, casuarinas, acacia and banksias. May also take berries, nectar, flowers and occasionally insects and their larvae (Marchant & Higgins 1993).	Low	Unlikely	Low	–	Unlikely The study area is situated outside of the regular range of this species.
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	~	The species is uncommon although widespread throughout suitable forest and woodland habitats, from the central Queensland coast to East Gippsland in Victoria, and inland to the southern tablelands and central western	Associated with a variety of forest types containing *Allocasuarina* species, usually reflecting the poor nutrient status of underlying soils (Environment Australia 2000; OEH 2013b). Intact drier forest types with less rugged landscapes are preferred (OEH 2013b). Nests in large trees with	High	Known	Moderate	–	Potential Suitable habitat within the Pilliga Box community in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted.

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				plains of NSW, with a small population in the Riverina. An isolated population exists on Kangaroo Island, South Australia (OEH 2013b)	large hollows (Environment Australia 2000).					No AoS has been undertaken.
Cercartetus nanus	Eastern Pygmy-possum	V	~	The Eastern Pygmy-possum is found in south-eastern Australia, from southern Queensland to eastern South Australia and in Tasmania. In NSW it extends from the coast inland as far as the Pilliga, Dubbo, Parkes and Wagga Wagga on the western slopes. (OEH 2013b). It occupies small home ranges, rarely greater than 1 ha.	Found in wet and dry eucalypt forest, subalpine woodland, coastal banksia woodland and wet heath (Menkhorst & Knight 2004). Pygmy-Possums feed mostly on the pollen and nectar from banksias, eucalypts and understorey plants and will also eat insects, seeds and fruit (Turner & Ward 1995). The presence of *Banksia* sp. and *Leptospermum* sp. are an important habitat feature (OEH 2013b). Small tree hollows are favoured as day nesting sites, but nests have also been found under bark, in old birds nests and in the branch forks of tea-trees (Turner & Ward 1995).	High	Known	Low	–	Unlikely Whilst the broader north-east Pilliga Forest contains known habitat for the Eastern Pygmy-possum, the study area does not support suitable habitat for this species (i.e. the study area does not have a heathy understorey suitable for foraging).

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Certhionyx variegatus	Pied Honeyeater	V	~	Widespread throughout acacia, mallee and Spinifex scrubs of arid and semi-arid Australia. Occasionally occurs further east, on the slopes and plains and the Hunter Valley, typically during periods of drought (OEH 2013b).	Inhabits wattle shrub (primarily Mulga, *Acacia aneura*), mallee, Spinifex and eucalypt woodlands, usually when shrubs are flowering; feeds on nectar, predominantly from various species of emu-bushes (*Eremophila* spp.); also from mistletoes and various other shrubs (e.g. *Brachystema* spp. and *Grevillea* spp.); also eats saltbush fruit, berries, seed, flowers and insects. Highly nomadic, following the erratic flowering of shrubs; can be locally common at times (OEH 2013b)	Low	Unlikely	Low	–	Unlikely
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Found mainly in areas with extensive cliffs and caves, from Rockhampton in Queensland south to Bungonia in the NSW Southern Highlands. It is generally rare with a very patchy distribution in NSW. There are scattered records from the New England Tablelands and North West Slopes. (OEH 2013b)	The Large-eared Pied Bat has been recorded in a variety of habitats, including dry sclerophyll forests, woodland, sub-alpine woodland, edges of rainforests and wet sclerophyll forests (Churchill 1998; DECC 2007). This species roosts in caves, rock overhangs and disused mine shafts and as such is usually associated with rock outcrops and cliff faces	High	Potential	High	Unlikely	Potential No breeding habitat for this species is present in the study area. The treed areas are suitable for foraging.

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					(Churchill 1998).					
Chalinolobus picatus	Little Pied Bat	V	~	The Little-Pied Bat is found in inland Queensland and NSW (including Western Plains and slopes) extending slightly into South Australia and Victoria.	Occurs in dry open forest, open woodland, mulga woodlands, chenopod shrublands, cypress-pine forest, mallee, Bimbil box. Roosts in caves, rock outcrops, mine shafts, tunnels, tree hollows and buildings. Feeds on moths and possibly other flying invertebrates.	High	Known	High	Potential	Potential Suitable habitat within the study areas for roosting and foraging.
Chthonicola sagittata	Speckled Warbler	V	~	The Speckled Warbler has a patchy distribution throughout south-eastern Queensland, the eastern half of NSW and into Victoria, as far west as the Grampians. The species is most frequently reported from the hills and tablelands of the Great Dividing Range, and rarely from the coast. There has been a decline in population density throughout its range, with the decline exceeding 40% where no vegetation remnants larger than	Occupies a wide range of eucalypt dominated communities with a grassy understorey, often on rocky ridges or in gullies (OEH 2013b). Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy (OEH 2013b). Large, relatively undisturbed remnants are required for the species to persist in an area (OEH 2013b). Pairs are sedentary and occupy a breeding territory of about ten hectares, with a slightly larger home-range when not breeding (OEH 2013b)	High	Known	High	–	Potential Suitable habitat on site close to large remnants.

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				100ha survive. (OEH 2013b)						
Circus assimilis	Spotted Harrier	V	~	The Spotted Harrier occurs throughout the Australian mainland, except in densely forested or wooded habitats of the coast, escarpment and ranges, and rarely in Tasmania. Individuals disperse widely in NSW and comprise a single population. (OEH 2013b)	Occurs in grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe. It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands. Builds a stick nest in a tree and lays eggs in spring (or sometimes autumn), with young remaining in the nest for several months. Preys on terrestrial mammals (e.g. bandicoots, bettongs, and rodents), birds and reptile, occasionally insects and rarely carrion.	Moderate	Potential	Moderate	Potential	Potential Breeding and foraging habitat for this species is present in the study area.

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Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	~	The Brown Treecreeper is endemic to eastern Australia and occurs in eucalypt forests and woodlands of inland plains and slopes of the Great Dividing Range. It is less commonly found on coastal plains and ranges. The western boundary of the range of Climacteris picumnus victoriae runs approximately through Corowa, Wagga Wagga, Temora, Forbes, Dubbo and Inverell and along this line the subspecies intergrades with the arid zone subspecies of Brown Treecreeper Climacteris picumnus picumnus which then occupies the remaining parts of the state (OEH 2013b)	Found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range. It mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and *Eucalyptus camaldulensis* (River Red Gum) Forest. Generally not found in woodlands with a dense shrub layer. Fallen timber is an important habitat component for foraging. It is sedentary and nests in tree hollows within permanent territories (OEH 2013b).	High	Unlikely The north-east Pilliga Forest lies outside of the geographically defined area for the eastern subspecies	High	Potential	No potential The north-east Pilliga Forest lies outside of the geographically defined area for the eastern subspecies
Crinia sloanei	Sloane's Froglet	V	~	Sloane's Froglet has been recorded from widely scattered sites in the floodplains of the Murray-Darling	It is typically associated with periodically inundated areas in grassland, woodland and disturbed habitats.	Low	Unlikely	Low	–	Unlikely

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				Basin, with the majority of records in the Darling Riverine Plains, NSW South Western Slopes and Riverina bioregions in New South Wales. It has not been recorded recently in the northern part of its range and has only been recorded infrequently in the southern part of its range in NSW (OEH 2013b)						
Daphoenositta chrysoptera	Varied Sittella	V	~	Varied Sittellas are endemic and widespread in mainland Australia. (OEH 2013b)	Varied Sittellas are found in eucalypt woodlands and forests throughout their range. They prefer rough-barked trees like stringybarks and ironbarks or mature trees with hollows or dead branches (OEH 2013b)	High	Known	High	–	Potential Suitable habitat within the Pilliga Box or Brigalow communities in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted. No AoS has been undertaken.

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Dasyurus maculatus	Spotted-tailed Quoll	V	E	The range of the Spotted-tailed Quoll has contracted considerably since European settlement. It is now found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Queensland. Only in Tasmania is it still considered common. (OEH 2013b)	It inhabits a range of environments including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Den sites are found in hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces. Females occupy home ranges of up to 750 ha and males up to 3,500 ha, which are usually traversed along densely vegetated creek lines. (OEH 2013b).	Moderate	Potential	Low	–	Potential Suitable habitat within the Pilliga Box or Brigalow communities in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted. No AoS has been undertaken.

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Delma torquata	Collared Delma	~	V	The main concentrations of records are from the western suburbs of Brisbane. Urban development in these suburbs has resulted in a contraction of previously recorded populations in this area (Ryan 2006a). The species is also known from the following sites: the Bunya Mountains; Blackdown Tableland National Park (NP); Bullyard Conservation Park (CP); D'Aquilar Range NP, Expedition NP; Naumgna and Lockyer Forest Reserves (inside Bunya Mountains NP; Western Creek, near Millmerran; and the Toowoomba Range (Davidson 1993; Ryan 2006a).	The Collared Delma normally inhabits eucalypt or acacia dominated woodland and open forest where it is associated with suitable microhabitats (exposed rocky outcrops, or a sparse understorey of tussock grass, shrubs or semi-evergreen vine thickets). *Corymbia citriodora* (Lemon-scented Gum) is typically the dominant canopy species. Other dominant canopy species include *Eucalyptus crebra*, E. melanophloia, *E. tessellaris*, *E. moluccana*, *E. microcorys*, *E. tereticornis*, *Angophora* sp. and *Acacia harpophylla* (Brigalow) (Peck 2003, cited in Peck & Hobson 2007; Ryan 2006a). Leaf Litter appears to be an essential part of the microhabitat and is always present. (DoE 2013b)	Low	Unlikely	Low	–	Unlikely
Drymodes brunneopygia	Southern Scrub-robin	V	~	This species is restricted to mallees and shrublands across southern Australia and in NSW is confined to two	Inhabits mallee and acacia scrub, particularly with dense sub-shrubs in the understorey, including Broombush and other dry shrubs	Moderate	Unlikely	Low	–	Unlikely The study area is situated outside of the regular range of this species.

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				main areas. The first is in central NSW and is centred on Round Hill and Nombinnie Nature Reserves, though suitable habitat probably exists on adjoining leasehold lands. The other population occurs in the far south west of NSW, mainly within the Scotia mallee centred on Tarawi NR and Scotia Sanctuary						
Ephippiorhynchus asiaticus	Black-necked Stork	E1	~	In Australia, Black-necked Storks are widespread in coastal and subcoastal northern and eastern Australia, south to central-eastern NSW and with vagrants recorded at scattered sites well away from the coast (for example, near Moree, north-east of Hay and in Victoria). In NSW, the species becomes more uncommon south of the Northern Rivers region, and rarely occurs south of Sydney (OEH 2013b)	Associated with tropical and warm temperate terrestrial wetlands, estuarine and littoral habitats, and occasionally woodlands and grasslands floodplains (Marchant & Higgins 1993). Forages in fresh or saline waters up to 0.5m deep, mainly in open fresh waters, extensive sheets of shallow water over grasslands or sedgeland, mangroves, mudflats, shallow swamps with short emergent vegetation and permanent billabongs and pools on floodplains (Marchant & Higgins 1993; OEH	Low	Unlikely	Low	–	Unlikely

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					2013b).					
Epthianura albifrons	White-fronted Chat	V	~	The White-fronted Chat is found across the southern half of Australia, It is found mostly in temperate to arid climates and very rarely sub-tropical areas, it occupies foothills and lowlands up to 1000 m above sea level. In NSW, it occurs mostly in the southern half of the state, in damp open habitats along the coast, and near waterways in the west. Along the coast, it is found mostly in saltmarsh vegetation but also in open grasslands and sometimes in low shrubs bordering wetland areas. (OEH 2013b)	Gregarious species, usually found foraging on bare or grassy ground in wetland areas, singly or in pairs. They are insectivorous, feeding mainly on flies and beetles caught from or close to the ground. Have been observed breeding from late July through to early March, with 'open-cup' nests built in low vegetation. Nests in the Sydney region have also been seen in low isolated mangroves. Nests are usually built about 23 cm above the ground (but have been found up to 2.5 m above the ground). (OEH 2013b)	Low	Unlikely	Low	–	Unlikely
Erythrotriorchis radiatus	Red Goshawk	CE	V	Red Goshawks are found from across northern Australia, down the east coast of Qld and into the northern coast of NSW. In NSW records are rare.	Its habitat consists of wooded and forested areas. Prefers forest and woodland with a mosaic of vegetation types, large populations of birds for prey and permanent water. Riverine vegetation is	Moderate	Unlikely	Low	–	Unlikely

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				Listed as having occurred south to Port Stephens.	highly utilised by this species. Its habits are not well known, but it is considered to be a solitary, sedentary bird. They nest in tree forks of *Eucalypt* sp. and *Melaleuca* sp. or those nests of other large birds such as Magpies or Crows. The nests are generally built of sticks, which are lined with soft twigs and leaves					
Falco hypoleucos	Grey Falcon	E1	~	The Grey Falcon is sparsely distributed in NSW, chiefly throughout the Murray-Darling Basin, with the occasional vagrant east of the Great Dividing Range. The breeding range has contracted since the 1950s with most breeding now confined to arid parts of the range. There are possibly less than 5000 individuals left. Population trends are unclear, though it is believed to be extinct in areas with more than 500 mm rainfall in NSW (OEH 2013b)	Usually restricted to shrubland, grassland and wooded watercourses of arid and semi-arid regions, although it is occasionally found in open woodlands near the coast. Also occurs near wetlands where surface water attracts prey (OEH 2013b)	Moderate	Potential	Low	–	Unlikely

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Gallinago hardwickii	Latham's Snipe, Japanese Snipe	~	M, Mar	The species has been recorded along the east coast of Australia from Cape York Peninsula through to south-eastern South Australia. The range extends inland over the eastern tablelands in south-eastern Queensland (and occasionally from Rockhampton in the north), and to west of the Great Dividing Range in New South Wales (DoE 2013b).	This species occurs in permanent and ephemeral wetlands up to 2000 m above sea-level, usually inhabiting open, freshwater wetlands with low, dense vegetation such as swamps, flooded grasslands or heathlands, around bogs and other water bodies. This species can also occur in habitats with saline or brackish water and in modified or artificial habitats. It feeds in mud, either exposed or in very shallow water with low, dense vegetation. Roosting occurs on the ground near or in foraging areas beside or under clumps of vegetation, among dense tea-tree, in forests, in drainage ditches or plough marks, among boulders, or in shallow water if cover is unavailable. They feed on a variety of seeds, plant material, and insects.	Low	Potential	Low	Unlikely	Unlikely

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Geophaps scripta scripta	Squatter Pigeon	E	V	The Squatter Pigeon (southern) occurs on the inland slopes of the Great Dividing Range. Its distribution extends from the Burdekin-Lynd divide in central Queensland, west to Charleville and Longreach, east to the coastline between Proserpine and Port Curtis (near Gladstone), and south to scattered sites though out south-eastern Queensland. It's distribution historically extended into NSW, however, there have been no confirmed records of the species in NSW since the 1970s.	The Squatter Pigeon (southern) occurs mainly in grassy woodlands and open forests that are dominated by eucalypts . It has also been recorded in sown grasslands with scattered remnant trees, disturbed habitats (i.e. around stockyards, along roads and railways, and around settlements, in scrub and acacia growth, and remains common in heavily-grazed country north of the Tropic of Capricorn (EPA 2006). The species is commonly observed in habitats that are located close to bodies of water.	Low	Unlikely	Low	Unlikely	Unlikely

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Glossopsitta pusilla	Little Lorikeet	V	~	The Little Lorikeet is distributed widely across the coastal and Great Divide regions of eastern Australia from Cape York to South Australia. NSW provides a large portion of the species' core habitat, with lorikeets found westward as far as Dubbo and Albury. Nomadic movements are common, influenced by season and food availability, although some areas retain residents for much of the year and 'locally nomadic' movements are suspected of breeding pairs (OEH 2013b).	Little Lorikeets mostly occur in dry, open eucalypt forests and woodlands. They have been recorded from both old-growth and logged forests in the eastern part of their range, and in remnant woodland patches and roadside vegetation on the western slopes. They feed primarily on nectar and pollen in the tree canopy, particularly on profusely-flowering eucalypts, but also on a variety of other species including melaleucas and mistletoes. On the western slopes and tablelands *Eucalyptus albens* and *E. melliodora* are important food sources for pollen and nectar respectively.	High	Known	High	–	Likely Suitable habitat on site and numerous records in the region. Likely to use the study area for foraging (especially for *E. crebra*).
Grantiella picta	Painted Honeyeater	V	~	The Painted Honeyeater is nomadic and occurs at low densities throughout its range. The greatest concentrations of the bird (and almost all breeding), occurs on the inland slopes of the Great Dividing	The Painted Honeyeater inhabits Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests. It feeds on mistletoes growing on woodland eucalypts and acacias. It nests from spring to autumn in a small, delicate nest hanging within the outer canopy of drooping	High	Likely	High	–	Potential Suitable habitat within the Pilliga Box or Brigalow communities in the north east of the site. There will be no disturbance to this habitat and no impacts are

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				Range in NSW, Victoria and southern QLD. During the winter it is more likely to be found in the north of its distribution (OEH 2013b)	eucalypts, she-oak, paperbark or mistletoe branches.					predicted. No AoS has been undertaken.
Grus rubicunda	Brolga	V	~	The Brolga was formerly found across Australia, except for the south-east corner, Tasmania and the south-western third of the country. It still abundant in the northern tropics, but very sparse across the southern part of its range (OEH 2013b).	The Brolga was formerly found across Australia, except for the south-east corner, Tasmania and the south-western third of the country. It still abundant in the northern tropics, but very sparse across the southern part of its range (OEH 2013b).	Low	Unlikely	Low	–	Unlikely
Haliaeetus leucogaster	White-bellied Sea-Eagle	~	M, Mar	The White-bellied sea-eagle is distributed along the coastline of mainland Australia and Tasmania. It also extends inland along some of the larger waterways, especially in eastern Australia. The inland limits of the species are most restricted in south-central and south-western Australia, where it is confined to a narrow band along	Forages over large open fresh or saline waterbodies, coastal seas and open terrestrial areas (Marchant & Higgins 1993, Simpson & Day 1999). Breeding habitat consists of tall trees, mangroves, cliffs, rocky outcrops, silts, caves and crevices and is located along the coast or major rivers. Breeding habitat is usually in or close to water, but may occur up to a kilometre away (Marchant & Higgins	Moderate	Known	Low	Unlikely	Potential Species likely to only overfly the study area and not utilise the habitat on site. As a result no impacts are predicted on this species. No AoS has been undertaken.

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				the coast (DoE 2013b).	1993)					
Hamirostra melanosternon	Black-breasted Buzzard	V	~	The Black-breasted Buzzard is found sparsely in areas of less than 500 mm rainfall, from north-western NSW and north-eastern South Australia to the east coast at about Rockhampton, then across northern Australia south almost to Perth, avoiding only the Western Australian deserts (OEH 2013b)	This species lives in a range of inland habitats including open forests, riverine woodlands, scrubs and heathlands. It is often found along timbered watercourses, which is preferred breeding habitat. It can also hunt over grasslands and includes reptiles, small mammals, birds and large eggs in its prey.	Low	Potential	Low	–	Potential There is potential for this species to forage on site
Hieraaetus morphnoides	Little Eagle	V	~	The Little Eagle is found throughout the Australian mainland excepting the most densely forested parts of the Dividing Range escarpment. It occurs as a single population throughout NSW.	The Little Eagle is seen over woodland and forested lands and open country, extending into the arid zone. It tends to avoid rainforest and heavy forest (OEH 2013b)	High	Likely	Moderate	–	Potential This species has potential to fly over the study area or forage in the study area. It is unlikely to breed in the study area.
Hirundapus caudacutus	White-throated Needletail	-	M, Mar	The White-throated Needletail is found throughout eastern and south-eastern Australia. In eastern NSW, it is found to	In Australia, this species is almost exclusively aerial and found over most types of habitat (DoE 2013b).	High	Known	High	Unlikely	Potential Species likely to only overfly the study area and not utilise the habitat on site.

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				extend inland to the western slopes of the Great Divide and occasionally to the adjacent inland plains (DoE 2013b).						As a result no impacts are predicted on this species. No AoS has been undertaken.
Hoplocephalus bitorquatus	Pale-headed Snake	V	~	A patchy distribution from north-east Queensland to north-east NSW. In NSW it occurs from the coast to the western side of the Great Divide as far south as Tuggerah (OEH 2013b).	Wide range of habitats from rain or wet sclerophyll forest to drier eucalypt forests and favours streamside habitat in drier areas (OEH 2013b).	High	Likely	Low	–	Unlikely
Jalmenus eubulus	Pale Imperial Hairstreak	CE	~	It is found in Queensland and NSW. In Queensland it is restricted to the seasonally sub-humid central and southern areas of the state. In NSW it is found only in Brigalow - dominated open forests and woodlands in northern areas of the state.	Suitable habitat is dominated by *Acacia harpophylla* (Brigalow) and *Casuarina cristata* (Buloke) on clay soils on flat to gently undulating plants, usually with scattered emergent eucalypts. It is only known to breed in old-growth forest or woodland and does not appear to colonise regrowth habitats after clearing	Low	Unlikely	Low	–	Unlikely
Lagorchestes leporides	Eastern Hare-wallaby	E4	Ex	The Eastern Hare-wallaby was common in open plains country around the Murray River and in the	This species generally spent the day sheltering and foraged at night, it sheltered under large tussocks which it	Low	No	Low	–	No

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				grasslands and woodlands of western Victoria and southeastern South Australia, but it has not been seen alive this century. Last South Australian record: Lucindale, 1892 (South Australia Museum n.d)	excavated itself.					
Lathamus discolor	Swift Parrot	E1	E, Mar	Breeds in Tasmania between September and January. Migrates to mainland in autumn, where it forages on profuse flowering Eucalypts (Blakers et al. 1984; Schodde and Tidemann 1986; Forshaw and Cooper 1981).	On mainland, autumn and winter flowering eucalypts are important for this species. Favoured feed trees include winter flowering species such as *Eucalyptus robusta*, *Corymbia maculata*, *C. gummifera* (Red Bloodwood), *E. sideroxylon* (Mugga Ironbark and *E. albens* (OEH 2013b).	High	Potential	Moderate	–	Potential Study area provides foraging habitat when *E. crebra* is in flower.
Leipoa ocellata	Malleefowl	E1	V, M	The stronghold for this species in NSW is the mallee in the south west centred on Mallee Cliffs NP and extending east to near Balranald and as far north as Mungo NP. In central NSW it has been significantly reduced through land clearance and fox	Dry inland scrub, mallee. Males tend large sand nest-mound (Simpson & Day 1999).	Low	Unlikely	Low	Potential	Unlikely Sub-optimal habitat on site with no mallee or scrub vegetation. Nest-mounds are highly obvious

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				predation and now occurs chiefly in Yathong, Nombinnie and Round Hill NRs and surrounding areas, though birds continue to survive in Loughnan NR (OEH 2013b).						
Leporillus apicalis	Lesser Stick-nest Rat	E4	Ex	The last specimen of the Lesser Stick-nest Rat was captured near Mt Crombie. south-west of the present Amata settlement, South Australia in 1933. However, in the nineteenth century it occupied a broad area stretching from the Riverina in New South Wales, through most of inland South Australia and into the Gibson Desert, reaching the Western Australian coast in the Gascoyne region (Burbidge et al. 1988; Cole & Woinarski 2000; Finlayson 1961).	The Lesser Stick-nest Rat occupied arid and semi-arid lands (Burbidge et al. 1988; Cole & Woinarski 2000).	Low	No	Low	–	Unlikely

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Limosa limosa	Black-tailed Godwit	V	~	In NSW, it is most frequently recorded at Kooragang Island (Hunter River estuary). Records in western NSW indicate that a regular inland passage is used by the species, as it may occur around any of the large lakes in the western areas during summer, when the muddy shores are exposed. It has been recorded within the Murray-Darling Basin, on the western slopes of the Northern Tablelands and in far north-western NSW.	The Black-tailed Godwit is a migratory wading bird that breeds in Mongolia and Eastern Siberia (Palaearctic) and flies to Australia for the southern summer, arriving in August and leaving in March. Primarily a coastal species, it is usually found in sheltered bays, estuaries and lagoons with large intertidal mudflats and/or sandflats. Further inland, it can also be found on mudflats and in water less than 10 cm deep, around muddy lakes and swamps.	Low	Unlikely	Low	–	Unlikely
Litoria booroolongensis	Booroolong Frog	E1	E	It is restricted to the tablelands and slopes from 200 to 1300 m above sea level in NSW and north eastern Victoria. The species is mostly found along the western-flowing streams and their headwaters of the Great Dividing Range. Catchments drain from the Northern	Typically inhabits rocky western-flowing creeks and their headwaters, although a small number of animals have also been recorded in eastern-flowing streams. along permanent streams with some fringing vegetation cover such as ferns, sedges or grasses (DoE 2013b)	No habitat	No	No habitat	–	No potential

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				Tablelands to the Tumut River in the Southern Highlands, and other tributaries of the Murrumbidgee River. The only records of the species in northern NSW outside the Northern Tablelands are from two streams near Tamworth, NSW.						
Lophochroa leadbeateri (*Cacatua leadbeateri*)	Major Mitchell's Cockatoo / Pink Cockatoo	V	~	Found across the arid and semi-arid inland, from south-western Queensland south to north-west Victoria, through most of South Australia, north into the south-west Northern Territory and across to the west coast between Shark Bay and about Jurien. In NSW it is found regularly as far east as about Bourke and Griffith, and sporadically further east than that. (OEH 2013b)	Inhabits a wide range of tree and treeless inland habitats, always within easy reach of water. Feeds mostly on the ground, especially on the seeds of native and exotic melons and on the seeds of species of saltbush, wattles and cypress pines. (OEH 2013b)	Moderate	Unlikely	Moderate	–	Potential Suitable habitat on site and the presence of water in the form of dams. However, the study area is situated outside of the regular range of this species. This species is unlikely to be reliant on the habitat in the study area and there is a low potential for impact by the proposed activity. No AoS has

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										been undertaken.
Lophoictinia isura	Square-tailed Kite	V	~	The Square-tailed Kite ranges along coastal and subcoastal areas from south-western to northern Australia, Queensland, NSW and Victoria. In NSW, scattered records of the species throughout the state indicate that it is a regular resident in the north, north-east and along the major west-flowing river systems. It is a summer breeding migrant to the south-east, including the NSW south coast, from September to March	In coastal areas, this species is associated with tropical and temperate forests and woodlands on fertile soils with an abundance of passerine birds (Marchant & Higgins 1993, OEH 2013b). May be recorded inland along timbered watercourses (OEH 2013b). In NSW it is commonly associated with ridge or gully forests dominated by *Eucalyptus longiflora* (Woollybutt), C*. maculata*, or *E. elata* and *E. smithii* (OEH 2013b).	High	Likely	Low	–	Unlikely Species is generally associated with watercourses and forest vegetation.
Maccullochella peelii	Murray Cod	-	V	The Murray Cod remains patchily distributed throughout the Murray-Darling Basin, but has undergone an extensive decline in abundance (Koehn and Clunie 2010). Commercial fisheries data indicate that natural populations	The Murray Cod is the largest Australian freshwater fish, and is endemic to the Murray-Darling River system (Lintermans 2007). It is a top order 'sit and wait' aquatic predator, which prefers deep holes in rivers with instream cover such as rocks, stumps, fallen trees or undercut banks	No habitat	No	No habitat	Unlikely	No

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				declined in the 1920s and then again dramatically in the 1950s (Lintermans 2007). More recent survey data from the Basin states indicates some NSW populations may be recovering (Koehn and Clunie 2010). Murray Cod populations in the Border Rivers, Gwydir, Namoi, mid-Murrumbidgee, lower Darling and lower Murray rivers appear to be in good condition (defined as widespread, abundant and recruiting) (Koehn and Clunie 2010).	(Lintermans 2007).					
Macropus dorsalis	Black-striped Wallaby	E1	~	From the Townsville area in Queensland to northern NSW where it occurs on both sides of the Great Divide. On the North West Slopes of NSW it occurs in Brigalow remnants to south of Narrabri. On the north coast it is confined to the upper catchments of the Clarence and	Preferred habitat is characterised by dense woody or shrubby vegetation within three metres of the ground. This dense vegetation must occur near a more open, grassy area to provide suitable feeding habitat. On the North West Slopes, it is associated with dense vegetation, including brigalow, ooline and semi-	High	Known	Moderate	–	Potential Site contains suitable Brigalow vegetation and adjacent open areas.

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				Richmond Rivers	evergreen vine thicket. On the north coast, it is closely associated with dry rainforest but also occur in moist eucalypt forest with a rainforest understorey or a dense shrub layer.					
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V	~	The Hooded Robin is, found across Australia, except for the driest deserts and the wetter coastal areas - northern and eastern coastal Queensland and Tasmania. However, it is common in few places, and rarely found on the coast. The south-eastern form (subspecies *cucullata* is found from Brisbane to Adelaide and throughout much of inland NSW, with the exception of the extreme north-west, where it is replaced by subsp. *picata*	Associated with a wide range of Eucalypt woodlands, Acacia shrubland and open forests. In temperate woodlands, the species favours open areas adjoining large woodland blocks, with areas of dead timber and sparse shrub cover. Hooded Robin home ranges are relatively large, averaging 18ha for birds from the New England Tableland. It is considered a sedentary species, but local seasonal movements are possible.	High	Known	High	–	Potential Suitable woodland habitat with adjoining open areas

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Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	~	This subspecies extends south from central Queensland, through NSW, Victoria into south eastern SA. In NSW it is widespread, with records from the tablelands and western slopes of the Great Dividing Range to the north-west and central-west plains and the Riverina. It is rarely recorded east of the Great Dividing Range, although regularly observed from the Richmond and Clarence River areas. It has also been recorded at a few scattered sites in the Hunter, Central Coast and Illawarra regions	Predominantly associated with box-ironbark association woodlands, especially *Eucalyptus sideroxylon*, *E. albens*, *E. microcarpa* and *E. tereticornis*. Also inhabits open forests of smooth-barked gums, stringybarks, ironbarks and tea-trees, and River Red Gum (OEH 2013b).	High	Likely	High	–	Potential Suitable habitat within the Pilliga Box or Brigalow communities in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted. No AoS has been undertaken.
Merops ornatus	Rainbow Bee-eater	~	M, Mar	The Rainbow Bee-eater is distributed across much of mainland Australia, and occurs on several near-shore islands. It is not found in Tasmania, and is thinly distributed in the	Occurs in open country, chiefly at suitable breeding places in areas of sandy or loamy soil: sand-ridges, riverbanks, road-cuttings, sand-pits, occasionally coastal cliffs (ibid). Nest is a chamber at the end of a burrow, up to 1.6 m long,	High	Known	Moderate	Unlikely	Potential. Suitable foraging habitat exists on site along with dams as nesting locations

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				most arid regions of central and Western Australia (DoE 2013b).	tunnelled in flat or sloping ground, sandy back or cutting (ibid).					
Miniopterus australis	Little Bentwing-bat	V	~	This species occurs along the East coast and ranges of Australia from Cape York in Queensland to Wollongong in NSW.	Prefers well-timbered areas including rainforest, wet and dry sclerophyll forests, Melaleuca swamps and coastal forests (Churchill 1998). This species shelters in a range of structures including culverts, drains, mines and caves (Environment Australia 2000). Relatively large areas of dense vegetation of either wet sclerophyll forest, rainforest or dense coastal banksia scrub are usually found adjacent to caves in which this species is found (OEH 2013b). Breeding occurs in caves, usually in association with *M. schreibersii* (OEH 2013b).	Low	Unlikely	Low	–	Unlikely
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	~	Eastern Bentwing-bats occur along the east and north-west coasts of Australia	Associated with a range of habitats such as rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grassland (Churchill 1998). It forages above and below the tree canopy on small insects	High	Known	High	–	Potential This species is known nearby to the study area and is likely to forage in the area.

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					(Dwyer 1995, Dwyer 1981). Will utilise caves, old mines, and stormwater channels, under bridges and occasionally buildings for shelter (Environment Australia 2000, Dwyer 1995).					
Monarcha melanopsis	Black-faced Monarch	~	M, Mar	Widespread in eastern Australia. In NSW, the species occurs around the slopes and tablelands inland to Armidale. It is rarely recorded further inland (DoE 2013b).	The Black-faced Monarch mainly occurs in rainforest ecosystems, including semi-deciduous vine-thickets, complex notophyll vine-forest, tropical (mesophyll) rainforest, subtropical (notophyll) rainforest, mesophyll (broadleaf) thicket/shrubland, warm temperate rainforest, dry (monsoon) rainforest and (occasionally) cool temperate rainforest (DoE 2013b)	Low	Unlikely	Low	–	Unlikely
Mormopterus norfolkensis	Eastern Freetail-bat	V	~	The Eastern Freetail-bat is found along the east coast from south Queensland to southern NSW.	Most records of this species are from dry eucalypt forest and woodland east of the Great Dividing Range (Churchill 1998). Individuals have, however, been recorded flying low over a rocky river in rainforest and wet sclerophyll forest and foraging in clearings at	Low	Unlikely	Low	–	Unlikely

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					forest edges (Environment Australia 2000; Allison & Hoye 1998). Primarily roosts in hollows or behind loose bark in mature eucalypts, but have been observed roosting in the roof of a hut (Environment Australia 2000; Allison & Hoye 1998).					
Myiagra cyanoleuca	Satin Flycatcher	~	M, Mar	In NSW, they are widespread on and east of the Great Divide and sparsely scattered on the western slopes, with very occasional records on the western plains (DoE 2013b)	Satin Flycatchers inhabit heavily vegetated gullies in eucalypt-dominated forests and taller woodlands, and on migration, occur in coastal forests, woodlands, mangroves and drier woodlands and open forests (DoE 2013b)	High	Known	Low	Unlikely	Unlikely
Myotis macropus	Large-footed / Southern Myotis	V	~	The Large-footed Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. It is rarely found more than 100 km inland, except along major rivers	Generally roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage. Forage over streams and pools catching insects and small fish by raking their feet across the water surface	Low	Unlikely	Low	–	Unlikely

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Neophema pulchella	Turquoise Parrot	V	~	The Turquoise Parrot's range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range (OEH 2013b)	Steep rocky ridges and gullies, rolling hills, valleys and river flats and the plains of the Great Dividing Range compromise the topography inhabited by this species (Marchant & Higgins 1993). Spends much of the time on the ground foraging on seed and grasses (OEH 2013b). It is associated with coastal scrubland, open forest and timbered grassland, especially low shrub ecotones between dry hardwood forests and grasslands with high proportion of native grasses and forbs (Environment Australia 2000).	High	Known	Moderate	–	Potential Apart from the north east corner there is little in the way of native forbs. There will be no disturbance to this habitat and no impacts are predicted. No AoS has been undertaken
Ninox connivens	Barking Owl	V	~	The Barking Owl is found throughout continental Australia except for the central arid regions. Although common in parts of northern Australia, the species has declined greatly in southern Australia and now occurs in a wide but sparse distribution in NSW. Core	Associated with a variety of habitats such as savanna woodland, open eucalypt forests, wetland and Riverine forest. Habitat is typically dominated by Eucalypts (often Redgum species), but can also be dominated by *Melaleuca* species in the tropics (OEH 2013b). It usually roosts in dense foliage in large trees such as *Casuarina*	High	Known	Moderate	–	Potential Few roosting resources on site but some marginal foraging habitat.

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				populations exist on the western slopes and plains (especially the Pilliga) and in some northeast coastal and escarpment forests (OEH 2013b)	*cunninghamiana*, other *Casuarina* and *Allocasuarina*, eucalypts, *Angophora*, *Acacia* and rainforest species from streamside gallery forests (NPWS 2003). It usually nests near watercourses or wetlands (NPWS 2003) in large tree hollows with entrances averaging 2-29 metres above ground.					
Ninox strenua	Powerful Owl	V	~	It is endemic to eastern and south-eastern Australia, mainly on the coastal side of the Great Dividing Range from Mackay to south-western Victoria. In NSW, it is widely distributed throughout the eastern forests from the coast inland to tablelands, with scattered, mostly historical records on the western slopes and plains. Now uncommon throughout its range where it occurs at low densities	It inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. The species breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation comprising species such as Turpentine, Black She-oak, Blackwood, Rough-barked Apple, Cherry Ballart and a number of eucalypt species.	Low	Unlikely	Low	–	Unlikely

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Nyctophilus corbeni (syn. *Nyctophilus timoriensis* (South-eastern form))	South-eastern Long eared Bat / Corben's Long-eared Bat	V	V	The distribution of the south eastern form coincides approximately with the Murray Darling Basin with the Pilliga Scrub region being the distinct stronghold for this species (OEH 2013b).	It inhabits a variety of vegetation types including mallee, bulloke and box eucalypt dominated communities. However, it is more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland. Roosts in tree hollows, crevices and under loose bark.	High	Known	High	Potential	Potential This species is known nearby to the study area and is likely to forage in the area.
Oxyura australis	Blue-billed Duck	V	~	The Blue-billed Duck is endemic to south-eastern and south-western Australia. It is widespread in NSW, but most common in the southern Murray-Darling Basin area. Birds disperse during the breeding season to deep swamps up to 300 km away. It is generally only during summer or in drier years that they are seen in coastal areas. (OEH 2013b)	The Blue-billed Duck prefers deep water in large permanent wetlands and swamps with dense aquatic vegetation (OEH 2013b). The species is completely aquatic, swimming low in the water along the edge of dense cover (OEH 2013b). They are partly migratory, with short-distance movements between breeding swamps and over-wintering lakes with some long-distance dispersal to breed during spring and early summer (OEH 2013b).	Low	Unlikely	Low	–	Unlikely
Pachycephala inornata	Gilbert's Whistler	V	~	This species occurs across most of NSW's semi-arid and arid	This species occurs in arid and semi-arid timbered habitats in mallee	Moderate	Potential	Moderate	–	Potential Suitable habitat

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				regions. The eastern population extends from the central NSW mallee (Yathong, Nombinnie and Round Hill NRs), south and east through the Cocoparra Range to Pomingalama Reserve (near Wagga Wagga) then north through the South West Slopes east as far as Cowra and Burrendong Dam, to the Goonoo reserves (with scattered records as far north as Pilliga (OEH 2013b).	shrubland, and occasionally in box-ironbark woodlands, Cypress Pine and Belah woodlands and River Red Gum forests. Within mallee the species often occurs in association with an understorey of Spinifex and low shrubs of acacias, hakeas, sennas and grevilleas. In woodland habitats, the understorey contains areas of dense shrubbery (OEH 2013b).					within the Pilliga Box or Brigalow communities in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted. No AoS has been undertaken.
Petaurus australis	Yellow-bellied Glider	V	~	This species is found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland, through NSW to Victoria	This species occurs in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. Forest type preferences vary, with mixed coastal forests to dry escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south. Their den sites are in hollows of large trees. They can occupy large home ranges between 20 to 85 ha to encompass dispersed and seasonally	Low	Unlikely	Low	–	Unlikely

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					variable food resources					
Petaurus norfolcensis	Squirrel Glider	V	~	The species is widely though sparsely distributed in eastern Australia, from northern Queensland to western Victoria. (OEH 2013b)	Associated with dry hardwood forest and woodlands (Menkhorst et al. 1988; Quin 1995). Habitats typically include gum barked and high nectar producing species, including winter flower species (Menkhorst et al. 1988). The presence of hollow bearing eucalypts is a critical habitat value (Quin 1995).	High	Likely	Moderate	–	Potential Suitable habitat within the Pilliga Box or Brigalow communities in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted. No AoS has been undertaken.
Petrogale penicillata	Brush-tailed Rock-wallaby	E1	V	The range of this species extends from south-east Queensland to the Grampians in western Victoria, roughly following the line of the Great Dividing Range. However the distribution across its original range has declined significantly in the west and south and has become more fragmented. In NSW they occur from the Queensland border in the north to the	This species occupies rocky areas (escarpments and outcrops) in a variety of habitats, typically north facing sites with numerous ledges, caves and crevices (Strahan 1995). They generally browse on vegetation in and adjacent to rocky areas, eating grasses and forbs as well as the foliage and fruits of shrubs and trees.	Moderate	Unlikely	Low	Unlikely	Unlikely

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				Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit (OEH 2013b).						
Petroica boodang	Scarlet Robin	V	~	The Scarlet Robin is found from SE Queensland to SE South Australia and also in Tasmania and SW Western Australia. In NSW, it occurs from the coast to the inland slopes. After breeding, some Scarlet Robins disperse to the lower valleys and plains of the tablelands and slopes. Some birds may appear as far west as the eastern edges of the inland plains in autumn and winter.	The Scarlet Robin is primarily a resident in forests and woodlands, but some adults and young birds disperse to more open habitats after breeding. It lives in dry eucalypt forests and woodlands with an understorey that is usually open and grassy with few scattered shrubs. It can live in both mature and regrowth vegetation with an abundance of logs and fallen timber an important component of its habitat.	High	Potential	High	–	Potential Suitable habitat within the Pilliga Box or Brigalow communities in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted. No AoS has been undertaken.
Petroica phoenicea	Flame Robin	V	~	The Flame Robin is endemic to SE Australia, and ranges from near the Queensland border to SE South Australia and also in Tasmania. In NSW, it breeds in	It breeds in upland tall moist eucalypt forests and woodlands, often on ridges and slopes. The species prefers clearings or areas with open understoreys. The ground layer of the breeding habitat is	Low	Unlikely	Low	–	Unlikely

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				upland areas and in winter, many birds move to the inland slopes and plains. It is likely that there are two separate populations in NSW, one in the Northern Tablelands, and another ranging from the Central to Southern Tablelands (OEH 2013b).	dominated by native grasses and the shrub layer may be either sparse or dense. It occasionally occurs in temperate rainforest, and also in herbfields, heathlands, shrublands and sedgelands at high altitudes (OEH 2013b).					
Phaethon rubricauda	Red-tailed Tropicbird	V	Mar	This species of Marine bird occurs throughout tropical and subtropical zones of the Indian and West Pacific Oceans. Breeding occurs on oceanic islands, with the largest breeding site occurring on Lord Howe Island. Vagrant birds occur in coastal water of NSW, and occasionally inland, particularly after storm events (OEH 2013b)	It is a Marine species that breeds in coastal cliffs and under bushes in tropical Australia. It nests on cliffs of the northern hills and southern mountains on the main island at Lord Howe Island (OEH 2013b)	Low	Unlikely	No habitat	–	No potential

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east Pilliga forest	Likelihood of occurrence in the north-east Pilliga forest	Availability of habitat in the study area	RPS 2012 Likelihood	Likelihood of occurrence & impact in study area
Phascogale tapoatafa	Brush-tailed Phascogale	V	~	The Brush-tailed Phascogale has a patchy distribution around the coast of Australia. In NSW it is mainly found east of the Great Dividing Range although there are some records west of the divide (OEH 2013b).	It prefers dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter, but can also inhabit heath, swamps, rainforest and wet sclerophyll forest. It nests and shelters in tree hollows, with entrances 2.5 - 4 cm wide and can use many hollows over a short time span (OEH 2013b).	Low	Unlikely	Low	–	Unlikely
Phascolarctos cinereus	Koala	V	V	The Koala has a fragmented distribution throughout eastern Australia from north-east Queensland to the Eyre Peninsula in South Australia. In NSW it mainly occurs on the central and north coasts with some populations in the west of the Great Dividing Range. It was briefly historically abundant in the 1890s in the Bega District on the south coast of NSW, although not elsewhere, but it now occurs in sparse and possibly disjunct populations. Koalas	Associated with both wet and dry Eucalypt forest and woodland that contains a canopy cover of approximately 10 to 70% (Reed et al. 1990), with acceptable Eucalypt food trees. Some preferred *Eucalyptus* species are: *Eucalyptus tereticornis*, *E. punctata*, *E. cypellocarpa* and *E. viminalis.*	High	Likely	Low	Potential	Potential Nearby records and some marginal habitat on site

Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east Pilliga forest	Likelihood of occurrence in the north-east Pilliga forest	Availability of habitat in the study area	RPS 2012 Likelihood	Likelihood of occurrence & impact in study area
				are also known from several sites on the southern tablelands (OEH 2013b).						
Polytelis anthopeplus monarchoides	Regent Parrot (Eastern Subspecies)	E1	V	The Regent Parrot (eastern) is confined to the semi-arid interior of southeastern mainland Australia. In NSW, the Regent Parrot (eastern) is confined to the southern Lower Western Region, mainly along the Murray River, from Kyalite, north west to Mallee Cliffs State Forest, and is also recorded near Wentworth and the Rufous River. Away from the Murray River, the subspecies is recorded at isolated localities including west of Moonlight Lake, Arumpo Station, and near Pooncarie	The Regent Parrot (eastern) primarily inhabits riparian or littoral *Eucalyptus camaldulensis* (River Red Gum) forests or woodlands and adjacent *E. largiflorens* (Black Box) woodlands. Nearby open mallee woodland or shrubland, usually with a ground cover of *Triodia* spp. (spinifex) or other grasses, supporting various eucalypts, especially *E. socialis* (Christmas Mallee) and *E. costata* (Yellow Mallee), as well as *Allocasuarina cristata* (Belah), *A. leuhmannii* (Buloke) or *Callitris preissii* (Slender Cypress Pine) also provide important habitat for this subspecies. They often occur in farmland, especially if the farmland supports remnant patches of woodland along roadsides or in paddocks. The subspecies seldom	Moderate	Unlikely	Moderate	–	Unlikely Out of species usual range

Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east Pilliga forest	Likelihood of occurrence in the north-east Pilliga forest	Availability of habitat in the study area	RPS 2012 Likelihood	Likelihood of occurrence & impact in study area
					occurs in more extensively cleared areas.					
Polytelis swainsonii	Superb Parrot	V	V	The Superb Parrot is found throughout eastern inland NSW. On the South-western Slopes their core breeding area is roughly bounded by Cowra and Yass in the east, and Grenfell, Cootamundra and Coolac in the west. Birds breeding in this region are mainly absent during winter, when they migrate north to the region of the upper Namoi and Gwydir Rivers. The other main breeding sites are in the Riverina along the corridors of the Murray, Edward and Murrumbidgee Rivers where birds are present all year round.	The Superb Parrot inhabits box-gum woodland, Box-Cypress-pine and Boree Woodlands and River Red Gum Forest. It forages at or near the ground and nest in hollows in small colonies (OEH 2013b).	Moderate	Potential	Low	Potential	Potential Suitable habitat within the Pilliga Box or Brigalow communities in the north east of the site. There will be no disturbance to this habitat and no impacts are predicted. No AoS has been undertaken.

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east Pilliga forest	Likelihood of occurrence in the north-east Pilliga forest	Availability of habitat in the study area	RPS 2012 Likelihood	Likelihood of occurrence & impact in study area
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	~	This species has two distinctive subspecies that intergrade to the south of the Gulf of Carpentaria. West of here the subspecies *rubeculus*, formerly considered a separate species (Red-breasted Babbler) is still widespread and common. The eastern subspecies (*temporalis*) occurs from Cape York south through QLD, NSW and Vic and formerly to the south east of SA. This subspecies also occurs in the Trans-Fly Region in southern New Guinea. In NSW, the eastern sub-species occurs on the western slopes of the Great Dividing Range, and on the western plains reaching as far as Louth and Balranald. It also occurs in woodlands in the Hunter Valley and in some locations on the north coast.	This species is found in open woodlands dominated by mature eucalypts with regenerating trees, tall shrubs, and an intact ground cover of grass and forbs (OEH 2013b). This species avoids very wet areas (Blakers et al. 1984).	High	Known	High	Known	Known Observed on site

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east Pilliga forest	Likelihood of occurrence in the north-east Pilliga forest	Availability of habitat in the study area	RPS 2012 Likelihood	Likelihood of occurrence & impact in study area
Pseudomys pilligaensis	Pilliga Mouse	V	V	Distribution restricted to the Pilliga region of New South Wales. Fox and Briscoe first described this species in 1980 (Fox and Briscoe 1980).	This species of small rodent occurs in Pilliga Scrub on an isolated area of low-nutrient deep sand predominantly in recently burnt moist gullies, areas dominated by Broombush and areas containing an understorey of Kurricabah (Acacia burrowii) with a *Corymbia trachyphloia* overstorey in the Pilliga region of NSW. They seem to prefer areas with a high species diversity and dense low shrub layer. The species is thought to live in burrows and is nocturnal. (OEH 2013b).	High	Known	Low	Potential	Unlikely Species prefers sandy soils and a low dense shrub layer not found on the site
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Grey-headed Flying-foxes are found within 200 km of the eastern coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria. They show a regular pattern of seasonal movement with much of the population moving to northern NSW and QLD during May and June where they exploit the winter flowering trees such	This species roosts in camps generally located within 20 km of a regular food source and are commonly found in gullies, close to water and in vegetation with a dense canopy. This species is known to forage in areas supporting subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps on the nectar and pollen of native trees, in particular eucalypts,	Moderate	Potential	Moderate	–	Potential A camp is not known within 20 km of the study area. Due to sporadic flowering of dominant canopy trees, this species has potential to forage in the study area on occasion.

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east Pilliga forest	Likelihood of occurrence in the north-east Pilliga forest	Availability of habitat in the study area	RPS 2012 Likelihood	Likelihood of occurrence & impact in study area
				as *Eucalyptus robusta*, *E. tereticornis* and Paperbark (OEH 2013b).	melaleucas and banksias.					
Rhipidura rufifrons	Rufous Fantail	~	M, Mar	The Rufous Fantail occurs in coastal and near coastal districts of northern and eastern Australia (DoE 2013b)	the Rufous Fantail mainly inhabits wet sclerophyll forests, often in gullies (DoE 2013b)	Low	Unlikely	Low	Unlikely	Unlikely
Rostratula australis (syn. *Rostratula benghalensis australis*)	Australian Painted Snipe	E1	E, Mar	The Australian Painted Snipe has been recorded at wetlands in all states of Australia. It is most common in eastern Australia, where it has been recorded at scattered locations throughout much of Queensland, NSW, Victoria and south-eastern South Australia. It has been recorded less frequently at a smaller number of more scattered locations farther west in South Australia, the Northern Territory and Western	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber (OEH 2013b). Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds (*ibid.*). Breeding is often in response to local conditions; generally occurs from September to December (OEH 2013b). Roosts during the day in dense vegetation (OEH 2013b). Forages nocturnally on mud-flats and in shallow water (OEH 2013b). Feeds on worms, molluscs, insects and	Low	Unlikely	Low	Unlikely	Unlikely

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east Pilliga forest	Likelihood of occurrence in the north-east Pilliga forest	Availability of habitat in the study area	RPS 2012 Likelihood	Likelihood of occurrence & impact in study area
				Australia.	some plant-matter (*ibid.*).					
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	~	The Yellow-bellied Sheathtail-bat is a wide-ranging species found across northern and eastern Australia. In the most southerly part of its range - most of Victoria, south-western NSW and adjacent South Australia - it is a rare visitor in late summer and autumn. There are scattered records of this species across the New England Tablelands and North West Slopes.	Found in almost all habitats, from wet and dry sclerophyll forest, open woodland (Churchill 1998), open country, mallee, rainforests, heathland and waterbodies (SFNSW 1995). It roosts in tree hollows and may also use caves. The species has also been recorded in a tree hollow in a paddock (Environment Australia 2000) and in abandoned sugar glider nests (Churchill 1998). It is dependent on suitable hollow-bearing trees to provide roost sites, which may be a limiting factor on populations in cleared or fragmented habitats (Environment Australia 2000).	High	Known	High	Potential	Potential This species is known nearby to the study area and is likely to forage in the area. Some roosting resources are also present.
Sminthopsis macroura	Stripe-faced Dunnart	V	~	Throughout much of inland central and northern Australia, extending into central and northern NSW, western Queensland, Northern Territory, South Australia and Western Australia. They are rare on the	Native dry grasslands and low dry shrublands, often along drainage lines. During periods of hot weather they shelter in cracks in the soil, in grass tussocks or under rocks and logs (OEH 2013b)	Low	Unlikely	Low	–	Unlikely

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east Pilliga forest	Likelihood of occurrence in the north-east Pilliga forest	Availability of habitat in the study area	RPS 2012 Likelihood	Likelihood of occurrence & impact in study area
				NSW Central West Slopes and North West Slopes with the most easterly records of recent times located around Dubbo, Coonabarabran, Warialda and Ashford. (OEH 2013b)						
Stagonopleura guttata	Diamond Firetail	V	~	The Diamond Firetail is endemic to south-eastern Australia, extending from central QLD to the Eyre Peninsula in SA. It is widely distributed in NSW, with a number of records from the Northern, Central and Southern Tablelands, the Northern, Central and South Western Slopes and the North West Plains and Riverina. Not commonly found in coastal districts, though there are records from near Sydney, the Hunter Valley and the Bega Valley. This species has a scattered distribution over the rest of NSW, and is	Typically found in grassy eucalypt woodlands, but also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities (OEH 2013b). It is often found in riparian areas and sometimes in lightly wooded farmland (OEH 2013b). Appears to be sedentary, though some populations move locally, especially those in the south (OEH 2013b).	High	Known	High	–	Potential Suitable habitat on site.

Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east Pilliga forest	Likelihood of occurrence in the north-east Pilliga forest	Availability of habitat in the study area	RPS 2012 Likelihood	Likelihood of occurrence & impact in study area
				rare west of the Darling River						
Stictonetta naevosa	Freckled Duck	V	~	The Freckled Duck is found primarily in south-eastern and south-western Australia, occurring as a vagrant elsewhere. It breeds in large temporary swamps created by floods in the Bulloo and Lake Eyre basins and the Murray-Darling system, particularly along the Paroo and Lachlan Rivers, and other rivers within the Riverina (OEH 2013b)	This species prefers permanent freshwater swamps and creeks with heavy growth of Typha, Lignum or Tea-tree. During drier times they move from ephemeral breeding swamps to more permanent waters such as lakes, reservoirs, farm dams and sewage ponds. They generally rest in dense cover during the day in deep water. They feed at dawn and dusk and at night on algae, seeds and aquatic grasses and sedges and small invertebrates. Nesting usually occurs between October and December but can take place at other times when conditions are favourable (OEH 2013b).	Low	Unlikely	Low	–	Unlikely

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east Pilliga forest	Likelihood of occurrence in the north-east Pilliga forest	Availability of habitat in the study area	RPS 2012 Likelihood	Likelihood of occurrence & impact in study area
Tyto longimembris	Eastern Grass Owl	V	~	Eastern Grass Owls have been recorded occasionally in all mainland states of Australia but are most common in northern and north-eastern Australia. In NSW they are more likely to be resident in the north-east. Eastern Grass Owl numbers can fluctuate greatly, increasing especially during rodent plagues (OEH 2013b).	This species is found in areas of tall grass, including grass tussocks, in swampy areas, grassy plains, swampy heath, and in cane grass or sedges on flood plains. They rest by day in a 'form' - a trampled platform in a large tussock or other heavy vegetative growth. They breeds on the ground and nests are found in trodden grass, and often accessed by tunnels through vegetation OEH 2013b.	Low	Unlikely	Low	–	Unlikely
Tyto novaehollandiae	Masked Owl	V	~	Extends from the coast where it is most abundant to the western plains. Overall records for this species fall within approximately 90% of NSW, excluding the most arid north-western corner. There is no seasonal variation in its distribution. (OEH 2013b)	The species is associated with forest with sparse, open, understorey, typically dry sclerophyll forest and woodland (OEH 2013b) and especially the ecotone between wet and dry forest, and non forest habitat (Environment Australia 2000). The species is known to utilise forest margins and isolated stands of trees within agricultural land (Hyem 1979) and heavily disturbed forest where its prey of small and medium sized mammals can be readily obtained (Kavanagh	High	Known	High	–	Potential Some foraging habitat is available on site.

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east Pilliga forest	Likelihood of occurrence in the north-east Pilliga forest	Availability of habitat in the study area	RPS 2012 Likelihood	Likelihood of occurrence & impact in study area
					& Peake 1993).					
Uvidicolus sphyrurus (syn. *Underwoodisaurus sphyrurus*)	Border Thick-tailed Gecko	V	V	The Border Thick-tailed Gecko is found only on the tablelands and slopes of northern NSW and southern Queensland, reaching south to Tamworth and west to Moree (OEH 2013b). Most common in the granite country of the New England Tablelands (OEH 2013b).	The Border Thick-tailed Gecko is found in rocky hills with dry open eucalypt forest or woodland (OEH 2013b). Favours forest and woodland areas with boulders, rock slabs, fallen timber and deep leaf litter (OEH 2013b).	Low	Unlikely	Low	Unlikely	Unlikely
Vespadelus troughtoni	Eastern Cave Bat	V	~	The Eastern Cave Bat is found in a broad band on both sides of the Great Dividing Range from Cape York to Kempsey, with records from the New England Tablelands and the upper north coast of NSW. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW, east of the ACT.	The species inhabits tropical mixed woodland and wet sclerophyll forest on the coast and the dividing range but extend into the drier forest of the western slopes and inland areas (Churchill 1998). It has been found roosting in sandstone overhand caves, boulder piles, mine tunnels and occasionally in buildings (Churchill 1998).	High	Known	High	Unlikely	Potential Some foraging habitat on site

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Appendix B: EP&A Act Seven Part Test

The EP&A Act includes in Section 5A, seven factors which are to be considered when determining if a proposed development or activity '*is likely to have a significant effect on the threatened species, populations or ecological communities, or their habitats'.* These seven factors must be taken into account by consent or determining authorities when considering the impacts of an activity on ecological values listed under the TSC Act.

The ecological values considered relevant to this assessment are identified in **Section 4** of this report and include:

Birds

- Regent Honeyeater
- Owls:
  - Barking Owl and Masked Owl
- Parrots:
  - Little Lorikeet and Swift Parrot
- Birds of prey:
  - Spotted Harrier, Black-breasted Buzzard and Little Eagle
- Woodland birds – ground and mid-storey foraging (passerines):
  - Grey-crowned Babbler, Diamond Firetail, Speckled Warbler and Hooded Robin

Mammals

- Koala
- Grey-headed Flying-fox
- Black-striped Wallaby
- Predominantly tree-roosting bats:
  - Yellow-bellied Sheathtail-bat and South-eastern Long-eared Bat
- Predominantly cave-roosting bats:
  - Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat and Little Pied Bat

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Regent Honeyeater

The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. Once recorded between Adelaide and the central coast of Queensland, its range has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland. There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years non-breeding flocks converge on flowering coastal woodlands and forests.

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The Regent Honeyeater mostly occurs in dry-ironbark eucalypt woodland and dry sclerophyll forest associations, where they prefer the most fertile site available, e.g. along creek flats, or in broad river valleys and foothills. In NSW, riparian forests containing *Casuarina cunninghamiana* (River Oak), and with *Amyema cambagei* (Needle-leaf Mistletoe), are also important for feeding and breeding. They may also use other woodland types and wet lowland coastal forest dominated by *Eucalyptus robusta* (Swamp Mahogany) or *C. maculata* (Spotted Gum).

Regent Honeyeaters inhabit woodlands that support a significantly high abundance and species richness of bird species. These woodlands have significantly large numbers of mature trees, high canopy cover and abundance of mistletoes.

The species breeds between July and January in Box-Ironbark and other temperate woodlands and riparian gallery forest dominated by River Sheoak.

The Regent Honeyeater is a generalist forager, which mainly feeds on the nectar from a wide range of eucalypts and mistletoes. Key eucalypt species include *E. sideroxylon* (Mugga Ironbark), *E. melliodora* (Yellow Box), *E. blakelyi* (Blakely's Red Gum), *E. albens* (White Box) and *E. robusta*. Also utilises : *E. microcarpa, E. punctata, E. polyanthemos, E. mollucana, Corymbia robusta, E. crebra, E. caleyi, Corymbia maculata, E. mckieana, E. macrorhyncha, E. laevopinea,* and *Angophora floribunda*. Nectar and fruit from the mistletoes *A. miquelii, A. pendula, A. cambagei* are also eaten during the breeding season. When nectar is scarce lerp and honeydew comprise a large proportion of the diet.

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The Regent Honeyeater was not identified on the site but was previously recorded within study region. Given the presence of winter-flowering gums across the site, its presence on the site at times is possible. The highly mobile nature of this species and response to sporadic flowering events suggests that individuals could use the resources on the site from time to time, although is unlikely to depend on its resources for survival.

The proposed activity would disturb 102.6 ha of marginal foraging habitat containing isolated paddock trees, equating to approximately 48.9% of this marginal foraging habitat on site. An additional 36.5 ha of higher quality habitat exists on site which will be retained within an exclusion zone. Regent Honeyeaters are highly mobile and the resources within the site are present throughout the immediate and wider area, with the proposed impact affecting approximately 0.03% of foraging habitat in the study region.

In addition, the Regent Honeyeater is known to only breed in a small number of specific locations, none of which occur in proximity to the study site or study region.

Considering these factors and provided the recommendations outlined in **Section 5** are fully adopted and implemented, the proposed activity is unlikely to have an adverse effect on the life cycle of this species, such that a viable local population, should one occur there from time to time, is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

This is not an endangered population.

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c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

This is not an endangered ecological community

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be remove or modified as a result of the action proposed, and

The proposed activity will result in the loss of 102.6 ha of marginal foraging habitat. The loss represents approximately 0.03% (0.11% cumulatively to date) of potential foraging habitat in the study region and includes the loss of approximately 155 out of 250 trees, few of which are mature. Considering the availability of potential foraging habitat in the study area and region and the high mobility of this species, the loss of potential foraging habitat due to the proposed activity is not likely to represent a significant loss to the species.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed activity will not result in the isolation of any areas of habitat. In addition, given the highly mobile nature of the species, it is considered unlikely that the proposed activity would result in fragmentation of habitat for this species.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long term survival of the species, population or ecological community in the locality,

The proposed activity will result in the removal of marginal foraging habitat, which is not likely to be critical habitat for the species. This is due primarily to the relatively sparse nature of foraging resources within the site and the extent of higher quality foraging habitat both within the study area and region.

Therefore, the disturbance of a small amount of potential foraging habitat is unlikely to affect the long-term survival of the species in the locality.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been declared for this species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is currently a Recovery Plan for the Regent Honeyeater (Menkhorst *et al* 1999). The proposed activity does not conflict with any of the proposed objectives.

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g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

One key threatening process is relevant to this proposed activity with respect to the Regent Honeyeater:

- Clearing of native vegetation.

The proposed activity involves the removal or modification of 102.6 ha of Derived Grassland, with an estimated loss of 155 out of 250 trees, few of which are mature. However, this represents only a small amount of potential habitat in the study region. There is a large amount of Derived Grassland mapped within the study region, only some of which contains paddock trees suitable for the Regent Honeyeater, with less than 0.11% currently impacted by the defined exploration and appraisal activities. The proposed activity only represents a marginal cumulative contribution to this key threatening process.

Conclusions

The proposed activity is unlikely to constitute a significant impact on Regent Honeyeater given that:

- The proposed activity will impact only marginal foraging habitat containing sporadically flowering tree species.
- Larger areas of suitable foraging habitat are present within the surrounding landscape.
- The proposed activity would not isolate or fragment any currently connecting areas of habitat in terms of use by this highly mobile species.

On the basis of the above considerations, it is unlikely that the proposed activity will constitute a significant impact on the Regent Honeyeater.

Owls: Barking Owl & Masked Owl

The Barking Owl is found throughout Australia except for the central arid regions and Tasmania. This species inhabits eucalypt woodland, open forest, swamp woodlands and, especially in inland areas, timber along watercourses. Denser vegetation is used occasionally for roosting. During the day they roost along creek lines, usually in tall understorey trees with dense foliage such as *Acacia* and *Casuarina* species, or the dense clumps of canopy leaves in large Eucalypts. They typically nest in hollows of large, old eucalypts including *E. camaldulensis* (River Red Gum), *E. albens*, *E. polyanthemos* (Red Box) and *E. blakelyi* (OEH 2013b).

The Masked Owl is distributed from the coast where it is most abundant to the western plains. This species lives in dry eucalypt forests and woodlands from sea level to 1100 m and is largely a forest owl, but often hunts along the edges of forests, including roadsides. This species roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting (OEH 2013b).

These species predominately inhabit woodland and/or dry eucalypt forest where there are suitable hollow-bearing trees for nesting. They both have large home ranges (up to 2,000 ha of Barking Owl and 1,000 ha for Masked Owl) and use a variety of habitats to forage, including closed forest and more open areas.

The Pilliga Forest, particularly the western Pilliga, is a stronghold of the Barking Owl which supports the largest remaining population of the species in NSW (NPWS 2003; Kavanagh and Stanton 2009).

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a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Neither species was recorded within the study area, however the proposed activity may potentially impact on the life cycles of the two owl species by reducing the amount of potential foraging habitat for both species. Both species have been identified previously within the study region. As both species forage within open forest and woodland and particularly in relation to the Masked Owl within open areas adjacent to forest it is possible that individuals could use the resources on the site from time to time, although they are unlikely to depend on the resources for survival.

The proposed activity would disturb 102.6 ha of marginal foraging habitat containing isolated paddock trees, equating to approximately 48.9% of this marginal foraging habitat on site. An additional 36.5 ha of higher quality habitat exists on site which will be retained within an exclusion zone. Both owl species are highly mobile and the resources within the site are present throughout the immediate and wider area, with the proposed impact affecting approximately 0.02% (0.07% cumulatively to date) of foraging habitat in the study region for the Barking Owl and 0.03% (0.11% cumulatively to date) for the Masked Owl.

Considering these factors and provided the recommendations outlined in **Section 5** are fully adopted and implemented, the proposed activity is unlikely to have an adverse effect on the life cycle of this species, such that a viable local population, should one occur there from time to time, is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

This is not an endangered population.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

This is not an endangered ecological community

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be remove or modified as a result of the action proposed, and

The proposed activity will result in the loss of 102.6 ha of marginal foraging habitat. The loss represents approximately 0.02% of foraging habitat in the study region for the Barking Owl and 0.03% for the Masked Owl and includes the loss of approximately 155 out of 250 trees, few of which are mature. Considering that large areas of potential foraging habitat on surrounding lands and the high mobility of these species, the loss of potential foraging habitat due to the proposed activity is not likely to represent a significant loss to either owl species.

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(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed activity will not result in the isolation of any areas of habitat. In addition, given the highly mobile nature of these species, it is considered unlikely that the proposed activity would result in fragmentation of habitat.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long term survival of the species, population or ecological community in the locality,

The proposed activity will result in the removal of marginal foraging habitat, which is not likely to be critical habitat for these species. This is due primarily to the relatively sparse nature of foraging resources within the site and the extent of higher quality foraging habitat both within the study area and the study region.

Therefore, the disturbance of a small amount of potential foraging habitat is unlikely to affect the long-term survival of these species in the locality.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been declared for these species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is currently a NSW Recovery Plan for the large forest owls which includes the Masked Owl (DEC 2006). There is also a draft NSW Recovery Plan for the Barking Owl (NPWS 2003). The proposed activity does not conflict with any of the proposed objectives in either plan.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Two key threatening processes are relevant to this proposed activity with respect to the Barking Owl and Masked Owl:

- Clearing of native vegetation.
- Loss of Hollow-bearing Trees.

The proposed activity involves the removal or modification of 102.6 ha of Derived Grassland, with an estimated loss of 155 out of 250 trees, few of which are mature. However, this represents only a small amount of potential habitat in the study region, particularly as only a small proportion of the grassland habitat adjacent to treed areas is considered suitable. There is a large amount of Derived Grassland mapped within the study region, with less than 0.11% currently impacted by defined exploration and appraisal activities. The proposed activity only represents a marginal cumulative contribution to this key threatening process.

This community has been described as having few mature canopy trees and very few tree hollows. As a result through the loss of approximately 60% of the trees on site it is assumed there will be no significant loss of hollow-bearing trees given the resources in the surrounding region. As a result this proposed activity only represents a marginal cumulative contribution to this key threatening process.

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Conclusions

The proposed activity is unlikely to constitute a significant impact on Barking Owl or Masked Owl given that:

- The proposed activity will impact only marginal foraging habitat.
- Larger areas of suitable foraging habitat are present within the surrounding landscape.
- The proposed activity would not isolate or fragment any currently connecting areas of habitat in terms of use by these highly mobile species.

On the basis of the above considerations, it is unlikely that the proposed activity will constitute a significant impact on either the Barking Owl or Masked Owl.

Parrots: Little Lorikeet & Swift Parrot

The Little Lorikeet is distributed widely across the coastal and Great Divide regions of eastern Australia from Cape York to South Australia. NSW provides a large portion of the species' core habitat, with lorikeets found westward as far as Dubbo and Albury. Feeds mostly on nectar and pollen and forage primarily on Eucalypts in open woodland but also utilise other trees such as *Angophora* and *Melaleuca* (OEH 2013b).

The Swift Parrot is a winter migrant to the south-eastern Australia mainland (March – October) from Tasmania, where they feed on winter-flowering eucalypts (OEH 2013b). The Swift Parrot is a highly mobile species able to utilise a variety of nectar sources over large areas (OEH 2013b). On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Favoured feed trees include winter flowering species such as *E. robusta*, *Corymbia maculata*, *C. gummifera* (Red Bloodwood), *E. sideroxylon*, and *E. albens*. Commonly used lerp infested trees include *E. microcarpa* (Inland Grey Box), *E. moluccana* (Grey Box) and *E. pilularis* (Blackbutt). This species breeds from September to January, nesting in old trees with hollows and feeding in forests dominated by Tasmanian Blue Gum *E. globulus* (OEH 2013b).

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Neither species have been recorded in the study area, however, the proposed activity may potentially impact on the life cycles of the two species by reducing the amount of potential foraging habitat for both species. Both species have been identified previously within the study region. Given the presence of sporadically flowering gums across the site, the presence of these species on the site at times is possible. The highly mobile nature of both of these species and their response to sporadic flowering events suggests that individuals could use the resources on the site from time to time, although they are unlikely to depend on its resources for survival.

The proposed activity would disturb 102.6 ha of marginal foraging habitat containing isolated paddock trees, equating to approximately 48.9% of this marginal foraging habitat on site. An additional 36.5 ha of higher quality habitat exists on site which will be retained within an exclusion zone. Both parrot species are highly mobile and the resources within the site are present throughout the immediate and wider area, with the proposed impact affecting approximately 0.03% of foraging habitat in the study region.

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Additionally, the Swift Parrot breeds in Tasmania and as such no breeding habitat will be impacted by the proposed activity.

Considering these factors and provided the recommendations outlined in **Section 5** are fully adopted and implemented, the proposed activity is unlikely to have an adverse effect on the life cycle of this species, such that a viable local population, should one occur there from time to time, is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

This is not an endangered population.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

This is not an endangered ecological community

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be remove or modified as a result of the action proposed, and

The proposed activity will result in the loss of 102.6 ha of marginal foraging habitat and a small potential disturbance to 1.5 ha of higher quality foraging habitat. The loss represents approximately 0.03% (0.11% cumulatively to date) of potential foraging habitat in the study region and includes the loss of approximately 155 out of 250 trees, few of which are mature and considered important as foraging resources. Considering that large areas of potential foraging habitat on surrounding lands and the high mobility of these species, the loss of potential foraging habitat due to the proposed activity is not likely to represent a significant loss to either parrot species.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed activity will not result in the isolation of any areas of habitat. In addition, given the highly mobile nature of these species, it is considered unlikely that the proposed activity would result in fragmentation of habitat.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long term survival of the species, population or ecological community in the locality,

The proposed activity will result in the removal of marginal foraging habitat, which is not likely to be critical habitat for these species. This is due primarily to the relatively sparse nature of foraging resources within the site and the extent of higher quality foraging habitat both within the study area and region.

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Therefore, the disturbance of a small amount of potential foraging habitat is unlikely to affect the long-term survival of these species in the locality.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been declared for these species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is a National Recovery Plan for the Swift Parrot (Saunders & Tzaros 2011). The proposed activity does not conflict with any of the proposed objectives in the plan. No recovery plan or threat abatement plan has been prepared for the Little Lorikeet.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Two key threatening processes are relevant to this proposed activity with respect to the Little Lorikeet and Swift Parrot:

- Clearing of native vegetation.
- Loss of Hollow-bearing Trees.

The proposed activity involves the removal or modification of 102.6 ha of Derived Grassland, with an estimated loss of 155 out of 250 trees, few of which are mature. However, this represents only a small amount of potential habitat in the study region, particularly as only a small proportion of the grassland habitat adjacent to treed areas is considered suitable. There is a large amount of Derived Grassland mapped within the study region, with less than 0.11% currently impacted by the defined exploration and appraisal activities. The proposed activity only represents a marginal cumulative contribution to this key threatening process.

This community has been described as having few mature canopy trees and very few tree hollows. As a result through the loss of approximately 60% of the trees on site it is assumed there will be no significant loss of hollow-bearing trees given the resources in the surrounding region. As a result this proposed activity only represents a marginal cumulative contribution to this key threatening process.

Conclusions

The proposed activity is unlikely to constitute a significant impact on the Little Lorikeet or Swift Parrot given that:

- The proposed activity will impact only marginal foraging habitat containing sporadically flowering tree species.
- Larger areas of suitable foraging habitat are present within the surrounding landscape.
- The proposed activity would not isolate or fragment any currently connecting areas of habitat in terms of use by these highly mobile species.

On the basis of the above considerations, it is unlikely that the proposed activity will constitute a significant impact on either the Little Lorikeet or Swift Parrot.

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Birds of Prey: Spotted Harrier, Black-breasted Buzzard & Little Eagle

These species are found in a range of woodland, forest and open habitats, however, all have been associated with some form of riparian habitat, such as timbered watercourses or inland wetlands that can be used for breeding or foraging.

The Spotted Harrier occurs in grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe. It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands. They build stick nests in a tree and lays eggs in spring (or sometimes autumn), with young remaining in the nest for several months. Preys on terrestrial mammals (e.g. bandicoots, bettongs, and rodents), birds and reptile, occasionally insects and rarely carrion.

The Black-breasted Buzzard lives in a range of inland habitats including open forests, riverine woodlands, scrubs and heathlands. It is often found along timbered watercourses, which is preferred breeding habitat. It can also hunt over grasslands and includes reptiles, small mammals, birds and large eggs in its prey

The Little Eagle occupies many habitats including open forest, woodland and scrub communities, as well as open agricultural land (Simpson & Day 2004). Little Eagles are known to nest in canopy trees during spring and early summer, in open woodland or riparian zones, where open areas are available to forage for birds, reptiles and mammals (Morcombe 2004; Marchant & Higgins 1993).

All of the birds of prey are highly mobile species that have extensive home ranges. Black-breasted Buzzard, Spotted Harrier, and Little Eagle have been identified as species that are negatively impacted by land clearing.

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

None of these species have been recorded in the study area, however, the proposed activity may potentially impact on the life cycles of the three species by reducing the amount of potential foraging habitat. All these species have been identified previously within the study region and can forage within grassland habitats and open agricultural land; hence the presence of these species on the site at times is possible.

The highly mobile nature of these species and their large foraging home ranges and paucity of nesting resources for the Spotted Harrier and Black-breasted Buzzard and lack of evidence of nesting of the Little Eagle on the site suggests that individuals could use the resources on the site from time to time, although they are unlikely to depend on its resources for survival.

The proposed activity would disturb 102.6 ha of marginal foraging habitat containing isolated paddock trees, equating to approximately 48.9% of this marginal foraging habitat on site. An additional 36.5 ha of higher quality habitat exists on site which will be retained within an exclusion zone. All these birds of prey are highly mobile and the resources within the site are present throughout the immediate and wider area, with the proposed impact affecting up to 0.59% of foraging habitat in the study region.

Considering these factors and provided the recommendations outlined in **Section 5** are fully adopted and implemented, the proposed activity is unlikely to have an adverse effect on the life cycle of this

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species, such that a viable local population, should one occur there from time to time, is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

This is not an endangered population.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

This is not an endangered ecological community

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be remove or modified as a result of the action proposed, and

The proposed activity will result in the loss of 102.6 ha of marginal foraging habitat. The loss represents up to 0.59% (1.19% cumulatively to date) of potential foraging habitat in the study region for these species. Considering that large areas of potential foraging habitat on surrounding lands and the high mobility of these species, the loss of potential foraging habitat due to the proposed activity is not likely to represent a significant loss to these birds of prey.

The Little Eagle can nest in open areas in mature trees. The site is characterised by a paucity of mature trees within the Derived Grassland community and no nests were recorded in the field surveys. Consequently, the area is not considered to constitute breeding habitat for the species.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed activity will not result in the isolation of any areas of habitat. In addition, given the highly mobile nature of these species, it is considered unlikely that the proposed activity would result in fragmentation of habitat.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long term survival of the species, population or ecological community in the locality,

The proposed activity will result in the removal of marginal foraging habitat, which is not likely to be critical habitat for these species. This is due primarily to extent of similar foraging habitat in the broader study region and the lack of suitable nesting habitat for the Spotted Harrier and Black-breasted Buzzard and lack of evidence of nesting of the Little Eagle.

Therefore, the disturbance of a small amount of potential foraging habitat is unlikely to affect the long-term survival of these species in the locality.

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e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been declared for these species

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

No recovery plan or threat abatement plan has been prepared for the Spotted Harrier, Black-breasted Buzzard or Little Eagle.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

One key threatening process is relevant to this proposed activity with respect to these birds of prey:

- Clearing of native vegetation.

The proposed activity involves the removal or modification of 102.6 ha of Derived Grassland, with an estimated loss of 155 out of 250 trees, few of which are mature. However, this represents only a small amount of potential habitat in the study region. There is a large amount of Derived Grassland mapped within the study region, with less than 0.11% currently impacted by the defined exploration and appraisal activities. The proposed activity only represents a marginal cumulative contribution to this key threatening process.

Conclusions

The proposed activity is unlikely to constitute a significant impact on the Spotted Harrier, Black-breasted Buzzard or Little Eagle given that:

- The proposed activity will impact only foraging habitat containing no suitable nesting habitat for the Spotted Harrier and Black-breasted Buzzard and lack of evidence of nesting of the Little Eagle.
- Larger areas of suitable foraging habitat are present within the surrounding landscape.
- The proposed activity would not isolate or fragment any currently connecting areas of habitat in terms of use by these highly mobile species.

On the basis of the above considerations, it is unlikely that the proposed activity will constitute a significant impact on the Spotted Harrier, Black-breasted Buzzard or Little Eagle.

Woodland birds – ground and mid-storey foraging (passerines): Grey-crowned Babbler, Diamond Firetail, Speckled Warbler & Hooded Robin

These species inhabit a range of woodland habitats associated with the proposed activity. The habitats also range in structural density and complexity.

Grey-crowned Babbler is found in open woodlands dominated by mature eucalypts with regenerating trees, tall shrubs, and an intact ground cover of grass and forbs (OEH 2013b). This species avoids very wet areas (Blakers et al. 1984)

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The Diamond Firetail can be found in grassy eucalypt woodlands, including Box-Gum Woodlands and Snow Gum Woodlands. This species can also be found in open forest, mallee, riparian vegetation, and grasslands. This species is usually seen in flocks of between five to forty birds. This species is a ground feeder, feeding on ripe and partly-ripe grass, herb seeds, green leaves, and on insects (OEH 2013b).

The Speckled Warbler inhabits a wide range of eucalypt dominated communities that have a grassy understorey, often on rocky ridges or in gullies. A typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy (OEH 2013b). Large, relatively undisturbed remnants are required for the species to persist in an area. The diet of this species consists of seeds and insects, with most foraging taking place on the ground around tussocks and under bushes and trees.

The Hooded Robin is considered a sedentary species, but local seasonal movements are possible. The south-eastern form is found from Brisbane to Adelaide throughout much of inland NSW, with the exception of the north-west. The species is widespread, found across Australia, except for the driest deserts and the wetter coastal areas - northern and eastern coastal Queensland and Tasmania.

The Hooded Robin prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. The Hooded Robin requires structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses (OEH 2013b). The species appears unable to survive in remnants smaller than 100 to 200 ha (Egan et al. 1997). Isolation of populations in small remnants increases vulnerability to local extinction as a result of stochastic events and can decrease their genetic viability in the long term. Low population densities and relatively large home ranges also exacerbate their vulnerability within a highly fragmented and predominantly cleared landscape (OEH 2013b).

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Of these woodland birds, only the Grey-crowned Babbler has been recorded in the study area. However, the proposed activity may potentially impact on the life cycles of these other three species by reducing the amount of potential foraging habitat. All these species have been identified previously within the study region and forage within open woodlands, typically with an understorey and ground cover of grasses, forbs and some small shrubs. Complexity of ground habitat including fallen timber is also preferred by these species. The Grey-crowned Babbler, Diamond Firetail and Hooded Robin will also venture into adjacent open areas to forage. The paucity of structural diversity in the understorey and ground cover and lack of habitat features such as fallen logs within the study area suggests that the area would primarily be used as foraging habitat for all these species. Nests of the Grey-crowned Babbler were identified within the more intact Pilliga Box community within the exclusion area at the site.

The proposed activity would disturb 102.6 ha of foraging habitat containing isolated paddock trees, equating to approximately 48.9% of this foraging habitat on site. An additional 36.5 ha of higher quality habitat exists on site which will be retained within an exclusion zone. All these woodland birds are mobile and the resources within the site are present throughout the immediate and wider area, with the proposed impact affecting up to 0.02% of foraging habitat in the study region.

Considering these factors and provided the recommendations outlined in **Section 5** are fully adopted and implemented, the proposed activity is unlikely to have an adverse effect on the life cycle of this

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species, such that a viable local population, should one occur there from time to time, is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

This is not an endangered population.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

This is not an endangered ecological community

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be remove or modified as a result of the action proposed, and

The proposed activity will result in the loss of 102.6 ha of foraging habitat. The loss represents approximately 0.02% (0.07% cumulatively to date) of potential foraging habitat in the study region and includes the loss of approximately 155 out of 250 trees, few of which are mature. Considering that large areas of potential foraging habitat on surrounding lands and the mobility of these species, the loss of potential foraging habitat due to the proposed activity is not likely to represent a significant loss to these woodland birds.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed activity will not result in the isolation of any areas of habitat. In addition, given the highly mobile nature of these species, it is considered unlikely that the proposed activity would result in fragmentation of habitat.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long term survival of the species, population or ecological community in the locality,

The proposed activity will result in the removal of foraging habitat, with the only nesting habitat found within the exclusion zone. This foraging habitat is not likely to be critical habitat for these species, due primarily to presence of superior habitat within the exclusion zone, extent of similar foraging habitat in the broader study region and the lack of suitable nesting habitat.

Therefore, the disturbance of a small amount of potential foraging habitat is unlikely to affect the long-term survival of these species in the locality.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been declared for these species

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f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

No recovery plan or threat abatement plan has been prepared for the Grey-crowned Babbler, Diamond Firetail, Speckled Warbler or Hooded Robin.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

One key threatening process is relevant to this proposed activity with respect to these woodland birds:

- Clearing of native vegetation.

The proposed activity involves the removal or modification of 102.6 ha of Derived Grassland, with an estimated loss of 155 out of 250 trees, few of which are mature. However, this represents only a small amount of potential habitat in the study region, particularly as only a small proportion of the grassland habitat adjacent to treed areas is considered suitable. There is a large amount of Derived Grassland mapped within the study region, with less than 0.11% currently impacted by the defined exploration and appraisal activities. The proposed activity only represents a marginal cumulative contribution to this key threatening process.

Conclusions

The proposed activity is unlikely to constitute a significant impact on the Grey-crowned Babbler, Diamond Firetail, Speckled Warbler or Hooded Robin given that:

- The proposed activity will impact only foraging habitat containing no suitable nesting habitat given the lack of key habitat components and structural complexity of the understorey and groundcover vegetation.
- Larger areas of suitable foraging habitat are present within the surrounding landscape.
- The proposed activity would not isolate or fragment any currently connecting areas of habitat in terms of use by these mobile species.

On the basis of the above considerations, it is unlikely that the proposed activity will constitute a significant impact on the Grey-crowned Babbler, Diamond Firetail, Speckled Warbler or Hooded Robin.

Koala

The Koala occurs along the east coast of Australia and extends into Woodland, Mulga and River Red Gum forests west of the Great Dividing Range. The range of the Koala covers all such suitable areas of NSW. In drier forested areas, Koalas are generally observed as individuals in low densities. They are more abundant in coastal woodland and in open forest.

Koalas are solitary and territorial (particularly males) yet live in established sedentary polygynous breeding aggregates arranged in a matrix of overlapping home ranges whose size varies according to and carrying capacity of the habitat (Phillips and Callaghan 1995).

Nationally, koalas have been observed feeding or resting in about 120 eucalypt species (66 in NSW) and 30 non-eucalypt (seven in NSW) species. Usage may also be determined by site-dependent edaphic factors e.g. soil type (Sharp and Phillips 1997), which affects the nutrient quality of forage.

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Forest consisting of primary browse species associations located on deep, fertile soils on floodplains, in gullies and along watercourses are generally considered preferred koala habitat. This may possibly be a reflection of the nutritional value of the foliage.

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Koalas have not been observed on the site and neither has indirect evidence been recorded despite substantial survey effort. However, Koala records are known nearby to the site and their presence in the area is considered likely. The habitat on the site represents only marginal foraging habitat due to the paucity of mature trees on site compared to the surrounding habitat. Large area of home ranges for the Koala in the Pilliga due to the lower carrying capacity of the habitat suggests that individuals could use the resources on the site from time to time, although they are unlikely to depend on its resources for survival.

The proposed activity would disturb 102.6 ha of marginal foraging habitat containing isolated paddock trees, equating to approximately 48.9% of this marginal foraging habitat on site. An additional 17.4 ha of higher quality Pilliga Box habitat exists on site which will be retained within an exclusion zone. The Koala is highly mobile and the resources within the site are present throughout the immediate and wider area, with the proposed impact affecting up to 0.03% of foraging habitat in the study region.

Considering these factors and provided the recommendations outlined in **Section 5** are fully adopted and implemented, the proposed activity is unlikely to have an adverse effect on the life cycle of this species, such that a viable local population, should one occur there from time to time, is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

This is not an endangered population.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

This is not an endangered ecological community.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be remove or modified as a result of the action proposed, and

The proposed activity will result in the loss of 102.6 ha of marginal foraging habitat. The loss represents approximately 0.03% (0.11% cumulatively to date) of potential foraging habitat in the study region and includes the loss of approximately 155 out of 250 trees, few of which are mature. Considering that large areas of potential foraging habitat on surrounding lands and the large home range of Koalas in the

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Pilliga, the loss of potential foraging habitat due to the proposed activity is not likely to represent a significant loss to this species.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed activity will not result in the isolation of any areas of habitat. In addition, given the highly mobile nature of these species, it is considered unlikely that the proposed activity would result in fragmentation of habitat.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long term survival of the species, population or ecological community in the locality,

The proposed activity will result in the removal of marginal foraging habitat, which is not likely to be critical habitat for the Koala. This is due primarily to the extent of similar foraging habitat in the broader study region and the large home ranges in the Pilliga.

Therefore, the disturbance of a small amount of potential foraging habitat is unlikely to affect the long-term survival of these species in the locality.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been declared for this species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is a NSW Recovery Plan for the Koala (DECC 2008). The proposed activity does not conflict with any of the proposed objectives in the plan.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

One key threatening process is relevant to this proposed activity with respect to the Koala:

- Clearing of native vegetation.

The proposed activity involves the removal or modification of 102.6 ha of Derived Grassland, with an estimated loss of 155 out of 250 trees, few of which are mature. However, this represents only a small amount of potential habitat in the study region. There is a large amount of Derived Grassland mapped within the study region, only some of which contains paddock trees suitable for the Koala, with less than 0.11% currently impacted by the defined exploration and appraisal activities. The proposed activity only represents a marginal cumulative contribution to this key threatening process.

Conclusions

The proposed activity is unlikely to constitute a significant impact on the Koala given that:

- The proposed activity will impact only marginal foraging habitat containing few mature trees.
- Larger areas of suitable foraging habitat are present within the surrounding landscape.
- The proposed activity would not isolate or fragment any currently connecting areas of habitat in terms of use by this mobile species.

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On the basis of the above considerations, it is unlikely that the proposed activity will constitute a significant impact on the Koala.

Grey-headed Flying Fox

The Grey-headed Flying-fox inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas (Churchill 1998, Eby 1996). The species has been recorded travelling long distances on feeding forays (Churchill 1998). Fruits and flowering plants of a wide variety of species are the main food source. The species roosts in large 'camps' of up to 200,000 individuals and are often located in gullies, typically close to water, in vegetation with a dense canopy (Churchill 1998).

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The Grey-headed Flying-fox was not recorded on the study area, however the proposed activity may potentially impact on the life cycle of the species by reducing the amount of potential foraging habitat. Grey-headed Flying-foxes have been identified previously within the study region. Given the presence of sporadically flowering gums across the site, the presence of this species on the site at times is possible. The highly mobile nature of Grey-headed Flying-foxes and their response to sporadic flowering events suggests that individuals could use the resources on the site from time to time, although they are unlikely to depend on its resources for survival.

The proposed activity would disturb 102.6 ha of marginal foraging habitat containing isolated paddock trees, equating to approximately 48.9% of this marginal foraging habitat on site. An additional 36.5 ha of higher quality habitat exists on site which will be retained within an exclusion zone. The Grey-headed Flying-fox is highly mobile and the resources within the site are present throughout the immediate and wider area, with the proposed impact affecting approximately 0.03% of foraging habitat in the study region.

Additionally, there are breeding camps of the Grey-headed Flying-fox known in the locality and as such no breeding habitat will be impacted by the proposed activity.

Considering these factors and provided the recommendations outlined in **Section 5** are fully adopted and implemented, the proposed activity is unlikely to have an adverse effect on the life cycle of this species, such that a viable local population, should one occur there from time to time, is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

This is not an endangered population.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

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(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

This is not an endangered ecological community

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be remove or modified as a result of the action proposed, and

The proposed activity will result in the loss of 102.6 ha of marginal foraging habitat and a small potential disturbance to 1.5 ha of higher quality foraging habitat. The loss represents approximately 0.03% (0.11% cumulatively to date) of potential foraging habitat in the study region and includes the loss of approximately 155 out of 250 trees, few of which are mature. Considering that large areas of potential foraging habitat on surrounding lands and the high mobility of this species, the loss of potential foraging habitat due to the proposed activity is not likely to represent a significant loss to the Grey-headed Flying-fox.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed activity will not result in the isolation of any areas of habitat. In addition, given the highly mobile nature of this species, it is considered unlikely that the proposed activity would result in fragmentation of habitat.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long term survival of the species, population or ecological community in the locality,

The proposed activity will result in the removal of marginal foraging habitat, which is not likely to be critical habitat for the Grey-headed Flying-fox. This is due primarily to the relatively sparse nature of foraging resources within the site and the extent of higher quality foraging habitat both within the study area and region.

Therefore, the disturbance of a small amount of potential foraging habitat is unlikely to affect the long-term survival of these species in the locality.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been declared for this species

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

There is a draft National Recovery Plan for the Grey-headed Flying-fox (DECCW 2009). The proposed activity does not conflict with any of the proposed objectives in the plan.

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g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

One key threatening process is relevant to this proposed activity with respect to the Grey-headed Flying-fox:

- Clearing of native vegetation.

The proposed activity involves the removal or modification of 102.6 ha of Derived Grassland, with an estimated loss of 155 out of 250 trees, few of which are mature. However, this represents only a small amount of potential habitat in the study region. There is a large amount of Derived Grassland mapped within the study region, only some of which contains paddock trees suitable for the Grey-headed Flying-fox, with less than 0.11% currently impacted by the defined exploration and appraisal activities. The proposed activity only represents a marginal cumulative contribution to this key threatening process.

Conclusions

The proposed activity is unlikely to constitute a significant impact on Grey-headed Flying-fox given that:

- The proposed activity will impact only marginal foraging habitat containing sporadically flowering tree species.
- Larger areas of suitable foraging habitat are present within the surrounding landscape.
- The proposed activity would not isolate or fragment any currently connecting areas of habitat in terms of use by this highly mobile species.

On the basis of the above considerations, it is unlikely that the proposed activity will constitute a significant impact on the Grey-headed Flying-fox.

Black-striped Wallaby

Preferred habitat is characterised by dense woody or shrubby vegetation within three metres of the ground. This dense vegetation must occur near a more open, grassy area to provide suitable feeding habitat. On the North West Slopes, it is associated with dense vegetation, including Brigalow, Ooline and semi-evergreen vine thicket. On the north coast, it is closely associated with dry rainforest but also occur in moist eucalypt forest with a rainforest understorey or a dense shrub layer.

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The Black-striped Wallaby was not recorded in the study area however, the proposed activity may potentially impact on the life cycle of the species by reducing the amount of potential foraging habitat. Black-striped Wallabies have been identified previously within the study region. As the species requires dense vegetation for cover next to open areas the potential impact area provides potential foraging habitat and the presence of this species on the site at times is possible. The highly mobile nature of Black-striped Wallabies and their requirement for dense woody vegetation for shelter suggests that individuals could use the resources on the site from time to time to forage, although they are unlikely to depend on its resources for survival.

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The proposed activity would disturb 102.6 ha of marginal foraging habitat containing isolated paddock trees, equating to approximately 48.9% of this marginal foraging habitat on site. An additional 36.5 ha of higher quality habitat exists on site which will be retained within an exclusion zone. The Black-striped Wallaby is highly mobile and the resources within the site are present throughout the immediate and wider area, with the proposed impact affecting approximately 0.02% of foraging habitat in the study region.

Considering these factors and provided the recommendations outlined in **Section 5** are fully adopted and implemented, the proposed activity is unlikely to have an adverse effect on the life cycle of this species, such that a viable local population, should one occur there from time to time, is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

This is not an endangered population.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

This is not an endangered ecological community

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be remove or modified as a result of the action proposed, and

The proposed activity will result in the loss of 102.6 ha of foraging habitat. The loss represents approximately 0.02% (0.07% cumulatively to date) of potential foraging habitat in the study region. Considering that large areas of potential foraging habitat on surrounding lands and the high mobility of these species, the loss of potential foraging habitat due to the proposed activity is not likely to represent a significant loss to the species.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed activity will not result in the isolation of any areas of habitat. In addition, given the highly mobile nature of this species, it is considered unlikely that the proposed activity would result in fragmentation of habitat.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long term survival of the species, population or ecological community in the locality,

The proposed activity will result in the removal of foraging habitat, with the only shelter habitat found within the exclusion zone. This foraging habitat is not likely to be critical habitat for these species, due

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primarily to presence of superior habitat within the exclusion zone, extent of similar foraging habitat in the broader study region and the lack of suitable sheltering habitat.

Therefore, the disturbance of a small amount of potential foraging habitat is unlikely to affect the long-term survival of this species in the locality.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been declared for this species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

No recovery plan or threat abatement plan has been prepared for the Black-striped Wallaby.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

One key threatening process is relevant to this proposed activity with respect to the Black-striped Wallaby:

- Clearing of native vegetation.

The proposed activity involves the removal or modification of 102.6 ha of Derived Grassland. However, this represents only a small amount of potential habitat in the study region. There is a large amount of Derived Grassland mapped within the study region, with less than 0.11% currently impacted by the defined exploration and appraisal activities. The proposed activity only represents a marginal cumulative contribution to this key threatening process.

Conclusions

The proposed activity is unlikely to constitute a significant impact on Black-striped Wallaby given that:

- The proposed will impact only foraging habitat containing no suitable sheltering habitat given the lack of structural complexity of the understorey and groundcover vegetation.
- Larger areas of suitable foraging habitat are present within the surrounding landscape.
- The proposed activity would not isolate or fragment any currently connecting areas of habitat in terms of use by this highly mobile species.

On the basis of the above considerations, it is unlikely that the proposed activity will constitute a significant impact on the Black-striped Wallaby.

Predominantly tree-roosting bats*:* Yellow-bellied Sheathtail-bat & South-eastern Long-eared Bat

The Yellow-bellied Sheathtail-bat roosts singly or in groups of up to six, in tree hollows and buildings. In treeless areas they are known to utilise mammal burrows. They forage in most habitats throughout their very wide range, including areas with and without trees and appear to defend an aerial territory (OEH 2013b).

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The South-eastern Long-eared Bat inhabits a variety of vegetation types including mallee, bulloke and box eucalypt dominated communities. However, it is more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland. Roosts in tree hollows, crevices and under loose bark.

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Neither species have been recorded in the study area despite targeted survey, however, the proposed activity may potentially impact on their life cycles by reducing the amount of potential foraging habitat for both species. Both species have been identified previously within the study region. Given that both species forage in a wide variety of habitats and in the case of the South-eastern Long-eared Bat within box/ironbark/cypress pine vegetation, the presence of these species on the site at times is possible. The site is predominantly considered to represent foraging habitat as few hollow-bearing trees were identified and the majority of trees were not considered to be mature (i.e. hollow forming). The highly mobile nature of both of these species suggests that individuals could use the resources on the site from time to time, although they are unlikely to depend on its resources for survival.

The proposed activity would disturb 102.6 ha of marginal foraging habitat containing isolated paddock trees, equating to approximately 48.9% of this marginal foraging habitat on site. An additional 36.5 ha of higher quality habitat exists on site which will be retained within an exclusion zone. Both bat species are highly mobile and the resources within the site are present throughout the immediate and wider area, with the proposed impact affecting approximately 0.02% of foraging habitat in the study region.

Considering these factors and provided the recommendations outlined in **Section 5** are fully adopted and implemented, the proposed activity is unlikely to have an adverse effect on the life cycle of this species, such that a viable local population, should one occur there from time to time, is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

This is not an endangered population.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

This is not an endangered ecological community.

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d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be remove or modified as a result of the action proposed, and

The proposed activity will result in the loss of 102.6 ha of foraging habitat. The loss represents approximately 0.02% (0.07% cumulatively to date) of potential foraging habitat in the study region and includes the loss of approximately 155 out of 250 trees, few of which are mature. Considering that large areas of potential foraging habitat on surrounding lands and the high mobility of these species, the loss of potential foraging habitat due to the proposed activity is not likely to represent a significant loss to either bat species.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed activity will not result in the isolation of any areas of habitat. In addition, given the highly mobile nature of these species, it is considered unlikely that the proposed activity would result in fragmentation of habitat.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long term survival of the species, population or ecological community in the locality,

The proposed activity will result predominantly in the removal of foraging habitat, which is not likely to be critical habitat for these species. This is due primarily to the sparse nature of foraging resources within the site in relation to the extent of higher quality foraging habitat both within the study area and region.

Therefore, the disturbance of a small amount of potential foraging habitat is unlikely to affect the long-term survival of these species in the locality.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been declared for these species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

No recovery plan or threat abatement plan has been prepared for the Yellow-bellied Sheathtail-bat or South-eastern Long-eared Bat.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Two key threatening processes are relevant to this proposed activity with respect to the Yellow-bellied Sheathtail-bat and South-eastern Long-eared Bat:

- Clearing of native vegetation.
- Loss of Hollow-bearing Trees.

The proposed activity involves the removal or modification of 102.6 ha of Derived Grassland, with an estimated loss of 155 out of 250 trees, few of which are mature. However, this represents only a small amount of potential habitat in the study region. There is a large amount of Derived Grassland mapped

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within the study region, only some of which contains paddock trees suitable for the Yellow-bellied Sheathtail-bat and South-eastern Long-eared Bat, with less than 0.11% currently impacted by the defined exploration and appraisal activities. The proposed activity only represents a marginal cumulative contribution to this key threatening process.

This community has been described as having few mature canopy trees and very few tree hollows. As a result through the loss of approximately 60% of the trees on site it is assumed there will be no significant loss of hollow-bearing trees given the resources in the surrounding region. As a result the proposed activity only represents a marginal cumulative contribution to this key threatening process.

Conclusions

The proposed activity is unlikely to constitute a significant impact on the Yellow-bellied Sheathtail-bat and South-eastern Long-eared Bat given that:

- The proposed activity will impact only some foraging habitat and a minimal impact to potential roosting resources.
- Larger areas of suitable foraging habitat are present within the surrounding landscape.
- The proposed activity would not isolate or fragment any currently connecting areas of habitat in terms of use by these highly mobile species.

On the basis of the above considerations, it is unlikely that the proposed activity will constitute a significant impact on either the Yellow-bellied Sheathtail-bat or South-eastern Long-eared Bat.

Predominantly cave-roosting bats*:* Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat & Little Pied Bat

The Eastern Bentwing-bat occupies a range of forested environments (including wet and dry sclerophyll forests). The Eastern Cave Bat is usually found in dry open forest and woodland, near cliffs or rocky overhangs. The Large-eared Pied Bat is found in well-timbered areas containing gullies in dry open forest and woodland close to caves or other roost sites but forages widely. The Little-Pied Bat occurs in dry open forest, open woodland, mulga woodlands, chenopod shrublands, cypress-pine forest, mallee and Bimbil box.

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

None of these species have been recorded in the study area despite targeted survey, however, the proposed activity may potentially impact on their life cycles by reducing the amount of potential foraging habitat for them all. These species have been identified previously within the study region and given that they forage in a wide variety of habitats, particularly in dry forest and woodland, the presence of these species on the site at times is possible.

The site is considered to only represent foraging habitat as no roosting resources in the form of caves and other suitable structures are found on the site. The highly mobile nature of these species suggests that individuals could use the resources on the site from time to time, although they are unlikely to depend on its resources for survival.

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The proposed activity would disturb 102.6 ha of marginal foraging habitat containing isolated paddock trees, equating to approximately 48.9% of this marginal foraging habitat on site. An additional 36.5 ha of higher quality habitat exists on site which will be retained within an exclusion zone. All these species are highly mobile and the resources within the site are present throughout the immediate and wider area, with the proposed impact affecting approximately 0.02% of foraging habitat in the study region.

Considering these factors and provided the recommendations outlined in **Section 5** are fully adopted and implemented, the proposed activity is unlikely to have an adverse effect on the life cycle of this species, such that a viable local population, should one occur there from time to time, is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

This is not an endangered population.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction

This is not an endangered ecological community

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be remove or modified as a result of the action proposed, and

The proposed activity will result in the loss of 102.6 ha of marginal foraging habitat. The loss represents approximately 0.02% (0.07% cumulatively to date) of potential foraging habitat in the study region. Considering that large areas of potential foraging habitat on surrounding lands and the high mobility of these species, the loss of potential foraging habitat due to the proposed activity is not likely to represent a significant loss to these bat species.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The proposed activity will not result in the isolation of any areas of habitat. In addition, given the highly mobile nature of these species, it is considered unlikely that the proposed activity would result in fragmentation of habitat.

(i) The importance of the habitat to be removed, modified, fragmented or isolated to the long term survival of the species, population or ecological community in the locality,

The proposed activity will result predominantly in the removal of foraging habitat, although which is not likely to be critical habitat for these species. This is due primarily to the sparse nature of foraging resources within the site in relation to the extent of higher quality foraging habitat both within the study area and region.

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Therefore, the disturbance of a small amount of potential foraging habitat is unlikely to affect the long-term survival of these species in the locality.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

No critical habitat has been declared for these species

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

No recovery plan or threat abatement plan has been prepared for the Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat or Little Pied Bat.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

One key threatening process is relevant to this proposed activity with respect to the Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat and Little Pied Bat:

- Clearing of native vegetation.

The proposed activity involves the removal or modification of 102.6 ha of Derived Grassland, with an estimated loss of 155 out of 250 trees, few of which are mature. However, this represents only a small amount of potential habitat in the study region. There is a large amount of Derived Grassland mapped within the study region, only some of which contains paddock trees suitable for the Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat and Little Pied Bat, with less than 0.11% currently impacted by the defined exploration and appraisal activities. The proposed activity only represents a marginal cumulative contribution to this key threatening process.

Conclusions

The proposed activity is unlikely to constitute a significant impact on Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat and Little Pied Bat given that:

- The proposed activity will impact only some foraging habitat and no impact to roosting resources.
- Larger areas of suitable foraging habitat are present within the surrounding landscape.
- The proposed activity would not isolate or fragment any currently connecting areas of habitat in terms of use by this highly mobile species.

On the basis of the above considerations, it is unlikely that the proposed activity will constitute a significant impact on the Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat and Little Pied Bat.

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Appendix C: EPBC Act Assessment of Significance

This section provides an assessment of the potential significance of impacts from the proposed activity on Matters of National Environmental Significance (MNES). The EPBC Act Administrative Guidelines on Significance (DoE 2013) set out 'Significant Impact Criteria' that are to be used to assist in determining whether a proposed action is likely to have a significant impact on matters of national environmental significance.

MNES considered relevant to this assessment include:

Critically endangered or endangered species

- Swift Parrot
- Regent Honeyeater

Vulnerable species

- Koala
- Grey-headed Flying-fox
- South-eastern Long-eared Bat
- Large-eared Pied bat

Migratory species

- Rainbow Bee-eater
- Wetland birds:
    - Great Egret & Cattle Egret

Endangered – Swift Parrot

The Swift Parrot is a winter migrants to the south-eastern Australia mainland (March – October) from Tasmania, where they feed on winter-flowering eucalypts (OEH 2013b). The Swift Parrot is a highly mobile species able to utilise a variety of nectar sources over large areas (OEH 2013b). On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Favoured feed trees include winter flowering species such as *E. robusta*, *Corymbia maculata*, *C. gummifera*, *E. sideroxylon*, and *E. albens*. Commonly used lerp infested trees include *E. microcarpa*, *E. moluccana* and *E. pilularis*. This species breeds from September to January, nesting in old trees with hollows and feeding in forests dominated by Tasmanian Blue Gum *E. globulus* (OEH 2013b).

An action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it will:

Criterion a: lead to a long-term decrease in the size of a population, or

The site only represents potential foraging habitat for the Swift Parrot during times of sporadic flowering of eucalypts on the site. Approximately 0.03% of foraging habitat from within the study region will be impacted and the proposed activity will not impact on breeding habitat for the species as it breeds in

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Tasmania. Given the availability of similar habitat in the study area and high mobility of the species the proposed activity is unlikely to lead to the long-term decline of a population of the Swift Parrot.

Criterion b: reduce the area of occupancy of a population, or

The proposed activity is unlikely to measurably reduce the area of occupancy of such a highly mobile species.

Criterion c: fragment an existing population into two or more populations, or

The Swift Parrot is a highly mobile species with nomadic, non-breeding flocks occasionally descending on areas similar to the study site. The proposed activity is unlikely to fragment an existing population of such a highly mobile species.

Criterion d: adversely affect habitat critical to the survival of a species, or

The site contains marginal foraging and roosting habitat for the Swift Parrot, however given the availability of similar habitat within the study area and mobility of the species, this habitat is unlikely to be critical to the survival of the species.

Criterion e: disrupt the breeding cycle of a population, or

The Swift Parrot breeds in Tasmania and the proposed activity will not disrupt the breeding cycle of the species.

Criterion f: modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or

The proposed activity will result in the loss of a small amount of foraging and roosting habitat relative to the available habitat within the study area and across the species range. The proposed activity is therefore unlikely to result in the decline of the species.

Criterion g: result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat*, or

The proposed activity will not result in the establishment of an invasive species that is harmful to the Swift Parrot. Invasive species considered harmful to the species are already known to be present on the site.

Criterion h: Introduce disease that may cause the species to decline;

The proposed activity will not result in the introduction of a disease that is harmful to the Swift Parrot.

Criterion i: interfere with the recovery of the species.

The proposed activity is unlikely to interfere with the recovery of the species

The action is not likely to have a significant impact on the Swift Parrot.

On the basis of the above considerations, the proposed action is not likely to have a significant impact on the Swift Parrot.

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Endangered – Regent Honeyeater

The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. Once recorded between Adelaide and the central coast of Queensland, its range has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland. There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years non-breeding flocks converge on flowering coastal woodlands and forests.

The Regent Honeyeater mostly occurs in dry-ironbark eucalypt woodland and dry sclerophyll forest associations, where they prefer the most fertile site available, e.g. along creek flats, or in broad river valleys and foothills. In NSW, riparian forests containing *Casuarina cunninghamiana*, and with *Amyema cambagei*, are also important for feeding and breeding. They may also use other woodland types and wet lowland coastal forest dominated by *E. robusta* or *C. maculata*.

Regent Honeyeaters inhabit woodlands that support a significantly high abundance and species richness of bird species. These woodlands have significantly large numbers of mature trees, high canopy cover and abundance of mistletoes.

The species breeds between July and January in Box-Ironbark and other temperate woodlands and riparian gallery forest dominated by River Sheoak.

The Regent Honeyeater is a generalist forager, which mainly feeds on the nectar from a wide range of eucalypts and mistletoes. Key eucalypt species include *E. sideroxylon*, *E. melliodora*, *E. blakelyi*, *E. albens* and *E. robusta*. Also utilises : *E. microcarpa, E. punctata, E. polyanthemos, E. moluccana, Corymbia robusta, E. crebra, E. caleyi, Corymbia maculata, E. mckieana, E. macrorhyncha, E. laevopinea,* and *Angophora floribunda*. Nectar and fruit from the mistletoes *A. miquelii, A. pendula, A. cambagei* are also eaten during the breeding season. When nectar is scarce lerp and honeydew comprise a large proportion of the diet.

An action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it will:

Criterion a: lead to a long-term decrease in the size of a population, or

The Regent Honeyeater mainly inhabits inland areas of south eastern Australia. The proposed activity will result in the loss of some foraging and roosting habitat but will not affect breeding habitat for the species. Given only 0.03% of foraging habitat from within the study region will be impacted and high mobility of the species, the proposed activity is unlikely to lead to the long-term decline of a population of the Regent Honeyeater.

Criterion b: reduce the area of occupancy of a population, or

The proposed activity is unlikely to measurably reduce the area of occupancy of such a highly mobile species.

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Criterion c: fragment an existing population into two or more populations, or

The Regent Honeyeater is a highly mobile species with semi-nomadic, non-breeding flocks occasionally descending on areas similar to the study site during prolific flowering events to forage. The proposed activity is unlikely to fragment an existing population of such a highly mobile species.

Criterion d: adversely affect habitat critical to the survival of a species, or

The site contains foraging and roosting habitat for the regent honeyeater, however given the site is not within the known breeding area of the species and availability of similar habitat within the study area and mobility of the species, the habitat on site is unlikely to be critical to the survival of the species.

Criterion e: disrupt the breeding cycle of a population, or

The Regent Honeyeater is not known to breed within the study region and as such, the proposed activity is unlikely to impact directly on the breeding cycle of the species. Impacts to potential foraging and roosting habitat for the species will be small and as such not likely to affect the breeding population.

Criterion f: modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or

The proposed activity will result in the loss of a small amount of foraging and roosting habitat relative to the available habitat within the study area and across the species range. The proposed activity is, therefore, unlikely to result in the decline of the species.

Criterion g: result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat*, or

The proposed activity will not result in the establishment of an invasive species that is harmful to the Regent Honeyeater. Invasive species considered harmful to the species are already known to be present on the site.

Criterion h: Introduce disease that may cause the species to decline;

The proposed activity will not result in the introduction of a disease that is harmful to the Regent Honeyeater.

Criterion i: interfere with the recovery of the species.

The proposed activity is unlikely to interfere with the recovery of the species

On the basis of the above considerations, the proposed action is not likely to have a significant impact on the Regent Honeyeater.

Vulnerable – Koala

The Koala occurs along the east coast of Australia and extends into woodland, Mulga and River Red Gum forests west of the Great Dividing Range. The range of the Koala covers all such suitable areas of NSW. In drier forested areas, Koalas are generally observed as individuals in low densities. They are more abundant in coastal woodland and in open forest.

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Koalas are solitary and territorial (particularly males) yet live in established sedentary polygynous breeding aggregates arranged in a matrix of overlapping home ranges whose size varies according to and carrying capacity of the habitat (Phillips and Callaghan 1995).

Nationally, koalas have been observed feeding or resting in about 120 eucalypt species (66 in NSW) and 30 non-eucalypt (seven in NSW) species. Usage may also be determined by site-dependent edaphic factors e.g. soil type (Sharp and Phillips 1997), which affects the nutrient quality of forage. Forest consisting of primary browse species associations located on deep, fertile soils on floodplains, in gullies and along watercourses are generally considered preferred koala habitat. This may possibly be a reflection of the nutritional value of the foliage.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Criterion a: lead to a long-term decrease in the size of an important population of a species

Koalas are known from within the study region and the population is considered to be an important population. However extensive surveys on the site did not record the species or any evidence of their use of the site. The habitat on the site represents only marginal foraging habitat due to the paucity of mature trees on site compared to the surrounding habitat. Large area of home ranges for the Koala in the Pilliga due to the lower carrying capacity of the habitat suggests that individuals could use the resources on the site from time to time, although they are unlikely to depend on its resources for survival. The proposed impact will affect up to 0.03% of foraging habitat in the study region which is not considered to cause a decrease in the size of any population in the region.

Criterion b: reduce the area of occupancy of an important population

The site only contains marginal foraging habitat, with extensive areas of higher quality habitat in the immediate vicinity. As such the proposed activity will not reduce the area of an important population of Koalas.

Criterion c: fragment an existing important population into two or more populations

The proposed activity will not result in the isolation of any areas of habitat. In addition, given the highly mobile nature of these species, it is considered unlikely that the proposed activity would result in fragmentation of habitat.

Criterion d: adversely affect habitat critical to the survival of a species

The habitat on site is only considered to be marginal foraging habitat and is not considered critical for the survival of the species.

Criterion e: disrupt the breeding cycle of an important population

As the site contains only marginal habitat and no evidence of their presence on the site has been recorded, the proposed activity will not disrupt the breeding cycle of an important population.

Criterion f: Adversely affect habitat critical to the survival of a species; modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;

The proposed activity will only impact on 0.03% of potential foraging habitat in the study region and the habitat on site is only considered marginal. In addition the proposed activity will not cause the

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fragmentation of any areas of habitat. As a result the proposed activity is not considered to impact on the species such that the species is likely to decline.

Criterion g: Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;

The proposed activity will not result in the establishment of an invasive species that is harmful to the Koala. Invasive species considered harmful to the species are already known to be present on the site.

Criterion h: Introduce disease that may cause the species to decline;

The proposed activity will not result in the introduction of a disease that is harmful to the Koala.

Criterion i: Interfere substantially with the recovery of the species;

Considering the above factors, the proposed activity will not interfere substantially with the recovery of the species.

On the basis of the above considerations, the proposed action is not likely to have a significant impact on the Koala.

Vulnerable – Grey-headed Flying-fox

The Grey-headed Flying-fox inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas (Churchill 1998, Eby 1996). The species have been recorded travelling long distances on feeding forays (Churchill 1998). Fruits and flowering plants of a wide variety of species are the main food source. The species roosts in large 'camps' of up to 200,000 individuals and are often located in gullies, typically close to water, in vegetation with a dense canopy (Churchill 1998).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Criterion a: lead to a long-term decrease in the size of an important population of a species

No important populations have been recorded within the study area. The site does not support key source populations for breeding or dispersal, populations necessary for maintaining genetic diversity, or populations near the limit of the species range.

Criterion b: reduce the area of occupancy of an important population

As above, the site does not support an important population of the species.

Criterion c: fragment an existing important population into two or more populations

As above, the site does not support an important population of the species . The proposed activity will not result in the isolation of any areas of habitat.

Criterion d: adversely affect habitat critical to the survival of a species

The site only provides sporadic foraging resources for the Grey-headed Flying-fox and is not considered habitat critical to the survival of the species.

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Criterion e: disrupt the breeding cycle of an important population

As above, the site does not support an important population of the species. In addition, the study area is not known to support 'camps' of flying foxes.

Criterion f: Adversely affect habitat critical to the survival of a species; modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;

The proposed activity will only impact on 0.03% of foraging habitat in the study region and the habitat on site is only considered sporadic and marginal. In addition the proposed activity will not cause the fragmentation of any areas of habitat. As a result the proposed activity is not considered to impact on the species such that the species is likely to decline.

Criterion g: Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;

The proposed activity will not result in the establishment of an invasive species that is harmful to the Grey-headed Flying-fox. Invasive species considered harmful to the species are already known to be present on the site.

Criterion h: Introduce disease that may cause the species to decline;

The proposed activity will not result in the introduction of a disease that is harmful to the Grey-headed Flying-fox.

Criterion i: Interfere substantially with the recovery of the species;

Considering the above factors, the proposed activity will not interfere substantially with the recovery of the species.

On the basis of the above considerations, the proposed action is not likely to have a significant impact on the Grey-headed Flying-fox.

Vulnerable – South-eastern Long-eared Bat

The South-eastern Long-eared Bat inhabits a variety of vegetation types including mallee, bulloke and box eucalypt dominated communities. However, it is more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland. Roosts in tree hollows, crevices and under loose bark.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Criterion a: lead to a long-term decrease in the size of an important population of a species

The Pilliga region is considered to support an important population of the South-eastern Long-eared Bat. The species has not been recorded in the study area despite some survey, however, the proposed activity may potentially impact potential foraging habitat. The South-eastern Long-eared Bat utilises box/ironbark/cypress pine vegetation hence the presence of this species on the site at times is possible. However, the site is predominantly considered to represent foraging habitat as few hollow-bearing trees were identified and the majority of trees were not considered to be mature (i.e. hollow forming). The

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highly mobile nature of this species suggests that individuals could use the resources on the site from time to time, although they are unlikely to depend on its resources for survival. As the proposed activity would disturb 0.02% of habitat in the study region the proposed activity is unlikely to decrease the size of an important population.

Criterion b: reduce the area of occupancy of an important population

The site only contains foraging habitat and marginal roosting resources, with extensive areas of higher quality habitat in the immediate vicinity. As such the proposed activity will not reduce the area of an important population of South-eastern Long-eared Bat.

Criterion c: fragment an existing important population into two or more populations

The proposed activity will not result in the isolation of any areas of habitat. In addition, given the highly mobile nature of these species, it is considered unlikely that the proposed activity would result in the fragmentation of an important population of this species.

Criterion d: adversely affect habitat critical to the survival of a species

The site only contains a relatively small amount of potential foraging habitat and some marginal roosting habitat. The species was not recorded during surveys, although the methodology used does not specifically target this species. Due to the condition of the habitat on site and amount of habitat in the region, the site is not considered to represent habitat critical to the survival of the species.

Criterion e: disrupt the breeding cycle of an important population

The Pilliga region is considered to support an important population of the South-eastern Long-eared Bat and the site only contains foraging habitat and some marginal roosting resources. However, due to the paucity of mature trees and few hollows recorded, the site is not considered to support any habitat important for the breeding of the species.

Criterion f: Adversely affect habitat critical to the survival of a species; modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;

The proposed activity will only impact on 0.02% of potential foraging habitat in the study region and the habitat on site is only considered marginal. In addition the proposed activity will not cause the fragmentation of any areas of habitat and the species was not recorded in targeted surveys. As a result the proposed activity is not considered to impact on the species such that the species is likely to decline.

Criterion g: Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;

The proposed activity will not result in the establishment of an invasive species that is harmful to the South-eastern Long-eared Bat. Invasive species considered harmful to the species are already known to be present on the site.

Criterion h: Introduce disease that may cause the species to decline;

The proposed activity will not result in the introduction of a disease that is harmful to the South-eastern Long-eared Bat.

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Criterion i: Interfere substantially with the recovery of the species;

Considering the above factors, the proposed activity will not interfere substantially with the recovery of the species.

On the basis of the above considerations, the proposed action is not likely to have a significant impact on the South-eastern Long-eared Bat.

Vulnerable – Large-eared Pied Bat

The Large-eared Pied Bat has been recorded in a variety of habitats, including dry sclerophyll forests, woodland, sub-alpine woodland, edges of rainforests and wet sclerophyll forests (Churchill 1998; OEH 2013b). This species roosts in caves, rock overhangs and disused mine shafts and as such is usually associated with rock outcrops and cliff faces (Churchill 1998).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Criterion a: lead to a long-term decrease in the size of an important population of a species

The species has not been recorded in the study area despite survey, however, the proposed activity may potentially impact potential foraging habitat. The highly mobile nature of this species suggests that individuals could use the resources on the site from time to time, although they are unlikely to depend on its resources for survival. As the proposed activity would disturb 0.02% of habitat in the study region the proposed activity is unlikely to decrease the size of an important population.

Criterion b: reduce the area of occupancy of an important population

The site only contains marginal foraging habitat and no roosting or breeding habitat is known within the immediate vicinity. In addition there are extensive areas of higher quality habitat in the immediate locality. As such the proposed activity will not reduce the area of an important population of Large-eared Pied Bat.

Criterion c: fragment an existing important population into two or more populations

The proposed activity will not result in the isolation of any areas of habitat. In addition, given the highly mobile nature of this species, it is considered unlikely that the proposed activity would result in the fragmentation of an important population of this species.

Criterion d: adversely affect habitat critical to the survival of a species

The site only contains a relatively small amount of potential foraging habitat and breeding habitat is not known within the vicinity of the site. The species was surveyed and was not recorded and as a result the site is not considered to represent habitat critical to the survival of the species.

Criterion e: disrupt the breeding cycle of an important population

No important Large-eared Pied Bat populations have been identified in the study area and the site only contains marginal foraging habitat. The site is not considered to support any habitat important for the breeding of the species.

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Criterion f: Adversely affect habitat critical to the survival of a species; modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;

The proposed activity will only impact on 0.02% of potential foraging habitat in the study region and the habitat on site is only considered marginal. In addition the proposed activity will not cause the fragmentation of any areas of habitat. As a result the proposed activity is not considered to impact on the species such that the species is likely to decline.

Criterion g: Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;

The proposed activity will not result in the establishment of an invasive species that is harmful to the Large-eared Pied Bat. Invasive species considered harmful to the species are already known to be present on the site.

Criterion h: Introduce disease that may cause the species to decline;

The proposed activity will not result in the introduction of a disease that is harmful to the Large-eared Pied Bat.

Criterion i: Interfere substantially with the recovery of the species;

Considering the above factors, the proposed activity will not interfere substantially with the recovery of the species.

On the basis of the above considerations, the proposed action is not likely to have a significant impact on the Large-eared Pied Bat.

Migratory Terrestrial – Rainbow Bee-eater

Rainbow bee-eaters are a common species and can be found during the summer in forested areas in most of southern Australia. They may be found in open woodlands, beaches, dunes, cliffs, mangroves, woodlands and they often visits parks and private gardens. They have a diet mainly of flying insects.

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

Criterion a: substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;

The Rainbow Bee-eater is distributed across the majority of mainland Australia, with the exception of the most arid zones of the central and western deserts. It can be found on several near-shore islands, but is not found in Tasmania. Southern populations of Rainbow Bee-eater are known to migrate following breeding to spend winter in northern Australia. It is found mainly in open forests, woodlands and shrublands, and can tolerate some level of human disturbance or habitation, but has been found in a wide range of habitat types from vine thickets to sedgelands to dune systems. The Rainbow Bee-eater generally forages from open perches, from which is may scan for prey. Prey usually consists of flying insects, however they have been known to occasionally eat earthworms, spiders and tadpoles.

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The Rainbow Bee-eater has not been recorded on site, but is known from within the study region.

Under the proposed activity, there will be suitable foraging and roosting habitat maintained on site. In addition, there is a large amount of this habitat available in the area surrounding the site.

Therefore, the action is unlikely to significant impact on important habitat for this species.

Criterion b: result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or

The proposed activity will not result in the establishment of an invasive species that is harmful to the Rainbow Bee-eater. Invasive species considered harmful to the species are already known to be present on the site.

Criterion c: seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

The Rainbow Bee-eater is considered widespread and common and the impacts from the proposed activities only have the potential to impact on a very small number of individuals, if at all. An ecologically significant proportion of the population of this species is not considered to be supported on the site and therefore will not be impacted.

Migratory Wetland – Great Egret & Cattle Egret

Eastern Great Egrets are widespread in Australia. They occur in all states/territories of mainland Australia and in Tasmania. They have been reported in a wide range of wetland habitats (for example inland and coastal, freshwater and saline, permanent and ephemeral, open and vegetated, large and small, natural and artificial).

The Cattle Egret is widespread and common according to migration movements and breeding localities surveys. The Cattle Egret occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands. High numbers have been observed in moist, low-lying poorly drained pastures with an abundance of high grass; it avoids low grass pastures. It has been recorded on earthen dam walls and ploughed fields.

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

Criterion a: substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;

Both of these species are widespread in Australia, and breeding populations are found all over the country with the exception of the driest regions of the interior. They inhabit a wide range of wetland habitats, usually foraging in shallow waters

Under the proposed activity, several small farm dams will be removed or modified. These areas of habitat are not considered to be critical foraging habitat and are not breeding habitat. In addition, the irrigated lands will provide intermittent foraging habitat for these species. A s a result, the action is unlikely to significant impact on important habitat for this species.

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Criterion b: result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or

The proposed activity will not result in the establishment of an invasive species that is harmful to these species. Invasive species considered harmful to these species are already known to be present on the site.

Criterion c: seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Both the Great Egret and Cattle Egret is considered widespread and common and the impacts from the proposed activities only have the potential to impact on a very small number of individuals, if at all. An ecologically significant proportion of the population of this species is not considered to be supported on the site and therefore will not be impacted.

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Appendix 9

Cultural heritage due diligence report (Central Queensland Cultural Heritage Management)

ABORIGINAL CULTURAL HERITAGE
DUE DILIGENCE REPORT

LEEWOOD PRODUCED WATER TREATMENT AND BENEFICIAL REUSE PROJECT

PREPARED BY

CENTRAL QUEENSLAND CULTURAL HERITAGE MANAGEMENT PTY LTD

PREPARED FOR

SANTOS NSW (EASTERN) PTY LTD

May 2014

CQCHM

CENTRAL QUEENSLAND

CULTURAL HERITAGE MANAGEMENT

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Appendix 2: Photographs of Scarred Trees

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Figure 3: Zoning scheme for Project Area 23

Executive Summary

Central Queensland Cultural Heritage Management Pty Ltd has been engaged by Santos NSW (Eastern) Pty Ltd (Santos) to prepare an Aboriginal Cultural Heritage Due Diligence Assessment for the Leewood Produced Water Treatment and Beneficial Reuse Project. Hereafter, this is referred to as the Project Area. The Project Area lies in the Narrabri Local Government Area (LGA).

This assessment has been undertaken in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects* (DECCW 2010) which requires reasonable and practicable steps be taken to:

- identify whether or not Aboriginal objects are, or are likely to be, present in an area;
- determine whether or not their activities are likely to harm Aboriginal objects (if present); and
- determine if an Aboriginal Heritage Impact Assessment is required (DECCW 2010:2).

Investigations under the code have included the following:

- A search of the Aboriginal Heritage Information Management System (AHIMS) database identified that there were no Aboriginal objects or Aboriginal places in the Project Area;
- Consideration of the following landforms - within 200 metres of water; within dune systems; on ridge tops and headlands; and immediately above or below cliff faces and/or rock shelters/cave - this report notes that none of these landforms are present in the Project Area;
- A desktop assessment including a review of previous archaeological and heritage studies in the vicinity of the Project Area; and
- A field examination of the Project Area was undertaken in which four Traditional Owner Field Officers participated.

Four Aboriginal objects or places have been identified within the Project Area. These consist of two scarred trees and two isolated stone artefacts (quartz flakes).

By application of the Avoidance Principle it is assessed that the risk of harm to Aboriginal objects can be avoided. If Santos rigorously applies the Avoidance Principle such that there

will be no Harm to the Aboriginal cultural heritage then no an Aboriginal Heritage Impact Permit (AHIP) will be necessary for the Project Activity.

Recommendations

This report has considered the available environmental and archaeological information for the Project Area, the land condition, as well as, the nature of the proposed activities. Taking account of these matters the following recommendations should be enacted in the management of Aboriginal cultural heritage.

Recommendation A

Santos must rigorously apply the Avoidance Principle to avoid causing any Harm to the Aboriginal cultural heritage that has been identified. In two instances (the scarred tree) this will involve exclusion of any Project Activities in the vicinity of the scarred trees. In the other two instances (the isolated quartz artefacts) this will involve the fencing of the isolated stone artefacts. These latter sites have been fenced with a 3m diameter buffer placed around them.

Recommendation B

It is recommended that Santos adopt the Precautionary Principle towards the Project Activity by initiating a program of monitoring during the course undertaking the Project Activity. This monitoring should consist of two persons nominated by the Narrabri Local Aboriginal Land Council and the Gomeroi native title claim group on at least two occasions when it is safe to do so immediately following earth-moving activities in the vicinity of the isolated quartz artefacts.

Recommendation C

If any additional Aboriginal object/s are identified in the Project Area during Project Activity, then all works in the immediate area must cease and the area is to be cordoned. The Office of Environment and Heritage must be notified by ringing the Enviroline 131 555 so that the site can be adequately assessed and managed in consultation with the relevant Aboriginal stakeholders.

Recommendation D

The proposed works can proceed within the Project Area subject to implementation of measures designed to give force to the Avoidance Principle and the Precautionary Principle. These are enunciated in Recommendations A-C.

Recommendation E

All relevant Santos staff and contractors should be made aware of their statutory obligations for heritage under NSW *National Parks and Wildlife Act 1974* which may be implemented as a heritage induction.

Recommendation F

This due diligence report must be kept by Santos so that it can be presented, if needed, as a defence from prosecution.

Recommendation G

In the event that skeletal remains are uncovered, work must cease immediately in that area and the area cordoned off. Santos must contact the NSW Police with no further action taken until written advice is provided by the Police. If the remains are determined to be of Aboriginal origin, the Office of Environment and Heritage must be notified by ringing the Enviroline 131 555 and a management plan prior to works recommencing must developed in consultation with the relevant Aboriginal stakeholders.

Recommendation H

In giving effect to Recommendations A, B, C (if necessary) and G engagement should be with the Narrabri Local Aboriginal Land Council and the Gomeroi native title claim group (in the latter case through their address for service – NSW Native Title Services).

Introduction

Central Queensland Cultural Heritage Management Pty Ltd (CQCHM) has been engaged by Santos (the proponent) to prepare an Aboriginal Cultural Heritage Due Diligence Report for the Leewood Produced Water Treatment and Beneficial Reuse Project.

The proposed activity is designed to treat produced water stored at Leewood from Santos' CSG exploration and appraisal activities, and beneficially reuse the treated water for irrigation, dust suppression, construction and drilling uses, and emergency firefighting purposes.

The purpose of a due diligence report is to demonstrate that reasonable and practicable measures were taken to prevent harm to an Aboriginal object or place and has been undertaken in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (2010) ("Due Diligence Code").

This report has considered the relevant environmental and archaeological information, landforms, disturbances and the nature of the proposed activity in addition to formulating appropriate recommendations.

The Project Area

This due diligence report has been prepared for the area subject to the proposed activities – described below and hereafter referred to as the Project Area. The Project Area is located approximately 24 kilometres southwest of Narrabri in the Narrabri Local Government Area – see figure 1.

Proposed Activity

Santos is currently constructing two multi-celled 300 ML produced water and brine management ponds and associated infrastructure at Leewood. These ponds are designed to store produced water from Santos' ongoing CSG exploration and appraisal activities within PAL 2 and PEL 238, and to receive produced water and brine from previous operations which is currently stored at a facility located in the Bibblewindi State Forest. It should be noted that the Pond area in the northwestern portion of the Project Area had been subject of previous due diligence study. This area was excluded from this assessment (see figure 2)

It was determined that a due diligence assessment under S1 and S2a of the Due Diligence Code (DECCW 2010:11) was required in advance of any ground disturbing activities.

Authorship

This report was prepared by Dr Luke Godwin (CQCHM - archaeologist) with contributions from Andrew Border (archaeologist) and Robert van Reijswoud (GIS).

Fieldwork was undertaken by Andrew Border (CQCHM - archaeologist) with assistance from Traditional Owner Field Officers – see below.

CQCHM has extensive experience in the provision of cultural heritage management services for the coal and gas industries. It has undertaken large-scale commissions in NSW for RTCA, Northparkes Mine and at Lake Cowal Mine. CQCHM completed a comprehensive audit of cultural heritage data for the greater Pilliga area for Santos in 2013.

Legislative Context

The following overview is provided by way of background and should not be interpreted as legal advice. If deemed necessary, specific legal advice should be obtained from a suitably qualified legal practitioner prior to any action being taken.

The primary Acts and Regulations applying to this report include:

National Parks & Wildlife Act 1974; and

National Parks & Wildlife Regulation 2009

The *National Parks & Wildlife Act 1974* protects Aboriginal cultural heritage (places and objects) within NSW;

The *National Parks and Wildlife Regulation 2009* provide a framework for undertaking activities and exercising due diligence.

National Parks & Wildlife Act 1974

The *National Parks & Wildlife Act 1974* (NPW Act) protects Aboriginal cultural heritage within NSW. Protection of Aboriginal cultural heritage is outlined in s86 of the Act, as follows:

- A person must not harm or desecrate an object that the person knows is an Aboriginal object s86(1);
- A person must not harm an Aboriginal object s86(2); and
- A person must not harm or desecrate an Aboriginal place s86(4).

Penalties apply for harming an Aboriginal object or place. The penalty for knowingly harming an Aboriginal object (s86(1)) and/or an Aboriginal place (s86(4)) is up to $550,000 for an individual and/or imprisonment for 2 years; and in the case of a corporation the penalty is up to $1.1 million. The penalty for a strict liability offence (s86(2)) is up to $110,000 for an individual and $200,000 for a corporation.

Harm

Under the NPW Act, harm is defined as any act that: destroys defaces or damages the object; moves the object from the land on which it has been situated; and/or causes or permits the object to be harmed.

However, it is a defence from prosecution if the proponent can demonstrate:

- that harm was authorised under an Aboriginal Heritage Impact Permit (AHIP) (and the permit was properly followed); or
- that the proponent exercised due diligence in respect to Aboriginal cultural heritage.

A defence of Due Diligence (s87(2)), states that if a person or company has exercised due diligence to ascertain that no Aboriginal object was likely to be harmed as a result of the activities proposed for the Project Area (subject area of the proposed activity); then liability from prosecution under the NPW Act will be removed or mitigated if it later transpires that an Aboriginal object was harmed. The actions reported herein conform to the requirements for this defence.

Notification of Aboriginal Objects

Under section 89A of the NPW Act Aboriginal objects (and sites) must be reported to the Director-General (now Chief Executive) of OEH within a reasonable time (unless it has previously been recorded and submitted to AHIMS). Penalties of $11,000 for an individual and $22,000 for a corporation may apply for each object not reported.

National Parks and Wildlife Regulation 2009

The *National Parks and Wildlife Regulation 2009* ("NPW Regulation") provides a framework for undertaking activities and exercising due diligence in respect to Aboriginal cultural heritage. Among other things, the NPW Regulation outlines the recognised due diligence codes of practice which are relevant to this report, but it also outlines procedures for Impact Permit (AHIP) applications and Aboriginal Cultural Heritage Consultation Requirements (ACHCRs).

Due Diligence and Codes of Practice

Due Diligence:

- assists in avoiding unintended harm to Aboriginal objects;
- provides certainty as to the requisite measures to be taken by land managers and developers;
- encourages a precautionary approach;
- offers a defence against prosecution to the extent that a party has complied with the process is followed.

Under the s80A *National Parks & Wildlife Regulation* 2009 ("NPW Regulation") the following due diligence a range of Due Diligence Codes are recognised.

This report has been written to meet the Due Diligence Code (DECCW 2010).

The Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales (DECCW 2010) sets out a benchmark for acceptable due diligence investigations to be followed.

The purpose of the code is set out reasonable and practical steps in order to:

- identify whether or not Aboriginal objects (and places) are, or are likely to be, present in an area; and
- determine whether or not their activities are likely to harm Aboriginal objects (if present); and
- determine whether an AHIP application is required. (DECCW 2010:2).

Investigations under the code include the following:

- A search of the Aboriginal Heritage Information Management System (AHIMS) database to identify if there are previously recorded Aboriginal objects or places in the Project area;
- The identification of landscape features including land within 200 metres of water, dune systems, ridge tops, headlands, land immediately above or below cliff faces and/or rock shelters/caves;
- A desktop assessment including a review of previous archaeological and heritage studies and any other relevant material;
- Field examination of the Project Area to identify if there are Aboriginal objects present; and
- Assessment as to whether an AHIP is required.

This report has complied with the requirements of the code listed above. Other requirements under the code are outlined below.

Technically, Aboriginal consultation is not required for an investigation under the Due Diligence Code (DECCW 2010:3). However, if the due diligence investigation shows that the activities proposed for the area are likely to harm objects or likely objects within the landscape,

then an AHIP will be required with full consultation undertaken in a manner consistent with the Consultation Requirements stipulated by OEH.

A record of the due diligence procedure followed must be kept to ensure it can be used as a defence from prosecution (DECCW 2010:15). This report constitutes this record.

Following a due diligence assessment (where an AHIP application is not required), such as this, an activity must proceed with caution. If any Aboriginal objects are identified during the activity, then works should cease in that area and OEH notified (DECCW 2010:13). The due diligence defence does not authorise continuing harm.

Aboriginal Community Consultation

Aboriginal community consultation is not a formal requirement of the due diligence process (DECCW 2010:3) and therefore the proponent is not obliged to undertake Aboriginal community consultation.

However, Santos has chosen to undertake preliminary community consultation for the purposes of ensuring participation of Traditional Owner Field Officers in the fieldwork associated with these due diligence assessments. To that end, Santos consulted with both the Narrabri Local Aboriginal Land Council and Gomeroi native title claim group and sought their participation in the field work reported herein.

Management Principles

Santos has adopted two management principles.

The first of these management principles is the Avoidance Principle. For the purposes of this study the Avoidance Principle is, to the greatest extent possible, to design any Project Activity such that there is no impact to Aboriginal cultural heritage, thus avoiding Harm to any Aboriginal object or site and obviating the need to apply for an AHIP.

The second of these management principles is the Precautionary Principle. For our purposes the Precautionary Principle has two elements:

- the implementation of actions that are reasonable and practicable to minimise causing Harm to known Aboriginal objects; and/or

- identifying Aboriginal objects so they can be managed in accordance with the provisions of relevant legislation and regulations, and by implementing reasonable and practicable management measures for these Aboriginal objects.

Reasonable and practicable measures are determined on a case by case basis.

Environmental Context

Aboriginal cultural heritage due diligence requires that available knowledge and information is considered and forms part of the desktop assessment required under S4 of the Due Diligence Code (DECCW 2010:12- 13). The purpose of reviewing the relevant environmental and heritage information is to assist in identifying whether Aboriginal objects or places are present within the Project Area.

As Hughes and Sullivan (1985) noted, the location, form and condition of Aboriginal cultural heritage, at least as it manifests in material form, is closely influenced by the local environmental conditions. Accordingly, review of certain critical environmental features can be of assistance in determining expectations of the archaeological and in interpreting the results of any survey.

Project Area

The Project Area is in the Pilliga sub-region of the Brigalow Belt South Bioregion (Purcell 2002). The Project Area is predominantly located on the Jurassic Pilliga Sandstone landscape. Pilliga Sandstone is coarse textured and porous quartz sandstone with inter-bedded claystones, pebble beds and conglomerates (Ward 1999: 14). These sandstones lend themselves to providing materials that can be used as part of grinding technology: manufacture of axes and other ground edge implements and the production of grinding slabs used to prepare food stuffs. In areas, Pilliga Sandstone overlies the Walloon Coal Measures, which comprise claystone, shale, siltstone (Geoscience Australia 2012: Online). These materials, where exposed, offer excellent material for the production of flaked stone artefacts.

The landscape is characterised by stepped sandstone ridges with low cliff faces, and broad alluvial floodplains and valleys. There is a high proportion of rock outcrop and long gentle outwash slopes, which are intersected by sandy stream beds and prior stream channels, and interspersed with patches of heavy clay (Wallis 1971: 1). The low cliff faces in sandstone offer opportunity for the occurrence of rock shelters. These landscape features support the dense growth of trees and shrubs and high species diversity (Norris 1996: 1). A highly inter-digitated environment, with considerable degree of ecotonal development, affords a wider range of resources to hunter-gatherers.

Soils in the Project Area are typically shallow black earths and red loams on basalts. Extensive harsh texture contrast duplex soils with linear patterns of deep yellow sands and stony red broth earths are typical, as are cracking clay sub-soils. These soils are typical of those derived

from the Pilliga Sandstone and are described as highly siliceous. Cracking clays can lead to the disaggregation of archaeological sites as they expend and contract.

Several water sources, all ephemeral are present in the vicinity of the Project Area. These include Bohena Creek and Mollee Creek, but these lie some distance from the Project Area.

The Project Area is located within the eastern sub-humid region of Australia and has erratic rainfall and no water surplus available for run-off. In the regional area, rainfall is typically well distributed geographically. However, long droughts and occasional high-intensity, short-duration storms are typical, resulting in unreliable water sources (Ward 1999: 18). Large permanent water sources are not readily available in the immediate vicinity of the Project Area. Hunter-gatherers would have been dependent on ephemeral sources in creeks and other water bodies holding water after heavy rains and run off. Otherwise, they would have been reliant on small springs dotted through the area. In either case, large populations could not have been sustained within the Project Area for extended periods of time.

Although vegetation in the regional area has largely been cleared for agricultural and farming purposes, vegetation at the time of European settlement was partly dry sclerophyll forest, pine forest and small areas of grassland (Ward 1999: 11). The majority of the Project Area has been previously cleared for agricultural use. However, remnants of these vegetation communities is observable in the immediate vicinity of the Project Area.

In upland areas, tree species such as bimble box, white cypress pine, Blakely's red gum, white box, bull oak and wilga are typical, as are various species of wattle. Wire-grasses are also dominant in these areas, and rough speargrass and slender bamboo grass may also be present. On the alluvial plains, grassland is dominant, with typical species including curly windmill grass, nardoo, common rush, various species of roly-poly and wild turnip. A sparse tree population is also present; belah, a *Casuarina* species is prominent, though bimble box, silver-leaved ironbark, wilga, white cypress pine and bull oak are also typical. Along some creeks, vegetation predominantly comprises common rush, while along the Namoi River, river red gum is common (Ward 1999: 11-12). The box trees provided bark commonly used to manufacture a wide range of items including canoes, gunyahs, coolamons and other utilitarian items. Many of the other plants and trees were also culturally useful. Nardoo, for instance, provides vast quantities of grass seed which was one of the staple foods of Aboriginal populations in this region prior to European settlement.

Background Research

Aboriginal Heritage Information Management System (AHIMS)

A search was undertaken of the Aboriginal Heritage Information Management System (AHIMS) on 24 April 2014 in accordance with the Due Diligence Code (DECCW 2010:11). The searches were conducted over the area shown on the AHIMS report – see appendix 1.

The searches revealed that there are no previously recorded Aboriginal sites and no previously declared Aboriginal places in, or within, the vicinity of the Project Area.

National Native Title Tribunal Registers

A search was undertaken of the National Native Title Tribunal (NNTT) registers in October 2013. This search identified one native title claimant, being the Gomeroi People. Their claim extends over an area of 111,340 km^2. This claim was filed with the NNTT on 20 December 2011 and has subsequently been registered by the NNTT. This claim remains current.

Archaeology and Cultural Heritage Literature Review

A review of previous archaeological and heritage reports has been undertaken in accordance with the code (DECCW 2010:13). Those particularly pertinent are summarised below.

Balme (1986)

In 1986 Balme prepared a regional desktop study of northwestern New South Wales for the then NPWS. This study included the Warrumbungle area, and the results of that have been mentioned above. The study also included commentary on the Pilliga forest. Balme (1986) drew heavily, if not exclusively, on data held in the site register of NPWS and in any case little research had been undertaken in the Pilliga itself. Her primary observation was that there were very few sites in the forest when compared to the larger region. With the lack of permanent water and the comparatively depauperate flora she suggested that little use was made of the forest. What use was made of it probably involved short term visits for the purpose of hunting smaller macropods and other marsupials found there. The lack of grindstone material (either grooves or portable objects) used in preparation of vegetable founds and notably the grinding of grass and other seeds was, to her, a notable absence.

Roberts (1991)

Subsequent to this, Roberts (1991) undertook a survey of sections of the forest in the course of which he identified 89 new sites. These included 62 Scarred Trees, 24 open sites, some of

these extending in a linear fashion along creeks, and three rock shelters. Santos has commissioned a comprehensive review of all relevant cultural heritage data. This review examined all sites in what was termed the Audit Area – an area of approximately 200,000 hectares that includes the Project Area. Some of these sites lie within the Audit Area. Roberts also recorded the presence of ovens, grinding materials and ochre associated with these sites. The presence of grinding equipment and more variability in site types suggests a wider variety of activities occurring than was contemplated by Balme (1986). Certainly, even the relatively small piece of work undertaken by Roberts suggested that Balme's observations were perhaps an oversimplification of the picture based as they were on limited data and that further work would result in a more complex pattern of sites and use emerging.

Trindall (2002)

An assessment of cultural heritage values was carried out (Trindall 2002) as part of a petroleum exploration license application in the Pilliga Forest. It was noted that fires had burned through the area in 1997 and again in 2002. Approximately 36 km of linear transect were examined, resulting in the documentation of 4 Isolated stone artefacts (1 core and 3 flakes) and 1 scarred tree. Several locations where culturally significant resource plants also were identified.

Hughes (2002)

As part of the Southern Brigalow Belt (Purcell 2002), independent peer review was sought. These included comments of Dr Phil Hughes, a highly experienced geomorphologist with archaeological credential. His comments were provided in a short report. The commentary is noteworthy in regard to interpretation of the results of other archaeological studies because of the highly experienced and informed position the reviewer holds in Australian archaeology:

> The geomorphic report by Dr Hesse is good and if its findings are properly understood and applied this report will be of great value to future cultural heritage management strategies . . .
>
> One implication from the geomorphic report is that only a very small proportion of archaeological sites/materials in the form of stone artefact scatters will be exposed at the ground surface and that these can only be poorly characterised by field surveys. More and more survey will provide more and more 'dots on the map', but the quality and quantity of data collected for the recorded sites will almost always be poor.

This cautionary note and recommendation needs to be borne in mind in the design of future survey and management strategies.

Appleton (2009)

In 2009 an Aboriginal heritage assessment was undertaken as part of EIS studies for a proposed coal mine carried out on the northeastern corner of the Audit Area 30 km southwest of Narrabri. An area of approximately 256 km² was inspected (Appleton 2009). A total of 121 sites were recorded, consisting mainly of isolated finds and low density artefact concentrations.

Pardoe (2010)

Pardoe, in the course of a much larger study, undertook statistical analysis of the finds made by Appleton, notably of the number of lithic items per site. He observed that the resultant graph was typical of site size distributions for central western NSW. Pardoe (2010: 84) observed that: 'the number of large sites is very small compared to the number of smaller sites. The implications for site prediction are that larger sites should be encountered less often on a linear transect'. This, of course, has important implications for survey design and interpreting the results of other surveys that have been linear in form.

AECOM (2011)

As part of EIS preparations, AECOM conducted a cultural heritage survey for the previous Eastern Star Gas Project in the Pilliga and surrounding areas. The survey was conducted over a period of 13 days: 14 November to 26 November 2010. The field survey consisted of a series of transects across representative landforms targeting gas well site locations. This included Cowallah and Bohena Creeks. The Bohena Creek results are particularly pertinent as this is the closest creek to the Project Area. AECOM found a series of sites in this area: see table 1 below.

AECOM noted that ground surface visibility during the survey was significantly reduced following substantial rain events in late 2010. They also suggested that the majority of artefact scatters identified were in areas of creek bank erosion, had been exposed by that erosion and were originally sub-surface in context. By implication there was likely a strong prospect of sub-surface material in such areas. They observed that scarred trees were found in close proximity to creek lines and permanent waterholes. They further noted, however, that additional scarred trees might be present in the area in which they undertook their surveys.

Based on these observations they argued that potential archaeological deposits associated with creek lines were considered at risk from being impacted by the proposed works.

They observed that higher order (larger) creek lines and confluences i.e. where two or more major creek lines meet, are of particular sensitivity and every effort should be undertaken to

avoid these landforms. However, where this could not be avoided, the precautionary principle demanded that appropriate actions including monitoring and test-pitting should be set in place.

Site name	Site Type	Comment
Bohena Creek ST1	Scarred Tree	Likely PFAMC ST1
Bohena Creek AS1	Artefact Scatter	Likely PFAMC AS4
Bohena Creek AS2	Artefact Scatter	
Bohena Creek AS3	Artefact Scatter	Likely PFAMC AS5
Bohena Creek AS4	Artefact Scatter	Likely PFAMC AS2
Bohena Creek ST2	Scarred Tree	
Bohena Creek ST3	Scarred Tree	
Bohena Creek ST4	Scarred Tree	
Bohena Creek ST5	Scarred Tree	
Bohena Creek ST6	Scarred Tree	

Table 1: AECOM site data – Cowallah Creek

Synthesis of Aboriginal Cultural Heritage Context

A review of the AHIMS data and previous archaeological work in the vicinity of the Project Area suggests that the Project Area may have been utilised by past Aboriginal communities. This is in part due to the availability of food, water and other resources; the availability of water being a crucial factor in the frequency of occupation.

The literature review indicates that various types of sites, such as artefact scatters, isolated finds and scarred trees (sometimes referred to as culturally modified trees) appear to be the most frequent site type encountered in the general area. High order (larger) creek lines noted by AECOM as likely more sensitive on a cultural heritage basis are absent in the Project Area.

All these cultural heritage data (including that available from Purcell 2002) have been captured in an Aboriginal cultural heritage audit that has been undertaken by CQCHM for Santos. A cultural heritage sensitivity map has been prepared for the Audit Area based on these data. The Audit Area includes the Project Area. Based on this comprehensive review one site has previously been recorded in the immediate vicinity of the Project Area, this being a scarred tree situated at its northern end – see table 4 and figure 3.

World Heritage

The World Heritage List is a register of sites considered to have outstanding universal value. A search of the World Heritage List revealed there to be 20 World Heritage listings (one listing may contain several properties) in Australia, six of which are in NSW (UNESCO 2012: Online). There are no World Heritage listings in the Narrabri LGA, and therefore no listings within the Project Area.

National Heritage

The National Heritage List is now the lead statutory document for the protection of heritage places considered to have national importance. Listed places are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). A search of the Australian Heritage Database with reference to the National Heritage List on 9 May 2014 indicates that there are no heritage items in the town of Narrabri or the Narrabri LGA, on the National Heritage List, and consequently no national heritage items within or near to the Project Area.

Commonwealth Heritage

There are no Commonwealth heritage items in the Project Area.

Inspection and Field Results

Prior to entering the field, digital data was prepared for use with a differential GPS and PDA device so the study area could be accurately and systematically surveyed. Differential GPS affords an accuracy of 0.6 metres under ideal conditions. A transect pattern was prepared for each well and stored in a transect database. These data are held by Santos. A cultural heritage sites database was also prepared and uploaded to the PDA device for use in the field in the event of any finds being made. In addition, large scale maps were prepared to be used for field orientation.

In February 2014 Santos requested Gomeroi representatives and the Local Aboriginal Land Council (LALC) to undertake a cultural heritage assessment of the proposed Leewood irrigation area and associated infrastructure. The Gomeroi and LALC each nominated two representatives for the Cultural Heritage Survey Team (CHST) and the nominees participated in the survey. The team included an archaeologist, Andrew Border and thus fieldwork was undertaken by a team of five people. The fieldwork was undertaken on 10- 11 April 2014.

The CHST assembled at the Narrabri Operations Centre (NOC) at 7.00 am on 10 April 2014. After checking that appropriate inductions were in place the CHST proceeded to the Leewood survey area and signed in at the Daracon construction office where a site specific induction was undertaken.

The survey began at around 11 am and followed the transect pattern which had been designed prior to fieldwork starting (see Figure 2). Eight transects were designed consisting of an outward leg and a return leg with each transect line designed to cover a width of 100 m per leg. The total planned transects length to be walked was 14.485 km (see Table 2).

Transect 8 was not walked due to the area being waterlogged. Santos advised that the wooded area at the northern end of the Leewood Block, which was covered by Transects 7 and 8, will not be developed.

During the fieldwork, a total of four (4) cultural heritage objects were recorded. These included two stone artefacts made with quartz and two scarred trees. Details of these Aboriginal objects are included in Table 3. Locational data provided in GDA94.

The two quartz flakes (Sites 1 and 2) were small in size and approximately 1 cm or less in total length. Gomeroi representatives advised at the time that the quartz material was not local and was likely to be introduced to the area by Aboriginal people. Consistent with the

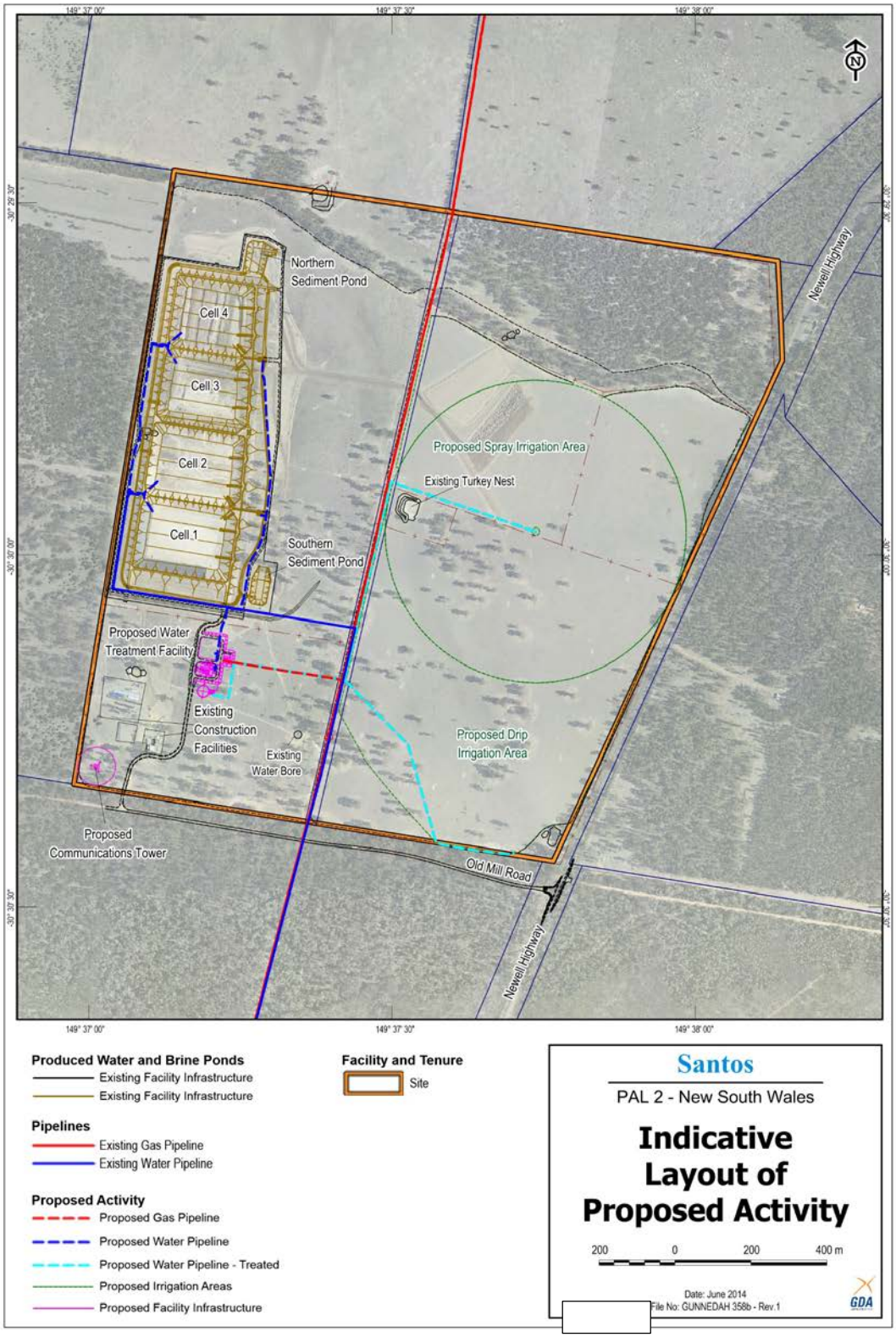


Figure 1: Leewood development area and associated infrastructure

ID	LENGTH (KM)	COMPLETED	DATE	GROUND SURFACE VISIBILITY %	NOTES
1	2.36	Yes	10/04/2014	90	
2	2.685	Yes	10/04/2014	90	
3	1.455	Yes	10/04/2014	90	
4	1.51	Yes	10/04/2014	90	
5	1.545	Yes	10/04/2014	90	
6	1.595	Yes	11/04/2014	90	
7	1.645	Yes	11/04/2014	90	
8	1.69	No	11/04/2014	NA	Waterlogged and not walked
	14.485				

Table 2: Pre-planned survey transects and completion data.

observations of the Gomeroi representatives, sources of quartz were not observed in surface deposits in the Project Area during the survey. However, the weathered sediments on which the Leewood site is located may contain quartz material below the ground which could be brought to the surface by farming activities or the excavation of post holes for fences. The flakes were clearly fractured off a larger block of quartz. However, no clear features which would identify the flakes as being produced anthropomorphically could be identified. Quartz artefacts can be difficult to identify. In these circumstances, adoption of the Precautionary Principle is appropriate and these flakes have been deemed to be Aboriginal objects. Two scarred trees were recorded in the remnant woodland at the northern end of the Leewood site (Sites 3 and 4). Photographs of the two scarred trees are provided at the end of the report as appendix 2. Details of the trees are provided in Table 3. One of these is in all probability a scarred tree that was identified as situated in this vicinity during the cultural heritage audit.

At the debriefing held at NOC on 11 April 2014, and immediately after the conclusion of the survey, Gomeroi and Narrabri LALC representatives indicated that salvage of the two quartz flakes and relocation out of the path of the development was an acceptable management option.

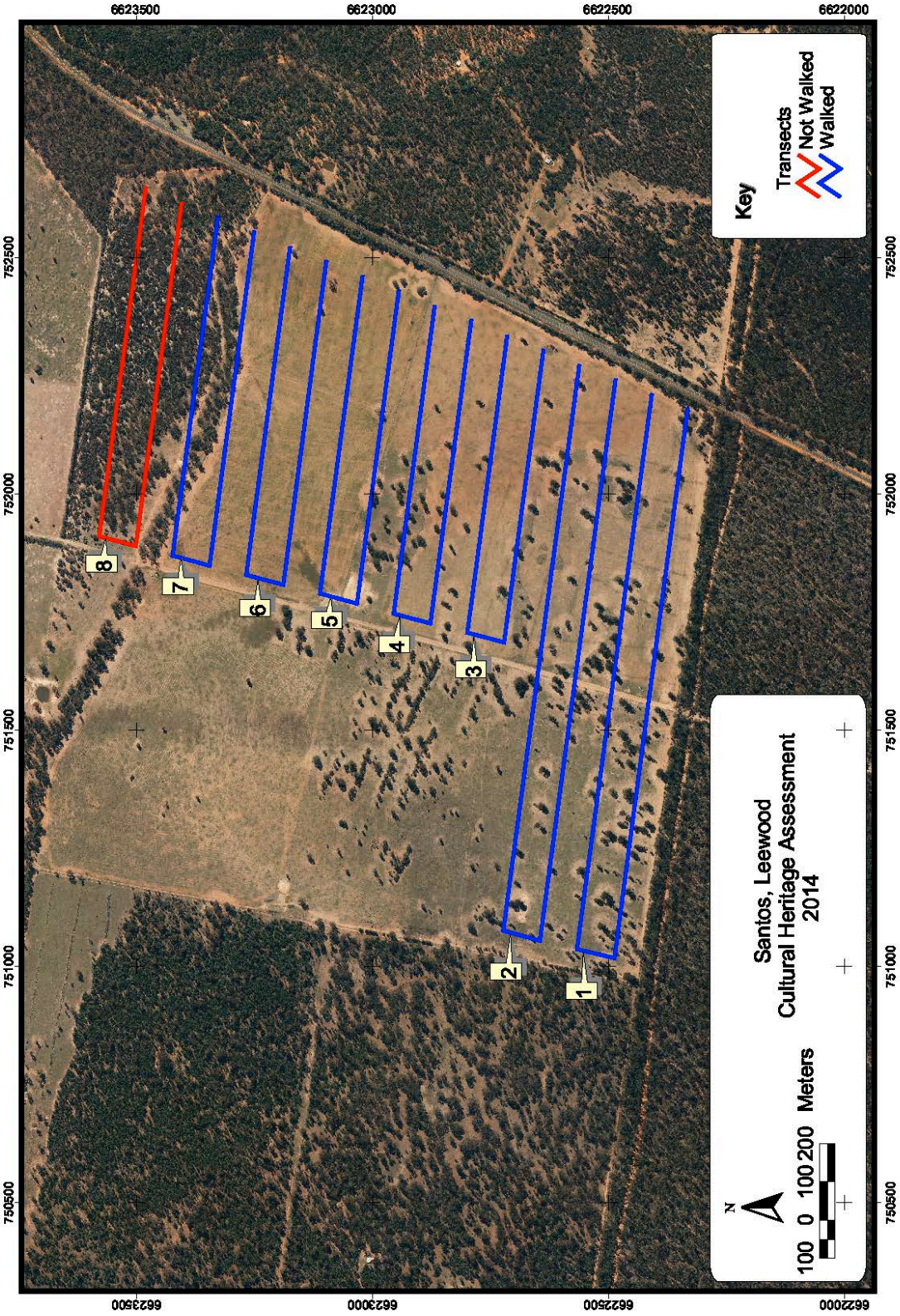
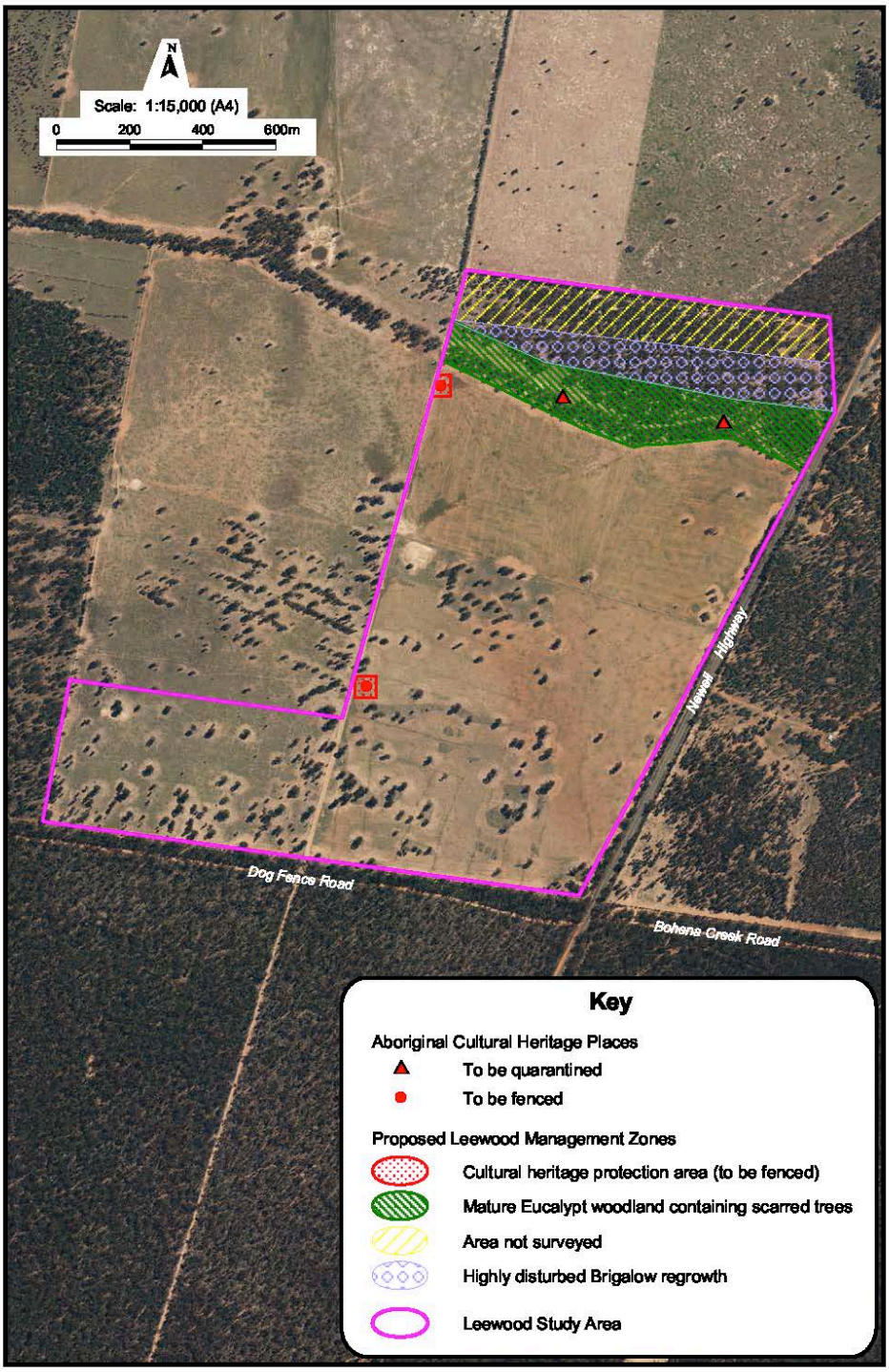


Figure 2: Leewood transect design

Site Id	Date Recorded	Easting	Northing	Site Type	Extent	Notes
1	10/04/2014	751854.16	6622693.05	Isolated Stone Artefact/s		1 quartz flake
2	11/04/2014	752047.34	6623428.54	Isolated Stone Artefact/s		1 quartz flake
3	11/04/2014	752330.82	6623390.69	Scarred Tree	1.4 x 0.25 m	live standing grey box, regrowth 0.3m
4	11/04/2014	752706.53	6623326.09	Scarred Tree	1.9 x 0.5 m	1m girth - live standing grey box

Table 3: Cultural heritage sites recorded for Leewood

They also advised that they wished a 20 metre exclusion zone be established around the two scar trees. No other management actions were required for the remainder of the Leewood site and that the development was free of any further cultural heritage constraints. A zoning map was produced post survey to identify areas free of cultural heritage constraints and areas subject to management actions - Figure 3.



Figue 3: Zoning scheme for Project Area .

Impact Assessment

The Project Area and the topography was of low relief. There are no features that conform to the highly sensitive landscape included in the Due Diligence Code (2010:11-12). There are no sites included in AHIMS. No sites had been identified during earlier surveys. Four sites were identified in the Project Area in the course of the fieldwork. These sites are protected under provisions of the *National Parks and Wildlife Act*. In the event that any Project Activity was to take place that impacted on these sites then Harm as that term is described in the Due Diligence Regulations would occur. Prior to taking any action to relocate these objects by way of salvage and mitigation it would be necessary to secure an AHIP. This would require Santos to take all actions necessary to comply with the OEH Consultation Requirements.

However, the Project Activities could proceed through rigorous implementation both of the Avoidance Principle and the Precautionary Principle. In relation to the Avoidance Principle:

- The scarred trees would be avoided by their inclusion in a quarantine zone designed to protect them and other native vegetation at the northern end of the Project Area. Santos has decided on this course of action.
- The isolated stone artefact (quartz) flakes can be avoided by installation of fencing around each location to ensure no disturbance of those areas was to occur during Project Activities.

These measures are depicted in figure 3 below. These constitute reasonable and practicable measures that avoid any charge of Harm. While the Gomeroi traditional owner field officers advised that the isolated stone artefacts could be salvaged and relocated such an action would not be necessary if the Avoidance Principle is implemented.

Attention is drawn to the comments of Hughes (2002) who notes of the general region that ‘a very small proportion of archaeological sites/materials in the form of stone artefact scatters will be exposed at the ground surface and that these can only be poorly characterised by field survey’. Consistent with this, studies in various locations demonstrate that as little as 5% of the artefactual material present at a location may be seen on the surface in ploughed areas (CQCHM 2005) such as is the case in the Project Area. Accordingly, noting these observations and in light of the discovery of Aboriginal objects, and notably the isolated stone artefacts, application of the Precautionary Principle in the form of reasonable and practicable measures to deal with further discovery of any other Aboriginal objects is warranted. A reasonable response in this case would be the engagement of monitors to inspect the Project

Area on at least two occasions when it is safe to do so immediately following earth-moving activities in the vicinity of these finds. Measures are also required in the event that the monitors identify any further cultural material in the course of monitoring.

Recommendations

This report has considered the available environmental and archaeological information for the Project Area, the land condition, as well as, the nature of the proposed activities. Taking account of these matters the following recommendations should be enacted in the management of Aboriginal cultural heritage.

Recommendation A

Santos must rigorously apply the Avoidance Principle to avoid causing any Harm to the Aboriginal cultural heritage that has been identified. In two instances (the scarred tree) this will involve exclusion of any Project Activities in the vicinity of the scarred trees. In the other two instances (the isolated quartz artefacts) this will involve the fencing of the isolated stone artefacts. These latter sites have been fenced with a 3m diameter buffer placed around them

Recommendation B

It is recommended that Santos adopt the Precautionary Principle towards the Project Activity by initiating a program of monitoring during the course undertaking the Project Activity. This monitoring should consist of two persons nominated by the Narrabri Local Aboriginal Land Council and the Gomeroi native title claim group on at least two occasions when it is safe to do so immediately following earth-moving activities in the vicinity of the isolated quartz artefacts.

Recommendation C

If any additional Aboriginal object/s are identified in the Project Area during Project Activity, then all works in the immediate area must cease and the area is to be cordoned. The Office of Environment and Heritage must be notified by ringing the Enviroline 131 555 so that the site can be adequately assessed and managed in consultation with the relevant Aboriginal stakeholders.

Recommendation D

The proposed works can proceed within the Project Area subject to implementation of measures designed to give force to the Avoidance Principle and the Precautionary Principle. These are enunciated in Recommendations A-C.

Recommendation E

All relevant Santos staff and contractors should be made aware of their statutory obligations for heritage under NSW *National Parks and Wildlife Act 1974* which may be implemented as a heritage induction.

Recommendation F

This due diligence report must be kept by Santos so that it can be presented, if needed, as a defence from prosecution.

Recommendation G

In the event that skeletal remains are uncovered, work must cease immediately in that area and the area cordoned off. Santos must contact the NSW Police with no further action taken until written advice is provided by the Police. If the remains are determined to be of Aboriginal origin, the Office of Environment and Heritage must be notified by ringing the Enviroline 131 555 and a management plan prior to works recommencing must developed in consultation with the relevant Aboriginal stakeholders.

Recommendation H

In giving effect to Recommendations A, B, C (if necessary) and G engagement should be with the Narrabri Local Aboriginal Land Council and the Gomeroi native title claim group (in the latter case through their address for service – NSW Native Title Services).

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AHIMS Web Services (AWS)
Search Result

Your Ref Number : 0101

Client Service ID : 132287

Andrew Border

Date: 22 April 2014

24 Gladstone Street
Coorparoo Queensland 4151

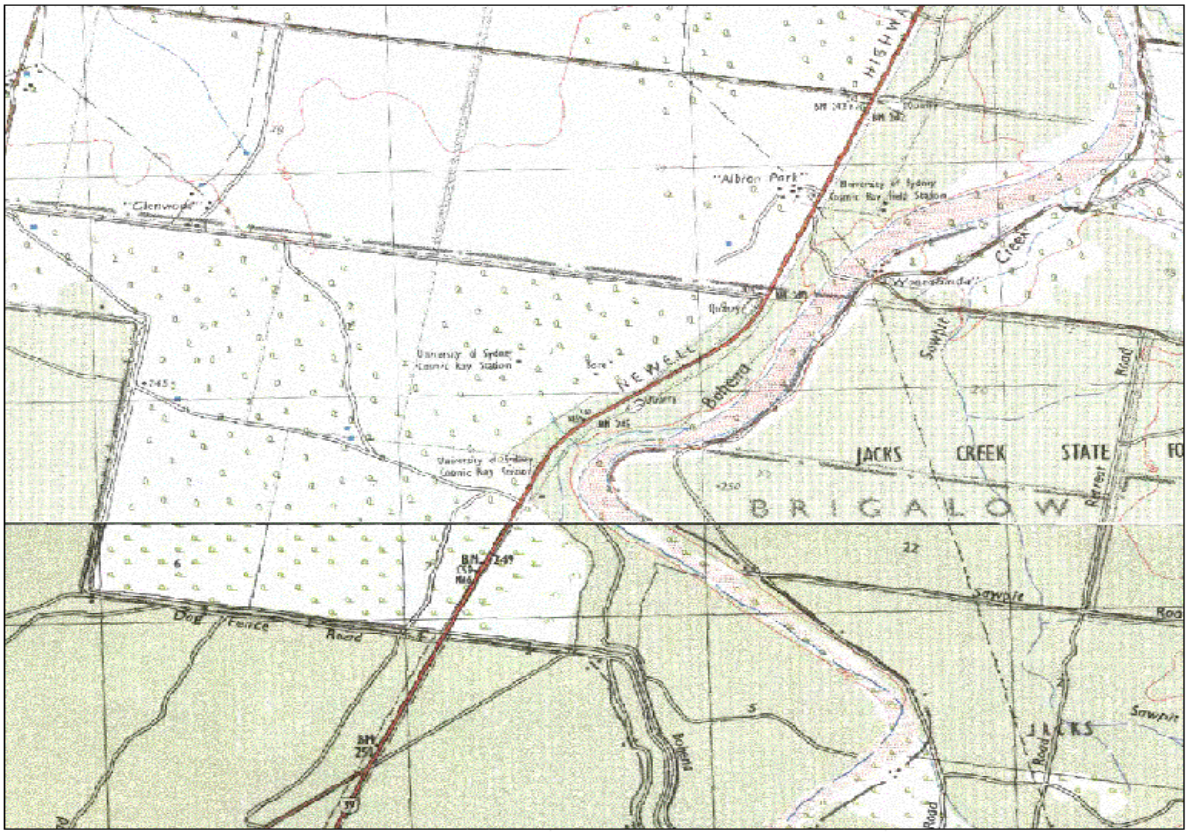
Attention: Andrew Border

Email: andrew.border@bigpond.com

Dear Sir or Madam:

AHIMS Web Service search for the following area at Lat, Long From : -30.52, 149.6 - Lat, Long To : -30.46, 149.68 with a Buffer of 50 meters, conducted by Andrew Border on 22 April 2014.

The context area of your search is shown in the map below. Please note that the map does not accurately display the exact boundaries of the search as defined in the paragraph above. The map is to be used for general reference purposes only.



A search of the Office of the Environment and Heritage AHIMS Web Services (Aboriginal Heritage Information Management System) has shown that:

1	**Aboriginal sites are recorded in or near the above location.**
0	**Aboriginal places have been declared in or near the above location. ***

If your search shows Aboriginal sites or places what should you do?

- You must do an extensive search if AHIMS has shown that there are Aboriginal sites or places recorded in the search area.
- If you are checking AHIMS as a part of your due diligence, refer to the next steps of the Due Diligence Code of practice.
- You can get further information about Aboriginal places by looking at the gazettal notice that declared it. Aboriginal places gazetted after 2001 are available on the NSW Government Gazette (http://www.nsw.gov.au/gazette) website. Gazettal notices published prior to 2001 can be obtained from Office of Environment and Heritage's Aboriginal Heritage Information Unit upon request

Important information about your AHIMS search

- The information derived from the AHIMS search is only to be used for the purpose for which it was requested. It is not be made available to the public.
- AHIMS records information about Aboriginal sites that have been provided to Office of Environment and Heritage and Aboriginal places that have been declared by the Minister;
- Information recorded on AHIMS may vary in its accuracy and may not be up to date .Location details are recorded as grid references and it is important to note that there may be errors or omissions in these recordings,
- Some parts of New South Wales have not been investigated in detail and there may be fewer records of Aboriginal sites in those areas. These areas may contain Aboriginal sites which are not recorded on AHIMS.
- Aboriginal objects are protected under the National Parks and Wildlife Act 1974 even if they are not recorded as a site on AHIMS.
- This search can form part of your due diligence and remains valid for 12 months.

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Photograph 1: Site 3 – Leewood – scarred tree



Photograph 2: Site 4 – Leewood – scarred tree

Appendix 10

Air quality and odour assessment (Pacific Environment)

Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology



Report

LEEWOOD PRODUCED WATER TREATMENT AND BENEFICIAL REUSE PROJECT - AIR QUALITY ASSESSMENT

RPS

Job ID. 08672E

12 March 2015

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1 INTRODUCTION

Pacific Environment was engaged by RPS on behalf of Santos NSW (Eastern) Pty Ltd ('Santos') to prepare an air quality and odour assessment for a proposed water and brine treatment plant (WBTP) located at Leewood, approximately 20 km south-west of Narrabri, NSW.

This Report quantifies the potential air quality and odour impacts that may arise due to the operation of the Leewood WBTP.

The assessment followed the procedures outlined in the NSW Environment Protection Authority's (EPA) document titled "Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW" (**EPA, 2005**).

This report provides information on the following:

- A description of the project.
- The air quality legislation and assessment criteria applicable to the project.
- The existing conditions in the area, including meteorology and air quality.
- The assessment of operational impacts.
- The assessment of construction impacts.
- A discussion of mitigation measures.

2 PROJECT DESCRIPTION

The proposed activity involves the design, construction, operation and maintenance of the WBTP on the Santos-owned Leewood property. The WBTP is a combined water treatment plant (WTP) and brine treatment plant (BTP).

The project setting is presented in its regional context in **Figure 2.1**. Leewood is located on the Newell Highway, approximately 24 kilometres south-west of Narrabri, NSW. The proposed site layout is presented in **Figure 2.2**. The site layout is provided in **Figure 2.3**.

The primary objective of the proposed activity is to construct and operate a purpose built, centralised water treatment facility outside of the Pilliga State Forest, to treat, manage and beneficially reuse produced water stored within the ponds.

Santos NSW (Eastern) Pty Limited is the proponent for the proposed activity on behalf of the titleholders of PAL 2. The proposed activity will include:

- construction and operation of:
  - a water treatment plant, including pre-treatment and reverse osmosis plant
  - a brine treatment plant
  - brine distribution manifold and associated piping at Leewood, to allow water distribution into the water treatment plant and associated return flows to brine storage ponds
  - a treated water storage tank (five megalitre capacity)
  - a managed irrigation system including a centre pivot and sub-surface drip irrigation system
  - other associated infrastructure, including a gas pipeline to fuel the generators
  - a small potable water treatment system for water extracted from the licensed bore
- the construction of (and the ability to operate) a treated water pipeline extending to the Leewood property boundary to transfer water to another location for irrigation by a third party (if required)
- re-use of treated water for irrigation at the Leewood property and other uses both on and off site including dust suppression, drilling and construction and firefighting . Santos is investigating the option of providing treated water to third parties for agricultural irrigation, although this potential use of treated water does not form part of the proposed activity for the purposes of this REF and will be subject to separate assessment and approvals.
- amelioration of soils within irrigation area by deep tillage, fertiliser, lime and gypsum in preparation for irrigation.
- decommissioning and rehabilitation of the site, if the Narrabri Gas Project does not proceed.

Santos (or its assigned operator) will operate the proposed activity for up to five years. The WBTP will treat up to 1.5 megalitres per day of produced water from Santos' CSG exploration and appraisal activities within PEL 238, PAL 2 and PPL 3. The operational process is expected to involve, but is not limited to:

- pumping of produced water from the produced water pond to the water treatment plant
- treatment of produced water within the water treatment plant, including removal of solids by filter (pre-treatment), reverse osmosis to separate the water and brine streams (treatment), and chemical and pH dosing (post-treatment) to make the treated water appropriate for irrigation
- transfer of treated water to the treated water storage tank or directly to the on-site managed irrigation system for beneficial re-use
- beneficial re-use of treated water for irrigation, or other uses both on and off-site such as dust suppression, drilling and construction and firefighting
- transfer of brine to the brine treatment plant for concentration and further recovery of treated water
- storage of brine in the existing Leewood ponds.

Power will be supplied by a 1.4-MW gas engine generator. If the gas generator is offline power will be supplied by a 0.8-MW diesel generator. An additional 0.2 MW generator would also be onsite but would be used for emergency situations only. Fuel for the gas generator will be supplied from the gas field via a fuel gas conditioning skid (FGCS) which removes liquid and solid contaminants from the gas to provide a suitable fuel quality. Diesel storage of up to 30,000 litres of fuel will be provided on site for power generation during times when the gas generator is offline.

Construction of the project is expected to take up to 50 weeks and be carried out in stages.



Figure 2.1: Regional setting

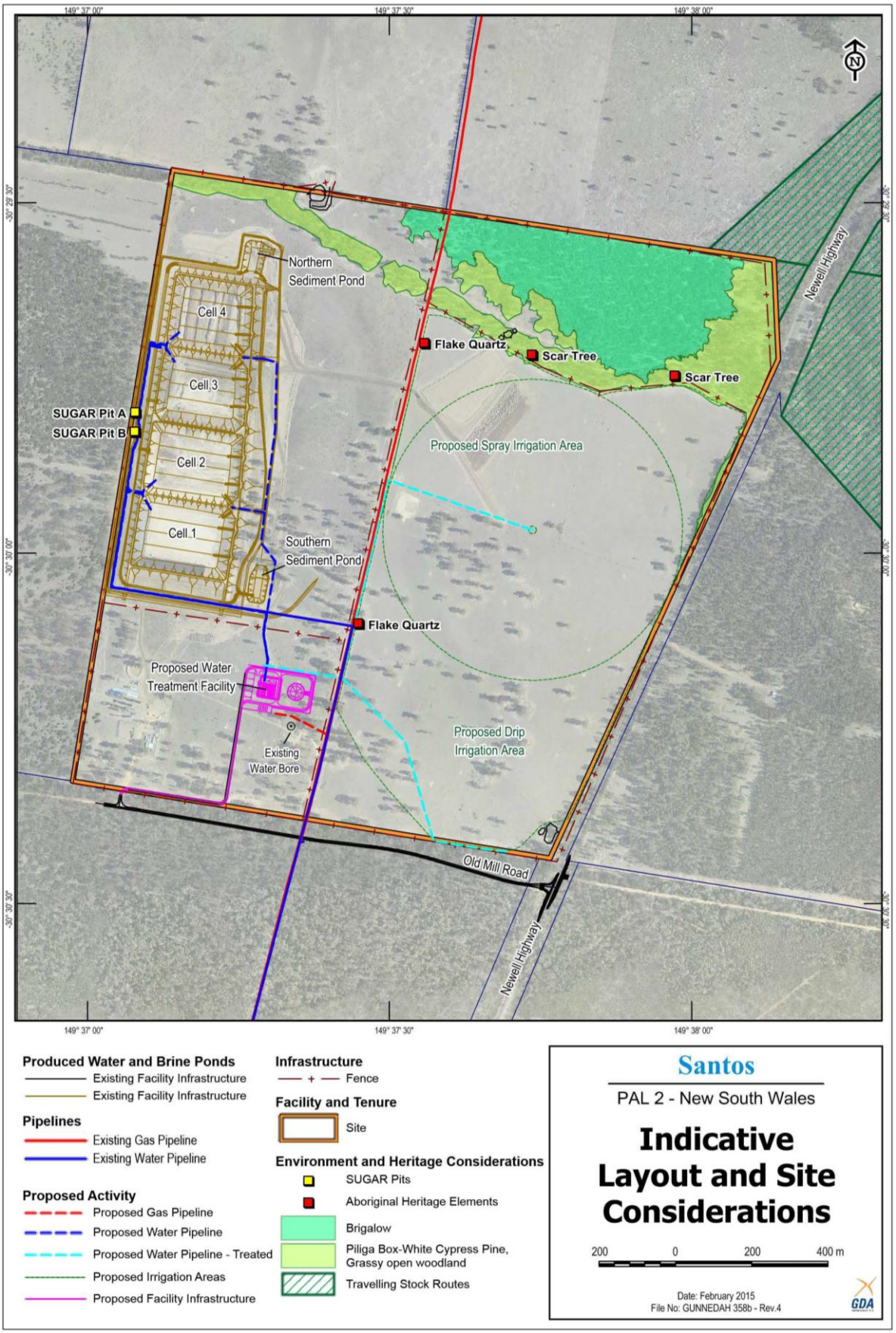


Figure 2.2: Site infrastructure

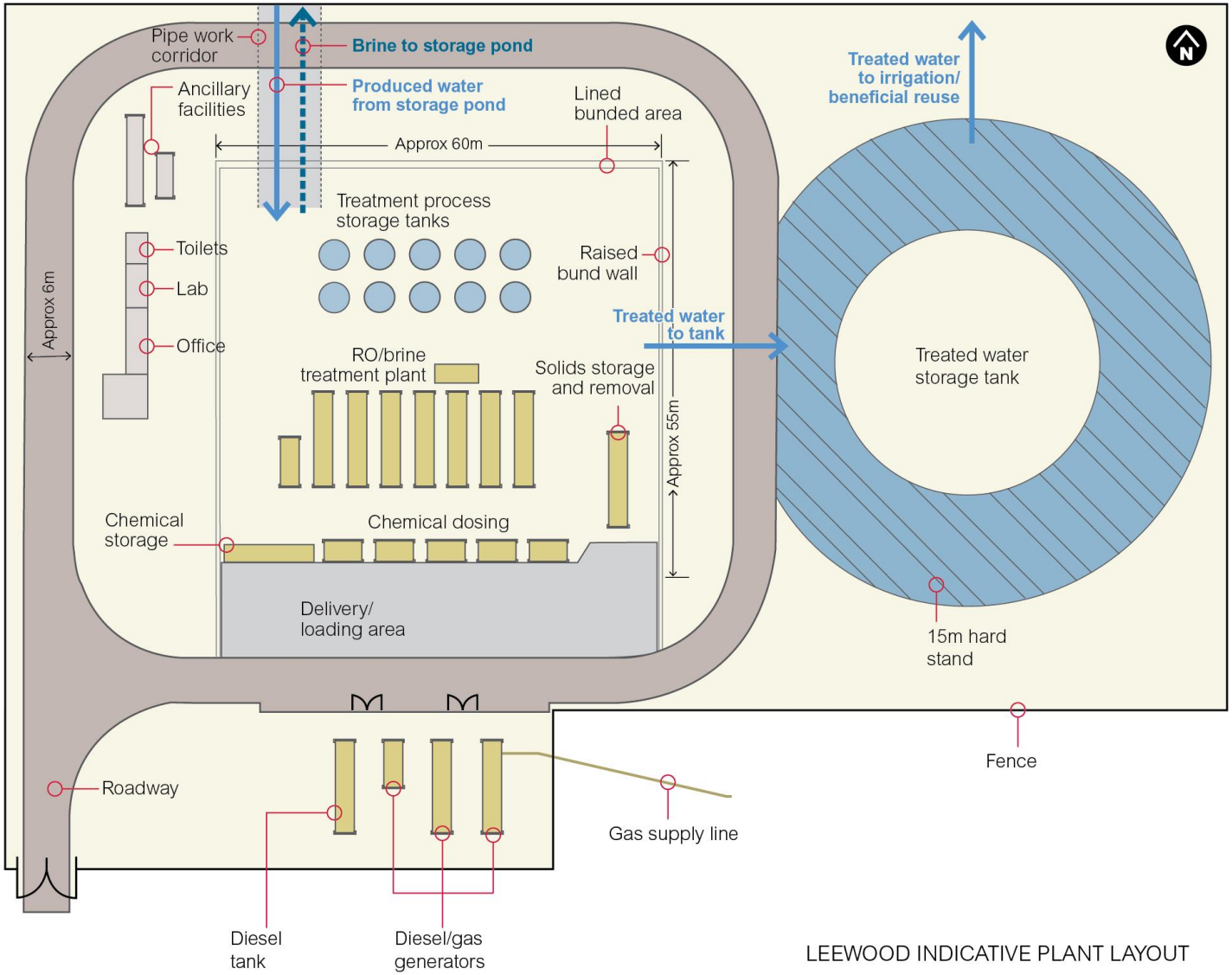


Figure 2.3: WBTP site layout

3 LEGISLATION AND ASSESSMENT CRITERIA

3.1 Assessment criteria

The Approved Methods specify air quality assessment criteria relevant for assessing impacts from air pollution (**EPA, 2005**). The impact assessment criteria refer to the total pollutant load in the environment and consideration of background particulate matter levels needs to be made when using these goals to assess potential impacts. These criteria are health-based (i.e. they are set at levels to protect against health effects).

The criteria are consistent with the National Environment Protection Measures for Ambient Air Quality (referred to in the report as the Ambient Air-NEPM) (**NEPC, 1998a**). However, the EPA's criteria includes averaging periods which are not included in the Ambient Air-NEPM, and also references other measures of air quality, namely dust deposition and total suspended particulates (TSP).

Table 3.1 summarises the air quality criteria for particulate matter that are relevant to this assessment. It is important to note that these criteria are also applied to the cumulative impact assessment (i.e. due to the proposed Leewood WBTP and in combination with other background sources).

Table 3.1: Air quality criteria for particulate matter

Air quality parameter	Averaging period	Concentration	Agency
TSP	Annual mean	90 µg/m³	National Health and Medical Research Council
PM_{10}	24-hour maximum	50 µg/m³	EPA impact assessment criteria. Ambient Air-NEPM reporting goal, allows five exceedences per year for bushfires and dust storms.
	Annual mean	30 µg/m³	EPA impact assessment criteria.
Sulfur dioxide (SO_2)	10-minute	712 µg/m³ (0.25 ppm)	EPA impact assessment criteria.
	1-hour	570 µg/m³ (0.2 ppm)	EPA impact assessment criteria.
	24-hour	228 µg/m³ (0.08 ppm)	EPA impact assessment criteria.
	Annual	60 µg/m³ (0.02 ppm)	EPA impact assessment criteria.
Nitrogen dioxide (NO_2)	1-hour	246 µg/m³ (0.12 ppm)	EPA impact assessment criteria.
	Annual	62 µg/m³ (0.03 ppm)	EPA impact assessment criteria.
Carbon monoxide (CO)	15-minute	100 mg/m³ (87 ppm)	EPA impact assessment criteria.
	1-hour	30 mg/m³ (25 ppm)	EPA impact assessment criteria.
	8-hour	10 mg/m³ (9 ppm)	EPA impact assessment criteria.
Volatile organic compound (VOC) (as Benzene)	1-hour	29 µg/m³ (9 ppm)	Impact assessment criterion for principal air toxic pollutant

Notes: (a) µg/m³ – micrograms per cubic metre.

In May 2003 the national Environmental Protection Council NEPC released a variation to the Ambient Air-NEPM (**NEPC, 2003**) to include advisory reporting standards for particulate matter with an equivalent aerodynamic diameter of 2.5 µm or less ($PM_{2.5}$), as shown in **Table 3.2**.

The Ambient Air NEPM $PM_{2.5}$ advisory reporting standards are not used as impact assessment criteria. Notwithstanding the above, in the absence of any other relevant standard/goal, the advisory

reporting standards have been used in this report for comparison against dispersion modelling results (**Section 5.3**).

Table 3.2: Advisory reporting standards for $PM_{2.5}$

Air quality parameter	Averaging period	Concentration [a]	Agency
$PM_{2.5}$	Annual mean	8 µg/m³	Ambient Air-NEPM Advisory Reporting Standard
	24-hour average	25 µg/m³	

Notes: (a) µg/m³ – micrograms per cubic metre.

3.2 Odour assessment criteria

For complex mixtures of air pollutants the odour impact assessment criteria take into account the population density in an area. **Table 3.3** lists the odour ground-level concentration criteria to be exceeded not more than 1% of the time, for different population densities. The differences between the odour criteria are based on a consideration of the risk of odour impact rather than differences in odour acceptability between urban and rural areas. For a given odour level there will be a wide range of responses in the population exposed to the odour. In a densely populated area there will therefore be a greater risk that some individuals within the community will find the odour unacceptable than in a sparsely populated area.

Table 3.3: Criteria for the assessment of odour

Population of affected community	Ground-level concentration criterion for complex mixtures of odorous air quality parameters (OU)
~2	7
~10	6
~30	5
~125	4
~500	3
Urban (2000) and/or schools and hospitals	2

*Source: Approved Methods (**EPA 2005**)*

A conservative approach has been adopted in the determination of the odour impact assessment criteria by basing the criteria on the most densely populated area within the vicinity of the proposed project. From **Figure 5.1** it can be inferred that the population density would be very low, with only six residences located within a 2-km radius of the Leewood WBTP. For conservatism, an odour criterion of 6 OU has been adopted for this assessment.

It is common practice to use dispersion models to determine compliance with odour criteria. This introduces a complication, as Gaussian dispersion models are only able to directly predict concentrations over an averaging period of three minutes or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a 3-minute period, odour levels can fluctuate significantly, depending on the nature of the source.

To determine more rigorously the ratio between the one-second peak concentrations and longer period average concentrations (referred to as the peak-to-mean ratio) that might be predicted by a Gaussian dispersion model, NSW EPA commissioned a study by **Katestone Scientific Pty Ltd (1995, 1998)**. This study recommended peak-to-mean ratios for a range of circumstances. The ratio is also dependent on atmospheric stability and the distance from the source. For this assessment we have assumed a peak-to-mean ratio of 2.3 for all stability classes. The EPA odour criteria take account of this peaking factor and the goals shown in **Table 3.3** are based on nose-response time, which is effectively assumed to be 1 second.

3.3 In-stack concentrations

The *Protection of the Environment Operations (Clean Air) Regulation 2010* specifies in-stack concentration criteria relevant to scheduled premises for general activities and plant. The emissions points for the Project must operate within these limits.

Table 3.4 summarises the in-stack concentration limits for particulate matter and other air quality parameters that are relevant to this assessment.

Table 3.4: In-Stack criteria under the *POEO (Clean Air) Regulation 2010*

Air quality parameter	Source	Group 6 (mg/m^3) [a, b]
Solid Particles (TSP) [b]	Clean Air Regulation – Schedule 4 "Any activity or plant"	50
NO_2 or nitric oxide (NO) or both as NO_2 equivalent	Clean Air Regulation – Schedule 4 "Stationary reciprocating internal combustion engines"	450
VOCs, as n-propane (or CO)	Clean Air Regulation – Schedule 4 "Any stationary reciprocating internal combustion engine using a gaseous fuel"	40 (125)
	Clean Air Regulation – Schedule 4 "Any stationary reciprocating internal combustion engine using a liquid fuel"	1,140 (5,880)

Notes: (a) mg/m^3 – milligrams per cubic metre. (b) Dry, 273 K, 101.3 kPa, 3% O_2 (c) Assumed to be also applicable to PM_{10} and $PM_{2.5}$.

4 EXISTING CONDITIONS

4.1 Meteorology

Air pollutant concentrations are strongly influenced by meteorological conditions, primarily in the form of prevailing wind directions and interactions with coastal influences such as sea breezes. Wind speed, wind direction, temperature and relative humidity all affect the dispersion and transport of pollution, and are basic input requirements for dispersion modelling. Narrabri Airport is the closest weather station that measure the parameters required for dispersion modelling. The local meteorology for Narrabri Airport have been summarised based on the available data.

4.1.1 Wind speed and direction

The Narrabri Airport automatic weather station (AWS) meteorological data have been reviewed for five consecutive years (2009 to 2013). Summary statistics for the wind data, including wind speed and percentage of 'calms' (winds less than 0.5 m/s), are shown in **Table 4.1**.

Table 4.1: Wind data – summary statistics

Year	Completeness of data set (%)	Average wind speed (m/s)	Calm periods (%)
2009	100	4.1	7.4
2010	100	3.8	9.8
2011	100	4.0	7.6
2012	100	3.9	8.7
2013	100	4.0	8.8
Average	100	4.0	8.5

The annual and seasonal wind roses for the years 2009 to 2013 are presented in **Figure 4.1** to **Figure** 4.5. The annual wind distribution patterns across the five years show a similar pattern. On an annual basis the predominant winds at Narrabri Airport AWS are from the north, southeast and south-southeast.

The prevailing winds transition across the seasons, with summer experiencing an even spread of wind originating from the north and southeast/south-southeast while in winter the northerly winds are far less frequent. There is a consistent seasonal pattern across all years.

The wind data for 2013 were found to be generally representative of the larger data set in terms of average wind speed, percentage of calms and directional patterns, and were therefore chosen to represent the meteorology in the analysis.

Figure 4.1: Annual and seasonal wind roses for Narrabri Airport AWS (2009)

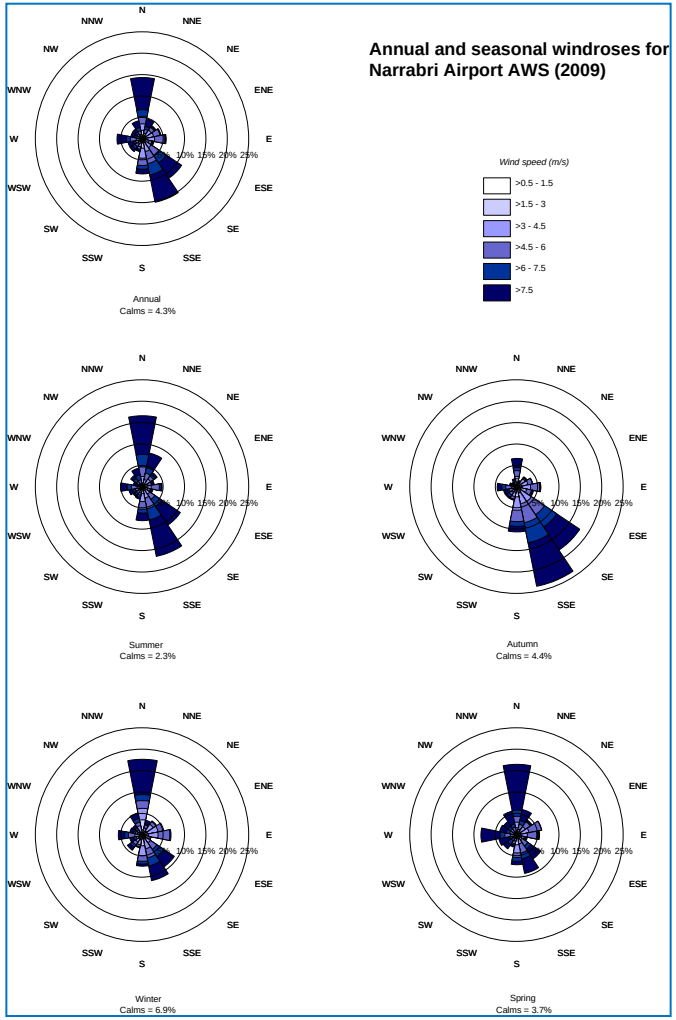


Figure 4.2: Annual and seasonal wind roses for Narrabri Airport AWS (2010)

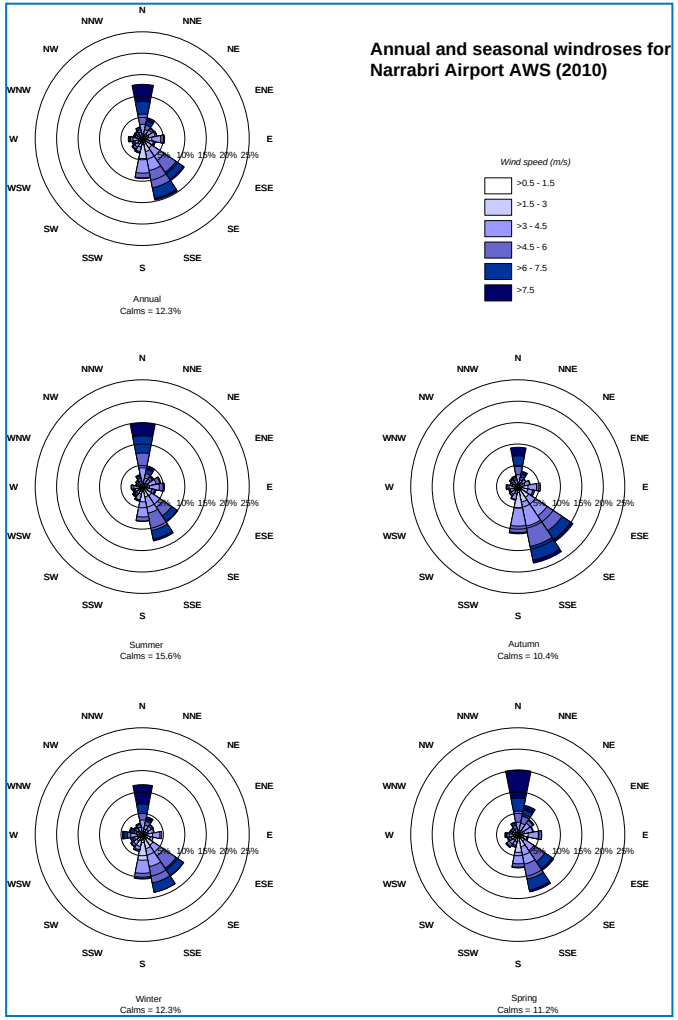


Figure 4.3: Annual and seasonal wind roses for Narrabri Airport AWS (2011)

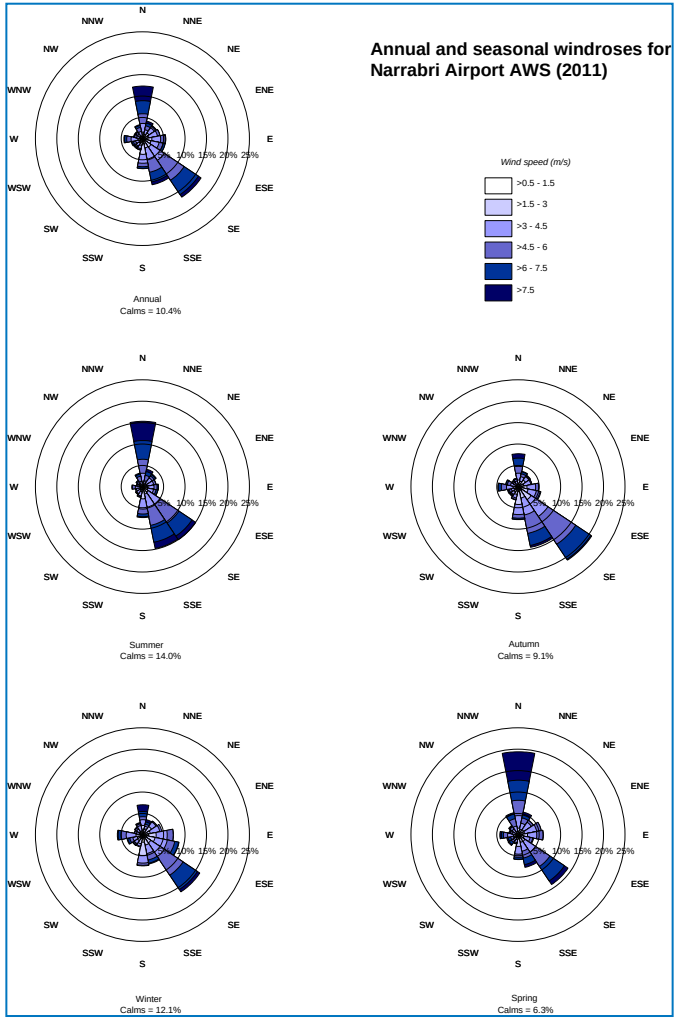


Figure 4.4: Annual and seasonal wind roses for Narrabri Airport AWS (2012)

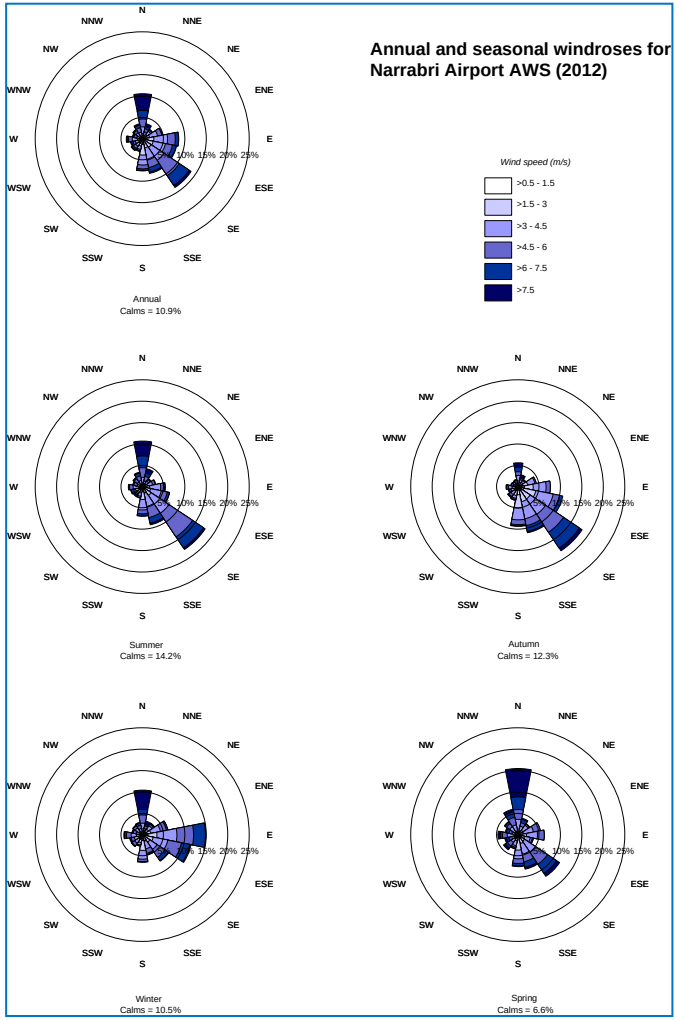
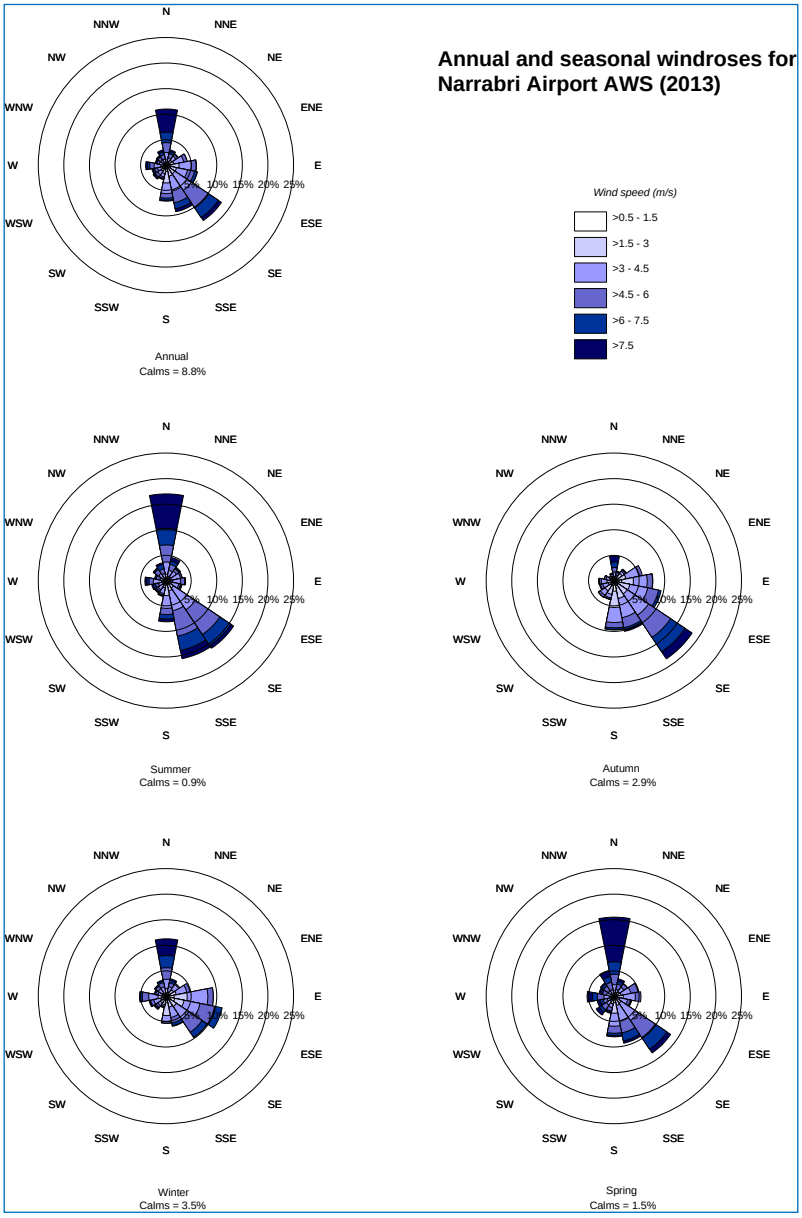


Figure 4.5: Annual and seasonal wind roses Narrabri Airport AWS (2013)



4.1.2 Rainfall, temperature and humidity

The measurements of temperature, humidity and rainfall at Narrabri Airport between 2009 and 2013 are summarised in **Table 4.2 (BoM, 2014)**. The temperature data consist of monthly average and minimum/maximum values. Also presented are the monthly average relative humidity and rainfall values.

The annual average temperature at Narrabri Airport AWS between 2009 and 2013 was 18.7°C. On average, January was the hottest month, with an average of 26.6°C and maximum of 43.4°C. July was the coldest month for the five year period, with average minimum temperature of 10.9°C.

The annual average relative humidity reading was 58%. The month with the highest relative humidity on average was June, with a 9 am average of 73%. The month with the lowest relative humidity on average was November, with 48%.

Table 4.2: Temperature, rainfall and humidity statistics for Narrabri Airport (2008 – 2012)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year average
Mean temperature (°C)	26.6	25.3	22.8	18.7	13.8	11.3	10.9	12.3	16.2	19.3	23.7	25.0	18.7
Minimum temperature (°C)	43.4	41.8	39.0	32.5	28.1	22.1	22.7	31.5	34.5	36.4	41.5	42.3	43.4
Maximum temperature (°C)	8.5	13.2	8.4	2.3	-0.9	-4.0	-4.1	-3.0	-0.9	2.3	6.4	6.9	-4.1
Relative humidity (%)	52	57	58	59	61	73	69	62	54	50	48	50	58
Mean rainfall (mm)	83	65	48	27	37	36	37	25	36	27	78	50	550

Source: **BoM (2014)**

The rainfall data collected at Narrabri Airport AWS show that January was the wettest month, with an average rainfall of 83 mm. The average annual rainfall was 550 mm. Total annual rainfall data measured over the 2009 to 2013 period are shown in **Figure 4.6**. With the exception of the *La Niña* years of 2010 and 2011, the annual rainfall in each year during this five-year period was generally lower than the longer-term climatic average of 550 mm.

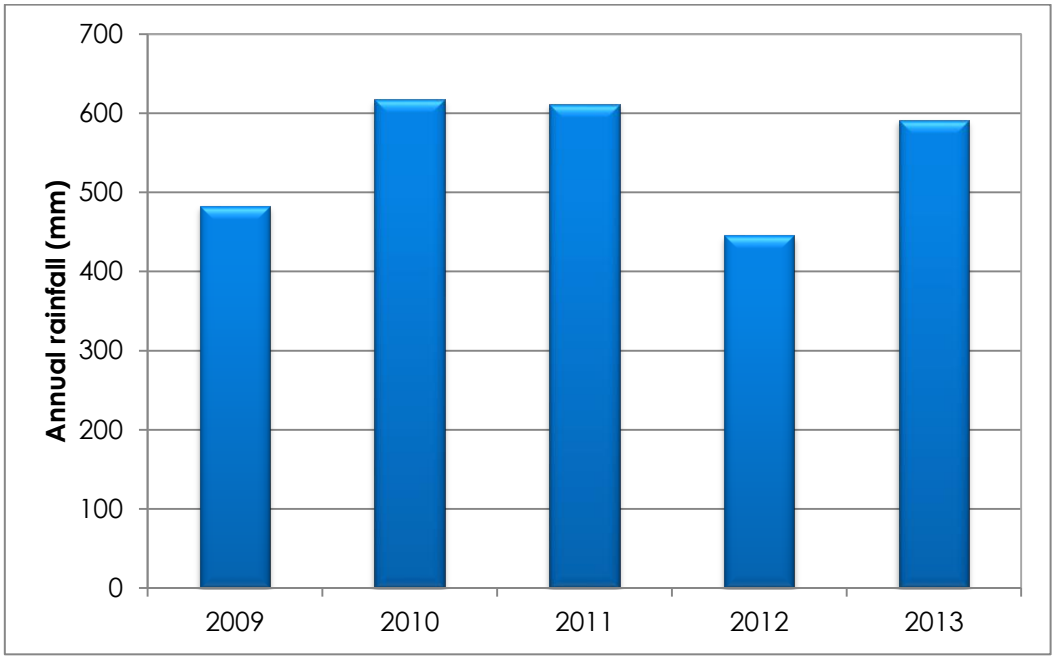


Figure 4.6: Annual rainfall at Narrabri Airport AWS (2009 – 2013)

4.2 Air quality

Air quality criteria refer to cumulative levels which include existing and proposed sources. To fully assess impacts against all the relevant air quality criteria (detailed in **Section 3**) it is therefore necessary to have information on existing pollutant concentrations in the vicinity of the Project.

No monitoring data were available at the proposed Leewood WBTP site, and therefore data were used from the EPA monitoring site at Tamworth, approximately 128 kilometres south-east of the Project. The rural EPA monitoring stations only measure particulate matter (PM_{10} and $PM_{2.5}$) concentrations, and in the case of Tamworth only PM_{10} is measured. Therefore, air quality monitoring data to cover the remaining pollutants ($PM_{2.5}$, NO_2, and SO_2) were taken from the Muswellbrook EPA monitoring site (265 km south-east of the Project). Monitoring data for CO were taken from Wyong. It is acknowledged that all three monitoring stations are located within urban/semi-urban areas with potential for industrial influences. Nevertheless, the adopted sites provide a conservative estimate of background concentrations of the air quality parameters investigated.

4.2.1 Particulate matter (PM_{10})

The 24-hour average PM_{10} concentrations measured between January 2009 and May 2014 are presented in **Figure 4.7**. The annual average and maximum recorded PM_{10} concentrations are presented in **Table 4.3**.

It can be seen that on a number of occasions the PM_{10} concentrations already approach or exceed the EPA criterion of 50 µg/m^3 for the 24-hour average, before consideration of emissions from the operation of the Leewood WTBP.

For presentation purposes, the 24 hour average PM_{10} concentrations measured on the day of a significant dust storm that impacted much of the east of Australia on 23 and 26 September 2009 (1,791 µg/m^3 and 227 µg/m^3) have been removed from the dataset.

Figure 4.7 indicates that there were a number of other elevated dust events in 2009, and this is considered an anomalous year of ambient particulate matter measurements. Since 2009 particulate matter levels have significantly dropped, with one elevated measurement above the 50 µg/m^3 EPA criterion on 20 September 2011 that was likely to be associated with high winds across the state **(BoM, 2013)**. The elevated concentration of 55 µg/m^3 measured on 25 October 2012 coincided with elevated PM_{10} concentrations also measured across the Upper and Lower Hunter Valley.

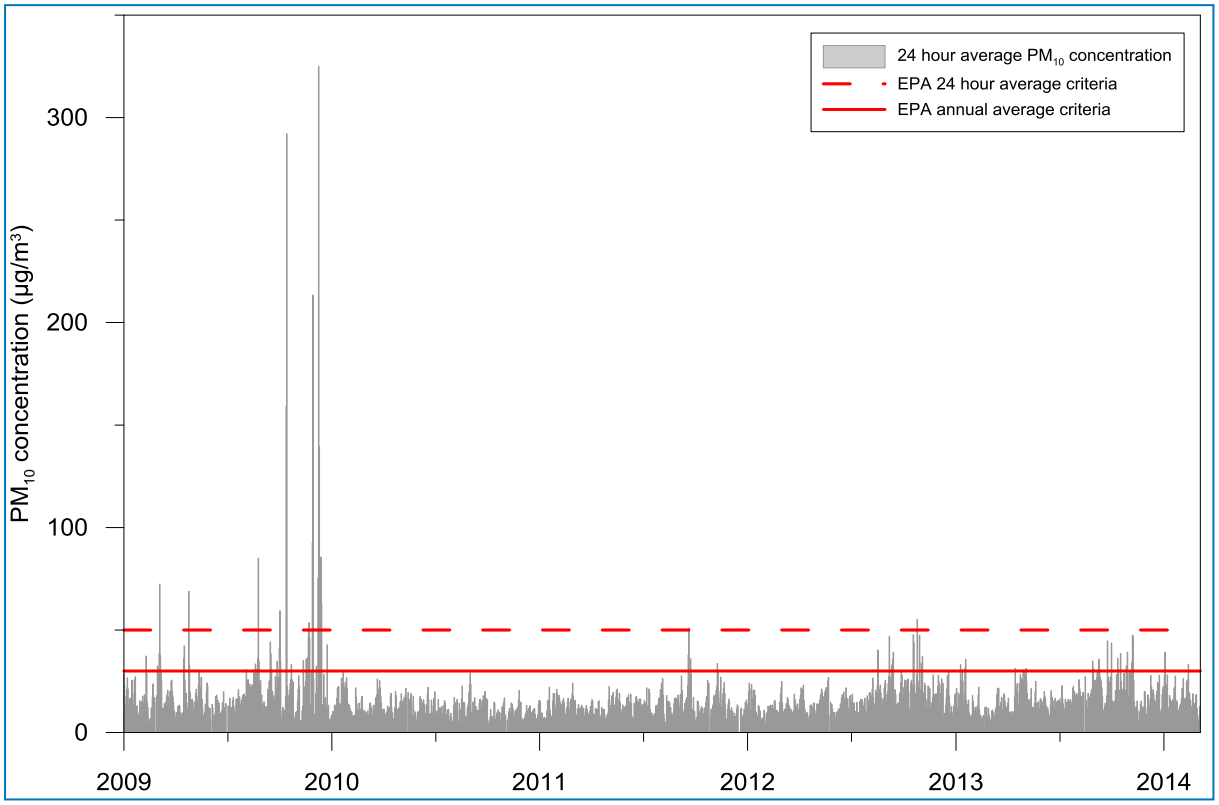


Figure 4.7: 24-hour average PM_{10} concentrations at Tamworth EPA monitoring station

Table 4.3: Annual average and maximum 24-hour average PM_{10} concentrations (µg/m³)

Year	Annual average	24-hour maximum
EPA criterion	**30**	**50**
2009	22.0 (b)	1791.4
2010	12.0	29.1
2011	13.0	50.9
2012	15.9	55.1
2013	16.6	47.5
2014 (a)	16.9	39.2

Notes: (a) Data available to 5 March 2014
(b) Annual average does not include dust storms measured on 23 and 26 September 2009

4.2.2 Particulate matter ($PM_{2.5}$)

At the Muswellbrook monitoring station simultaneous measurements of PM_{10} and $PM_{2.5}$ concentrations are available and can be used to establish an approximate ratio of $PM_{2.5}$:PM_{10} in rural NSW. The data indicate that approximately 44% of PM_{10} comprise $PM_{2.5}$. The ratio has been applied to the Tamworth PM_{10} dataset, to give an approximately annual average 2013 of 7.3 µg/m³ and for the 24-hour averaging period a corresponding maximum of 20.5 µg/m³. These values are below the NEPM advisory goals of 8 µg/m³ and 25 µg/m³, respectively.

4.2.3 Nitrogen dioxide (NO_2)

Contemporaneous ozone data are required to calculate the rate of NO_x to NO_2 conversion (further discussed in **Section 5.1.1**). Muswellbrook is considered to give a conservative estimate of NO_2 levels in the Project area due to the greater influence of heavy industry and traffic in the Muswellbrook area. A summary of the data from November 2011 to March 2014 is presented in **Table 4.4**. All values are well below the EPA impact assessment criterion of 62 µg/m³ and 246 µg/m³ for the annual average and maximum 1-hour averages, respectively.

Table 4.4: Annual average and maximum 1 hour average NO_2 concentrations (µg/m³)

Year	Annual average	1 hour maximum
EPA criterion	**62**	**246**
2011 (a)	15	94
2012	20	90
2013	19	86
2014 (b)	18	68

Notes: (a) Data available to 18 November 2011
(b) Data available to 5 March 2014

4.2.4 Sulfur dioxide (SO_2)

A summary of the SO_2 monitoring data measured at Muswellbrook from November 2011 to March 2014 is presented in **Table 4.5**. All values are well below the EPA impact assessment criterion of 60 µg/m³ and 228 µg/m³ for the annual average and maximum 24-hour averages, respectively.

Table 4.5: Annual average and maximum 1-hour and 24-hour average SO_2 concentrations (µg/m³)

Year	Annual average	24-hour maximum	1-hour maximum
EPA Criterion	**60**	**228**	**570**
2011 (a)	9.0	51.5	317.5
2012	6.4	48.6	414.7
2013	6.4	62.9	423.3
2014 (b)	15.0	45.8	386.1

Notes: (a) Data available to 17 November 2011
(b) Data available to 5 March 2014

4.2.5 Carbon monoxide (CO)

A summary of the CO monitoring data measured at Wyong from November 2011 to March 2014 is presented in **Table 4.6**.

Table 4.6: Annual average and maximum 8 hour average CO concentrations (mg/m³)

Year	Annual average	8-hour maximum
EPA criterion	**n/a**	**10**
2012 (a)	0.14	0.5
2013	0.14	1.0
2014 (b)	0.12	0.4

Notes: (a) Data available to 16 October 2012
(b) Data available to 5 March 2014

All values are well below the EPA impact assessment criterion of 10 mg/m³ for the maximum 8-hour rolling average. There is no EPA assessment criterion for the annual average CO concentration.

4.2.6 VOCs

As the site is isolated from other industry, cumulative VOC issues have not been considered as part of this assessment.

4.2.7 Odour

As the site is isolated from other industry, cumulative odour issues have not been considered as part of this assessment.

4.3 Summary of background data

The background pollutant concentrations adopted for the assessment, based on the available monitoring data described above, are presented in **Table 4.7**.

For short-term maxima where no monitoring data existed, the background value was obtained using the power-law formula from **Borgas (2000)** to estimate short-term peak values from longer-term average concentrations. For example, to determine a 10-minute peak value from a one-hour value the formula is:

$$C_{10} = C_{60} \times (60/10)^{0.21}$$

C_{10} is the estimated peak value and C_{60} is the average one-hour value.

Table 4.7: Summary of adopted background data

Air quality parameter	Averaging period	EPA criterion	Adopted background concentration
PM_{10}	Annual	30 µg/m³	16.6 µg/m³
	24 hour	50 µg/m³	47.5 µg/m³
$PM_{2.5}$	Annual	8 µg/m³	7.3 µg/m³
	24 hour	25 µg/m³	20.5 µg/m³
NO_x	Annual	62 µg/m³	19.1 µg/m³ (d)
	1 hour	246 µg/m³	8.1 µg/m³ (d)
SO_2	Annual	60 µg/m³	6.0
	24-hour	228 µg/m³	62.9
	1-hour	570 µg/m³	423.3
	10-minute (a)	712 µg/m³	616.7
CO	8-hour	10 mg/m³	1.0
	1-hour (a)	30 mg/m³	3.0
	15-minute (a)	100 mg/m³	4.4
VOCs	1-hour	29 µg/m³	n/a (b)
Odour (c)	1-hour	6 OU	n/a (c)

*Notes: (a) Calculated based on **Borgas (2000)**.*

(b) No other sources of similar odour character in vicinity of Leewood WBTP.

(c) No other sources of similar odour character in vicinity of Leewood WBTP.

*(d) Background ozone data is also required in calculating the NO_2 concentration using the OLM methodology (see **Section 5.1.1**). The adopted ozone concentrations were taken from the same site at the NO_2 data (Muswellbrook). An annual average value of 37 µg/m³ for the annual average and 169 µg/m³ for the maximum 1-hour were derived.*

5 OPERATIONAL IMPACTS

5.1 Approach to assessment

The overall approach to the assessment followed the Approved Methods using the Level 2 assessment methodology. The Approved Methods specify how assessments based on the use of air dispersion models should be completed. They include guidelines for the preparation of meteorological data to be used in dispersion models and the relevant air quality criteria for assessing the significance of predicted concentration and deposition rates from the Project. The approach taken in this assessment followed as closely as possible the approaches suggested by the guidelines.

The air dispersion modelling conducted for this assessment was based on the advanced modelling system AERMET/AERMOD model.

AERMOD was chosen as the most suitable model due to the source types involved, the locations of the nearest receptors, and the nature of local topography. AERMOD is the US-EPA's recommended steady-state plume dispersion model for regulatory purposes. AERMOD replaced the Industrial Source Complex (ISC) model for regulatory purposes in the US in December 2006 as it incorporates more recent, and potentially more accurate, algorithms to represent both meteorological interactions and air quality dispersion. Ausplume, a steady-state Gaussian plume dispersion model developed by the Victorian EPA and frequently used in Australia for simple near-field applications is based on ISC, which has now been replaced by AERMOD.

A significant feature of AERMOD is that the Pasquill-Gifford stability-based dispersion is replaced with a turbulence-based approach that uses the Monin-Obukhov length scale to account for the effects of atmospheric turbulence-based dispersion.

The AERMOD system includes AERMET, used for the preparation of meteorological input files and AERMAP, used for the preparation of terrain data. Terrain data were sourced from NASA's Shuttle Radar Topography Mission (SRTM) Data (3 arc-second (~90m) resolution) and processed within AERMAP to create the necessary input files.

AERMET requires surface and upper air meteorological data as input. Surface data were sourced from the BoM Narrabri Airport AWS located approximately 6.2 km from the Leewood WBTP. Cloud cover data is required for AERMET and as this was not available from the Narrabri Airport AWS site or from any other close by, these data were sourced from TAPM. TAPM is a prognostic meteorological model that generates gridded three-dimensional meteorological data for each hour of the model run period.

Appropriate values for three surface characteristics are required for AERMET as follows:

- Surface roughness, which is the height at which the mean horizontal wind speed approaches zero, based on a logarithmic profile.
- Albedo, which is an indicator of reflectivity of the surface.
- Bowen ratio, which is an indicator of surface moisture.

Values of surface roughness, Bowen ratio and albedo were determined based on a review of aerial photography for a radius of 3 km centred on the Project site. Default values for urban, grassland and water were chosen for three separate sectors to represent the varying land use types in the surrounding area.

5.1.1 Modelling of NO_x chemistry

One of the most common atmospheric chemistry issues is the estimation of NO_2 from modelled NO_x concentrations. The amount of NO_2 in the exhaust stream as it is released from combustion sources is typically in the order of 5-10% of total NO_x (expressed as NO_2 equivalents), but can be much higher for some sources, such as modern diesel vehicles equipped with catalytically regenerating particle filters.

However, following release, the NO_2 proportion also changes through complex photochemical reactions of atmospheric ozone and NO_x.

Several approaches are available for compensating for the transformation of NO to NO_2 that occurs after the exhaust gases are discharged. In this project the 'ozone limiting method' (OLM) was used. The OLM is based on the assumption that approximately 10% of the NO_x emissions are generated as NO_2 **(Alberta Environment, 2003)**. The majority of the NO_X emission is in the form of NO, which reacts with ambient levels of ozone to form additional NO_2. If the ozone concentration is greater than 90% of the predicted NO_x concentration, all the NO_x is assumed to be converted to NO_2. Otherwise NO_2 concentrations are calculated using the equation below, which assumes total conversion of the ozone and adds the 10% of the NOx that was emitted as NO_2:

$$NO_2 = O_3 + 0.1 \times NO_X$$

The predicted NO_2 concentration is then added to the background NO_2 concentration.

To apply the OLM, background concentrations of ozone and NO_2 in 2013 were obtained from the EPA monitoring station at Muswellbrook. The maximum NO_2 concentration at each receptor was calculated using the above equation, and then added to the maximum hourly background value from the Muswellbrook site. The same approach was adopted in determining the annual average values.

5.1.2 SO_2 estimation

As the vast majority of SO_X emissions are SO_2, it is assumed that all SO_X predicted by AERMOD are SO_2.

5.1.3 Sensitive receptors

A sensitive receptor is defined as a location where people are likely to work or reside; and may include a dwelling, school, hospital office or public recreational area in addition to known or likely future locations (**EPA, 2005**).

The nearest residence to the proposed activity is located on the adjoining property to the east of Leewood, approximately 360 metres to the east.

Components of the Sydney University Giant Air-shower Recorder (SUGAR) array were identified at Leewood during field investigations. A SUGAR station, comprising two pits, is located along the western boundary of Leewood. The pits are not registered on the OEH State Heritage Inventory; nor are they listed in the Narrabri LEP, however they have been identified as having potential heritage significance. The proposed activity has been located at least 50 metres from the SUGAR pits. As the SUGAR pits are unoccupied they have not been considered a sensitive receptor in assessing potential local air quality impacts.

There are six sensitive receptors that are considered for this assessment and are shown in **Figure 5.1**.

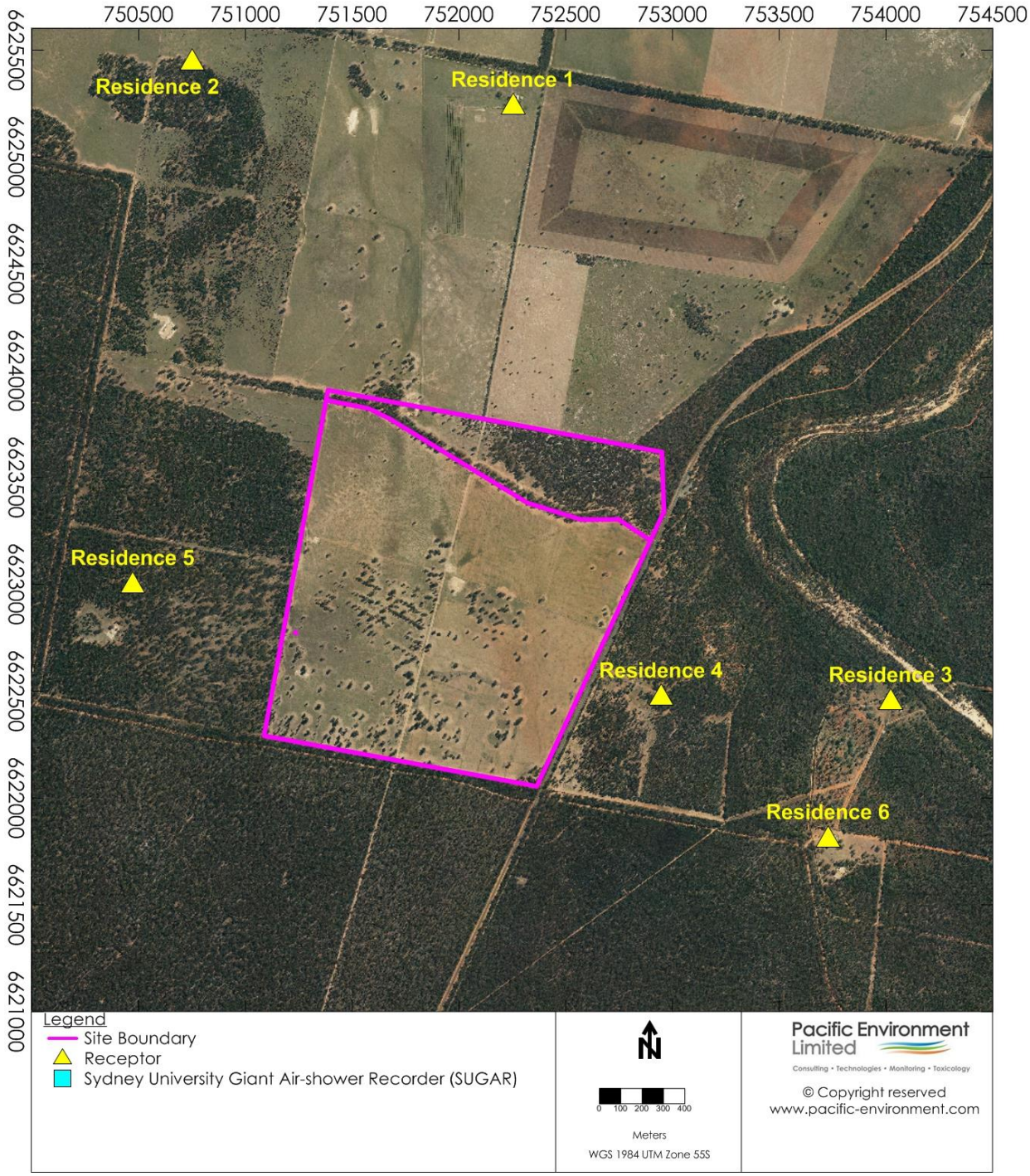


Figure 5.1: Location of sensitive receptors

5.2 Emissions

As discussed in **Section 2**, power will be supplied to the site by a 1.4 MW gas engine generator. An additional 0.8 MW diesel generator would operate as a back-up power supply. An additional 0.2 MW generator would also be onsite but would be used for emergency situation only. Given its limited usage and smaller emissions footprint, this latter emergency generator has not been considered further.

Fuel for the gas generator would be supplied via the existing pipeline that runs through the Leewood site. Storage for up to 30,000 litres of diesel would be provided on site for periods when the gas generator is offline. Two scenarios have been evaluated quantitatively for potential air impacts during operation:

- Scenario 1 – 1.4 MW gas generator for onsite power supply
- Scenario 2 – 0.8 MW diesel generator for onsite power supply

Separate to these scenarios are the results for potential odour impacts when the proposed Leewood WBTP is operating under normal conditions.

Some minor particulate matter emissions will arise as a result of the Lucerne being cut and bailed in the irrigation area (see **Figure 2.2**). However, this will occur on only five occasions per year and in consideration of the nearby land use (agriculture and bushland) has not been considered further.

At the brine plant there will be an air purge stream that will release a mixture of carbon dioxide (CO_2), air and steam. While this plume will be visible, it is understood that there will be no significant odour or criteria pollutant emissions, and therefore it was not considered further.

5.2.1 Criteria pollutants

The stack parameter inputs used for the gas (Scenario 1) and diesel (Scenario 2) generators are provided in **Table 5.1**. The location of the two generators is shown in **Figure 2.3**.

The pollutant mass emission rates are provided in **Table 5.2**. The mass emission rates are based on typical in-stack concentration data provided by the client.

A 98% control factor has been applied to the CO and VOC emissions from the gas generator as a catalytic converter will be employed. The supplier of the gas generator has provided a performance guarantee (see **Appendix A**) confirming compliance with the NSW POEO in-stack concentration limits described in **Section 3.3**.

A twin exhaust system will be used for the diesel generator. Note that data for particulate matter were not apportioned into discrete particle size fractions (i.e. PM_{10} and $PM_{2.5}$). To provide a conservative estimate, it has been assumed that 100% of emission would comprise both PM_{10} and $PM_{2.5}$. Given the fuel source, there is not anticipated to be any SO_2 emissions associated with the combustion emissions from the gas generator and therefore this parameter has not been assessed within Scenario 1.

Table 5.1: Stack parameters for each scenario

Emission parameter	Units	Scenario 1 (gas)	Scenario 2 (diesel)
Stack height[a]	m	10	3.3
Stack diameter[a]	m	0.75	0.15
Exit velocity[b]	m/s	8.5	84
Exit temperature[a]	K	690	850
Power[a]	MW	1.4	0.8

Notes: (a) provided by generator supplier, Cummins Generation
(b) calculated from stack diameter and exhaust flow rate.

Table 5.2: Criteria pollutant mass emission rates

Pollutant	Scenario 1 (gas) (g/s)	Scenario 2 (diesel) (g/s)
NO_x	0.67	1.21
SO_2	N/A	0.02
CO	0.04	1.4
PM_{10}	0.01	0.02
$PM_{2.5}$	0.01	0.02
VOCs	0.05	0.05

5.2.2 In-stack concentration limits

The POEO Regulations in-stack concentration criteria relevant to this assessment along with the calculated in-stack concentration to which the proposed diesel and gas generators would operate are presented in **Table 5.3**.

The calculated in-stack concentrations were based on the provided exhaust flow and emission rate information along with worst-case pollutant mass rates.

All in-stack concentrations comply with the POEO Regulatory limits. The supplier of the gas and diesel engines has provided a performance guarantee (see **Appendix A**) that both engines will comply with the NSW POEO in-stack concentration limits described in **Section 3.3.**

Table 5.3: In-stack concentrations

Emission parameter	POEO Regulation limit (mg/m³)	Scenario 1 (gas) (mg/m³)	Scenario 2 (diesel) (mg/m³)
NO_x	450	450	261
PM_{10}	50	10	4
$PM_{2.5}$	50	10	4
VOC	40 [(a)] / 1,440 [(b)]	34	12
CO	125 [(a)] / 5,880 [(b)]	27	58

Notes: (a) Any stationary reciprocating internal combustion engine using a gaseous fuel – applicable to Scenario 1.
(b) Any stationary reciprocating internal combustion engine using a liquid fuel – applicable to Scenario 2.

5.2.3 Cumulative emissions

There are a number of other industrial emitters in the area with the potential to affect local air quality and include:

- Existing CSG exploration and appraisal activities being carried out by Santos
- Boral Narrabri Quarry
- Cargill Processing Narrabri
- Lowes petroleum Narrabri Depot
- Boland Petroleum Narrabri Depot
- Narrabri Coal Mine – Baan Baa
- Wilga Park Power Station
- Newell Highway

The above listed sources are all located at a sufficient distance from the proposed Leewood WBTP that potential cumulative impacts would be negligible within the study area. Furthermore, the adopted

background contributions are considered to be conservative enough to allow for potential emissions from the respective sources to be account for.

5.2.4 Odour

Information provided by Santos indicates that there would be a number of potential sources of odour that would arise from the proposed Leewood WBTP. However, the site processing facilities are proposed to be enclosed, with relatively minor emissions being released from the plant via intermittent vent releases.

The most significant source of emissions would be those associated with ammonia removal during post treatment. Fugitive odour emissions would be similar to a chlorine pool that would originate from the chlorine contact tank.

Other less significant emissions are anticipated to arise from the septic tank that will be emptied as needed and waste trucked away. However this source would be relatively minor as it will form part of the onsite utilities.

Detailed design parameters for the proposed Project have yet to be developed and as such there are no specific emissions data available for the assessment. Therefore, emissions data are based on information made publicly available on the Sydney Water database (**Sydney Water, 2007**). It is acknowledged that the emissions taken from Sydney Water are those that are associated with fugitive odour emissions from sewage treatment plants in the urban areas of Sydney. Nevertheless, the processes associated with the odour sources from the Leewood WBTP are considered similar in character and will provide a conservative estimate of potential odour impacts in the local air shed.

The respective potential emissions should be further reviewed during the detailed design phase. It is anticipated that minimal fugitive odour emissions would occur due to the enclosure of the odour sources and relatively large distance to the nearest sensitive receptor (750m).

5.3 Results

The concentrations of the pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO and VOCs) were determined for 6 discrete receptors located near the proposed WBTP. The following sections present the results for two operational scenarios:

- Scenario 1 – Gas generator for onsite power supply
- Scenario 2 – Diesel generator for onsite power supply

Separate to these scenarios are the results for potential odour impacts when the proposed Leewood WBTP is operating under normal conditions.

The results have been provided in a summary table to which the results can be referenced against the EPA impact assessment criteria or NEPM advisory reporting goal ($PM_{2.5}$ only). Contour plots have also been prepared for Scenario 2 (the worst case scenario) to show the spatial distribution of each pollutant with the local air shed and can be viewed in **Appendix B**.

5.3.1 Particulate matter (PM_{10} and $PM_{2.5}$)

The predicted maximum 24-hour PM_{10} and $PM_{2.5}$ concentrations at each of the sensitive receptors are added to the adopted background levels and presented in **Table 5.4**. In the case of the 24-hour average cumulative predictions, the adopted back ground of 47.5µg/m^3 contributes to approximately 95% of the EPA assessment criterion of 50µg/m^3, with contribution from the project accounting for less than 1%.

The annual average predictions are presented in **Table 5.5**.

When existing background concentrations are included, there are no sensitive receptors that are predicted to exceed the maximum 24-hour annual average assessment or the annual average PM_{10} EPA criterion or $PM_{2.5}$ advisory goals.

The contour plots (see **Appendix B**) for the cumulative annual average concentration show that the highest concentrations are likely to occur to the northwest and southwest of the proposed Leewood WBTP. The contour plots for the maximum 24-hour show a more even distribution around all directions of the compass.

Table 5.4: Predicted maximum 24-hour PM_{10} concentrations at receptor locations

Sensitive receptor ID	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)	
	Incremental	Cumulative	Incremental	Cumulative
EPA Criterion / NEPM goal	***n/a***	***50***	***n/a***	***25***
Scenario 1 – Gas Generator				
Residence 1	0.01	47.5	0.01	20.5
Residence 2	0.01	47.5	0.01	20.5
Residence 3	0.01	47.5	0.01	20.5
Residence 4	0.01	47.5	0.01	20.5
Residence 5	0.02	47.5	0.02	20.5
Residence 6	0.01	47.5	0.01	20.5
Scenario 2 – Diesel Generator				
Residence 1	0.06	47.6	0.06	20.6
Residence 2	0.08	47.6	0.08	20.6
Residence 3	0.05	47.6	0.05	20.6
Residence 4	0.10	47.6	0.10	20.6
Residence 5	0.15	47.6	0.15	20.6
Residence 6	0.09	47.6	0.09	20.6

Table 5.5: Predicted annual average PM_{10} concentrations at receptor locations

Sensitive receptor ID	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)	
	Incremental	Cumulative	Incremental	Cumulative
EPA Criterion / NEPM goal	***n/a***	***30***	***n/a***	***8***
Scenario 1 – Gas Generator				
Residence 1	<0.01	16.6	<0.01	7.3
Residence 2	<0.01	16.6	<0.01	7.3
Residence 3	<0.01	16.6	<0.01	7.3
Residence 4	<0.01	16.6	<0.01	7.3
Residence 5	<0.01	16.6	<0.01	7.3
Residence 6	<0.01	16.6	<0.01	7.3
Scenario 2 – Diesel Generator				
Residence 1	<0.01	16.6	<0.01	7.3
Residence 2	0.01	16.6	0.01	7.3
Residence 3	<0.01	16.6	<0.01	7.3
Residence 4	<0.01	16.6	<0.01	7.3
Residence 5	0.01	16.6	0.01	7.3
Residence 6	<0.01	16.6	<0.01	7.3

5.3.2 NO_2

The dispersion modelling results for maximum 1 hour and annual average NO_2 are presented in **Table 5.6**. As discussed in **Section 5.1.1**, the OLM method has been applied for the prediction of NO_2 concentrations surrounding the Leewood WBTP taking the maximum 1-hour and annual NO_2 and O_3 monitoring data combined with the maximum NO_x prediction for each residence for each of the respective averaging periods. This approach provides an added level on conservatism estimate in determining the NO_x to NO_2 conversion.

Table 5.6: Predicted maximum 1-hour and annual average NO_2 concentrations at receptor Locations

Sensitive receptor ID	NO_2 1-hour (µg/m³)		NO_2 Annual (µg/m³)	
	Incremental [(a)]	Cumulative	Incremental [(a)]	Cumulative
EPA criterion	***n/a***	***246***	***n/a***	***62***
Scenario 1 – Gas Generator				
Residence 1	4.2	90.3	<0.1	19.1
Residence 2	4.3	90.4	0.1	19.2
Residence 3	4.4	90.5	<0.1	19.1
Residence 4	6.5	92.6	0.1	19.2
Residence 5	5.1	91.2	0.2	19.3
Residence 6	4.7	90.8	<0.1	19.1
Scenario 2 – Diesel Generator				
Residence 1	51.8	90.3	0.2	19.3
Residence 2	59.0	90.4	0.5	19.6
Residence 3	33.8	90.5	0.1	19.2
Residence 4	48.4	92.6	0.3	19.4
Residence 5	58.9	91.2	0.8	19.9
Residence 6	49.8	90.8	0.1	19.2

Notes: (a) This value assumed 100% NO_x to NO_2 conversion.

For both the maximum 1–hour and annual average time periods, the model results are predicted to be well below the EPA criterion when the background contributions to NO_2 concentrations are accounted for.

The distribution of the plume dispersion can be seen in the contour plots provided in **Appendix B**. The annual average also shows a characteristic spread, with concentrations predicted to be highest to the northwest, west and southwest of the project boundary. The maximum 1-hour spread shows no directional trend.

5.3.3 SO_2

As previously mentioned, there are not anticipated to be any SO_2 emissions associated with the combustion emissions from the gas generator and therefore this parameter has not been assessed within Scenario 1.

The predicted maximum 10-minute and 1-hour SO_2 concentrations at each of the sensitive receptors are added to the adopted background levels and presented in **Table 5.7** for Scenario 2. The maximum 24-hour and annual average predictions are presented in **Table 5.8**.

At all receptors, for all averaging periods, the SO_2 concentrations are predicted to be well below the SO_2 EPA criteria.

The spread of the plume for the annual average predictions (see the contours plots in **Appendix B**) indicates that slightly higher concentrations are predicted to occur to the northwest, west and southwest of the project boundary.

Table 5.7: Predicted maximum 10-minute and 1-hour SO_2 concentrations at receptor locations

Sensitive receptor ID	SO_2 10-minute (µg/m³)		SO_2 1-hour (µg/m³)	
	Incremental	Cumulative	Incremental	Cumulative
EPA Criterion	***n/a***	***712***	***n/a***	***570***
Scenario 2 – Diesel Generator				
Residence 1	1.25	617.9	0.86	424.2
Residence 2	1.42	618.1	0.98	424.3
Residence 3	0.82	617.5	0.56	423.9
Residence 4	1.17	617.9	0.80	424.1
Residence 5	1.42	618.1	0.97	424.3
Residence 6	1.20	617.9	0.82	424.1

Table 5.8: Predicted maximum 24-hour and annual average SO_2 concentrations at receptor locations

Sensitive receptor ID	SO_2 24-hour (µg/m³)		SO_2 Annual (µg/m³)	
	Incremental	Cumulative	Incremental	Cumulative
EPA Criterion	***n/a***	***228***	***n/a***	***60***
Scenario 2 – Diesel Generator				
Residence 1	0.06	63.0	<0.01	6.0
Residence 2	0.08	63.0	0.01	6.0
Residence 3	0.05	63.0	<0.01	6.0
Residence 4	0.10	63.0	<0.01	6.0
Residence 5	0.15	63.0	0.01	6.0
Residence 6	0.09	63.0	<0.01	6.0

5.3.4 CO

The predicted maximum 15-minute, 1-hour and 8-hour CO concentrations at each of the sensitive receptors are added to the adopted background levels and presented in **Table 5.9**.

At all receptors, for all averaging periods, the CO concentrations are predicted to be well below the CO EPA criteria.

The spread of the plume for the short term averaging periods (see the contour plots in **Appendix B**) shows little direction in plume spread.

Table 5.9: Predicted maximum 15-minute, 1-hour and 8-hour concentrations at receptor locations

Sensitive receptor ID	CO 15-minute (mg/m³)		CO 1-hour minute (mg/m³)		CO 8-hour minute (mg/m³)	
	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative
EPA Criterion	***n/a***	***100***	***n/a***	***30***	***n/a***	***10***
Scenario 1 – Gas Generator						
Residence 1	0.0003	4.4	0.0002	3.0	0.0001	1.0
Residence 2	0.0003	4.4	0.0003	3.0	0.0001	1.0
Residence 3	0.0004	4.4	0.0003	3.0	0.0001	1.0
Residence 4	0.0005	4.4	0.0004	3.0	0.0001	1.0
Residence 5	0.0004	4.4	0.0003	3.0	0.0001	1.0
Residence 6	0.0004	4.4	0.0003	3.0	0.0001	1.0
Scenario 2 – Diesel Generator						
Residence 1	0.015	4.4	0.012	3.0	0.002	1.0
Residence 2	0.018	4.4	0.013	3.0	0.003	1.0
Residence 3	0.010	4.4	0.008	3.0	0.001	1.0
Residence 4	0.014	4.4	0.011	3.0	0.003	1.0
Residence 5	0.018	4.4	0.013	3.0	0.005	1.0
Residence 6	0.015	4.4	0.011	3.0	0.003	1.0

5.3.5 VOC (as Benzene)

The predicted maximum 1-hour VOC (as benzene) concentrations at each of the sensitive receptors are added to the adopted background levels and presented in **Table 5.10**.

At all receptors, for all averaging periods, the VOC concentrations are predicted to be well below the EPA criterion.

The spread of the plume (see the contour plots in **Appendix B**) indicates that slightly higher concentrations are predicted to occur to the northwest and southwest of the project boundary.

Table 5.10: Predicted maximum 1-hour concentration at receptor locations

Sensitive receptor ID	VOCs (as benzene) 1-hour minute (µg/m³)	
	Scenario 1	Scenario 2
EPA Criterion	***29***	***29***
Residence 1	0.3	1.1
Residence 2	0.3	1.2
Residence 3	0.3	0.7
Residence 4	0.5	1.0
Residence 5	0.4	1.2
Residence 6	0.4	1.0

5.3.6 Odour

The dispersion modelling results for the 1 second (nose response) average 99th percentile odour predictions for the operation of the Project are presented in **Table 5.11**. The cumulative impacts of odour were not considered for this assessment as discussed in **Section 4.2.7**.

Table 5.11: Predicted 99th percentile odour concentrations at receptor Locations

Sensitive receptor ID	Odour 99th percentile
EPA Criterion	***6.0***
Residence 1	<0.1
Residence 2	<0.1
Residence 3	<0.1
Residence 4	<0.1
Residence 5	<0.1
Residence 6	<0.1

The contour plot for the predicted ground level concentrations of odour is presented **Appendix B**. The adopted 6 OU odour criterion for the surrounding area is complied with at all area outside of the Leewood WBTP project boundary.

5.4 Summary of impacts

The results of the dispersion modelling indicate that the emissions from the Leewood WBTP will be below the NSW EPA impact assessment criteria and NEPM advisory reporting goals at all offsite sensitive receptors investigated as part of this study. Therefore impacts are expected to be negligible.

6 CONSTRUCTION IMPACTS

6.1 Overview

This Chapter deals with the potential impacts of the construction phase of the project. The main air pollution and amenity issues at construction sites are:

- Annoyance due to dust deposition (soiling of surfaces) and visible dust plumes.
- Elevated PM_{10} concentrations due to dust-generating activities.
- Exhaust emissions from diesel-powered construction equipment[a,b].

Very high levels of soiling can also damage plants and affect the diversity of ecosystems.

Dust emissions can occur during the preparation of the land (e.g. earth moving and development of the irrigation area) and during construction itself, and can vary substantially from day to day depending on the level of activity, the specific operations being undertaken, and the weather conditions. A significant portion of the emissions results from site plant and road vehicles moving over temporary roads and open ground. If mud is allowed to get onto local public roads, dust emissions can occur at some distance from the construction site **(IAQM, 2014)**.

The risk of dust impacts from a construction site causing loss of amenity and/or health or ecological impacts is related to the following **(IAQM, 2014)**:

- The nature of the activities being undertaken
- The duration of the activities
- The size of the site
- The meteorological conditions (wind speed, direction and rainfall). Adverse impacts are more likely to occur downwind of the site and during drier periods
- The proximity of receptors to the activities
- The sensitivity of the receptors to dust
- The adequacy of the mitigation measures applied to reduce or eliminate dust

It is very difficult to quantify dust emissions from construction activities. Due to the variability of the weather it is impossible to predict what the weather conditions would be when specific construction activities are undertaken. Any effects of construction on airborne particle concentrations would also generally be temporary and relatively short-lived. Moreover, mitigation should be straightforward, as most of the necessary measures are routinely employed as 'good practice' on construction sites. It is therefore usual to provide a qualitative assessment of potential construction dust impacts. A largely qualitative approach has also been used here, and the impacts of construction have not been specifically modelled. The approach used for this assessment is based on that described by **IAQM (2014)**. The aim is to identify risks and to recommend appropriate mitigation measures.

The IAQM guidance is designed primarily for use in the UK, although it may be applied elsewhere. Here, the guidance has been adapted for use in NSW, taking into account factors such as the assessment criteria for ambient PM_{10} concentrations.

[a] There are other potential impacts, such as the release of heavy metals, asbestos fibres or other pollutants during the demolition of certain buildings such as former chemical works, or the removal of contaminated soils. The release of certain fungal spores during the demolition of old buildings can give rise to specific concerns if immune-compromised people are likely to be exposed, for example close to an oncology unit of a hospital. These issues need to be considered on a site by site basis **(IAQM, 2014)**.

[b] Exhaust emissions from onsite plant and site traffic are unlikely to have a significant impact on local air quality, and in the majority of cases they will not need to be quantitatively assessed **(IAQM, 2014)**.

6.2 Construction activities

A wide range of construction equipment is likely to be used for the construction of the Project and the associated infrastructure. This includes:

- 4WD
- vacuum truck
- water cart
- dozer
- excavator
- tipper
- mulcher
- concrete truck
- kerb profiler
- dump truck
- generator
- grader
- rollers
- whacker
- crane
- elevated work platform (EWP)/cherry picker
- hand tools
- truck and dog
- backhoe
- welder

Construction of the project is expected to take up to 50 weeks and be carried out in stages. The assessment of each construction activity in isolation could lead to an underestimation of risk. Therefore, for the construction assessment the activities were combined according to the single worst case scenario.

6.3 Assessment procedure

The IAQM assessment procedure for assessing risk is shown in **Figure 6.1**. Professional judgement is required in some steps, and where justification cannot be given a precautionary approach is adopted.

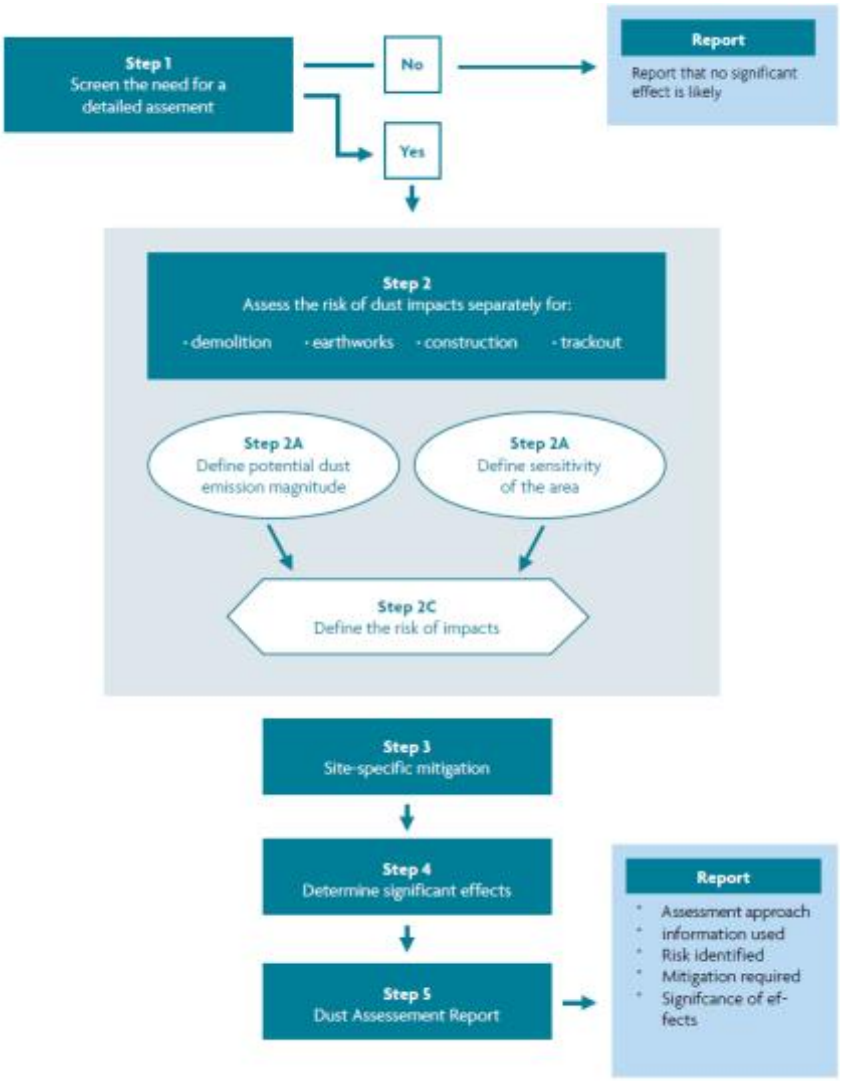


Figure 6.1: Steps in an assessment of construction dust (IAQM, 2014)

Activities on construction sites can be divided into four types to reflect their different potential impacts, and the potential for dust emissions is assessed for each activity that is likely to take place. These activities are:

- *Demolition*. Demolition is any activity that involves the removal of existing structures. This may also be referred to as de-construction, specifically when a building is to be removed a small part at a time.
- *Earthworks*. This covers the processes of soil stripping, ground levelling, excavation and landscaping. Earthworks will primarily involve excavating material, haulage, tipping and stockpiling.
- *Construction*. Construction is any activity that involves the provision of new structures, modification or refurbishment. A structure will include a residential dwelling, office building, retail outlet, road, *etc*.
- *Track-out*. This involves the transport of dust and dirt by HDVs from the construction site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network.

The assessment methodology considers three separate dust impacts:

- Annoyance due to dust soiling
- The risk of health effects due to an increase in exposure to PM_{10}
- Harm to ecological receptors

The assessment is used to define appropriate mitigation measures to ensure that there will be no significant effect.

The assessment steps, as they were applied to the construction of the Project, are summarised in the following Sections.

6.4 Step 1: Screening

Step 1 is a screening assessment. A construction dust assessment will normally be required where:

- There are human receptors within 350 m of the boundary of the site and/or within 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site entrance(s).
- There are ecological receptors within 50 m of the boundary of the site and/or within 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site entrance(s).

A 'human receptor', refers to any location where a person or property may experience the adverse effects of airborne dust or dust soiling, or exposure to PM_{10} over a time period relevant to air quality standards and goals. In terms of annoyance effects, this will most commonly relate to dwellings, but may also refer to other premises such as buildings housing cultural heritage collections (e.g. museums and galleries), vehicle showrooms, food manufacturers, electronics manufacturers, amenity areas and horticultural operations (e.g. salad or soft-fruit production). An 'ecological receptor' refers to any sensitive habitat affected by dust soiling. This includes the direct impacts on vegetation or aquatic ecosystems of dust deposition, and the indirect impacts on fauna (e.g. on foraging habitats) **(IAQM, 2014)**.

It can be seen from **Figure 6.2** that all six off-site human receptors are located at least 350 m of the boundary of the Leewood WBTP. It is understood that the SUGAR Pits are located at least 50 m from the proposed activity (see **Section 5.1.3**). While the listed Brigalow Woodland community in the north of the Leewood property is located adjacent to the proposed irrigation area, it is well over 50 metres from the WBTP, associated infrastructure areas and irrigation infrastructure, where most of the construction activities will occur.

In view of the outcomes of the construction screening analysis potential construction impacts are considered to be minimal.

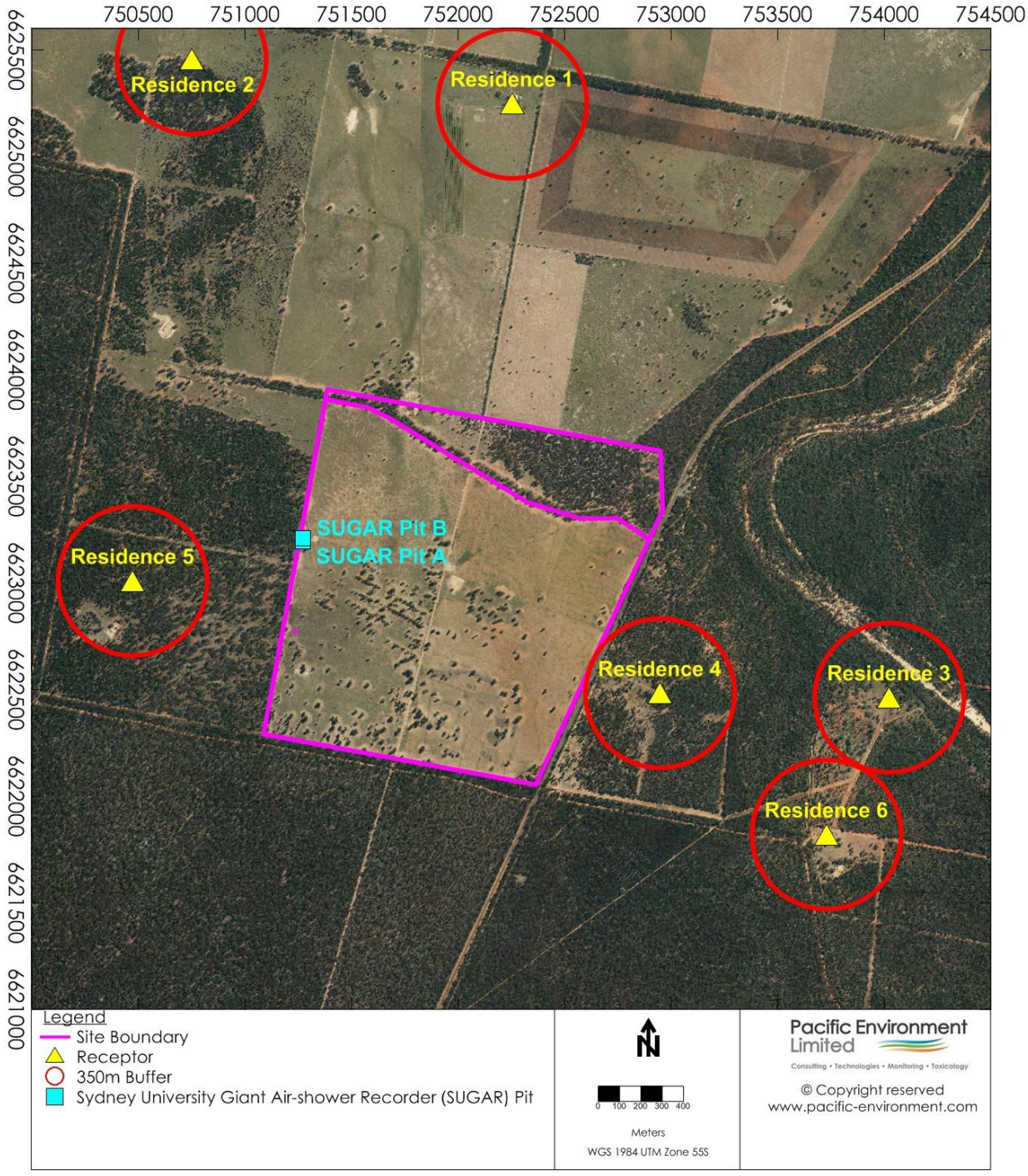


Figure 6.2: Screening assessment – human receptors

7 MITIGATION MEASURES

Regardless of the minimal air quality impact of the project's construction and operation on local air quality, Santos have committed to a number of mitigation strategies to ensure Santos operates at the highest standards.

Santos will strive to meet air quality guidelines for the new facility through REF assessment, quantifying emissions through direct monitoring or estimation techniques, recording external and internal complaints related to offensive air emissions or odour, and establishing and maintaining an air quality monitoring program if required by the relevant environmental agency. Specific mitigation measures for each phase of the project are discussed below.

7.1 Construction

It is recommended that before construction proceeds, an Air Quality Management Plan (AQMP) is developed that would cover:

- Methods to monitor the effects of construction activities.
- Measures required to minimise dust and vehicle emissions during the construction of the project.

Recommended mitigation measures to reduce potential emissions during construction activities are listed below and represent best practice management tools for construction site dust control.

- The land cleared for construction purposes will be kept to the minimum necessary, especially during the drier months of the year. This shall include minimising size of equipment lay-down/storage areas.
- The number and sizes of stockpiles will be kept to a minimum.
- The cleared areas and stockpiles will be progressively rehabilitated through revegetation and/or mulching.
- Dust suppression shall be undertaken during construction and clearing activities, particularly during high wind conditions. Haul roads and other unsealed areas may be watered to suppress dust.
- Ensure that all vehicles and machinery are fitted with appropriate emission control equipment, maintained frequently and serviced to the manufacturers' specification.
- Minimise construction equipment idling time.

7.2 Operation

During operation the water treatment facility air emissions are predominantly related to electricity generation. Smaller volume fugitive emissions are associated with process operations within the plant.

Recommended mitigation measures to reduce potential air emissions during operational activities include:

- Implementation of a preventative maintenance program to ensure major equipment (particularly the diesel generator) is operating efficiently to minimise carbon monoxide emissions and uncombusted hydrocarbons.
- Implementation of a quantifiable monitoring and measuring program.
- Generators used on site will utilise modern combustion technology to minimise production of NO_x, CO and particulate emissions.
- As soon as production activities allow, generators will be fuelled by gas which will reduce NO_x and particulate emissions.

8 CONCLUSIONS

RPS commissioned Pacific Environment to conduct an air quality and odour assessment for the proposed Leewood Water and Brine Treatment Plant.

Dispersion model predictions were completed for two scenarios to demonstrate compliance with the relevant air quality standards for NO_2, SO_2, CO, PM_{10}, $PM_{2.5}$, and odour at all sensitive receptors. Cumulative impacts were also considered where appropriate, taking into account the Leewood WBTP and other sources.

The results of the dispersion modelling indicate that the emissions from the Leewood WBTP will be below the NSW EPA impact assessment criteria and NEPM advisory reporting goals at all offsite sensitive receptors investigated as part of this study. Therefore impacts are expected to be negligible.

The outcomes of the construction screening analysis determined that potential construction impacts are considered to be minimal.

The supplier of the gas and diesel engines has provided a manufacturer's guarantee that the gas generator will operate in compliance with the in-stack concentration limits prescribed under the *Protection of the Environment Operations (Clean Air) Regulation 2010* and will employ a catalytic converter.

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Appendix A ENGINE PERFORMANCE GUARANTEE

Clarke Energy
Engineer - Install - Maintain

Our ref: C1309-T0-CQ-01

Attention Mr Ivor Theseira Project Manager
OSMOFLO

8th January 2015

Subject: Gas Engine Compliance to NSW EPA Regulations

Dear Sir,

Clarke Energy can confirm that the GE Jenbacher J420 Gas Engine that has been proposed for your project with SANTOS in NSW complies with the emission limits as per Schedule 4 of the Protection of the Environment Operations (Clean Air) Regulation 2010.

Regards



Alan G Stewart
Sales Engineer
Clarke Energy Australia Pty Ltd

Clarke Energy
(Australia) Pty Ltd
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South Australia 5031,
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Fax. +61 (0)8 8443 5848
australia@clarke-energy.com
www.clarke-energy.com

Registered address as above.
Company Registered No. ACN 086 492 935
ABN 20 086 492 935

Distributor & Service Provider
Gas Engines

Appendix B CONTOUR PLOTS FOR SCENARIO 2

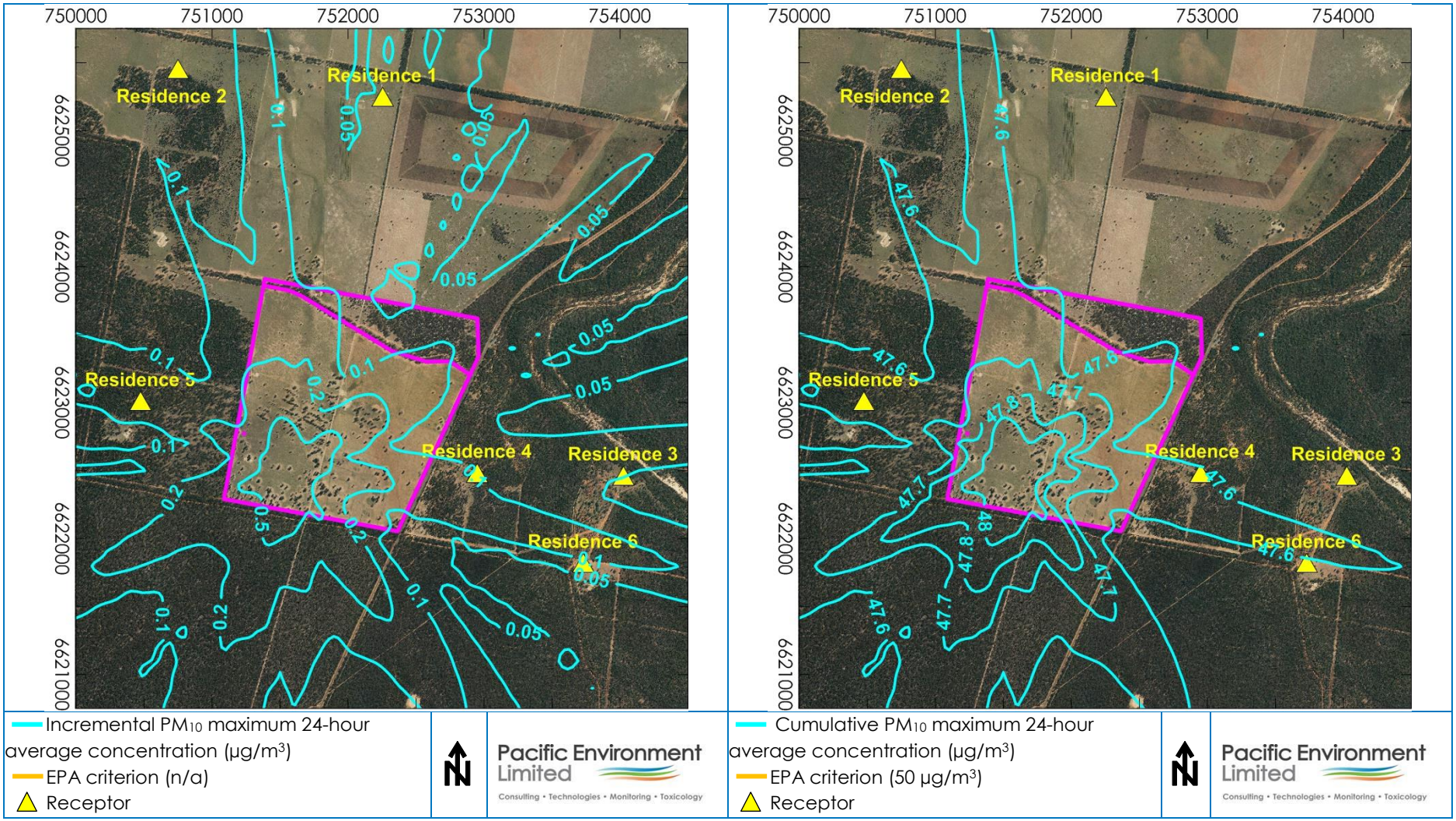

Figure B-1: Incremental and cumulative PM_{10} 24-hour model predictions – Scenario 2

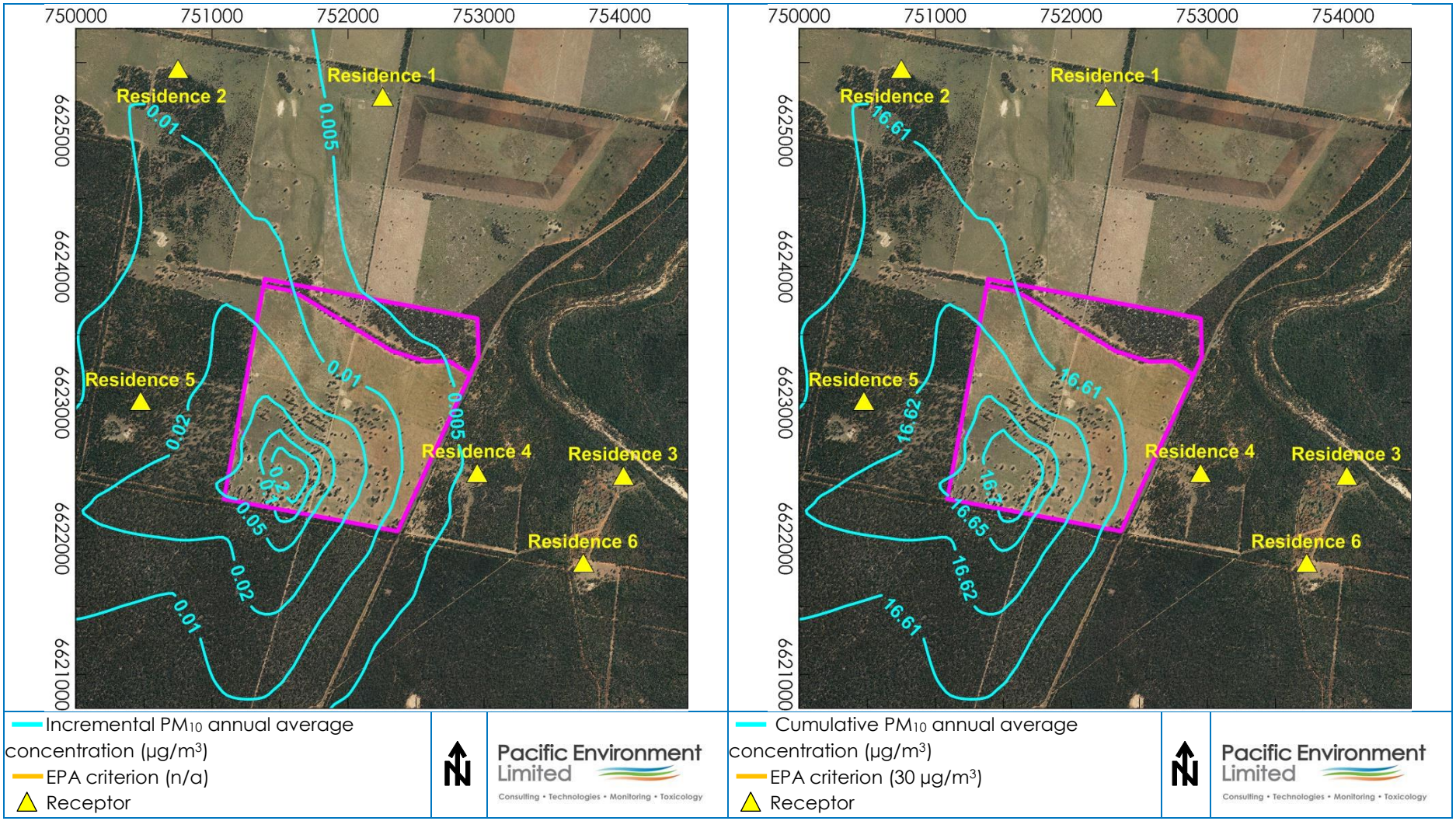

Figure B-2: Incremental and cumulative PM_{10} annual average model predictions – Scenario 2

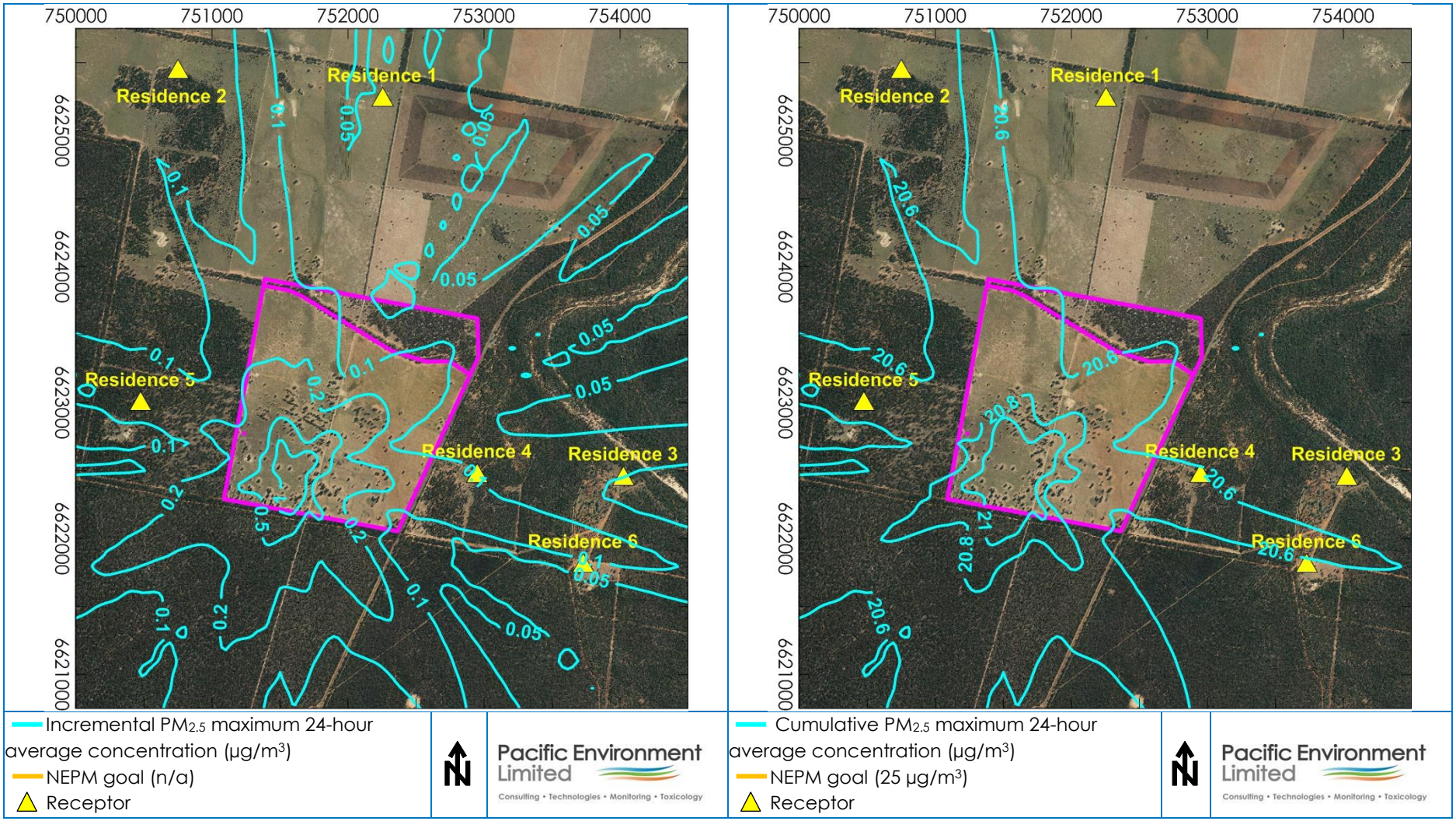

Figure B-3: Incremental and cumulative $PM_{2.5}$ 24-hour model predictions – Scenario 2

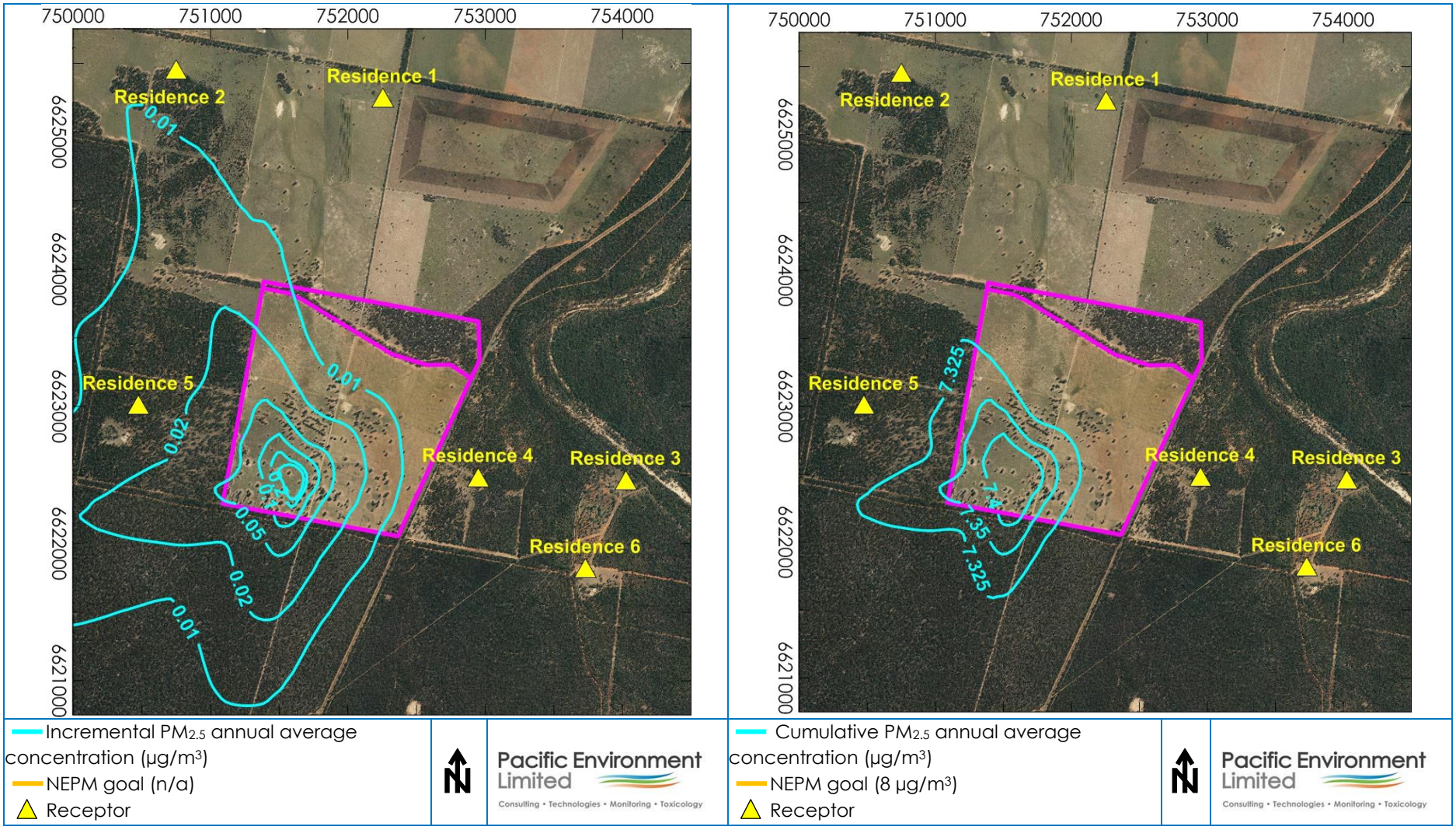

Figure B-4: Incremental and cumulative $PM_{2.5}$ annual average model predictions – Scenario 2

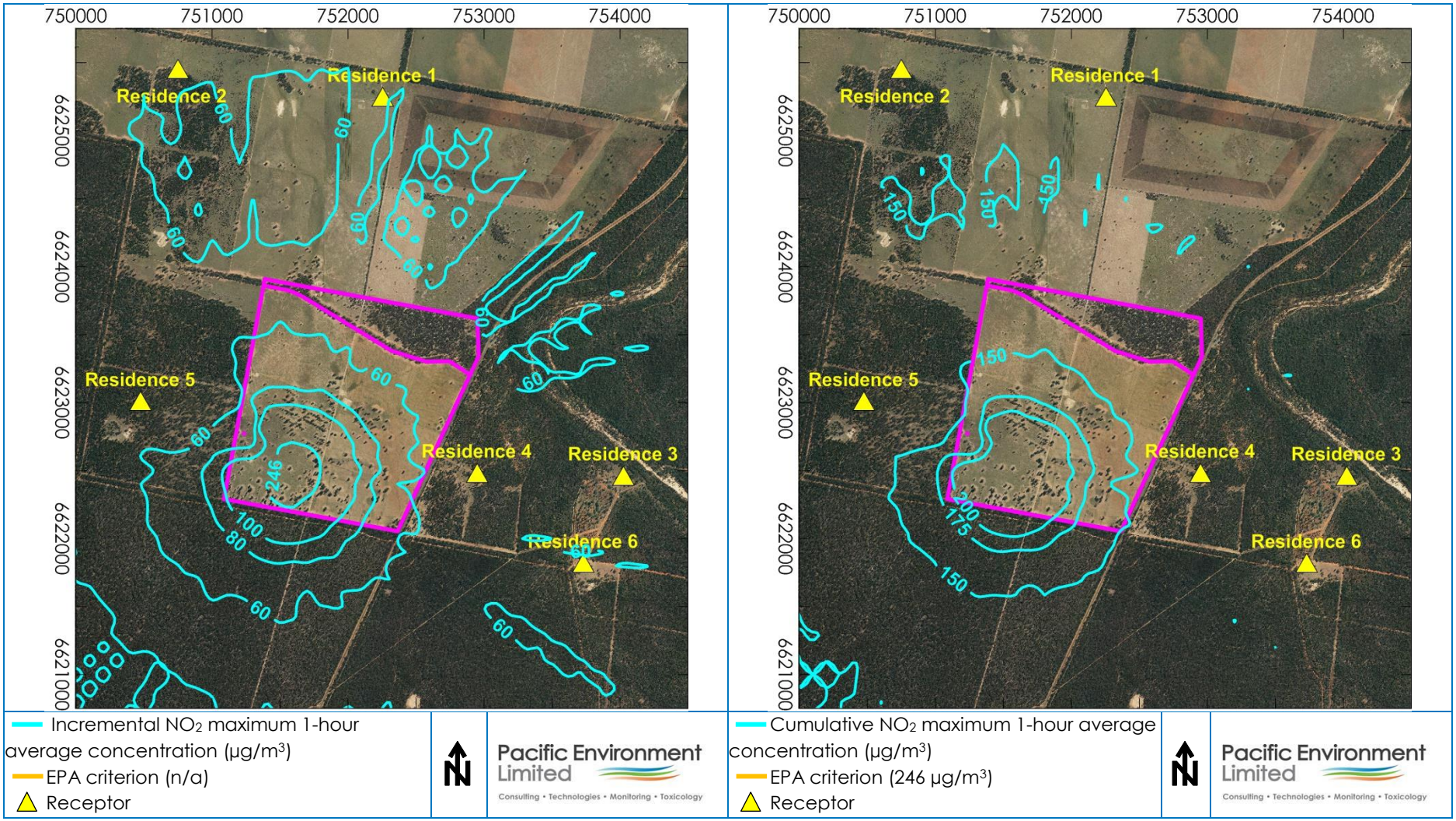

Figure B-5: Incremental and cumulative NO_2 1-hour model predictions – Scenario 2

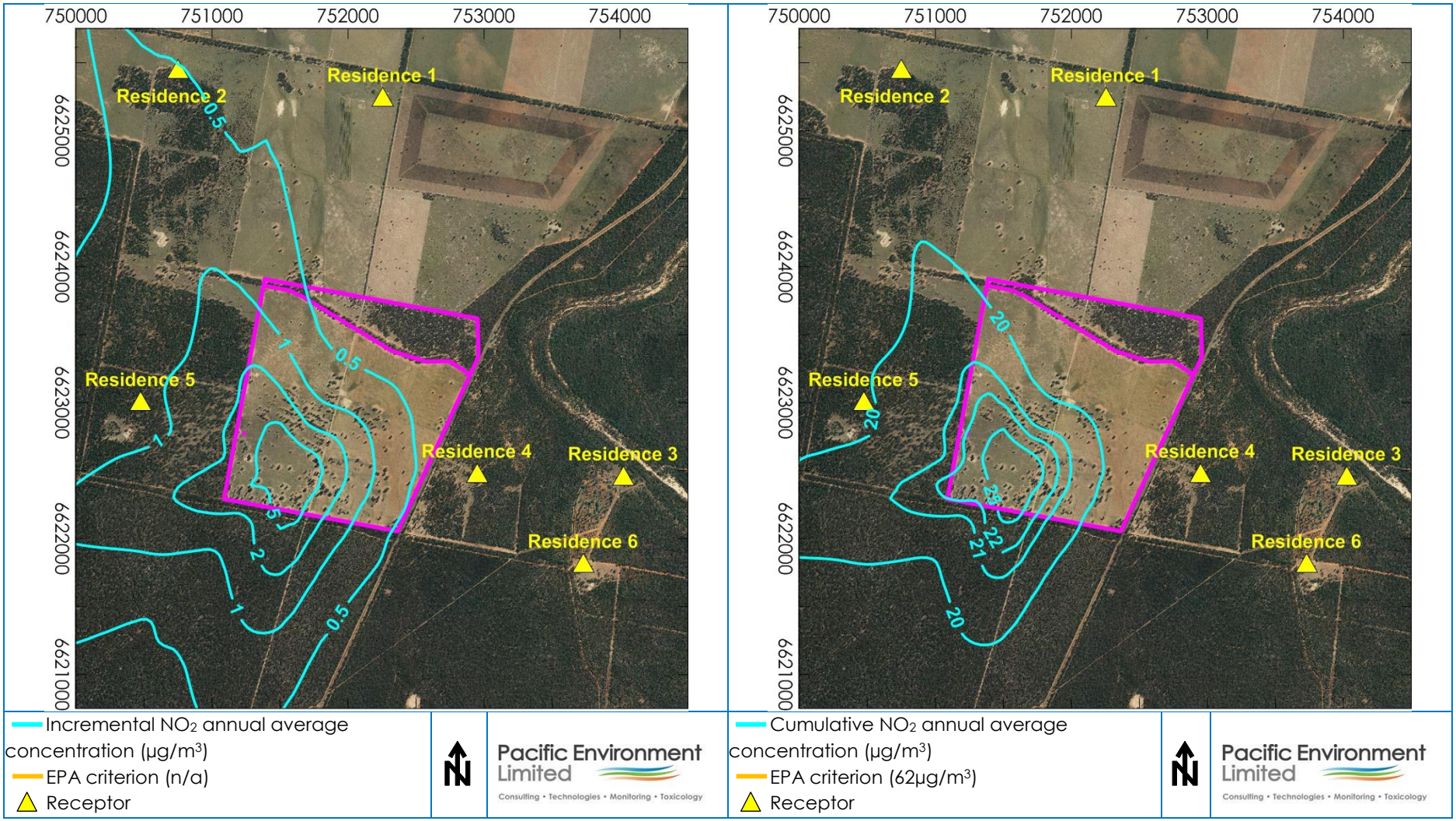

Figure B-6: Incremental and cumulative NO_2 annual average model predictions – Scenario 2

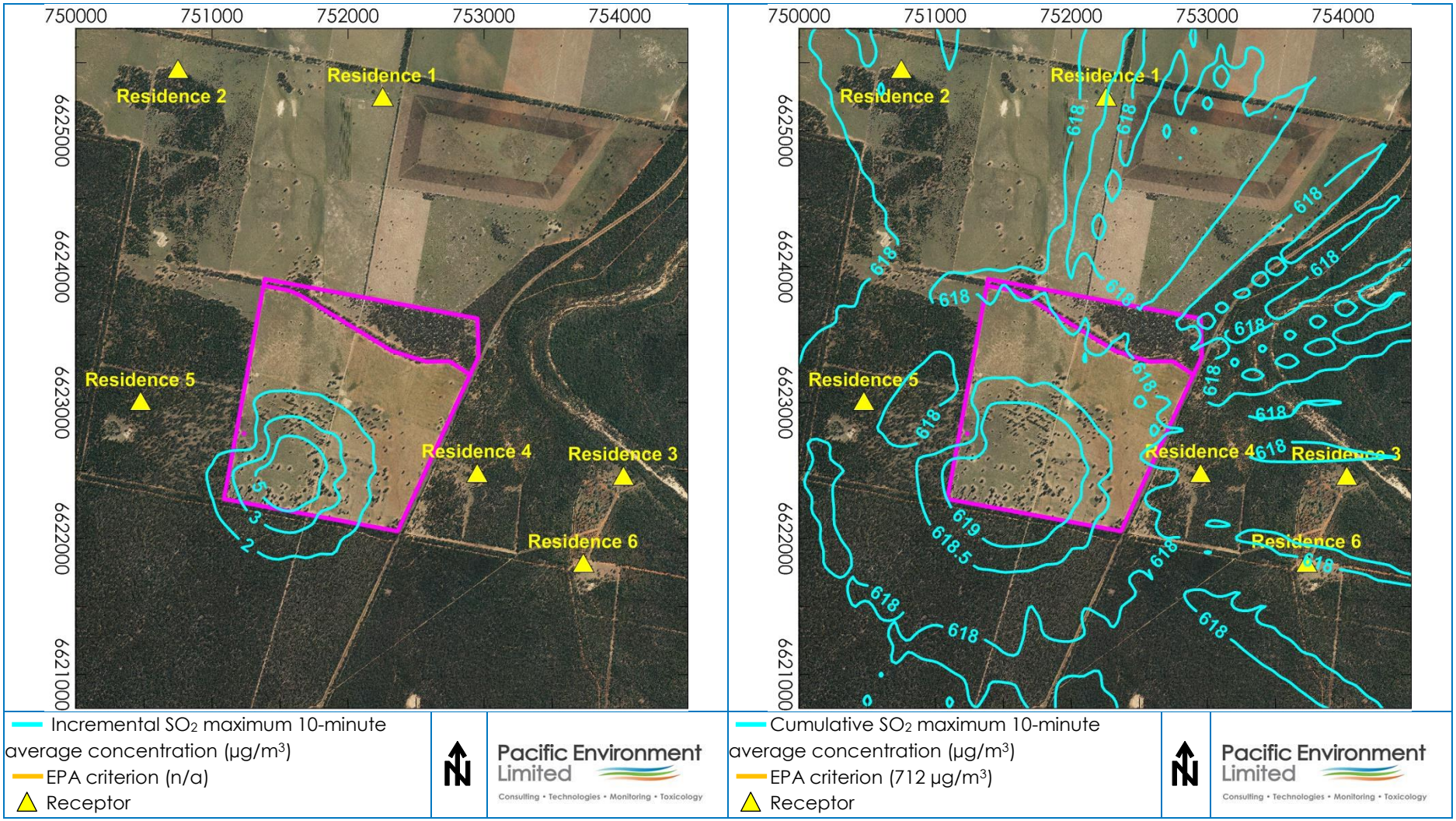

Figure B-7: Incremental and cumulative SO_2 10-minute model predictions – Scenario 2

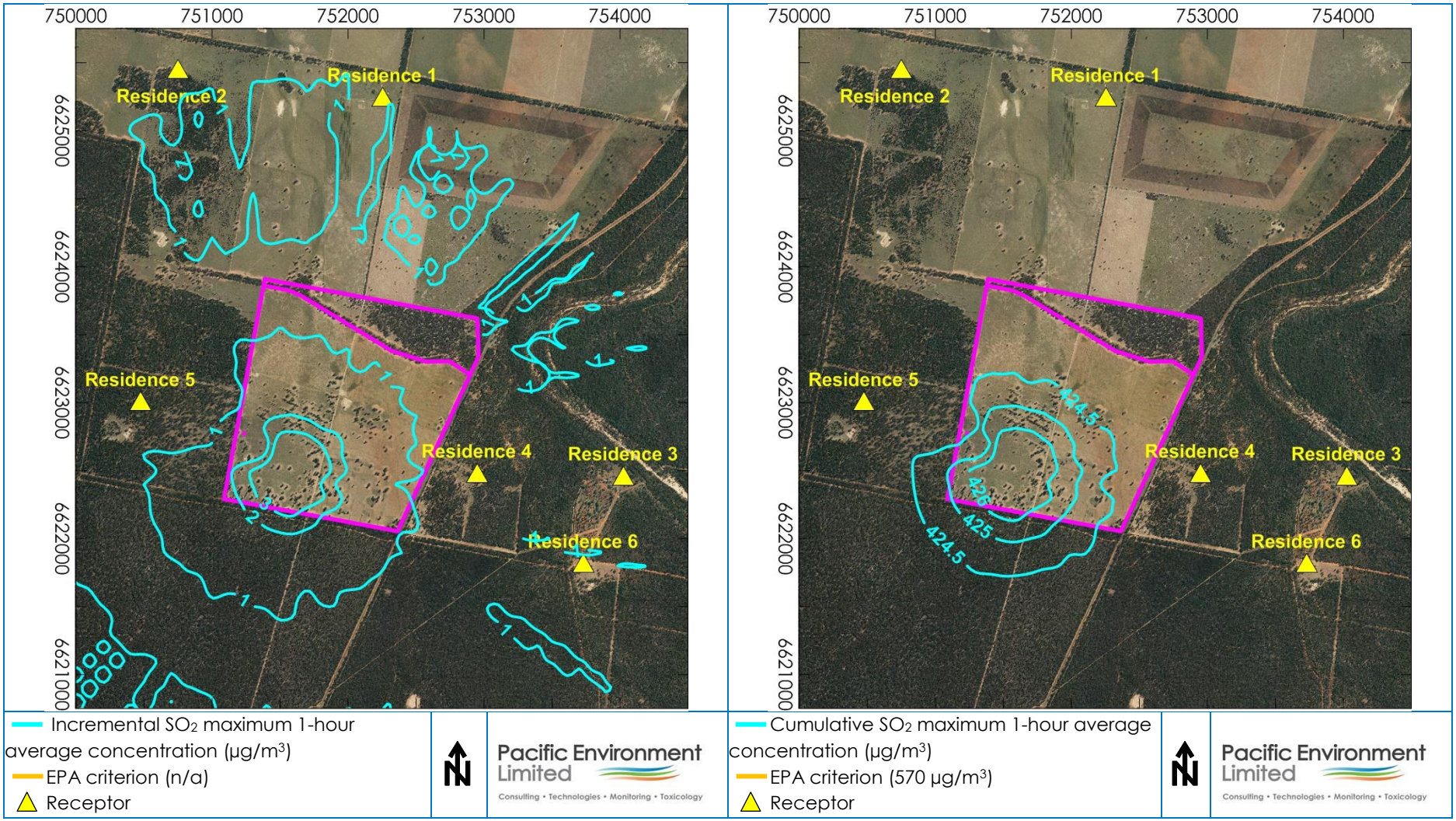

Figure B-8: Incremental and cumulative SO_2 1-hour model predictions – Scenario 2

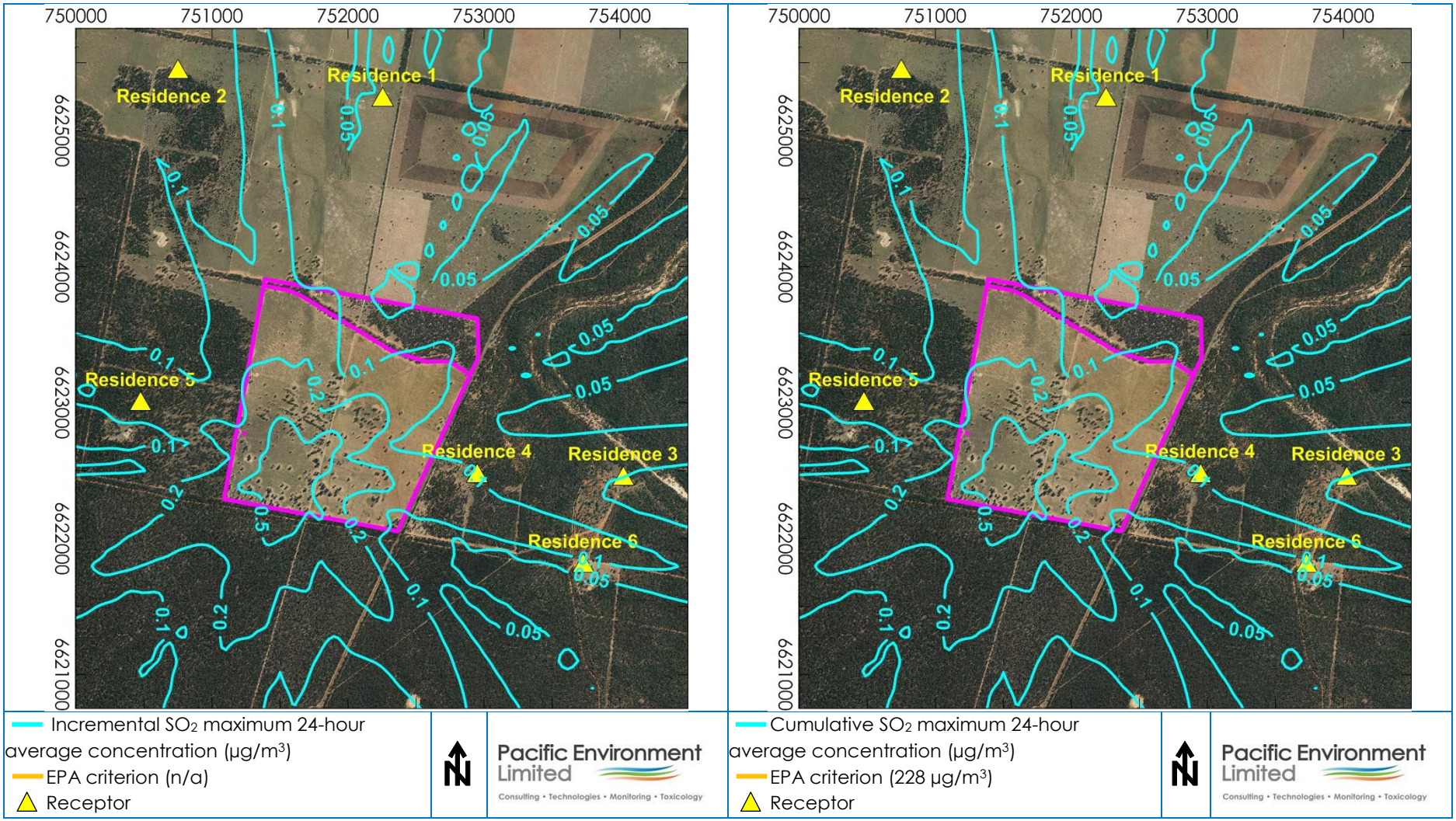

Figure B-9: Incremental and cumulative SO_2 24-hour model predictions – Scenario 2

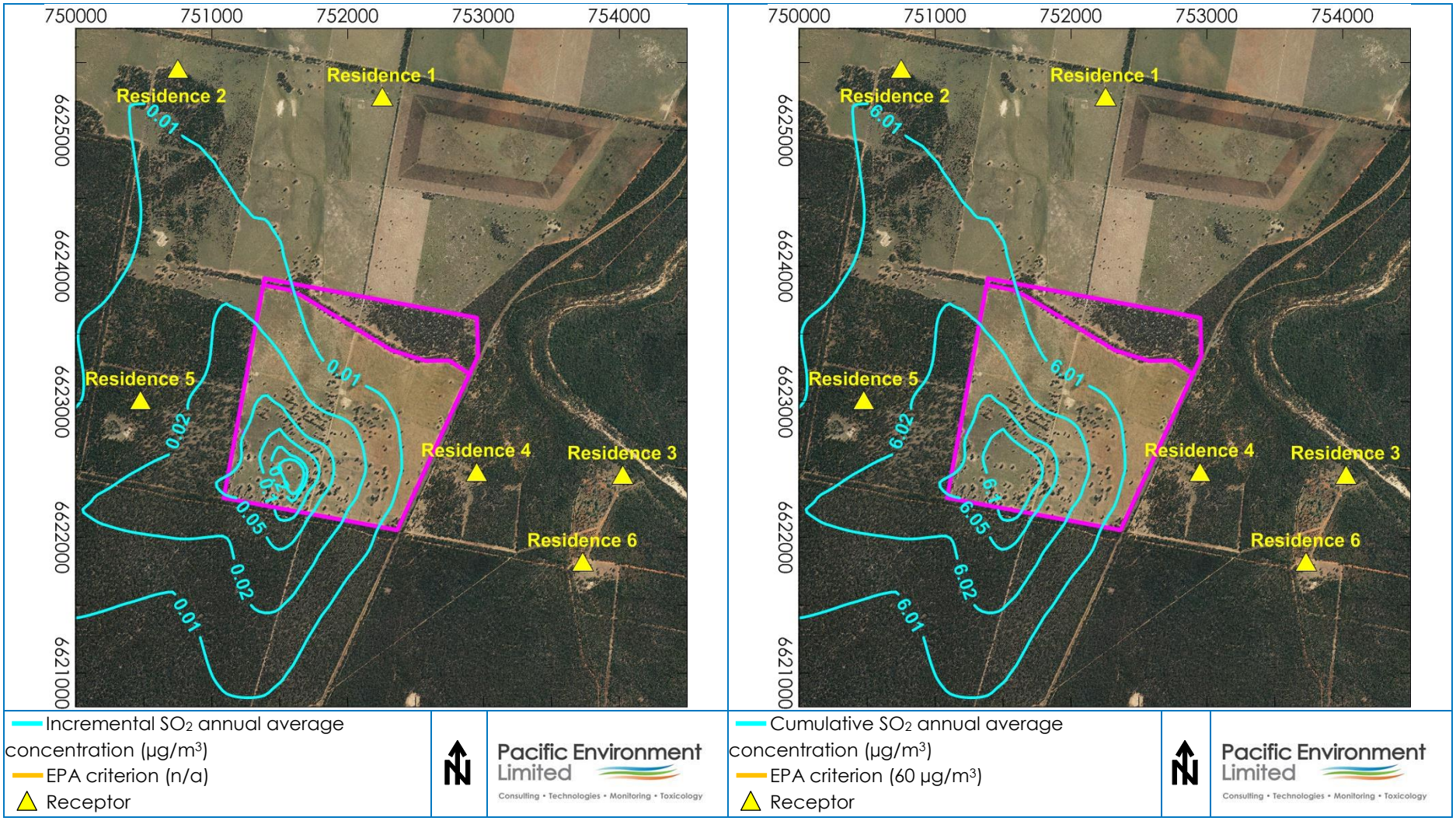

Figure B-10: Incremental and cumulative SO_2 annual average model predictions – Scenario 2

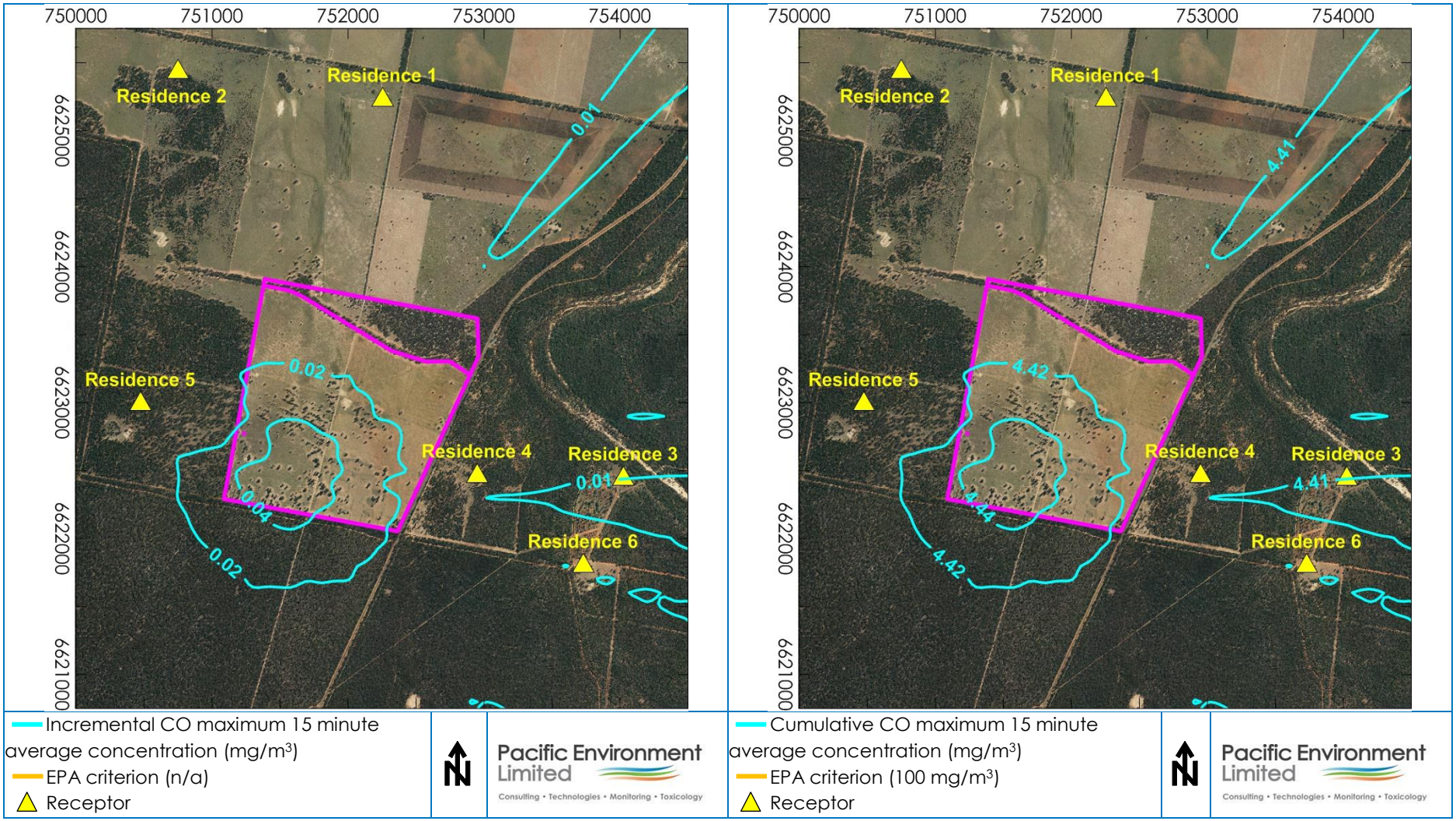

Figure B-11: Incremental and cumulative CO 15-minute model predictions – Scenario 2

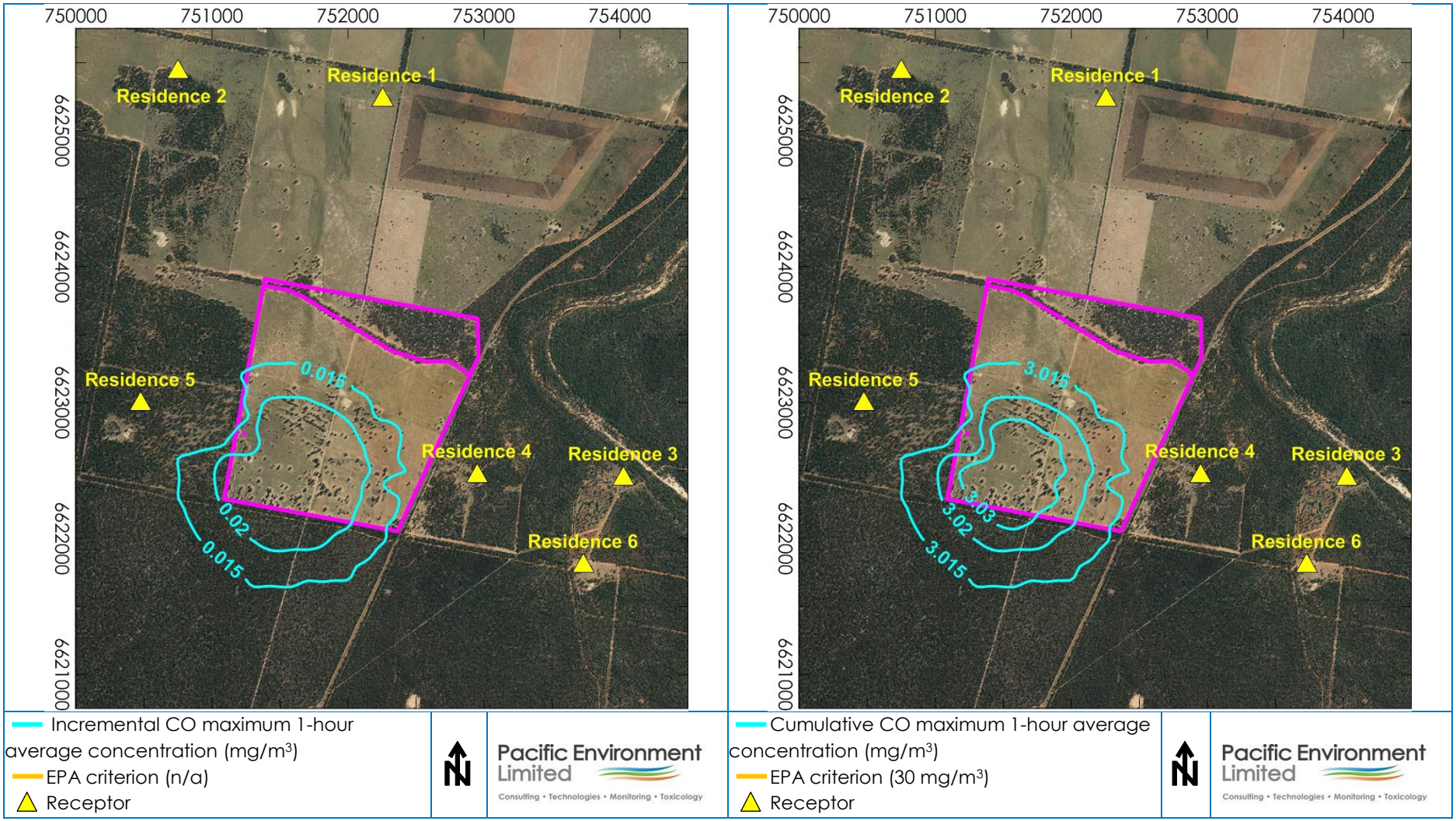

Figure B-12: Incremental and cumulative CO 1-hour model predictions – Scenario 2

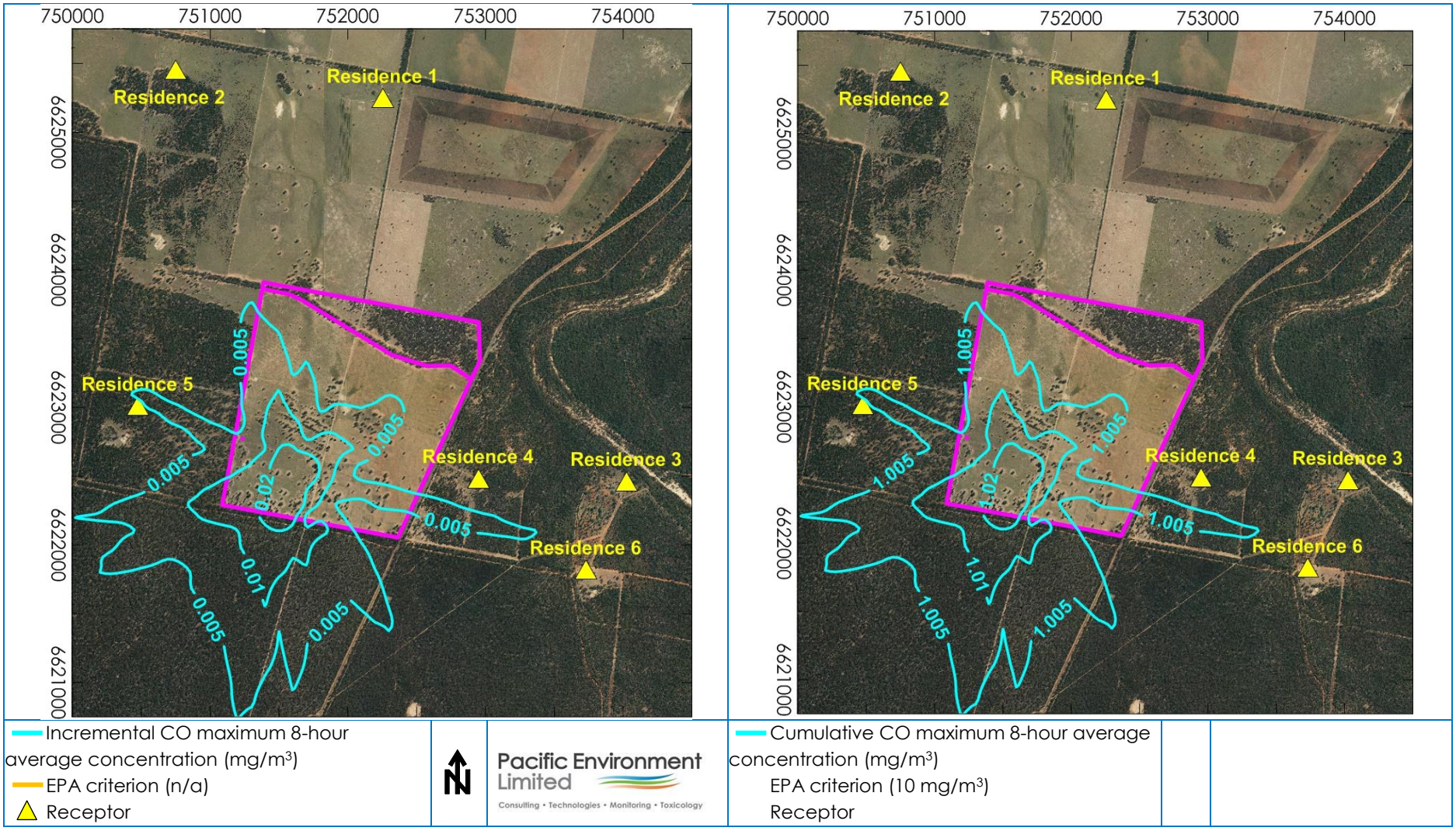

Figure B-13: Incremental and cumulative CO 8-hour model predictions – Scenario 2

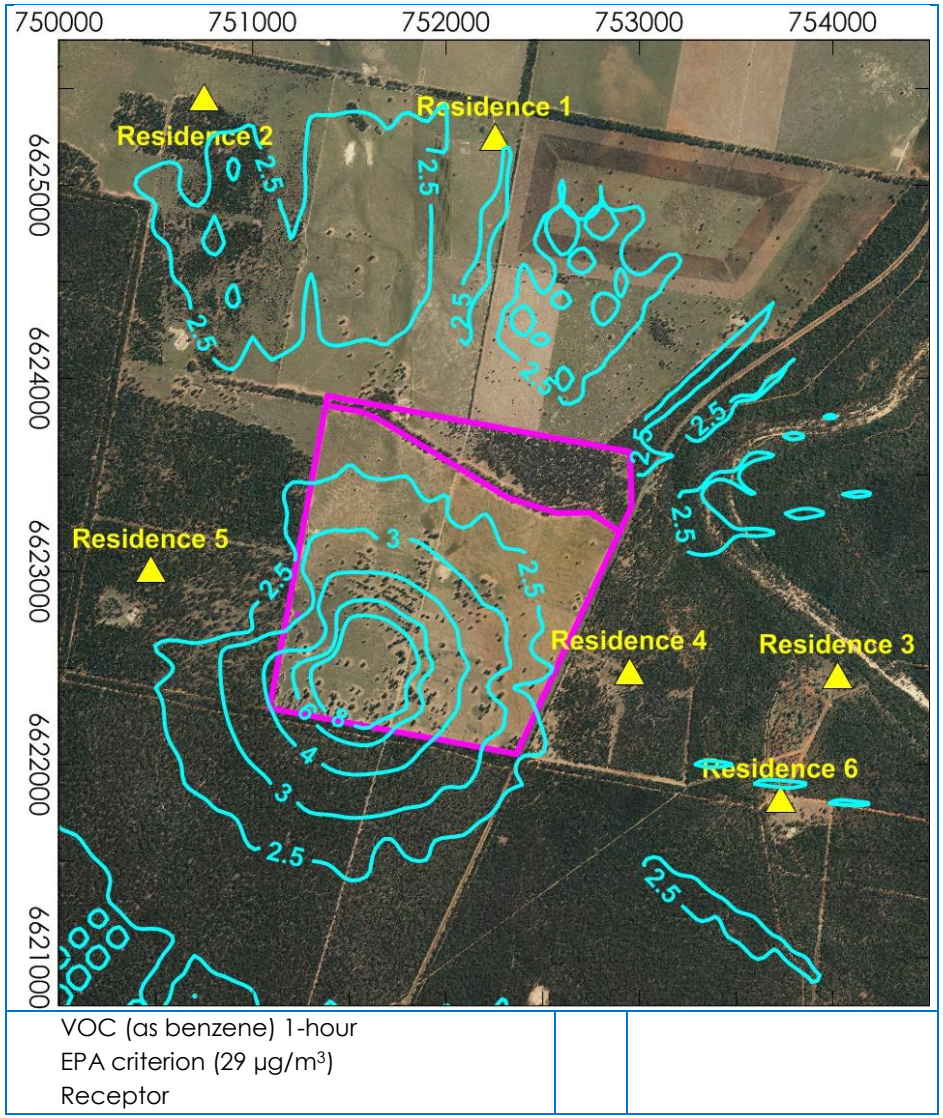

Figure B-14: Incremental VOC (as benzene) model predictions

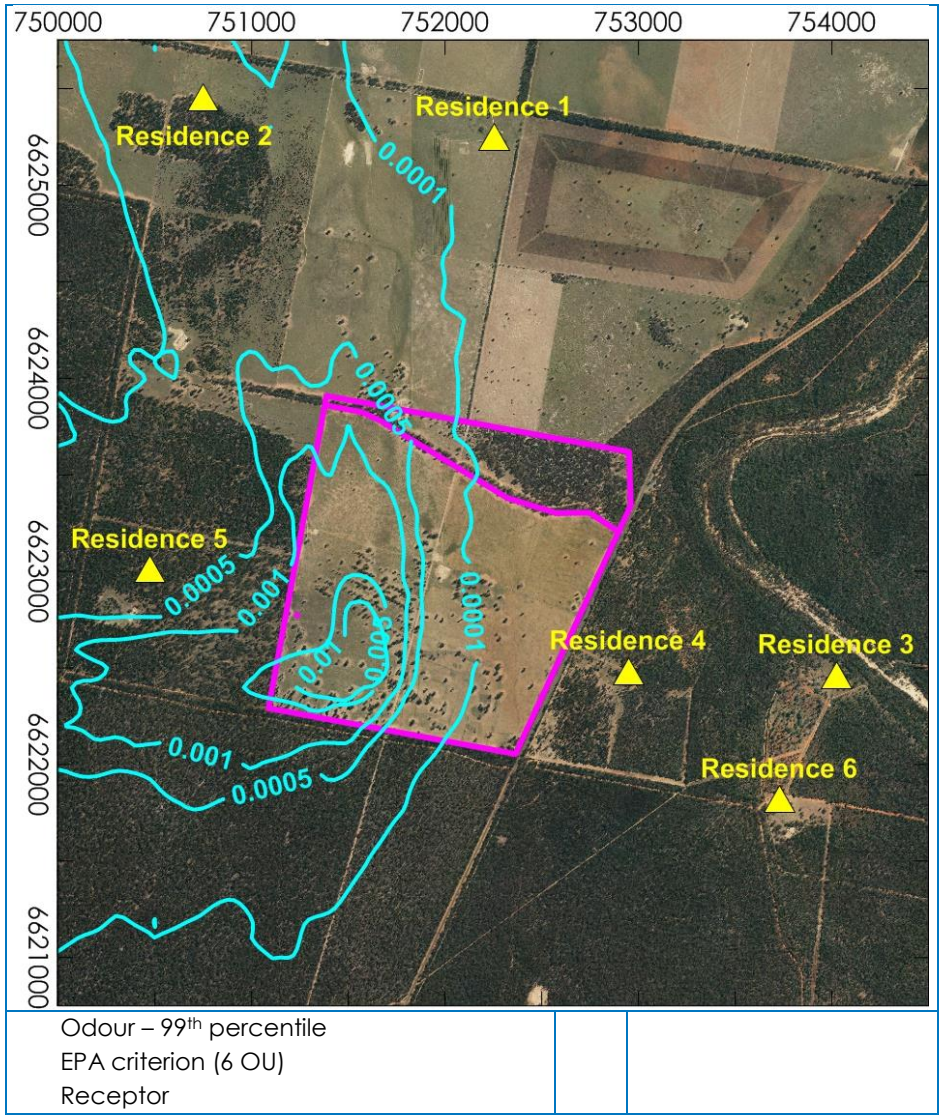

Figure B-15: 99th percentile odour model predictions

Appendix 11

Noise and vibration assessment (Pacific Environment)

Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology



Report

LEEWOOD PRODUCED WATER TREATMENT AND BENEFICIAL REUSE PROJECT NOISE AND VIBRATION ASSESSMENT

RPS

Job ID. 08672E

11 March 2015

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1 INTRODUCTION

Pacific Environment was engaged by RPS on behalf of Santos NSW (Eastern) Pty Ltd (Santos) to prepare a noise and vibration assessment for a proposed Water and Brine Treatment Plant (WBTP; the combined water (WTP) and brine treatment plant (BTP)) located at Leewood, approximately 22km south west of Narrabri, NSW.

1.1 Objectives of the Study

The objective of this study was to undertake an operational noise, construction noise and vibration and road traffic noise impact assessment for the proposed WBTP.

The assessment was performed with reference to the following guidelines, policies and standards:

- AS 1055.1 Acoustics – Description and measurement of environmental noise – Part1: General procedures.
- Australian Standard, 2006, AS 2187.2 Explosives – Storage and Use – Part 2: Use of Explosives.
- AS 2436 Guide to noise and vibration control on construction, demolition and maintenance sites.
- Interim Construction Noise Guideline (ICNG), EPA, 2007.
- Industrial Noise Policy (INP), EPA, 2000.
- Road Noise Policy (RNP), EPA, 2011.
- Assessing Vibration: A Technical Guideline, EPA, 2004.
- Environmental Noise Management Manual (ENMM), RMS, 2001.

1.2 Scope of Work

The scope of work for this project included:

- Obtain detailed characteristics of the proposed WBTP including the full list of equipment to be installed.
- Using previously conducted measurements, establish operational noise criteria in accordance with the INP (EPA 2000) and construction noise criteria in accordance with the ICNG (EPA 2007). Vibration criteria are derived from Assessing Vibration: A technical guideline (EPA 2004).
- Using historical meteorological data collected from the surrounding Bureau of Meteorology monitoring sites, identify prevailing meteorological conditions as prescribed in the INP.
- Estimate operational noise sources based on data supplied by Santos and Pacific Environment's database.
- Model operational noise emissions for the proposed WBTP.
- Estimate construction noise and vibration sources.
- Model construction noise and vibration emissions.
- Assess the potential road traffic noise impacts associated with the proposed WBTP during construction and operation in accordance with the RNP (EPA 2011) and ENMM (RMS 2001).
- Where applicable, identify in-principle noise and vibration mitigation measures needed to achieve relevant criteria.
- Prepare a report describing the methodology and results of the assessment.

2 PROJECT DESCRIPTION

2.1 Site and Proposed Development

The proposed activity involves the design, construction, operation and maintenance of a WBTP (the combined WTP and BTP).

Leewood is located on the Newell Highway approximately 24 kilometres south west of Narrabri, NSW. The project setting is presented in Figure 2-1. The proposed site layout is presented in Figure 2-2 and an indicative plant layout in shown in Figure 2-3.

The primary objective of the proposed activity is to construct and operate a purpose built, centralised water treatment facility outside of the Pilliga State Forest, to treat, manage and beneficially reuse produced water stored within the ponds.

Santos NSW (Eastern) Pty Limited is the proponent for the proposed activity on behalf of the titleholders of PAL 2. The proposed activity will include:

- construction and operation of:
    - a water treatment plant, including pre-treatment and reverse osmosis plant
    - a brine treatment plant
    - a brine distribution manifold and associated piping at Leewood, to allow water distribution into the water treatment plant and associated return flows to brine storage ponds
    - a treated water storage tank (five megalitre capacity)
    - a managed irrigation system including a centre pivot and sub-surface drip irrigation system
    - other associated infrastructure, including a gas pipeline to fuel the generators
    - a small potable water treatment system for water extracted from the licensed bore.
- the construction of (and the ability to operate) a treated water pipeline extending to the Leewood property boundary to transfer water to another location for irrigation by a third party (if required)
- re-use of treated water for irrigation at the Leewood property and other uses both on and off site including dust suppression, drilling and construction and firefighting . Santos is investigating the option of providing treated water to third parties for agricultural irrigation, although this potential use of treated water does not form part of the proposed activity for the purposes of this REF and will be subject to separate assessment and approvals
- amelioration of soils within irrigation area by deep tillage, fertiliser, lime and gypsum in preparation for irrigation
- decommissioning and rehabilitation of the site, if the Narrabri Gas Project does not proceed.

Santos (or its assigned operator) will operate the proposed activity for up to five years. The WBTP will treat up to 1.5 megalitres per day of produced water from Santos' CSG exploration and appraisal activities within PEL 238, PAL 2 and PPL 3. The operational process is expected to involve, but is not limited to:

- pumping of produced water from the produced water pond to the water treatment plant
- treatment of produced water within the water treatment plant, including removal of solids by filter (pre-treatment), reverse osmosis to separate the water and brine streams (treatment), and chemical and pH dosing (post-treatment) to make the treated water appropriate for irrigation.
- transfer of treated water to the treated water storage tank or directly to the on-site managed irrigation system for beneficial re-use
- beneficial re-use of treated water for irrigation, or other uses both on and off-site such as dust suppression, drilling and construction and firefighting
- transfer of brine to the brine treatment plant for concentration and further recovery of treated water
- storage of brine in the existing Leewood ponds.

Power will be supplied by a 1.4-MW gas engine generator. If the gas generator is offline power will be supplied by a 0.8-MW diesel generator. An additional 0.2 MW generator would also be onsite but would

be used for emergency situations only. Fuel for the gas generator will be supplied from the gas field via a fuel gas conditioning skid (FGCS) which removes liquid and solid contaminants from the gas to provide a suitable fuel quality. Diesel storage of up to 30,000 litres of fuel will be provided on site for power generation during times when the gas generator is offline.

Construction of the project is expected to take up to 50 weeks and be carried out in stages.

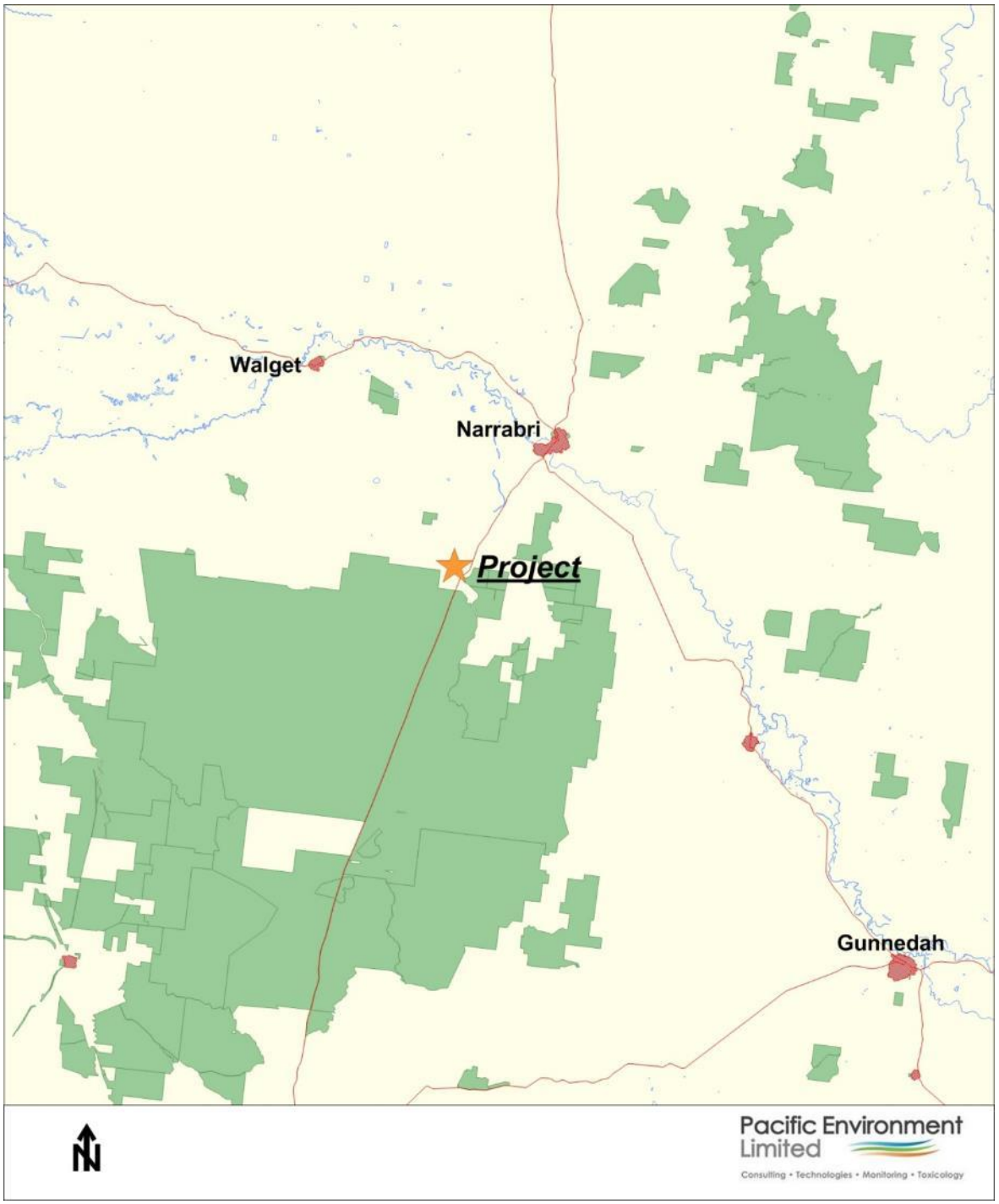

Figure 2-1: Regional Setting

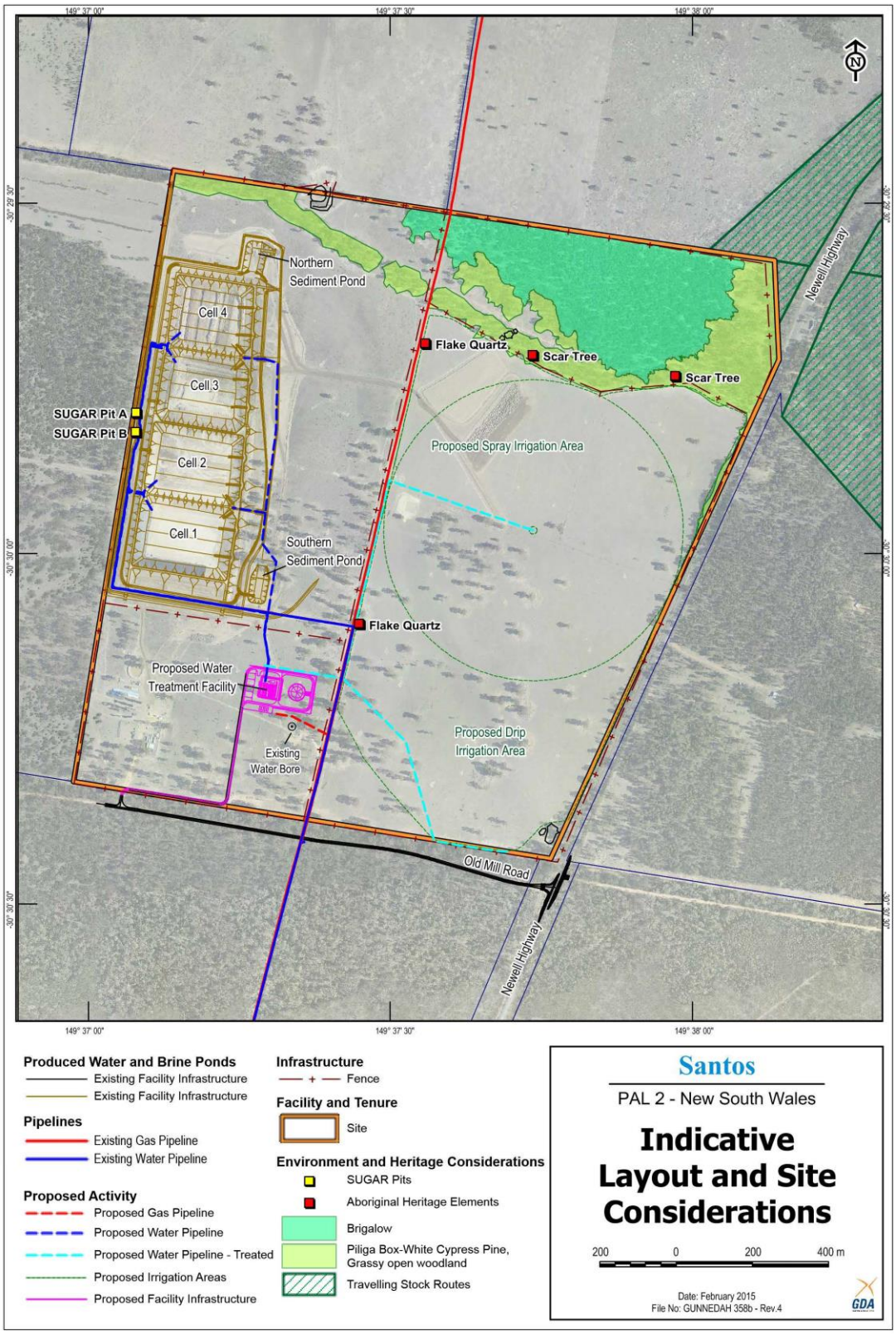

Figure 2-2: Site Infrastructure

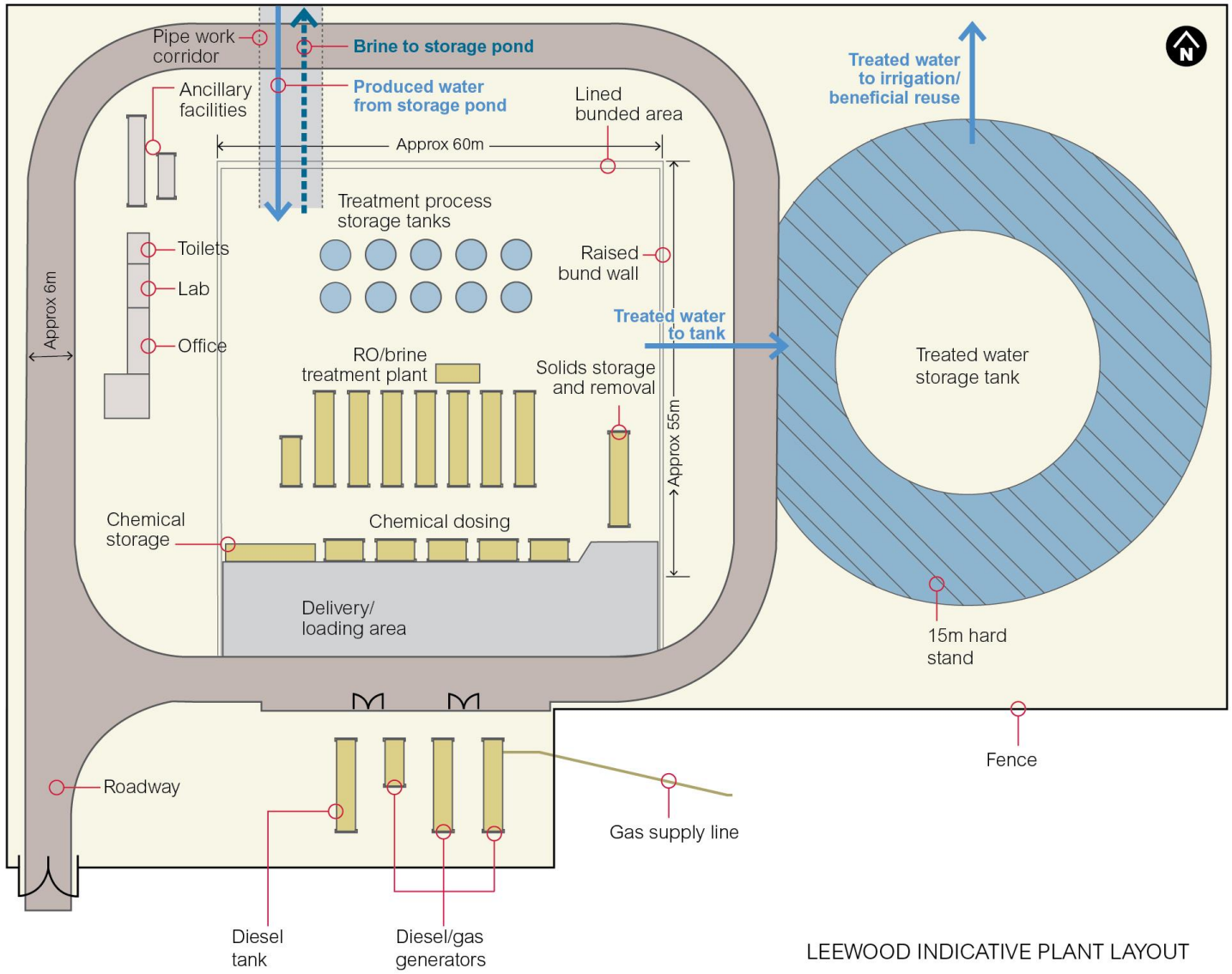

Figure 2-3: Indicative Water and Brine Treatment Plant Site Layout

2.2 Sensitive Receivers

Based on information supplied by the Santos and satellite imagery, the closest six residential receivers were identified in the vicinity of the site. These are summarised in Table 2-1 and the locations are shown in Figure 2-4.

Table 2-1: Summary of Closest Sensitive Receptors (WGS84 Zone 56)

Receptors		Easting (m)	Northing (m)
ID	Names		
R1	Residence 1	752254	6625248
R2	Residence 2	750749	6625456
R3	Residence 3	754023	6622463
R4	Residence 4	752948	6622483
R5	Residence 5	750473	6623010
R6	Residence 6	753729	6621820

Road noise sensitive receivers are located approximately 20m from the Newell Highway within Narrabri. On the Newell Highway between the site and Narrabri, receivers are generally sparse and vary from 50m to 600m and greater from the Highway.

Two pits that form part of the Sydney University Giant Air-shower Recorder (SUGAR) are located approximately 50 metres from the proposed construction activity along the western boundary of Leewood. While the pits are not registered as heritage items under either the OEH State Heritage Inventory or the Narrabri LEP, they have been identified as having potential heritage value and therefore are considered in the construction vibration assessment.

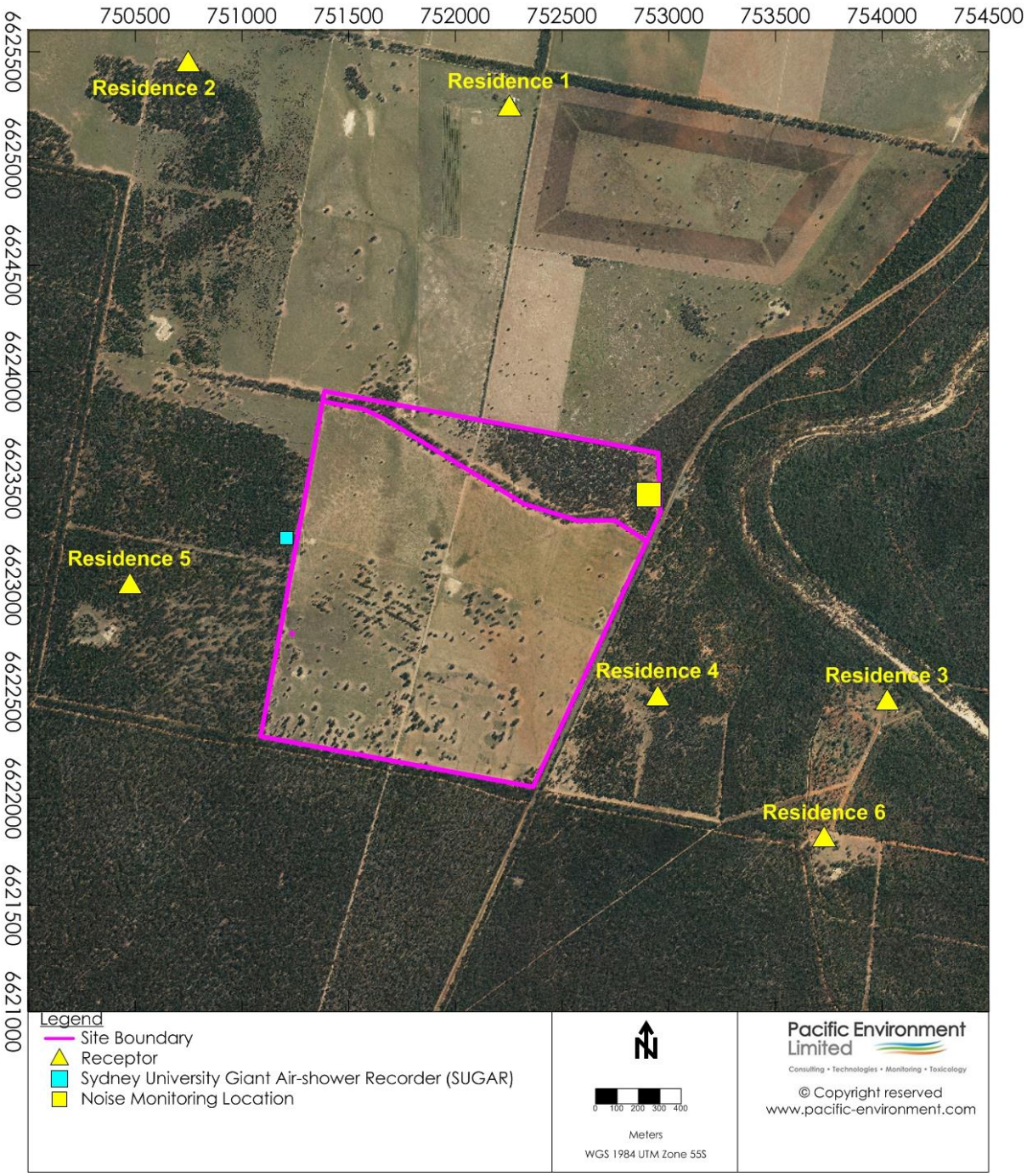

Figure 2-4: Sensitive Receivers Locations and Noise Monitoring Location

3 EXISTING ENVIRONMENT

3.1 Noise Environment

Unattended and attended noise monitoring at the project site was previously conducted by GHD (GHD, 2013, *Santos Noise Monitoring)* in December 2013. Noise monitoring was conducted at the Leewood site in the north eastern corner near to the Newell Highway. The monitoring location is shown in Figure 2-4.

The noise levels obtained are expressed in terms of, $L_{A90,15min}$ and $L_{Aeq,15min}$.

- $L_{A90,15min}$ is the A-weighted noise level that is exceeded for 90% of the monitoring time period (15 minutes).
- The $L_{Aeq,15min}$ is the 15 minute equivalent continuous noise level containing the same acoustic energy as the actual fluctuating noise level.

The $L_{A90,15min}$ is commonly referred to as the background noise level and the lowest 10th percentile $L_{A90,15min}$ over a period (day, evening, night) is referred to as the period Assessment Background Level (ABL). The Rating Background Level (RBL) for each day, evening and night period of the monitoring occurrence is then calculated by taking the median of the ABLs.

The $L_{Aeq,\ period}$ is the logarithmic average of all of the $L_{Aeq,15min}$ measurements during each assessment period (day, evening and night).

Table 3-1 presents a summary of the long term unattended noise monitoring results. Where the measured RBLs were below 30 dB(A), the INP states that it should be set to 30 dB(A).

Table 3-1: Summary of Unattended Noise Monitoring Results (GHD, 2013)

Location	Measured RBL dB(A)			Measured Ambient Noise Level $L_{eq,period}$ dB(A)		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Leewood	32	30	30[4]	65	64	61

Notes: 1.Day is defined as 7:00 am to 6:00 pm, Monday to Saturday and 8:00 am to 6:00 pm Sundays & Public Holidays.
2. Evening is defined as 6:00 pm to 10:00 pm, Monday to Sunday and Public Holidays.
3. Night is defined as 10:00 pm to 7:00 am, Monday to Saturday and 10:00 pm to 8:00 am Sundays and Public Holidays.
4. Measured noise level less than 30 dB(A). RBL set to 30 dB(A) in accordance with the INP (EPA 2000).

Short term attended noise measurements were also carried out by GHD during December 2013 to characterise the existing noise environment at the long term monitoring locations. Table 3-2 presents a summary of the attended measurements. The measurements show that there was no significant industrial noise in the vicinity of the project site and that road traffic noise was a major contributor at the monitoring location.

It was noted that the approved water and brine storage ponds were under construction during the monitoring location, however attended measurements indicated that the construction works did not influence the long term noise monitoring.

The measured RBL for the daytime period was 32 dB(A). The noise monitoring location selected by GHD is in close proximity to the Newell Highway. Figure 2-4 indicates that the receiver locations are at a much greater offset distance to the highway than the monitoring location.

It is expected that at distances further from the Newell Highway, background noise levels would be lower as there are no other significant noise sources in the vicinity of the site and receivers. The lowest RBL that can be used for assessment under the INP is 30 dB(A). In light of this, the daytime RBL has been set to 30 dB(A) for the purposes of conservatism in this assessment.

Table 3-2: Attended Measurement Results (GHD, 2013)

Location	Date and Time	Measured Noise Level dB(A)		Notes
		L_{eq}	L_{90}	
Leewood	10/12/2013 04.00 am	61	24	Road traffic noise from Newell Highway, mainly heavy vehicles and the occasional light vehicle, low insect noise, no wind.
	10/12/2013 04.16 am	60	23	Road traffic noise from Newell Highway, mainly heavy vehicles and the occasional light vehicle, low insect noise, no wind.
	11/12/2013 7.00 am	66	35	Road traffic noise from Newell Highway, mix of heavy vehicles and light vehicles, truck idling at truck stop, birds, light breeze, Leewood construction site not audible.
	11/12/2013 7.15 am	65	34	Road traffic noise from Newell Highway, mix of heavy vehicles and light vehicles, truck idling at truck stop, birds, light breeze, Leewood construction site not audible.

3.2 Meteorological Environment

The existing meteorological environment was determined using data from the nearest Bureau of Meteorology (BoM) site at Narrabri West Post Office (site no. 053030) and The Atmospheric Pollution Model (TAPM) modelling that was conducted by the Air Quality Consultants (Pacific Environment) for the project site.

The climate statistics for the region are summarised in Table 3-3.

Table 3-3: Temperature, Rainfall and Humidity Statistics for Narrabri West Post Office

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year average
Mean temperature (°C)	26.6	26.2	23.8	19.6	15.4	12.0	10.9	12.2	15.5	19.4	22.5	25.4	19.1
Maximum temperature (°C)	33.8	33.2	31.2	27.3	22.5	18.7	18	19.8	23.4	27.1	30.1	33	26.5
Minimum temperature (°C)	19.3	19.1	16.4	11.9	8.3	5.2	3.7	4.6	7.6	11.7	14.8	17.7	11.7
Relative humidity (%)	49.5	52.5	51.5	54	63.5	68	66	57.5	52	47	49	48	55
Mean rainfall (mm)	3.3	63.6	57	38.6	47.8	48.3	46.5	40.3	42.1	51.9	61.6	77.1	658.9

Source: **BoM (2014)**

Wind in the direction of source to receiver has the potential to enhance noise levels at the receiver. The INP (EPA, 2000) states that where winds less than 3 m/s at 10 m height are present for more than 30% of the time in any assessment period (day, evening, night) during any season, they are to be considered as a feature of the area and should be considered when predicting noise impacts. The INP considers 3 m/s as the upper limit of wind speed that can noticeably increase source noise levels without increasing ambient noise levels so that they mask noise from the source.

Table 3-4 presents a summary of the percentage of occurrence of winds less than 3 m/s. When considering adjacent wind directions, there are feature winds from the east north east, east and east south east during autumn and winter evenings and nights. Gradient winds from east south east, east and east north east will be considered in the modelling during the evening and night.

Table 3-4: Percentage of Winds less than 3m/s

Percentage Occurrence of Winds less than 3m/s												
	Summer			Autumn			Winter			Spring		
	Day	Eve.	Night	Day	Eve.	Night	Day	Eve.	Night	Day	Eve.	Night
N	1%	1%	2%	1%	0%	2%	2%	2%	1%	1%	2%	1%
NNE	0%	4%	1%	1%	1%	2%	2%	1%	3%	0%	2%	2%
NE	0%	5%	4%	1%	4%	6%	2%	**5%**	8%	1%	3%	4%
ENE	1%	4%	3%	0%	**10%**	9%	1%	**10%**	**8%**	0%	4%	6%
E	1%	4%	3%	1%	**13%**	10%	2%	**15%**	**12%**	0%	7%	6%
ESE	1%	3%	3%	4%	**8%**	8%	4%	**9%**	**10%**	1%	3%	3%
SE	2%	4%	5%	6%	5%	10%	4%	5%	**8%**	1%	4%	7%
SSE	3%	4%	5%	5%	4%	9%	3%	3%	5%	1%	5%	9%
S	2%	3%	3%	6%	4%	6%	3%	3%	5%	2%	4%	3%
SSW	3%	2%	1%	5%	3%	3%	2%	3%	1%	2%	3%	2%
SW	1%	1%	1%	5%	1%	2%	3%	2%	2%	2%	2%	1%
WSW	2%	0%	1%	4%	1%	1%	3%	1%	1%	2%	1%	0%
W	3%	0%	0%	3%	1%	0%	4%	0%	1%	2%	1%	0%
WNW	2%	1%	0%	2%	0%	0%	3%	1%	1%	2%	1%	0%
NW	2%	2%	1%	2%	0%	1%	2%	1%	1%	2%	1%	0%
NNW	1%	1%	0%	1%	0%	1%	2%	2%	0%	2%	2%	1%

The potential for temperature inversions has also been considered. The INP states that where temperature inversions (both F and G stability class – see Glossary of Terms) occur for more than 30% of the time during winter nights (6.00pm to 7.00am) then they should be considered a feature and accounted for in the assessment.

The default temperature inversion conditions for a non-arid area (more than 500mm rainfall per year) is to consider a moderate temperature inversion equivalent to Pasquil stability class F (3°C/100m). Table 3-3 shows that the area is non-arid and therefore the default conditions from the INP for non-arid areas will be used for a conservative assessment.

The surrounding terrain is generally flat with no significant topographical features between sources and receivers. As such, significant drainage flow winds are not expected and have not been assessed further.

4 CRITERIA

4.1 Environmental Protection Licence

An environmental protection licence (EPL) (Licence No. 20350) was issued for the site for the approved water and brine storage ponds operations currently occurring. It is expected that this licence would be updated to cover the proposed activities that are assessed in this report.

The relevant license conditions for noise are L3 and L4.

The operational noise limits under this licence are $L_{Aeq,15min}$ 35 dB(A) at any residential sensitive receptor not subject to a private negotiated agreement, during the day, evening and night period.

The operational noise limits apply under all meteorological conditions except for the following:

- Wind Speeds greater than 3 m/s at 10 metres above ground level; or

- Stability category F temperature inversion conditions and wind speeds greater than 2 m/s at 10 metres above ground level; or
- Stability category G temperature inversion conditions.

The construction hours are limited to standard hours (7.00am to 6.00pm Monday to Friday, 8.00am to 1.00pm Saturday). All other times are considered outside of the permitted construction hours.

Outside of the permitted hours the following may be carried out (as per Condition L4.2 of the EPL):

- Construction work that causes $L_{Aeq(15\ minute)}$ noise levels that are not more than 5dB above rating background level at any residence not subject to a private negotiated agreement, in accordance with the *Interim Construction Noise Guideline* (DECCW, 2009);
- Delivery of plant, equipment and materials which is required to be delivered outside of the standard construction hours by Police and/or other authorised authorities; and
- Emergency work to avoid loss of life, damage to property and/or environmental harm.

4.2 Construction Noise

Appropriate construction noise management levels are given in the *NSW Interim Construction Noise Guideline* (DECCW 2009). Construction noise management levels for residential receivers are detailed in Table 4-1. The management levels represent the noise level at which when exceeded, the measures outlined in Table 4-1 would apply.

Table 4-1: Construction Noise Management Levels at Residences using Quantitative Assessment

Time of Day	Management Level $L_{Aeq,15min}$	How to Apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or Public Holidays	Noise affected RBL + 10dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq,(15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dBA	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

A summary of the project specific construction noise management levels for residential receivers is presented in Table 4-2. The unattended measured background noise levels summarised in Section 3.1 have been used for residential receivers.

The derived construction noise criteria outside of standard hours are consistent with the current EPL.

Table 4-2: Project Specific Construction Noise Management Level, dB(A)

Land Use	Construction Noise Management Level, $L_{Aeq,15min}$ dB(A)		
	Standard hours Monday to Friday 7am to 6pm Saturday 8am to 1pm	Outside of standard hours Evening Monday to Sunday 6pm to 10pm	Night time Monday to Saturday 10pm to 7am Sunday & Public Holidays 10pm to 8am
Residential	40	35	35

4.3 Operational Noise

In accordance with EPA requirements, the project will be assessed with consideration to the INP.

The INP recommends two criteria to meet environmental noise objectives. The Intrusiveness Criteria for residential receivers to address the potential for intrusive noise and Amenity Criteria to maintain acoustic amenity appropriate to the relevant land use category of the area.

Intrusiveness Noise Criterion – The $L_{Aeq,15min}$ noise level within the day (7.00am to 6.00pm, 8.00am to 6.00pm Sundays and Public Holidays), evening (6.00pm to 10.00pm) or night time (10.00pm to 7.00am, 10.00pm to 8.00am Sundays and Public Holidays) assessment periods should not exceed the Rating Background Level (RBL), as defined by the INP, within that period by more than 5 dB(A). The purpose of this noise goal is to minimise the likelihood of disturbance.

Amenity Noise Criterion – The maximum ambient L_{Aeq} noise level within the day, evening and night assessment period should not exceed the "acceptable noise levels" (ANL) published in the INP and reproduced in Table 4-3 for applicable land uses.

The ANL is dependent on the relevant receiver type and area category for the residential receiver. The purpose of this noise goal is to provide an upper limit to industry related noise emissions and prevent industrial noise levels from creeping higher with each new successive industrial development.

The amenity criteria may be amended based on the noise level of the existing industrial noise so that any new sources of industrial noise do not increase or significantly contribute to the existing level of industrial noise.

Table 4-3: Recommended L_{Aeq} Noise Levels from Industrial Noise Sources, dB(A)

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level dB(A)	
			Acceptable	Recommended Maximum
Residential	Rural	Day	50	55
		Evening	45	50
		Night	40	45

Note: This table is a reproduction of Table 2.1 of the INP. It should be read in conjunction with the notes from Section 2.2.1 of the INP. Time periods are defined as: Day (7.00am-6.00pm Monday to Saturday and 8.00am-6.00pm Sundays and Public Holidays), Evening (6.00pm-10.00pm), Night (10.00pm-7.00am, unless preceding a Sunday or Public Holiday).

The INP includes provisions for certain characteristics of the noise emitted from an industrial premises. The characteristics include tonality, impulsiveness, intermittency or dominant low frequency content.

The operational noise criteria for the project are presented in Table 4-4, for the receiver type within the project area. The intrusive noise criteria are based on the RBLs in Table 3-1. The amenity criteria have been derived using the unattended and attended noise measurements. Since no significant industrial noise was noted during the monitoring, no adjustments to the ANL have been applied.

The INP requires the comparison of the derived intrusive and amenity criteria and the most stringent criteria are selected to be assessed against. Table 4-4 shows that the controlling criteria for residential receivers is the intrusive criteria during the day, evening and night.

The derived project specified criteria are consistent with the current EPL operational noise limits.

Table 4-4: Operational Noise Criteria, dB(A)

Receiver	Period[1]	Amenity			Intrusive		Project Specific Criteria
		ANL	Existing Industrial Noise[2] $L_{eq,industrial}$	Adjusted ANL $L_{Aeq,period}$	RBL	Intrusiveness Criteria RBL+5 $L_{Aeq15min}$	
R1-R6	Day	50	-	50	30	35	35
	Evening	45	-	45	30	35	35
	Night	40	-	40	30	35	35

Notes: 1. Day (7.00am-6.00pm Monday to Saturday and 8.00am-6.00pm Sundays and Public Holidays), Evening (6.00pm-10.00pm), Night (10.00pm-7.00am, unless preceding a Sunday or Public Holiday).

2. No existing industrial noise was observed in the area as shown in Section 3 – Existing Environment.

4.4 Low Frequency Noise

Table 4.1 of the INP states that low frequency noise is considered dominant where the difference between the A-weighted and C-weighted noise levels is 15 dB or greater. Where this difference occurs the INP recommends a modifying factor of 5 dB is added to the predicted noise level.

The C-weighting network was designed to account for the ear's response to low frequency noise at high noise levels and is typically used to assess short peaks of high noise levels to ensure protection against hearing damage.

Recent research into annoyance from low frequency noise when assessed at lower noise levels suggests that the approach of subtracting C and A weighted noise levels is not representative of annoyance potential in environmental noise settings and in many situations would results in the 5 dB penalty being applied to sources which are very low risk of causing annoyance.

It is recognised that the difference between A-weighted and C-weighted noise levels can provide an indication of how much low frequency noise is present in a sound, Broner (*Acoustics Australia Vol. 39, 2011*) states that the predictive ability of the C-A difference is of limited value for the following reasons:

- Averaging the sound pressure levels to obtain the difference can lead to loss of information in terms of fluctuations and spectral balance. Broner recommends to also consider the modulation.
- Greater difference may be permissible at low A-weighted levels, as there is empirical evidence that C-A difference for low levels of background noise may exceed 20-25 dB without causing complaints. Broner recommends the implementation of an overall noise level criterion.

Based on the review of many case histories and the literature, Broner recommends the following criteria listed in Table 4-5, with a 5 dB(C) penalty if the sound pressure level is fluctuating at least +/- 5 dB(C).

Table 4-5: Low Frequency Noise Criteria

Sensitive Receiver		Range	Criteria L_{Ceq}, dB(C)
Residential	Night time or 24/7 operation	Desirable	60
		Maximum	65
	Daytime or Intermittent operation (1-2 hours)	Desirable	65
		Maximum	70

4.5 Cumulative Noise Impacts

Cumulative noise impacts affecting receivers from all industrial noise sources are assessed according to the INP's amenity criteria. The combined impact of all industrial noise sources at a receiver point should be considered, where industrial facilities are either operating or have been approved for development.

The cumulative noise criteria that apply for the residential receivers within the project area are the acceptable noise levels shown in Table 4-3.

4.6 Sleep Disturbance

The EPA does not currently have an explicit policy regarding sleep disturbance caused by noise from construction or industrial operation activities. However there is some guidance mentioned in the INP application notes, which states *"The potential for high noise level events at night and effects on sleep should be addressed in noise assessments for both the construction and operational phases of a development."*

Where research exists, such as that reported in the INP and Environmental Criteria for Road Traffic Noise (ECRTN), the results are diverse and EPA has therefore not set a specific criterion. However, in lieu of further and more definite research a screening criterion of RBL + 15 dB $L_{A1,1min}$ dB(A) is adopted as suggested in the INP Application Notes. This screening criterion indicates that if the criterion is met, sleep disturbance is unlikely.

Project specific screening criteria are presented in Table 4-6.

Table 4-6: Sleep Disturbance Screening Criteria, dB(A)

Receiver	Sleep Disturbance Screening Criteria $L_{1,1min}$ dB(A)
R1-R6	45

4.7 Road Traffic Noise

The *NSW Road Noise Policy (EPA, 2011)* provides guidance, criteria and procedures for assessing noise impacts from existing, new and redeveloped roads and traffic generating developments. The assessment of road traffic noise impacts on public roads is assessed under the RNP.

The RNP provides several assessment criteria for traffic generating developments. The criteria are expressed as absolute levels and relative increase criteria for different land uses.

The noise assessment criteria for residential land uses affected by additional traffic generated by land uses developments are presented in Table 4-7. For non-residential land uses along project related roads, the noise level criteria in Table 4-8 apply.

Table 4-7: Road Traffic Noise Assessment Criteria for Residential Land Uses

Road Category	Type of Project/Land use	Assessment Criteria – dB(A)[1]	
		Day (7.00am to 10.00pm)	Night (10.00pm to 7.00am)
Freeway/arterial/sub-arterial	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq,15hr}$ 60 (external)	$L_{Aeq,9hr}$ 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq,15hr}$ 55 (external)	$L_{Aeq,9hr}$ 50 (external)

Note: 1. Noise level criteria are façade-corrected noise levels.

Table 4-8: Road Traffic Noise Assessment Criteria for Non-Residential Land Uses Affected by Proposed Road Projects and Traffic Generating Developments

Existing Sensitive Land Use	Assessment criteria Day (7.00am to 10.00pm)	Night (10.00pm to 7.00am)	Additional Considerations
School classrooms	$L_{Aeq,1hr}$ 40 (internal)	-	In the case of buildings used for education or health care, noise level criteria for spaces other than classrooms and wards may be obtained by interpolation from the 'maximum' levels shown in Australian Standard 2107:2000 (Standards Australia 2000).
Open space (active use)	$L_{Aeq,15hr}$ 60 (external)	-	Active recreation is characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion. Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. playing chess, reading. In determining whether areas are used for active or passive recreation, the type of activity that occurs in that area and its sensitivity to noise intrusion should be established. For areas where there may be a mix of passive and active recreation, e.g. school playgrounds, the more stringent criteria apply. Open space may also be used as a buffer zone for more sensitive land uses.
Open space (passive use)	$L_{Aeq,15hr}$ 55 (external)	-	

The RNP specifies relative increase criteria for the increase in total traffic noise level due to a traffic generating project where the existing traffic noise level is below the criteria in Table 4-7 and Table 4-8. Where this occurs an increase must be limited to 12 dB above the existing day or night noise level.

Additional specific relative increase criteria apply to traffic generating developments. The Road Noise Policy Application Notes (EPA, 2013) states the following:

"any increase in the total traffic noise level as a result of the development should be limited to 2 dB above that of the noise level without the development. This limit applies wherever the noise level without the development is within 2 dB of, or exceeds the relevant day or night noise assessment criterion."

4.8 Vibration

Impacts from vibration can be considered both in terms of effects on building occupants (human comfort) and the effects on the building structure (building damage).

No significant operational vibration sources were identified and subsequently the impacts are considered to be negligible, therefore operational vibration has not been assessed. Only potential impacts from vibration arising from construction activities have been assessed. It is assumed that vibration sources from construction would be intermittent not constant.

4.8.1 Human Comfort

The EPA administered guideline entitled *Assessing Vibration: A Technical Guideline* provides acceptable levels for intermittent vibration. A vibration dose is calculated and acceptable values are shown in Table 4-9 below.

Table 4-9: Acceptable Vibration Dose Values for Intermittent Vibration (m/s$^{1.75}$)

Location	Daytime[1]		Night Time[1]	
	Preferred Value	Maximum Values	Preferred Value	Maximum Value
Residences	0.20	0.40	0.13	0.26

Notes: 1 Daytime is 7.00am to 10.00pm and night time is 10.00pm to 7.00am.
2 Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas. Source BS 6472-1992.

For construction, it is more convenient to express criteria for human response to vibration offsite in terms of peak particle velocity (PPV) as this is the parameter most commonly measured on construction sites. Guidance within *BS 5228:2009 Code of practice for noise and vibration on construction and open sites – Part Vibration* provides some guidance on vibration levels, reproduced in Table 4-10.

Table 4-10: Guidance on the Effect of Vibration Levels

Approximate Vibration Level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mm/s	Vibration might be just perceptible in residential environments
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level

4.8.2 Building Damage

There is currently no specific Australian standard for managing construction vibration on structures. Guidance on suitable vibration levels for construction activity in Australia is typically referenced from *BS 7385:1993 Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from groundbourne vibration*.

The recommended limits (guide values) from BS 7385:1993 for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 4-11.

Table 4-11: Transient Vibration Guide Values for Minimum Risk of Cosmetic Damage

Type of Building	Peak Component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures, Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	N/A
Unreinforced or light framed structures, Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

The standard states that the guide values in Table 4-11 relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings.

5 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

5.1 Introduction

Information concerning the construction of the project was supplied by Santos. The works are expected to include construction and installation of:

- Water Treatment Plant (WTP).
- Brine Treatment Plant (BTP).
- Treated water storage tank.
- Associated infrastructure.
- Irrigation area establishment and infrastructure.

Construction is expected to occur for approximately 50 weeks (weather dependent) and occur 7.00am to 6.00pm seven days a week. Construction will be conducted in stages, the most significant of which are summarised in Table 5-1.

As required by the *Interim Construction Noise Guidelines*, the construction of the project should be quantitatively assessed against the noise management levels developed in Section 4.2.

5.2 Construction Scenarios and Sound Power Levels

The primary construction scenarios and their associated significant items of equipment are summarised in Table 5-1.

Sound power levels were sourced from Santos, Australian *Standard AS 2436-2010 Guide to noise and vibration control on construction, demolition and maintenance sites* and Department of Environment, Food and Rural Affairs, UK (2005) *Update of Noise Database for Prediction of Noise on Construction and Open Sites.*

Table 5-1: Construction Scenarios and Noise and Vibration Sources

Activity	Plant	Quantity	Activity Use	Sound Power Level (per item)
1. Service location	4WD	2	Staff site vehicle movements	92
	Vacuum Truck	1	Non-destructive service location	110
	Water Cart	1	Dust suppression	110
2. Clearing Stripping	4WD	4	Staff site vehicle movements	92
	Dozer	1	Clearing and vegetation removal	115
	Excavator	1	Clearing, stripping and stockpiling	107
	Water Cart	1	Dust suppression	110
	Tipper	2	Relocation of spoil to stockpile	109
	Mulcher	1	Vegetation Mulching	116
3. Amenities	Generators	2	Site power	103
	Excavator	1	Preparation of grade materials	107
	Roller[1]	1	Compaction of grade materials	113
	Water Cart	1	Dust suppression	110
4. Earthworks	Excavator	1	Trenching, backfilling and stockpiling	107
	Roller[1]	2	Compaction of backfill materials	113
	Whacker	2	compaction around pipework	98
	Water Cart	1	Dust suppression	110
	CAT 740 Dump truck	2	Spoil movement	109
	Grader	1	Shaping and preparation of materials	112
	Dozer	1	Clearing and materials handling	115

Activity	Plant	Quantity	Activity Use	Sound Power Level (per item)
5. Structures	Crane	1	Lifting/placing steel frames & demountables	107
	Elevated Work Platform (EWP)	2	Erection of steel frame buildings	107
	Cherry Picker	2	Erection of steel frame buildings	107
	4WD	4	Staff site vehicle movements	92
	Hand tools[1]	2	Power drills, angle grinders etc.	114
6. Mechanical	Crane	1	Installation of WBTP plant & equipment	104
	EWP	2	Installation of piping	107
	Hand tools[1]		Drills, grinders etc.	111
	Welders	2	Pipe welding and cutting	96
	4WD	4	Staff site vehicle movements	92
7. Electrical	EWP	2	Installation of cable trays, lighting etc.	107
	Hand Tools[1]	2	Drills, Grinders etc.	111
	4WD	4	Staff site vehicle movements	92
8. Landscaping	Excavator	1	Distribution of topsoil and mulch	109
	CAT 740 Dump truck	1	Movement of topsoil and mulch	109
	Water Cart	1	Dust suppression	110
9. Irrigation Area Land Preparation	4WD	3	Staff site vehicle movements	92
	Truck	1	Delivery of Heavy Equipment	108
	Excavator	1	Tree Removal	107
	Dozer	1	Stick Raking and Deep Ripping	115
	Tractor	1	Discing, Harrowing, Seeding	108
	All terrain vehicle (ATV)	1	Management, shuttling people and small equipment	104
10. Centre Pivot Installation	Flatbed Truck	1	Delivery of items	108
	4WD	3	Staff site vehicle movements	92
	ATV	1	Management, shuttling people and small equipment	104
	Telehandler	1	Moving materials	104
	Backhoe	1	Trenching and excavation	107
11. Subsurface Drip Installation	Flatbed Truck	2	Delivery of items	108
	4WD	3	Staff site vehicle movements	92
	ATV	1	Management, shuttling people and small equipment	104
	Telehandler	1	Moving materials	104
	Small Excavator	1	Trenching and excavation	107
12. Pump Station	Telehandler	1	Moving materials	104
	Transit Concrete Mixer Truck	2	Supply of Concrete	108
	4WD	4	Staff site vehicle movements	92
	Delivery Trucks	2	Delivery of items	108

Note: 1. A 5 dB(A) penalty is added to these items in accordance with the ICNG.

5.3 Noise Assessment

5.3.1 Methodology

Noise modelling was undertaken using the ISO9613 algorithm, as implemented within the CadnaA acoustic modelling package. The noise modelling takes into consideration the sound power level of the proposed site operations, activities and equipment, and applies adjustments for attenuation from geometric spreading, acoustic shielding from intervening ground topography and barriers, ground effect and atmospheric absorption.

The ICNG states that recommended construction hours are Monday to Friday 7.00am to 6.00pm and Saturdays 8.00am to 1.00pm. All work outside of these times is considered outside of standard hours.

5.3.2 Predicted Noise Levels

Using the sound power levels and scenarios described in Table 5-1, worst-case noise levels were predicted assuming all plant is operating simultaneously. Noise levels are presented as a range representing when noise sources are at their closest and furthest point from the receivers. The WBTP works were considered to occur in and around the WBTP area and the irrigation works in and around the irrigation area.

The predicted noise levels are presented in Table 5-2.

Table 5-2: Predicted Construction Noise Levels

Construction Scenario	Noise Management Level $L_{eq,15min}$ dB(A)		Predicted Noise Level $L_{eq,15min}$ dB(A)					
	Standard hours[1]	Outside of standard hours[2]	R1	R2	R3	R4	R5	R6
1	40	35	21-22	<20-21	20-23	27-32	29-34	21-25
2	40	35	28-30	26-29	28-31	35-40	37-42	28-32
3	40	35	21-22	<20-20	<20-22	26-31	28-33	20-24
4	40	35	28-30	27-29	26-30	33-38	36-41	27-31
5	40	35	25-27	21-25	22-27	30-35	32-37	23-29
6	40	35	25-27	21-25	22-27	30-35	32-36	23-29
7	40	35	24-26	20-24	21-27	29-34	31-36	22-28
8	40	35	22-24	20-22	21-24	29-33	31-36	22-26
9	40	35	23-30	20-27	26-30	32-44	26-31	25-31
10	40	35	20-26	<20-22	20-25	28-38	<20-25	20-25
11	40	35	<20-39	<20-34	<20-37	24-47	21-36	<20-35
12	40	35	<20-21	<20	<20-22	25-30	23-27	<20-23

Note: 1. Standard hours are defined as Monday to Friday 7.00am to 6.00pm and Saturdays 8.00am to 1.00pm
2. Outside of standard hours are all times not included in standard hours.

In addition, WBTP works (scenarios 1-8) and the irrigation area works (scenarios 9-12) may occur simultaneously. In order to account for the potential impacts, the predicted noise levels for each WBTP construction scenario was considered with each irrigation area construction scenario. The predicted noise levels are presented in Table 5-3 to Table 5-6.

Table 5-3: Predicted Construction Noise Levels for WBTP Works and Irrigation Construction Scenario 9

WBTP Construction Scenario	Irrigation Area Construction Scenario	Noise Management Level $L_{eq,15min}$ dB(A)		Predicted Noise Level $L_{eq,15min}$ dB(A)					
		Standard hours[1]	Outside of standard hours[2]	R1	R2	R3	R4	R5	R6
1	9	40	35	25-31	22-28	27-31	33-44	31-36	26-32
2	9	40	35	29-33	27-31	30-34	37-45	37-42	30-35
3	9	40	35	25-31	22-28	27-31	33-44	30-35	26-32
4	9	40	35	29-33	28-31	29-33	36-45	36-41	29-34
5	9	40	35	27-32	24-29	27-32	34-45	33-38	27-33
6	9	40	35	27-32	24-29	27-32	34-45	33-37	27-33
7	9	40	35	27-31	23-29	27-32	34-44	32-37	27-33
8	9	40	35	26-31	23-28	27-31	34-44	32-37	27-32

Note: 1. Standard hours are defined as Monday to Friday 7.00am to 6.00pm and Saturdays 8.00am to 1.00pm
2. Outside of standard hours are all times not included in standard hours.

Table 5-4: Predicted Construction Noise Levels for WBTP Works and Irrigation Construction Scenario 10

WBTP Construction Scenario	Irrigation Area Construction Scenario	Noise Management Level $L_{eq,15min}$ dB(A)		Predicted Noise Level $L_{eq,15min}$ dB(A)					
		Standard hours[1]	Outside of standard hours[2]	R1	R2	R3	R4	R5	R6
1	10	40	35	24-27	20-25	23-27	31-39	29-35	24-28
2	10	40	35	29-31	26-30	29-32	36-42	37-42	29-33
3	10	40	35	24-27	20-24	23-27	30-39	28-34	23-28
4	10	40	35	29-31	27-30	27-31	34-41	36-41	28-32
5	10	40	35	26-30	22-27	24-29	32-40	32-37	25-30
6	10	40	35	26-30	22-27	24-29	32-40	32-36	25-30
7	10	40	35	25-29	21-26	24-29	32-39	31-36	24-30
8	10	40	35	24-28	21-25	24-28	32-39	31-36	24-29

Note: 1. Standard hours are defined as Monday to Friday 7.00am to 6.00pm and Saturdays 8.00am to 1.00pm
2. Outside of standard hours are all times not included in standard hours.

Table 5-5: Predicted Construction Noise Levels for WBTP Works and Irrigation Construction Scenario 11

WBTP Construction Scenario	Irrigation Area Construction Scenario	Noise Management Level $L_{eq,15min}$ dB(A)		Predicted Noise Level $L_{eq,15min}$ dB(A)					
		Standard hours[1]	Outside of standard hours[2]	R1	R2	R3	R4	R5	R6
1	11	40	35	22-39	19-34	22-37	29-47	30-38	22-35
2	11	40	35	28-40	26-35	28-38	35-48	37-43	28-37
3	11	40	35	22-39	19-34	21-37	28-47	29-38	22-35
4	11	40	35	28-40	27-35	27-38	34-48	36-42	27-36
5	11	40	35	26-39	22-35	23-37	31-47	32-40	24-36
6	11	40	35	26-39	22-35	23-37	31-47	32-39	24-36
7	11	40	35	25-39	21-34	22-37	30-47	31-39	23-36
8	11	40	35	23-39	21-34	22-37	30-47	31-39	23-36

Note: 1. Standard hours are defined as Monday to Friday 7.00am to 6.00pm and Saturdays 8.00am to 1.00pm
2. Outside of standard hours are all times not included in standard hours.

Table 5-6: Predicted Construction Noise Levels for WBTP Works and Irrigation Construction Scenario 12

WBTP Construction Scenario	Irrigation Area Construction Scenario	Noise Management Level $L_{eq,15min}$ dB(A)		Predicted Noise Level $L_{eq,15min}$ dB(A)					
		Standard hours[1]	Outside of standard hours[2]	R1	R2	R3	R4	R5	R6
1	12	40	35	23-25	21-23	22-26	29-34	30-35	23-27
2	12	40	35	29-31	27-29	28-32	35-40	37-42	28-33
3	12	40	35	23-25	21-23	21-25	29-34	29-34	22-27
4	12	40	35	29-31	27-29	27-31	34-39	36-41	28-32
5	12	40	35	26-28	22-26	23-28	31-36	33-37	24-30
6	12	40	35	26-28	22-26	23-28	31-36	33-37	24-30
7	12	40	35	25-27	22-25	22-28	30-35	32-37	23-29
8	12	40	35	24-26	22-24	22-26	30-35	32-37	23-28

Note: 1. Standard hours are defined as Monday to Friday 7.00am to 6.00pm and Saturdays 8.00am to 1.00pm
2. Outside of standard hours are all times not included in standard hours.

5.3.3 Assessment

A review of Table 5-2 indicates the following:

- During standard hours, exceedance of the criteria is expected at R5 during scenarios 2 and 4, and R4 during scenarios 9 and 11. Outside of standard hours, exceedance of the criteria is expected at:
    - R1 during scenario 11
    - R3 during scenario 11
    - R4 during scenarios 2, 4, 9, 10 and 11
    - R5 during scenarios 2, 4, 5, 6, 7, 8 and 11
- No receivers are expected to be highly noise affected at any time during the construction works.

A review of Table 5-3 to Table 5-6 indicates:

- With irrigation area scenario 9 concurrent to WBTP scenarios, exceedances are expected during standard hours at:
    - R4 for scenarios 1- 8
    - R5 for scenarios 2 and 4.
- Outside of standard hours, exceedances are expected at:
    - R4 for scenarios 1-8
    - R5 for scenarios 1, 2, 4, 5, 6, 7, 8
- With irrigation area scenario 10 concurrent with WBTP scenarios, exceedances are expected during standard hours at:
    - R4 and R5 for scenarios 2 and 4
- Outside of standard hours for scenario 10 concurrent with WBTP scenarios, exceedances are expected at:
    - R4 for scenarios 1-8
    - R5 for scenarios 2, 4, 5, 6, 7, 8
- With irrigation area scenario 11 concurrent with WBTP scenarios, exceedances are expected during standard hours at:
    - R4 for scenarios 1-8
    - R5 for scenarios 2 and 4.
- Outside of standard hours for scenario 11 concurrent with WBTP scenarios, exceedances are expected at:
    - R1, R3, R4 and R5 for scenarios 1-8
    - R6 for scenarios 2, 4, 5, 6, 7, 8
- With irrigation area scenario 12 concurrent to WBTP scenarios, exceedances are expected during standard hours at:
    - R5 for scenarios 2 and 4.
- Outside of standard hours for scenario 11 concurrent with WBTP scenarios, exceedances are expected at:
    - R4 for scenarios 2, 4, 5, 6
    - R5 for scenarios 2, 4, 5, 6, 7, 8.

As exceedances of the noise management levels are predicted, noise mitigation measures are recommended.

5.4 Noise Mitigation

5.4.1 Santos Noise Mitigation Strategy

Construction for the proposed activity will be carried out from 7:00am to 6:00pm Monday to Sunday. The rating background level of the site is 30 dB(A) during the day, evening and night periods (refer to Section 3.1). Therefore construction work that causes noise levels no more than 35 dB(A) at any residence not subject to a private negotiated agreement, may be undertaken outside of standard construction hours in accordance with conditions specified in the EPL.

Construction activities will be managed to ensure that noise levels of 35 dB(A) are not exceeded at any residence outside of standard construction hours unless that residence is subject to a private negotiated agreement. Specific measures to ensure that this level is not exceeded are provided in the following section.

5.4.2 Noise Mitigation Recommendations

In light of the predicted exceedances it is recommended that noise mitigation and management measures be considered for implementation where reasonable and feasible. It is also recommended that a construction noise management plan be developed. It should consider the following:

- Limiting concurrent noise intensive activities where feasible and reasonable.
- Providing respite periods for noise intensive activities during hours when receivers are most sensitive, e.g. early mornings.
- Noise monitoring on site and at sensitive receivers where appropriate to ensure satisfactory noise levels and provide ongoing noise management.
- Training and awareness.
- Communication with the community as outlined in Table 4-1.
- Incident and emergency response.
- Non-conformance, preventative and corrective action.

Education and training of site staff is necessary for satisfactory implementation of noise mitigation measures. Education and training strategies should focus on:

- Site awareness training / environmental inductions that include a section on noise mitigation techniques / measures to be implemented throughout the project.
- Ensuring work occurs within approved hours.
- Locating noisy equipment away from sensitive receivers.
- Using noise screens for mobile plant and equipment.
- Ensuring plant and equipment is well maintained and not making excessive noise.
- Turning off machinery when not in use.

Table 5-7 provides a summary of noise mitigation measures with an indicative noise reduction benefit.

Table 5-7: Indicative Noise Reduction Benefit of Noise Mitigation, dB(A)

Engineering Controls	Possible Noise Benefit, dB(A)
Portable temporary screens.	5-7
Screen or enclosure for stationary equipment.	5-10
Maximising the offset distance between noisy plant items and receptors.	1-6
Avoiding using noisy plant simultaneously and/or close together, adjacent to receptors.	1-3
Orienting equipment away from receptors.	3-5
Carrying out loading and unloading away from receptors.	3-5
Using noise source controls, such as the use of residential class mufflers, to reduce noise from all plant and equipment including cranes, graders, excavators and trucks.	2-8
Using spotters, "smart" reversing alarms, or broadband (white noise) type reversing alarms in place of traditional reversing alarms.	Tonal component
Employ non noise-generating structures such as site offices, workshops, storage sheds, stockpiles and tanks as noise barriers.	5-7

Where appropriate noise mitigation measures could include:

- Not operating noisy equipment at the same time, where possible, this has the potential to substantially reduce noise emissions.
- Using site structures to provide shielding to sensitive receivers.
- Orientating equipment away from sensitive receivers.
- Operating excavators and other mobile plant in a manner that would reduce the likelihood of maximum noise level events occurring such as:
    - Sudden changes in vehicle direction/engine load.
    - Shaking excavator buckets.
    - Excavator buckets or similar contacting the ground or other solid structures.
- Minimising drop and unload heights
- Avoiding dropping materials or items from height
- Carrying out loading and unloading away from sensitive receivers.
- Selecting plant and equipment based on noise emission levels.
- Using alternative construction methods.
- Using spotters, closed circuit television monitors, "smart" reversing alarms, or "squawker" type reversing alarms in place of traditional reversing alarms.

Table 5-8 outlines specific controls for each construction scenario and item of plant. Where controls are implemented, noise levels are expected to be reduced below the criteria.

Table 5-8: Construction Scenario Noise Controls

Construction Scenario	Time of Day	Equipment	Noise Control Measure
2	Standard hours	Dozer and Mulcher	Operate Dozer and Mulcher either separately or at maximum offset possible to R5.
2	Outside of standard hours	Dozer and Mulcher	Do not operate Dozer and Mulcher simultaneously. Or provide screen to receptors R4 and R5 in close proximity to Mulcher as the Dozer is mobile it is not able to be screened practically.
4	Standard Hours	Dozer and Roller	Do not operate dozer and roller simultaneously at boundaries close to receivers. Instead consider using them in different areas with a greater separation distance to receivers. Where practical, use excavated material stockpiles to screen mobile operations to R5. Use water cart judiciously to minimise simultaneous operation with other mobile plant.
4	Outside of standard hours	Dozer and Roller	Maximise offset distance to R4 and R5. Alternatively, do not operate dozer and roller.
5, 6, 7	Outside of standard hours	Hand Tools (grinders, saws etc.)	Operate hand tools (grinders and concrete saws) behind a screen in close proximity to activity. Screening could be provided by site buildings, large vehicles or other solid objects that block line of sight to receiver. Alternatively, do not operate grinders and saws and other noisy hand tools simultaneously.
8	Outside of standard hours	Dump Trucks	Maximise offset distance to R5. Alternatively, do not operate dump trucks
9	Standard hours	Dozer and Tractor	Do not operate Dozer and Tractor simultaneously at the eastern extent of the irrigation area. Dozer and Tractor can be operated simultaneously when offset to R4 is maximised.
9	Outside of Standard hours	Dozer, Tractor and Excavator	Do not operate Dozer, Tractor and Excavator at the eastern extent of the irrigation area, near R4. Avoid where practical operating simultaneously.

Construction Scenario	Time of Day	Equipment	Noise Control Measure
10	Outside of standard hours	Trencher and Telehandler	Do not operate simultaneously at the pivot circumference near to R4.
11	Standard hours	Tractor, Telehandler and Excavator	Do not operate Telehandler, Tractor and Excavator simultaneously at the eastern extent of the irrigation area, near to R4. Avoid Operating Telehandler and Tractor simultaneously.
11	Outside of Standard hours	Tractor, Telehandler and Excavator	Do not operate Telehandler, Tractor and Excavator simultaneously. Avoid using excavator at the eastern extent of irrigation area, near R4.
12	Outside of Standard hours	Concrete Mixing Trucks	Maximise offset of concrete mixing trucks to R5 and where possible use site buildings, existing bunds and other solid objects to shield mixing trucks from R4 and R5.

5.5 Vibration Assessment

5.5.1 Methodology

The most significant source of construction vibration has been identified as:

- Rollers
- Whackers
- Dozer.

The assessment takes into account the distance between the sensitive receivers and the activities and applies the distance attenuation according to the method in the USA's Federal Transit Administration *Transit Noise and Vibration Impact Assessment Guideline* (FTA 2006). It is noted that the attenuation of ground vibration can vary from site to site depending on the specific geological conditions and a conservative approach has been taken.

5.5.2 Vibration Source Levels

Vibration source levels were taken from the Environmental Noise Management Manual (RMS, 2001) and are summarised in Table 5-9.

Table 5-9: Vibration Source Levels

Equipment	Peak Particle Velocity (PPV) at 10m (mm/s)
Dozer	4
Roller	7.5
Whacker	7

5.5.3 Predicted Vibration Levels

Table 5-10 provides indicative vibration levels for different construction activities at the receivers closest to the works R4, R5 and SUGAR pits. Where compliance is achieved at these closest receivers, compliance is also expected at R1-3 and R6 which are further away from the works.

The criteria presented for comparison represent the most stringent criteria applicable to the sensitive land use. For residential receivers, the human comfort criteria are the most stringent and for the SUGAR pits, the cosmetic damage criteria are the most stringent.

Table 5-10: Predicted Vibration Levels

Receiver	Approx. closest distance to works (m)	Criteria PPV (mm/s)[1]	Predicted PPV (mm/s)		
			Dozer	Roller	Whacker
R4	360	0.14	0.02	0.04	0.03
R5	742	0.14	0.01	0.01	0.01
SUGAR Pits	50	15	0.4	0.7	0.6

Note: 1. Criteria for human comfort applied at residences

5.5.4 Assessment

A review of Table 5-10 indicates that vibration levels from construction will be well below the most stringent criteria applicable to the sensitive receiver. Therefore impacts are expected to be negligible.

6 OPERATIONAL NOISE ASSESSMENT

6.1 Noise Model

Noise modelling was undertaken using the CadnaA acoustic modelling package. The noise modelling takes into consideration the sound power level of the proposed site operations, activities and equipment, and applies adjustments for attenuation from geometric spreading, acoustic shielding from intervening ground topography and barriers, ground effect and atmospheric absorption.

Ground absorption conditions were modelled according to the land type as identified by the project plans and aerial photography being generally either open grass land or forest. The potential for acoustic attenuation provided by dense forest has been ignored for the purposes of conservative assessment.

6.2 Meteorological Conditions

Noise modelling was conducted for conditions favourable to noise propagation derived from default procedures set out in the INP and using prevailing meteorological conditions discussed in Section 3.2.

The meteorological conditions are modelled as follows:

- Neutral (Daytime, Evening, Neutral Night) – Stability Class D without wind.
- Adverse (Adverse Evening, Night) –
    - Stability Class F without wind.
    - Stability Class D, wind speed 3 m/s in direction east south east, east and east north east.
- For daytime scenarios, a temperature of 20°C and 70% relative humidity.
- For evening and night time scenarios, a temperature of 10°C and 90% relative humidity.

6.3 Modelling Scenario

Two modelling scenarios have been considered for this assessment to take the typical operations of the WBTP and the operation of the WBTP with harvesting of the irrigation area into account.

The WBTP only scenario is modelled using neutral and adverse meteorological conditions as described in Section 6.2. As the harvesting is expected only to occur during the day, it will be assessed for neutral meteorological conditions only.

From time to time, minor maintenance may be carried out on the irrigation area, however it is not expected to be a frequent occurrence. Therefore as a part of the conservative approach the harvesting activities have been considered to be the potentially worst case irrigation area operations.

The noise modelling was based upon the following assumptions:

- All WBTP equipment is assumed to operate 24 hours/day and 7 days/week.
- The harvesting of the irrigation area is expected to be carried out once per year during the day only.
- On site structures are made from shipping containers with nominal dimensions of 12.6m by 2.4m by 2.6m (length, width, height).
- No additional mitigation measures were applied to noise sources, with the exception of the compressor, which is assumed to be mitigated by at least 5 dB(A) by use of an enclosure and the irrigation area pumps which are mitigated by a minimum of 5 dB(A) by use of a shed.
- The proposed power generation is typically by gas engine generator, however in the event of a fault, a diesel generator will be utilised. Typical operations using a gas generator has been used in the modelling.
- On advice from the equipment manufacturer, the generators and exhaust stacks (diesel and gas) will achieve a noise emission rating of 85 dB(A) measured at 1m.

- All other WTBP equipment noise levels were supplied by Santos and it is assumed that equipment will therefore meet these requirements. Where manufacturers cannot meet these noise levels, additional assessment may be required.
- 5 light vehicles travel along the access road to the administration area, south of the WBTP.
- Light vehicle movements have also been included in the night-time (10.00pm to 6.00am) scenario.
- Harvesting the irrigation area is undertaken by a tractor travelling at 10 km/h.
- The harvesting of the irrigation area is considered at the boundaries of the irrigation area to represent a conservative assessment.

6.4 Source Noise Levels

Table 6-1 summarises the source noise levels for equipment associated with the project, which may have the potential to impact the surrounding sensitive receivers. Overall source noise levels were derived from information as supplied by Santos and the frequency spectra derived from similar equipment or the likely dominant source from Bies and Hansen *Engineering Noise Control* (B&H 2009) and Pacific Environment's database. Spectral data is included in Appendix B.

It is assumed that the noise emission of the plant is generally steady state and continuous, free from tones and does not have significant low frequency content, therefore adjustment for these characteristics are not considered applicable.

Table 6-1: Source Noise Levels for Site Equipment, dB(A)

Area	Process Unit	No. Off Operating	Height above ground[2]	Sound Pressure Level (per item) at 1m dB(A)
Produced Water and Permeate Pumping Station	Produced Water Pumps	2	1	80
	Permeate Water Pumps	2	1	80
Solids Handling System	Solids Handling System[1]	1	1	80
MF/UF System (microfiltration / ultrafiltration)	Feed Pumps	2	1	80
	Strainers	2	2	80
	MF Units[1]	2	2.6	80
	CIP Pump (clean in place)	1	1	80
RO (Reverse Osmosis)	Feed Pumps	2	1	80
	RO Units[1]	2	2.6	80
	HP Pumps – Stage 1	2	1	90
	HP Pumps – Stage 2	2	1	90
	CIP Pumps	2	1	80
	CIP Water Heater	1	1	80
	Flush Pumps	1	1	80
Brine Squeezer	Feed Pumps	2	1	80
	Brine Squeezer[1]	2	2.6	80
	HP Pumps	2	1	90
	Recirculation Pump	2	1	90
Miscellaneous	Polymer Prep. System	1	1	80
	Dry Chemical Prep. System	1	1	80
	Sewage Treatment	1	1	80
	Compressors (with 5 dB attenuation)	1	1.5	90
	Service Water	1	1	80
	Air Conditioning	1	0.5	80
	Generator 1.4MW[1]	1	2.6	85
	Generator Stack	1	10	85
	CO2 Plant	1	2.6	85
	Pilot Carbonation Plant	1	2.6	82
Waste Tank	Return Pumps	1	1	80
	Mixer	1	1	80
Staff Vehicles	Light Vehicle	5	1	74
Irrigation Pump Station	75 kW Pump	4	1	85
Irrigation Area	Tractor	1	1	98

Note: 1. Sources modelled as area sources of equivalent area to standard shipping containers, 12.6m long.
2. For area sources, represents the highest point of the area source.

6.5 Predicted Noise Levels

The sound power levels nominated in Table 6-1 were modelled using CadnaA noise modelling software and the predicted noise levels for the WBTP at the nearest sensitive receivers are presented in Table 6-2 where the greatest predicted noise level for the conditions is presented.

Predicted noise levels during the day for the WBTP and harvesting the irrigation area are presented in Table 6-3. A range of values is presented for scenarios with the harvesting activities to show the range of levels predicted when the activities are at their closest and furthest point from receivers.

Predicted C-weighted noise levels for the WBTP are presented in Table 6-4.

Noise contour plots for neutral and adverse conditions for operation of the WBTP are presented in Appendix A. The grid resolution is 20 m and therefore contours plots are indicative only.

Table 6-2: Predicted Noise Levels for the WBTP

Receiver	Project Specific Criteria	Predicted Noise Level $L_{Aeq,15min}$ dB(A) Neutral (Day/Evening/Night)[1]	Adverse (Night)	Comply
R1	35	<20	23	Yes
R2	35	<20	22	Yes
R3	35	<20	24	Yes
R4	35	26	31	Yes
R5	35	29	34	Yes
R6	35	20	25	Yes

Note: 1. Noise levels presented are the greatest predicted noise level during either the day, evening or night under neutral conditions.

Table 6-3: Predicted Noise Levels for the WBTP and Harvesting Irrigation Area

Receiver	Project Specific Criteria	Predicted Noise Level $L_{Aeq,15min}$ dB(A) Neutral (Day)	Comply
R1	35	<20	Yes
R2	35	<20	Yes
R3	35	<20-21	Yes
R4	35	27-36	Marginal
R5	35	28-29	Yes
R6	35	<20-22	Yes

Table 6-4: Predicted C-weighted noise levels for the WBTP

Receiver	Project Specific Criteria dB(C)	Predicted Noise Level $L_{Aeq,15min}$ dB(C) WBTP Only Adverse (Night)	WBTP and Harvesting Neutral (Day)	Comply
R1	60	35	33-34	Yes
R2	60	34	31-32	Yes
R3	60	36	33-34	Yes
R4	60	40	39-45	Yes
R5	60	44	42-43	Yes
R6	60	37	35-35	Yes

6.6 Operational Noise Assessment

Table 6-2 and Table 6-4 shows that the predicted operational noise levels from the WBTP only are expected to comply with the project specific criteria and the current EPL operational noise limits.

A marginal 1 dB exceedance was identified during harvesting operations in Table 6-3, when the tractor is at its closest to R4. This exceedance is not considered significant as a difference in noise level of 2 dB or less is generally not perceptible. The marginal exceedance would be limited to when operations are at the eastern extent of the irrigation area and when operations move west, predictions in Table 6-3 indicate compliance would be achieved. Furthermore, the harvesting operations occur five times a year for a short period and this would limit any possible occurrence of an exceedance.

Compliance is predicted at all other receivers (R1, R2, R3, R5 and R6) for the harvesting scenario.

6.7 Sleep Disturbance Assessment

It is expected that the major sources of maximum noise level events would be a compressor release/pressure relief, use of light vehicles door slamming or engines starting and the processing equipment occasionally starting or stopping.

The noisiest source is likely to be a compressor release and a maximum noise level assumed was L_{Amax} 120 dB(A).

The noise level at the closest sensitive receiver was calculated using the noise model to be L_{Amax} 44 dB(A). This level is below the sleep disturbance screening criteria and as such sleep disturbance impacts are not expected.

6.8 Cumulative Impact Assessment

The potential for cumulative impacts to occur has been considered. The cumulative impact criteria are the INP amenity criteria which consider the impact of all industrial noise sources at the receiver.

The closest industrial development to the receivers is the Tintsfield CSG Pilot, located over 9kms to the north.

The most stringent criteria for the cumulative assessment is $L_{Aeq,9hr}$ 40 dB(A) during the night. The CSG Pilot is over 9 kms away, therefore any contribution at the receivers from the CSG Pilot would not be expected to be significant. This is confirmed by the fact that no contribution from industrial sources was noted at receivers during the noise measurements described in Section 3.1.

In light of the above, cumulative noise impacts at the receivers closest to the project are expected to be negligible.

6.9 Discussion and Recommendations

The assessment shows that the operational noise levels from the WBTP are not expected to be above the appropriate criteria at the nearest receivers.

The noise assessment is based on assumptions and it is recommended that equipment is selected to have the same or better acoustic performance as assumed in this report. Where equipment noise levels or spectra differ significantly from those detailed, potential noise impacts should be re-assessed.

It is recommended that for harvesting activities, engines be shut off when not in use and where possible carry out activities away from receivers to the east of the site. Where activities are required near R4, they should be carried out during less sensitive periods, such as during the middle of the day.

All plant and equipment should be operated and maintained in the appropriate manner to reduce the likelihood of excess noise emission.

Where appropriate, noise monitoring should be carried out to confirm equipment noise levels and noise predictions.

7 ROAD TRAFFIC NOISE ASSESSMENT

7.1 Methodology

Road traffic noise has been assessed according to the predicted increase in total traffic noise levels as a result of the development. Both the construction and operational stages have been considered.

As outlined in Section 4.7, the limiting criteria for road traffic noise, where existing noise levels are either within 2 dB or in excess of the criteria, is that any increase in overall traffic noise as a result of additional traffic due to a land use development is limited to 2 dB above the existing road traffic noise level.

Therefore where a predicted increase in road traffic noise levels is less than 2 dB, it is considered that the project would comply with all RNP criteria, and so is used as the limiting criterion in this case.

The predicted increase in road traffic noise levels was predicted using the Calculation of Road Traffic Noise (CoRTN) as implemented within the CadnaA noise modelling software.

The standard prediction procedures have been modified as follows:

- L_{Aeq} values were calculated from the L_{A10} values predicted by the CoRTN algorithms using the well-validated approximation of $L_{Aeq,1hr} = L_{A10,1hr} - 3$. (NSW RMS, 2001).
- Noise source heights were set at 0.5 m for cars, 1.5 m for heavy vehicle engines and 3.6m for heavy vehicle exhausts, representing typical values for Australian vehicles.
- Noise from a heavy vehicle exhaust is modelled 8dB lower than the noise from the engine.
- Previous research in Australia has established a negative correction to the CoRTN predictions of -1.7dB for façade-corrected levels. Corrections for Australian conditions have been included in noise modelling for this project (Samuels and Saunders, 1982).
- Noise levels are predicted as façade reflected.

The project related roads are expected to be as follows:

- Newell Highway
- Old Mill Road

Information supplied to Pacific Environment indicates that the majority of project related traffic would travel to and from site from Narrabri during the day period (7.00am to 10.00pm). Therefore in order to provide a conservative assessment, it has been assumed that all traffic is travelling to and from Narrabri along the Newell Highway.

The section of Old Mill Road from the Newell Highway to the site entrance is at least 750 m from the nearest sensitive receiver. The RNP states that the assessment of road traffic noise impacts is typically limited to 600 m from the road. Therefore no further assessment is provided for Old Mill Road.

7.2 Traffic Volumes

The project is expected to generate road traffic during both the construction and operation phase. The following table provides a summary of the project generated traffic during each phase.

The project generated traffic has been based on information provided by Santos. The project generated traffic assumes the following:

- All trips are to and from the Narrabri town area and therefore the number of movements incorporates the journey there and back.
- One (1) light vehicle per worker (to be conservative the use of a minibus to and from the worker's camp is ignored), fifty (50) workers are assumed for each WBTP construction scenario.

- Heavy vehicle movements during operations include ten (10) trucks a week for salt removal, one (1) truck per day for the irrigation and five (5) trucks per week for the WBTP facility.
- Light vehicle movements during operations include ten (10) per day for the WBTP and two (2) per day for the irrigation facility.

Table 7-1 provides a summary of the project generated traffic volumes. It has been considered that the construction of the irrigation infrastructure will occur at the same time as WBTP construction. Therefore in order to provide a conservative assessment, the construction stages from both the WBTP and irrigation infrastructure have been considered simultaneously.

Table 7-1: Project Related Traffic Movements

Stage	Activity	Estimated Duration	Peak Heavy Vehicle Movements (per day)	Peak Light Vehicle Movements (per day)
Construction 1	Mobilisation (Delivery of plant equipment, construction amenities to site and temporary services)	6-8 weeks	20	106
	Irrigation Area (Land preparation)		10	
Construction 2	Earthworks (Excavation and trenching)	6-8 weeks	40	106
	Irrigation Area (Land preparation and installation)		10	
Construction 3	Concrete (Concrete trucks deliveries for foundation pours)	2 weeks	20	100
	Irrigation Area (Installation)		5	6
Construction 4	Mechanical and Electrical (Delivery and installation of WBTP plant and equipment)	10-12 weeks	20	100
	Irrigation Area (Installation)	13 weeks	5	6
Operations		5 years	20	20

Traffic volume information as sourced from Santos and the traffic (GTA Consultants, 2013, Leewood Project – Phase 1 Newell Highway, Narrabri Transport Assessment ref: 1351042200) and noise assessments (Noise Measurements Services, 2013, Noise Assessment Report Traffic noise assessment for Santos Leewood Ponds ref: 2453R3) for the approved water and brine storage ponds are summarised below. The assumptions for these existing traffic volumes are contained within these reports.

Construction stage 2 is considered a worst-case scenario as it has the most projected traffic movements. In addition, the irrigation area heavy vehicle movements have also been considered as a worst case, to occur simultaneously. The combined total heavy vehicle movements assumed is 50 per day. Therefore where this scenario complies, it is expected that the other construction scenarios will also comply. Table 7-2 provides a summary of the traffic volumes used in the assessment.

Table 7-2: Assessed Traffic Volumes

Road	Conditions	Existing		Construction		Operation	
		Light Vehicles (18 hour)	Heavy Vehicles (18 hour)	Light Vehicles (18 hour)	Heavy Vehicles (18 hour)	Light Vehicles (18 hour)	Heavy Vehicles (18 hour)
Newell Highway	Peak	967	744	1073	794	991	750
	Low	762	586	868	636	786	592

7.3 Assessment

The predicted noise levels were predicted for distances from 10 to 600 m from the road. The predicted increase in road traffic noise is presented in Table 7-3 for receivers within 600 m of the subject road, as discussed in Section 2.2.

Table 7-3: Predicted Increase in Traffic Noise Levels on Newell Highway

Distance from Road (m)	Predicted increase in total road traffic $L_{eq,15hr}$ noise Level dB(A)			
	Construction		Operations	
	Peak	Low	Peak	Low
10	0.3	0.4	0.1	0.1
20	0.3	0.3	0.1	0.1
30	0.3	0.4	0.1	0.1
40	0.3	0.4	0.1	0.1
50	0.4	0.4	0.1	0.1
100	0.3	0.4	0.1	0.1
150	0.3	0.3	0.1	0.1
200	0.3	0.4	0.1	0.1
250	0.3	0.4	0.1	0.1
300	0.3	0.4	0.1	0.1
350	0.3	0.4	0.1	0.1
400	0.3	0.4	0.1	0.1
450	0.3	0.4	0.1	0.1
500	0.3	0.4	0.1	0.1
550	0.3	0.4	0.1	0.1
600	0.3	0.4	0.1	0.1
Maximum Increase	0.4	0.4	0.1	0.1

A review of Table 7-3 shows that the predicted increase in total traffic noise levels as a result of project generated traffic for the worst-case construction and operation scenarios complies with the RNP criteria.

8 CONCLUSION

RPS commissioned Pacific Environment to conduct a construction noise and vibration, operational noise and road traffic noise assessment for the proposed Leewood Water and Brine Treatment Plant.

The assessment was conducted for operations, construction and road traffic in accordance with the relevant guidelines, standards and policies. Assessment was made using a number of conservative assumptions as outlined in the report.

The construction noise assessment indicated the following:

- Exceedance of the noise management levels is expected at some of the receivers during both standard hours and outside of standard hours for certain construction scenarios.
- No receiver is predicted to be Highly Noise Affected.

Construction activities will be managed to ensure that noise levels of $L_{Aeq,15min}$ 35 dB(A) are not exceeded at any residence outside of standard construction hours unless that residence is subject to a private negotiated agreement. Specific measures to assist in achieving the limits are provided in Section 5.4.

The construction vibration assessment indicated that the most significant vibration generating activities would comply with the most stringent criteria at all sensitive receivers.

The operational noise assessment indicated that noise emissions from the operating plant would comply with the most stringent criteria including the current EPL limits under both neutral and adverse meteorological conditions for WBTP operations.

During harvesting activities, compliance is predicted at receivers R1, R2, R3, R5, and R6. A marginal 1dB exceedance was identified at R4 when harvesting activities are at their closest. This exceedance is not considered significant as a difference in noise level of 2 dB or less is generally not perceptible. Further to this, harvesting activities take place five times a year for a short period and therefore limit the occurrence of potential exceedances. It is recommended that where possible, harvesting activities should take place away from R4. When required on the eastern boundary, they should occur during less sensitive periods of the day, e.g. during the middle of the day.

The road traffic noise assessment indicated that the predicted increase in road traffic noise from both construction and operational traffic would not be above the limiting criteria.

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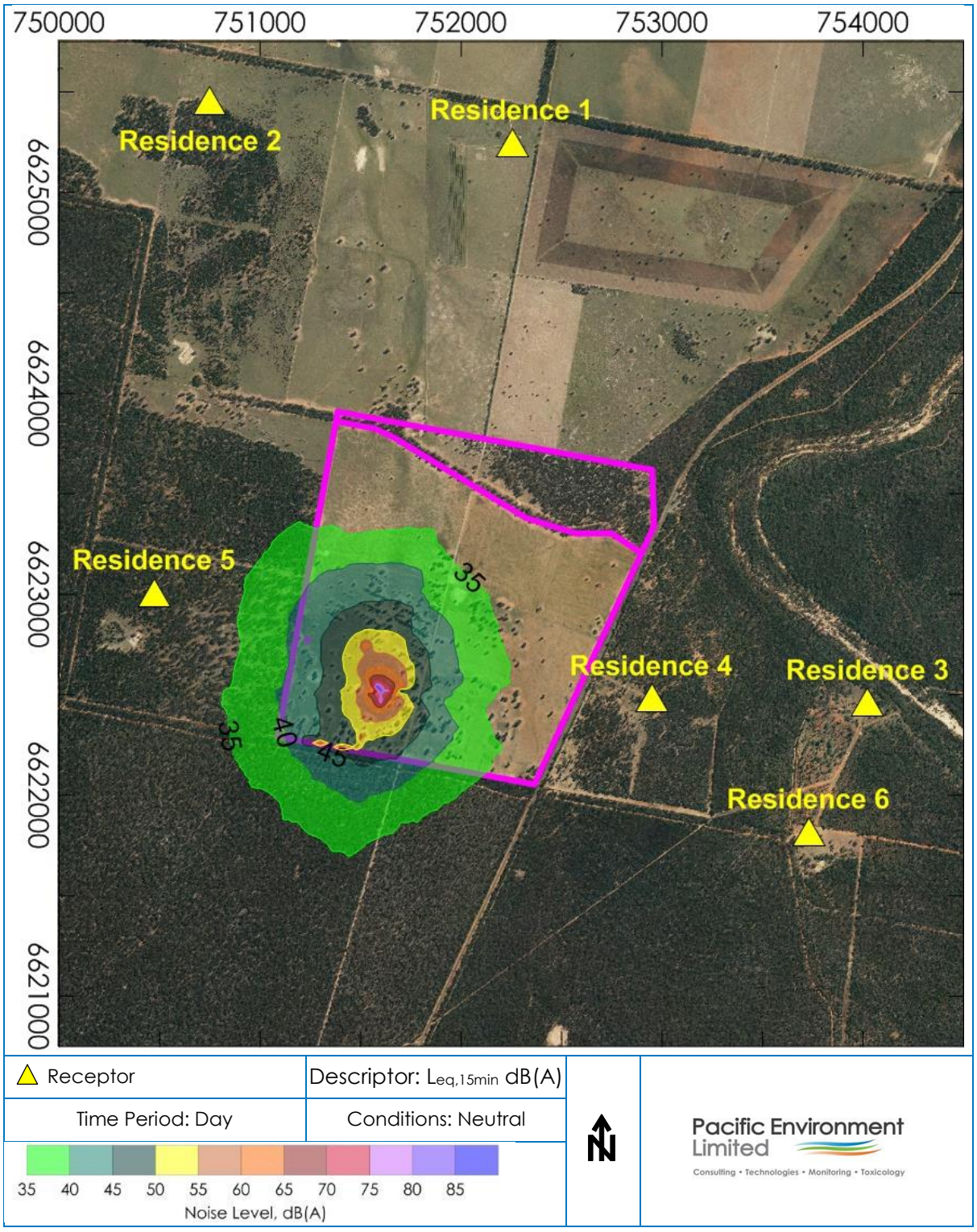
Appendix A OPERATIONAL NOISE CONTOURS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Pacific Environment Limited
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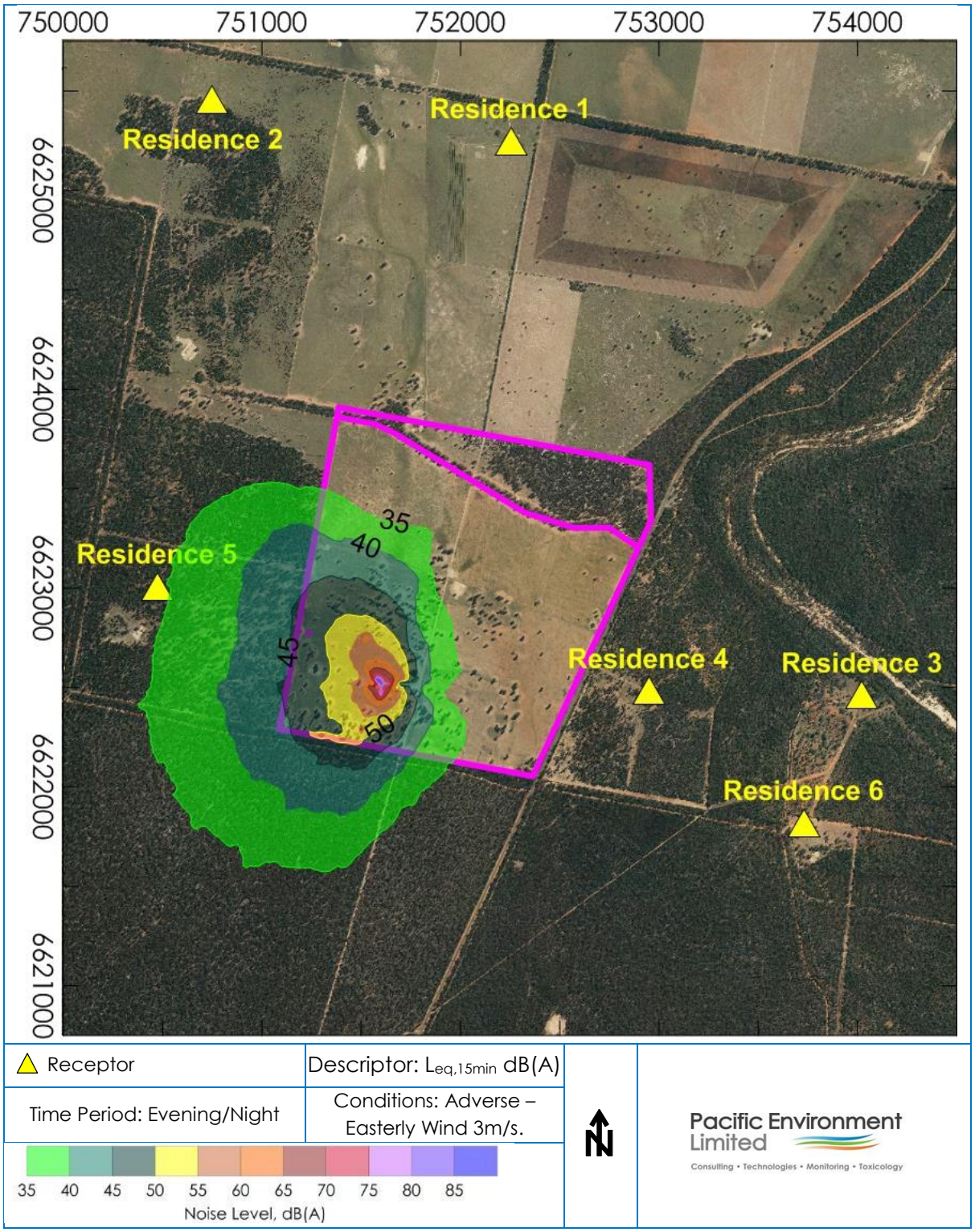
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Receptor
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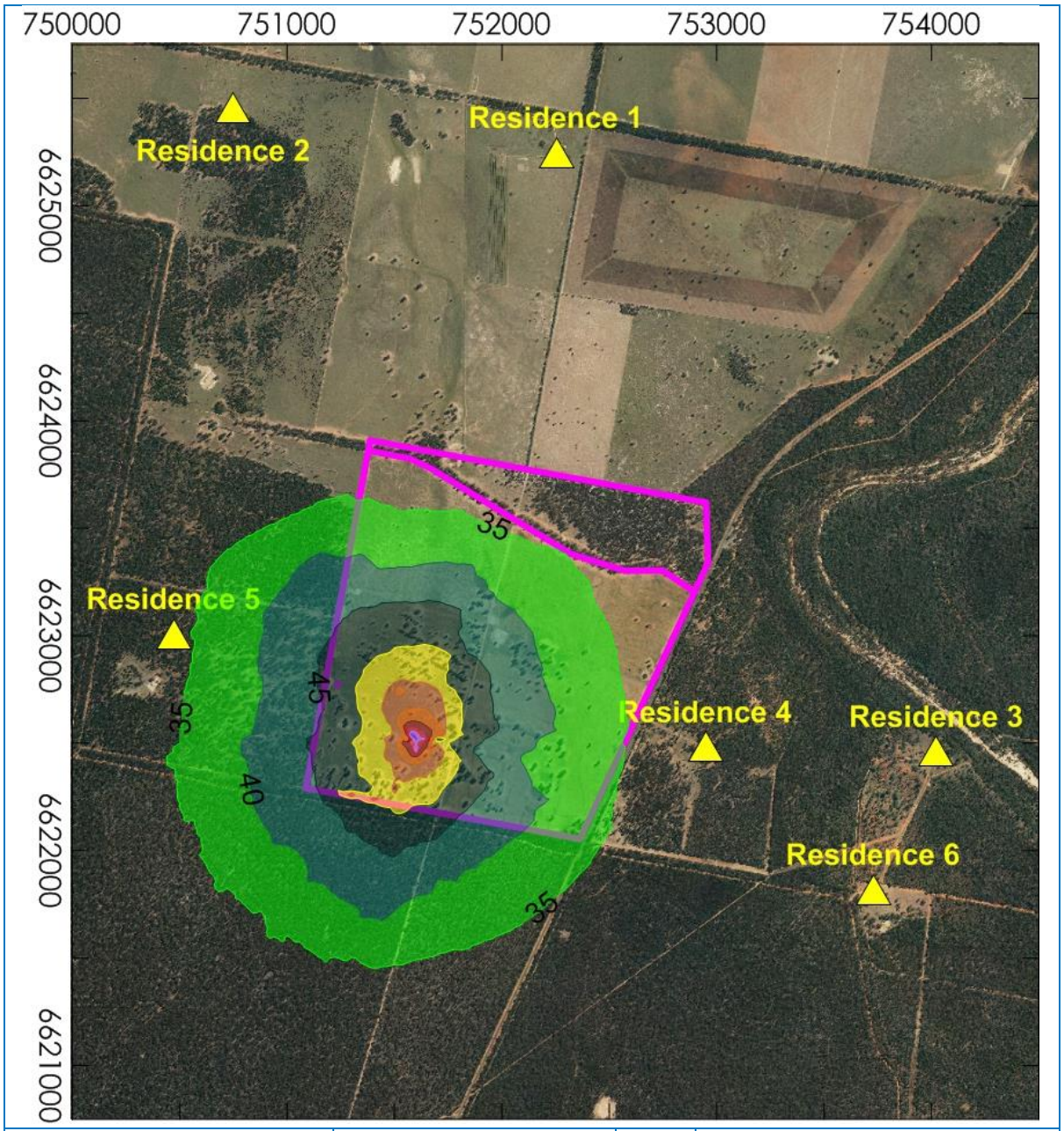
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Receptor
Descriptor: Leq,15min dB(A)
Time Period: Evening/Night
Conditions: Adverse – Temperature Inversion, Calm Conditions.
35 40 45 50 55 60 65 70 75 80 85
Noise Level, dB(A)
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Appendix B INDICATIVE SOUND POWER LEVELS

Source	Octave Band Sound Power Level, (Hz) dB(A)									Total SWL dB(A)
	31.5	63	125	250	500	1000	2000	4000	8000	
High Pressure Pump	48	62	73	83	88	94	93	88	80	98
Pump	38	52	63	73	78	84	83	78	70	88
Valve	24	38	48	55	66	74	80	85	83	88
Heater	76	77	78	80	80	81	79	77	74	88
Electric Motor	44	57	69	77	83	83	82	75	64	88
Compressor	48	58	71	86	96	83	82	88	87	98
AC Unit	53	70	82	81	82	81	78	72	64	88
RO/MF/BS Unit Long Side	32	45	55	63	73	81	87	92	90	95
RO/MF/BS Unit Short Side	27	41	51	58	69	77	83	88	86	91
RO/MF/BS Unit Roof	32	45	55	63	73	81	88	92	90	95
Solids Handling System Long Side	48	62	85	88	92	88	84	77	67	95
Solids Handling System Short Side	43	58	81	84	87	83	80	73	63	91
Solids Handling System Roof	48	62	85	89	92	88	84	78	68	96
Generator Long Side	51	62	73	82	86	90	91	96	85	99
Generator Short Side	48	59	70	79	83	87	88	93	82	96
Generator Roof	51	62	73	82	86	90	91	96	85	98
Generator Stack Tip	71	76	88	87	86	86	81	76	74	93