



Review of Environmental Factors  
Kahlua Pilot Wells - Single Well  
Test - PEL 1 Gunnedah Basin

Prepared by:

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## Executive Summary

### Background

Santos QNT Pty Ltd (Santos) has entered into a Farmin Agreement with the titleholder of PEL 1, Australian Coalbed Methane Pty Ltd to explore for petroleum (in accordance with the *Petroleum (Onshore) Act 1991*). Santos has been appointed the Operator for and on behalf of the titleholder under the Farmin Agreement.

Condition 1.0 of the PEL 1 licence states that prior to carrying out any petroleum activities a Review of Environmental Factors (REF) is required to be submitted to the Department of Industry and Investment (DII) to enable a determination to be made under Part 5 of the *Environmental Planning and Assessment Act 1979*.

In September 2010, Santos received approval from the Department of Primary Industries-Mineral Resources (DPI-MR) section of the DII to drill and complete four Kahlua pilot wells (Kahlua 2, 3, 4, and 5) to obtain information on coal depths, seam sizes, continuity and quality to assess the coal seam gas potential of the Gunnedah Basin in PEL 1.

This Review of Environmental Factors (REF) has been prepared to undertake a single well pilot test located at Kahlua 2. The pilot test is arranged in such way that the central well will test for gas and water whilst the outer wells will monitor pressure variation. The data collected will provide valuable information to assist optimisation of future appraisal activities in the area, especially relating to water quality, water rates, coal seam connectivity, directional permeability, well spacing and well design.

The REF has been prepared to assist determining authorities to make a determination under Part 5 of the *Environmental Planning and Assessment Act* in relation to stage 2 of the project. It assesses the relevant environmental impacts to the fullest extent possible as required by section 111 of the EP&A Act and clause 228 of the *Environmental Planning and Assessment Regulation*.

### The Proposal

The pilot test is arranged in such way that the central well will test for gas and water whilst the outer wells will monitor pressure variation. The data collected will provide valuable information to assist optimisation of future appraisal activities in the area, especially relating to water quality, water rates, coal seam connectivity, directional permeability, well spacing and well design.

The single well pilot will involve:

- Installation of surface equipment, including a small flare, at Kahlua 2;
- Installation of surface monitoring equipment at Kahlua 2, 3, 4 and 5; and
- Construction of the incidental water storage tanks and truck load out.

As the proposed activities to be completed at Kahlua 3, 4 and 5 for the single well pilot involves remote monitoring no potential impacts are likely at these sites.

All Kahlua well sites are located on a privately owned rural property that is presently used for petroleum drilling and completing activities. The proposed activities for the single well pilot test will not require clearing of native vegetation.

A temporary water storage tank area will be established in a cleared area adjacent to the current temporary workers accommodation camp. The water storage area will be approximately 100 by 60 metres. The single well Kahlua pilot test is expected to occur over a 60 day period, or less if 10 mega litres (ML) of incidental water is produced before 60 days, not including the construction period or site restoration.

The proposal requires access to each of the four Kahlua pilot wells sites. All vehicles accessing the site will use the existing road network. No new roads are being constructed for these activities.

### **Potential Environmental Impacts**

The Kahlua single well pilot test at Kahlua 2 is to be located on an operating farm. The land is zoned 1(a) Rural (Agriculture Protection) in the Gunnedah Local Environmental Plan 1998 (LEP).

No vegetation clearing will be required for the proposed activities. The construction of the temporary water storage tank area will be located on land that has been previously cleared for rural activities.

The nearest resident is located more than 1km to the southwest of Kahlua 2 and the nearest watercourse is greater than 40 metres from Kahlua 2.

Environmental aspects considered by Santos for the single well Kahlua pilot included potential impacts of noise, light and dust to the nearest sensitive receptor (i.e. greater than 1000m), proximity to a watercourse (i.e. greater than 40m), proximity to registered archaeological, flora or fauna sites and the potential for sediment and erosion from the proposed site (i.e. slope greater than 10 degrees) and potential impact on groundwater and surface water.

Santos has contacted the affected landowner and negotiated an agreement regarding land access, compensation and rehabilitation, together with the next nearest landholder. Regular contact with all landholders is to be maintained during the testing activities at the site.

The proposed activities will avoid any threatened species and critical habitat previously identified in the desktop assessment and field assessment by an ecologist (Santos 2010).

The proposed activities have associated potential environmental impacts, which are common to testing activities carried out elsewhere in the Gunnedah Basin. It is considered that the potential impacts can be successfully mitigated with the application of the management measures outlined in this document. The measures utilised by Santos and its contractors are consistent with the APPEA Code of Environmental Practice and are typical of good hydrocarbon field practice.

Section 5A of the *Environmental Planning and Assessment Act 1979* lists seven factors to be taken into account in deciding whether there is likely to be a significant effect on threatened species, populations or ecological communities or their habitats, commonly referred to as the seven part test of significance. An assessment was made against the seven factors concluded that:

- There are no known threatened species that would be impacted by the planned activities. The size and nature of the proposal is unlikely to affect the life cycle of any viable populations of threatened flora/fauna if present.
- There are no known endangered populations that have been identified that would be impacted by this proposal. The size and nature of the proposal is unlikely to affect the life cycle of any viable populations of endangered populations if present at the sites.
- There are no known endangered ecological communities or critically endangered communities that have been identified that would be impacted by this proposal.

Santos plans to avoid vegetation clearing therefore the planned activities will not constitute a threatening process.

The potential environmental impacts have been assessed. It is considered that the likely potential environmental impacts with mitigation measures in place are

negligible, and therefore the activities are not likely to have a significant impact on the environment. In particular, it is expected that:

- Impacts on landholders will be negligible;
- Impacts to air quality will be negligible, localised and insignificant;
- Adverse effects on water resources will be negligible (a maximum of 10ML is to be removed from the targeted coal seam during the test);
- Off-site impacts to soils will be avoided and on-site impacts will be negligible and temporary;
- Noise impacts will be short term, and no threatened species or communities are likely to be significantly impacted;
- There will be no significant use of, or impact to, natural resources including groundwater;
- Impacts on the community and visual amenity will be negligible and short term, particularly as the sites are in a sparsely populated area;
- Impacts to heritage places or sites will be avoided;
- Disturbances to pastoral and cropping land use will be negligible and short term and managed in consultation with affected landholder(s); and
- There will be no significant cumulative environmental impacts.

## Table of Contents

|  |           |
|--|-----------|
| <b>EXECUTIVE SUMMARY .....</b>   | <b>II</b> |
| <b>TABLE OF CONTENTS .....</b>   | <b>V</b>  |
| <b>LIST OF FIGURES.....</b>  | <b>VI</b> |
| <b>LIST OF TABLES .....</b>  | <b>VI</b> |
| <b>1 INTRODUCTION.....</b>   | <b>1</b>  |
| 1.1 BACKGROUND.....  | 1         |
| 1.2 PROPONENT CONTACT INFORMATION.....                                       | 1         |
| 1.3 STRUCTURE .....  | 2         |
| <b>2 LEGISLATION &amp; PLANNING FRAMEWORK.....</b>                           | <b>3</b>  |
| 2.1 PLANNING FRAMEWORK.....  | 3         |
| 2.2 LEGISLATIVE REQUIREMENTS, PETROLEUM LICENSES AND APPROVALS REQUIRED..... | 4         |
| 2.3 STAKEHOLDER CONSULTATION.....  | 8         |
| <b>3 PROJECT DESCRIPTION .....</b>   | <b>11</b> |
| 3.1 LOCATION AND TENURE.....   | 11        |
| 3.2 KAHLUA PILOT TEST – A CONCEPTUAL PLAN.....                               | 12        |
| 3.3 REF 2 PLANNED ACTIVITIES.....  | 14        |
| 3.4 COMPLETION OF REF 2 ACTIVITIES.....                                      | 18        |
| 3.5 JUSTIFICATION OF THE ACTIVITY .....                                      | 18        |
| 3.6 EVALUATION OF ALTERNATIVES.....  | 18        |
| <b>4 REGIONAL DESCRIPTION.....</b>   | <b>19</b> |
| 4.1 BIOREGION.....   | 21        |
| 4.2 CLIMATE .....  | 21        |
| 4.3 COMMUNITY – SOCIAL AND ECONOMIC .....                                    | 22        |
| 4.4 CULTURAL HERITAGE.....   | 22        |
| 4.5 FLORA AND FAUNA .....  | 23        |
| 4.6 PROTECTED AREAS.....   | 27        |
| 4.7 GEOLOGY .....  | 27        |
| 4.8 TOPOGRAPHY.....  | 32        |
| 4.9 WATER RESOURCES .....  | 33        |
| <b>5 ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES .....</b>                 | <b>36</b> |
| 5.1 GENERAL.....   | 36        |
| 5.2 AIR EMISSIONS.....   | 36        |
| 5.3 COMMUNITY, SOCIAL AND ECONOMIC.....                                      | 38        |
| 5.4 CULTURAL HERITAGE.....   | 40        |
| 5.5 FLORA AND FAUNA .....  | 40        |
| 5.6 NOISE EMISSIONS .....  | 42        |
| 5.7 SOILS, LAND-USE AND TERRAIN .....  | 44        |
| 5.8 WASTE .....  | 46        |
| 5.9 SURFACE AND GROUND WATER RESOURCES.....                                  | 47        |
| 5.10 CUMULATIVE ENVIRONMENTAL IMPACTS.....                                   | 49        |
| 5.11 CLAUSE 228 CHECKLIST .....  | 55        |
| <b>6 CONCLUSIONS.....</b>  | <b>57</b> |
| <b>7 REFERENCES.....</b>   | <b>58</b> |

|  |           |
|--|-----------|
| <b>APPENDIX A.....</b>   | <b>60</b> |
| <i>Groundwater Impact Study – Kahlua Pilot Test – Golder Associates.....</i>   | <i>60</i> |
| <b>APPENDIX B.....</b>   | <b>62</b> |
| <i>Pickanjinnie Pad Wells Compliance Noise Measurements Report Number 20-2014R14 17 November 2010<br/>URS Pty Ltd.....</i> | <i>62</i> |
| <b>APPENDIX C.....</b>   | <b>64</b> |
| <i>Santos Group Risk Assessment Matrix.....</i>  | <i>64</i> |

## List of Figures

|  |    |
|--|----|
| Figure 2.1: Local Government Area Covering the Kahlua Pilot Site.....              | 4  |
| Figure 3.1: Kahlua Pilot Test Location.....  | 12 |
| Figure 3.2: Proposed Layout of Surface Facility.....                               | 18 |
| Figure 4.1: Regional Map.....  | 19 |
| Figure 4.2: Aerial Photograph Showing the location of local residence.....         | 20 |
| Figure 4.3: Aerial Photograph Kahlua 2 Well site and Water Storage Facilities..... | 21 |
| Figure 4.4: Stratigraphy of the Gunnedah Basin.....                                | 29 |
| Figure 4.5: Kahlua Pilot Site Topography.....                                      | 33 |
| Figure 4.6: Major Surface Drainage.....  | 35 |

## List of Tables

|   |    |
|---|----|
| Table 2.1: PEL 1 Licence Conditions and Applicable Legislation..... | 7  |
| Table 3.1: Co-ordinates for the Kahlua 2 well site (GDA94).....     | 11 |
| Table 3.2: Expected Incidental Water Quality.....                   | 16 |
| Table 4.1: Noxious weeds recorded within the study area.....        | 26 |
| Table 5.1: Risk Assessment for the Proposed Activities.....         | 50 |
| Table 5.2: Clause 228 Checklist.....                                | 55 |

# 1 Introduction

## 1.1 Background

Santos QNT Pty Ltd (Santos) has entered into a Farmin Agreement with the titleholder of Petroleum Exploration Licence (PEL) 1 located in New South Wales (NSW), Australian Coalbed Methane Pty Ltd to explore for petroleum (in accordance with the *Petroleum (Onshore) Act 1991*). Santos has been appointed the Operator for and on behalf of the titleholder under the Farmin Agreement.

In 8 September 2010, Santos received approval from the Department of Primary Industries-Mineral Resources (DPI-MR) section of the Department of Industry & Investment (DII) to drill and complete four Kahlua pilot wells (Kahlua 2, 3, 4, and 5).

This Review of Environmental Factors (REF) has been prepared for stage 2 of the Concept Plan detailed in Section 3.2 of this REF. Stage 2 is the single well pilot test located at Kahlua 2 located on a privately owned rural property that is presently used for petroleum drilling and completing activities. The proposed activities for the single well pilot test will not require clearing of native vegetation and access to Kahlua 2 is via an existing track.

The pilot test is arranged in such way that the central well will test for gas and water whilst the outer wells will monitor pressure variation. The data collected will provide valuable information to assist optimisation of future appraisal activities in the area, especially relating to water quality, water rates, coal seam connectivity, directional permeability, well spacing and well design.

Condition 1.0 of the PEL 1 licence instrument states that, prior to carrying out any petroleum activities, a REF is required to be submitted to the DII to enable a determination to be made under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The purpose of this REF is to assess the environmental impacts of the proposal to the fullest extent possible under section 111 of the EP&A Act and clause 228 of the *Environmental Planning and Assessment Regulation*.

## 1.2 Proponent Contact Information

The correspondence address for Santos is:

|                 |   |
|-----------------|---|
| Operator:       | Santos QNT Pty Ltd (ABN 33 083 077 196) for and on behalf of the Titleholder Australian Coalbed Methane Pty Ltd |
| Address:        | Level 22, Santos Place, 32 Turbot Street, Brisbane, Qld, 4000   |
| Telephone:      | 07 3838 3676  |
| Email:          | reception.brisbane@Santos.com   |
| Contact Person: | Mr J Pinedo, Gunnedah Project Execution Manager   |

## 1.3 Structure

This REF consists of:

- Section 1: Introduction and contact details
- Section 2: Summary of relevant regulations applicable to the activity;
- Section 3: Proposed activities including location and timing;
- Section 4: Description of the local environment including its physical, natural and socio-economic overview;
- Section 5: Outline of the potential environmental impacts and mitigation measures; and
- Section 6: Concluding comments on the likely impacts.

## 2 Legislation & Planning Framework

### 2.1 Planning Framework

#### 2.1.1 Overview

The *Environmental Planning & Assessment Act 1979* is the primary legislation regulating land use planning in NSW. It provides the framework for the development of state and local planning instruments that through their hierarchy determine the statutory process for environmental impact assessment. Under the EP&A Act there are three distinctive processes, which are:

- Part 3A, regulates specific types of 'projects' and requires an Environmental Assessment report to be prepared and submitted to the Department of Planning for the Planning Minister's approval;
- Part 4, regulates 'development' and requires a development application accompanied by a Statement of Environmental Effects to be submitted to council for development approval; and
- Part 5, regulates 'activities' and requires a Review of Environmental Factors for consideration by the determining authority.

The proposal satisfies the definition of an activity under Part 5 of the EP&A Act because the proposal:

- may be carried out without development consent;
- is not an exempt development; and
- requires the approval of a determining authority.

A determining authority, for the purposes of this activity, is defined in Part 5 of the EP&A Act to include, but is not limited to a public authority whose approval is required before an activity may be carried out. In relation to petroleum exploration licences the DII is the determining authority for approving exploration activities covered by this REF. In order to assist the determining authority to comply with its obligations under Part 5 of the EP&A Act, Santos has considered s.111 of the EP&A Act and Clause 228 of the *Environmental Planning Regulation* (See Section 5.11) in preparing this REF.

#### 2.1.2 Environmental planning instruments

The Environmental Planning Instruments (EPIs) regulate the permissibility to undertake an activity and the type of assessment process that is required. EPI is the generic term used to describe state environmental planning policies, regional environmental plans and local environmental plans.

State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (SEPP 2007) recognises the importance to New South Wales of mining, petroleum production and extractive industries. SEPP 2007 seeks to facilitate the orderly and economic use of land containing mineral, petroleum and extractive material resources, whilst encouraging ecologically sustainable development.

Subject to certain exemptions, SEPP 2007 allows development for the purposes of petroleum exploration to be carried out without development consent under Part 4 of the EP&A Act. The definition of petroleum under SEPP 2007 includes any naturally occurring hydrocarbon, whether in gaseous, liquid or solid state. SEPP 2007 has the

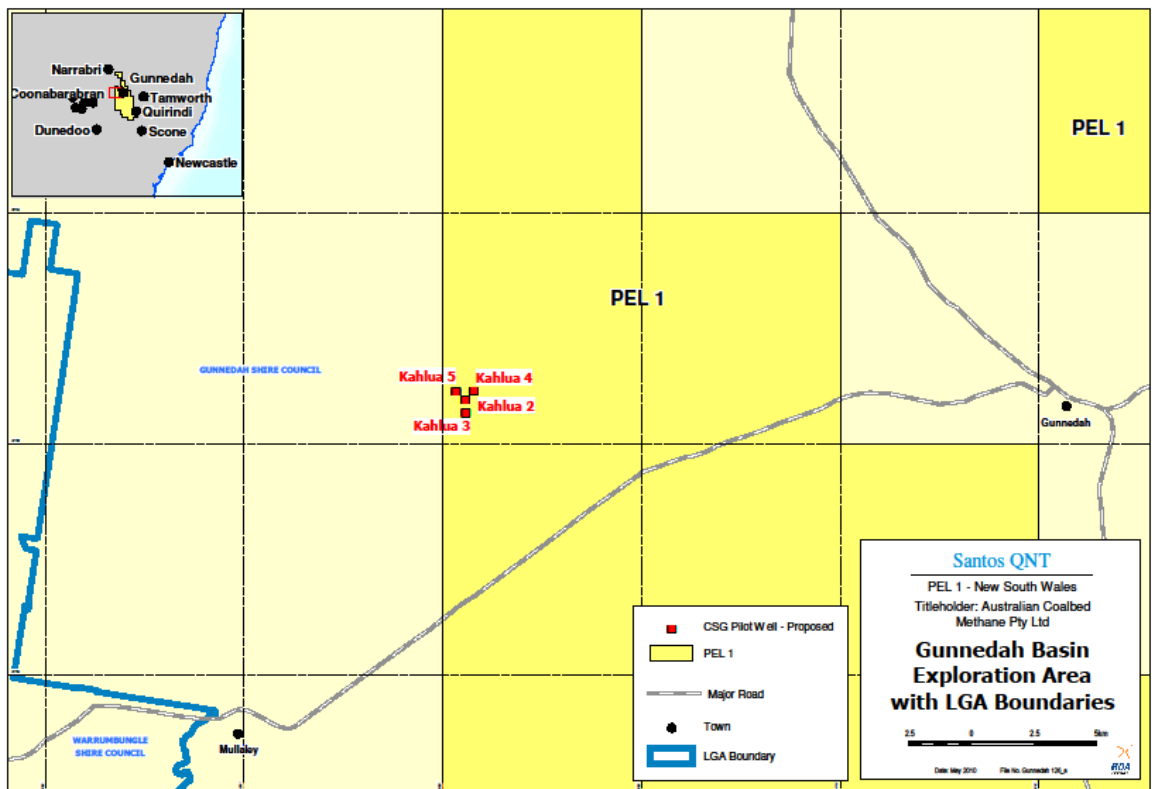
effect that the works may be carried out without development consent but will be subject to the assessment process under Part 5 of the EP&A Act.

### 2.1.3 Land Zone and Local Environmental Plan

The shire councils of Narrabri, Gunnedah and Liverpool Plains regulate the Local Environmental Plans (LEP) applicable to PEL 1. Figure 2.1 shows the location of the various LGAs and the Kahlua pilot well sites.

The proposed single well Kahlua pilot site (Kahlua 2) falls within the local government area of Gunnedah Shire Council. The site is zoned Zone no. 1(a) Rural (Agricultural Protection) under Gunnedah LEP 1998. Development for the purposes of petroleum exploration is permissible with development consent within Zone 1(a). However, SEPP 2007 has the effect of making development of the purposes of petroleum exploration permissible without development consent but subject to Part 5 of the EP&A Act.

Figure 2.1: Local Government Area Covering the Kahlua Pilot Site



## 2.2 Legislative Requirements, Petroleum Licenses and Approvals Required

### Petroleum (Onshore) Act 1991 (NSW)

Santos has entered a Farmin Agreement with the holder of PEL 1 Australian Coalbed Methane (ACM) that grants the right to Santos as Operator to explore for petroleum subject to meeting landholder and legislative requirements.

Prior to any exploration on private land, an access agreement and compensation arrangements must be agreed between the titleholder (or its agent) and the

landowner (Petroleum (Onshore) Act 1991, Part 4). Section 69D specifies the issues that an access agreement may cover. Including:

- periods during which access may be permitted;
- parts of the land on which exploration may be undertaken;
- conditions to be observed during exploration, and
- compensation to be paid to the landholder.

In preparing this REF the necessary considerations found at the DII website at <http://www.dpi.nsw.gov.au/minerals/titles/landholders-rights> have been considered.

Santos' negotiated a voluntary agreement with the affected landowner for access and compensation.

### **Environmental Planning and Assessment Act 1979 (NSW)**

Santos, on behalf of the titleholder, must also obtain an approval from the DII prior to carrying out drilling activities. Before granting the approval, the DII is required to comply with Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The DII is required to consider the environmental impact of the activity to the fullest extent possible. The purpose of this REF is to provide an environmental assessment of the proposed activity to assist the DII to consider the environmental impact of the activity under Part 5 of the EP&A Act.

Section 5A lists seven factors to be taken into account in deciding whether there is likely to be a significant effect on threatened species, populations or ecological communities or their habitats, commonly referred to the 'seven part' test of significance. These are as follows:

- 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; and
- 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

#### **Protection of the Environment Operations Act 1997 (NSW)**

Under the *Protection of the Environment Operations Act 1997*, it is an offence to pollute waters. There are also broad offences of wilfully or negligently causing a substance to escape that causes or is likely to cause environmental harm without lawful authority.

Pollution incidents causing or threatening material harm must be notified to the Environment Protection Authority. Under Section 147 material harm means:

- harm to the environment is material if:
  - a) it involves actual or potential harm to the health or safety of human beings or to ecosystems that is not trivial or it results in actual or potential loss or property damage of an amount, or amounts in aggregate, exceeding \$10,000 (or such other amount as is prescribed by the regulations); and
  - b) loss includes the reasonable costs and expenses that would be incurred in taking all reasonable and practicable measures to prevent, mitigate or make good harm to the environment.

#### **National Parks and Wildlife Act 1974 (NSW)**

The *National Parks and Wildlife Act 1974* (NPW Act), protects Aboriginal objects and places (under Part 6). Under section 90(1), the Director-General may issue an Aboriginal heritage impact permit. It is an offence to harm or desecrate Aboriginal objects or places (section 86) but it is a defence under section 87 if the defendant shows that:

- (a) the harm or desecration concerned was authorised by an Aboriginal heritage impact permit; and
- (b) the conditions to which the Aboriginal heritage impact permit was subject were not contravened.

The NPW Act with the Threatened Species Conservation Act 1997 (NSW) also protects threatened species, populations and ecological communities, their habitats and critical habitats (Part 8A).

#### **Environment Protection and Biodiversity Conservation Act 1999 (Cth)**

The *Environment Protection and Biodiversity Conservation Act 1999* (Cth) protects matters of national significance. As outlined in Section 4.5.4 Santos does not consider that this proposal will trigger this Act, and does not propose to lodge a referral to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities.

#### **Water Management Act 2000 (NSW)**

Under the regulations of the *Water Management Act 2000* there is an exemption (clause 18 (e) of the *Water Management (General) Regulation 2004* (NSW)) for the need of an access licence for persons lawfully engaged in prospecting or fossicking for minerals or petroleum under the *Mining Act 1992* or the *Petroleum (Onshore) Act 1991*, in relation to water required for that purpose.

### Water Act 1912 (NSW)

The site of the Kahlua Pilot wells is not within the area of a water sharing plan under the Water Management Act 2000 (NSW). The Water Act 1912 (NSW) applies in relation to this area. Santos has applied to the NSW Office of Water for a water bore licence under Part 5 of the Water Act 1912 (NSW) for the activities covered by this REF. Order 12 Schedule 2 of the Water Act 1912 grants an exemption whereby monitoring and test bores for groundwater investigation and/or environmental management purposes are granted. The New South Wales Office of Water is the determining authority for the purposes of Part 5 of the EP&A Act. The relevant Acts are summarised in Table 2.1.

Table 2.1: PEL 1 Licence Conditions and Applicable Legislation

| Legislation  | Requirements of Schedule 2 Licence Conditions  | Administering Authority                                 |
|--|--|---|
| <i>Petroleum (Onshore) Act 1991</i>                      | The activities do not cause other than minimal/nil impact on features listed in Section 75 (i.e. of Aboriginal, Architectural, archaeological, historical or geological interest). Where these are present, an exploration protocol acceptable to the Department must be completed prior to exploration commencing to ensure that exploration activities will not have an adverse impact on these features.<br><br>Full rehabilitation in accordance with Department guidelines/standards is carried out after completion of the exploration activities. | Department of Industry & Investment – Mineral Resources |
| <i>Environmental Planning and Assessment Act 1979</i>    | Assess the impact of the activity on the environment under Part 5 of the <i>Environmental Planning and Assessment Act 1979</i> (EP&A Act) from the DPI-MR prior to carrying out drilling activities.   | Department of Primary Industry – Mineral Resources      |
| <i>Threatened Species Conservation Act 1995</i>          | The Licence holder is required to consult the register of Critical Habitat kept by the Director-General, and consider the significance of any notations in respect of the area of any proposed exploration activity  | Department of Environment, Climate Change and Water     |
| <i>Fisheries Management Act 1994</i>                     | Consult the register of critical habitat kept under this Act.  | Department of Primary Industries – Fisheries            |
| <i>National Parks and Wildlife Act 1974</i>              | The activities do not contravene Part 6 (Aboriginal objects and Aboriginal places) of this Act.  | National Parks and Wildlife Service                     |
| <i>Native Vegetation Conservation Act 1997(now 2003)</i> | The licence holder must not cut, destroy, ringbark or remove any timber or other vegetative cover on any land subject of the licence except such as directly obstructs or prevents the carrying on of operations. Any clearing not authorised under the <i>Petroleum (Onshore) Act 1991</i> , must comply with   | Department of Environment, Climate Change and Water     |

|                             |  |                                 |
|-----------------------------|--|---------------------------------|
|                             | the provisions of this Act.  |                                 |
| <i>Rural Fires Act 1997</i> | Santos must take all precautions against causing an outbreak of fire and must comply with the provisions and regulations of the Act and must not burn off any grass, foliage or herbage without the current consent of the owner or occupier and the local fire authority. | NSW Rural Fires Service         |
| <i>Water Act 1912</i>       | Santos must take all precautions against intersecting an aquifer and has applied for Water Bore Licenses under the Water Act 1912.   | New South Wales Office of Water |

## 2.3 Stakeholder Consultation

In April 2008, Santos commenced community consultation for the proposed coal seam gas (CSG) exploration program in the Gunnedah Basin. Stakeholder consultation is guided by Santos' community policy which states that "*We work to be a valued member of the communities of which we are a part*". For this reason, Santos is committed to ongoing consultation activities with key stakeholders prior to work starting and for the duration of our presence in the region.

Key stakeholder groups include:

- Landholders
- Business
- All levels of government
- Utilities operators
- Local Aboriginal Land Councils
- Special interest and activist groups

Consultation aims to:

- Increase understanding of the coal seam gas industry in NSW
- Explain the differences between petroleum exploration legislation and mining legislation in NSW
- Identify issues that generate community interest and concern in the Gunnedah Basin

We recognise that many stakeholders have an interest in more than one PEL (for example Local, State and Federal government and their elected representatives and industry representative associations such as NSW Farmers' Association, Chambers of Commerce and Local Aboriginal Land Councils) and for that reason make available information about our activities across the entire exploration area using the following consultation methods:

1. Community consultation sessions and presentations are held early and late each year in areas that are close to upcoming work. Community consultation sessions are attended by subject specialists (geologists, drilling engineers, hydrologists and hydrogeologists, government relations and stakeholder management).
2. AgQuip (every August) Santos displays equipment and has up to eight subject specialists in attendance to answer questions from the public.

3. 1800 number - attended during business hours, all calls returned within 48 business hours.
4. Public email address – emails returned within 48 business hours.
5. Briefing of key Local, State and Federal government staff and elected representatives.
6. Website [www.santos.com/gunnedah](http://www.santos.com/gunnedah) – information includes factsheets, newsletters and presentations, frequently asked questions, photographs of sites and equipment, materials safety data sheets for chemicals used, upcoming events, industry terminology and a link to the Namoi Catchment Water Study website.
7. Factsheets – a set of six factsheets (CSG Overview, CSG Regulation in NSW, Exploration Core Hole Drilling and Pilot Testing, Incidental Water Management, Seismic Testing) available in printed or electronic versions (see <http://www.santos.com/exploration-acreage/gunnedah-basin-gas/factsheets-msds.aspx>).
8. Newsletter (4 times per year, direct mailed to a database of over 5 000 stakeholders).
9. Field trips to drill and seismic work sites (on request, year round).
10. Presentations to community groups (on request, year round).
11. Gunnedah regional office – 88 Marquis Street, Gunnedah.
12. Notification of neighbours (those sharing boundaries with properties on which Santos is working) prior to commencement of activities.

To ensure that the community is aware of the proposed activities for the Glasserton Pilot testing activities well in advance of them starting, the following pilot-specific consultation activities were undertaken:

1. Community consultation sessions (public meetings) were run at Spring Ridge on Tuesday 23 March and Gunnedah on Wednesday 24 March 2010. Both ran from 2-8pm. In the afternoon, team members (drilling engineer, geologist, hydrologist) were available for one-on-one conversations. In the evening, pilot-focused presentations on geology, drilling and water handling were given in a facilitated session. The sessions were advertised in local papers (2 weeks prior to event), in the March edition of the newsletter (sent to 4 800 recipients) and by email.
2. Community consultation sessions (guided conversations) are being held on the following topics:

| <b>TOPIC</b>                            | <b>QUIRINDI</b>  | <b>GUNNEDAH</b>  |
|---|------------------|------------------|
| Gunnedah Basin Geology                  | 17 November 2010 | 18 November 2010 |
| Pilot testing design principles         | 8 December 2010  | 9 December 2010  |
| Pilot testing water handling principles | 9 February 2011  | 10 February 2011 |
| Beneficial water reuse                  | 13 April 2011    | 14 April 2011    |

3. Meetings held with local MP's as well as briefings provided to the Minister for Mining and Forestry Resources' office and the office of the Shadow Minister outlining the pilot location and activities.

4. Revision of factsheets to include specific information on pilot testing. These factsheets were available at community sessions.
5. The June newsletter provided detailed information on water handling during pilot testing (direct mailed to over 5 000 property owners and stakeholders in the region); the November newsletter gave further information on pilot site logistics, water monitoring and coal geology; and the December newsletter explains specific field operations and work plans for 2011.
6. During the pilot phase, the Santos website is regularly updated to include:
  - a. New FAQs
  - b. Newsletters
  - c. Presentations
  - d. Upcoming events

### 3 Project Description

#### 3.1 Location and Tenure

##### 3.1.1 Location

Table 3.1 shows the co-ordinates of the proposed Kahlua single well test site. Figure 3.1 shows the location of the Kahlua single well pilot.

Table 3.1: Co-ordinates for the Kahlua 2 well site (GDA94)

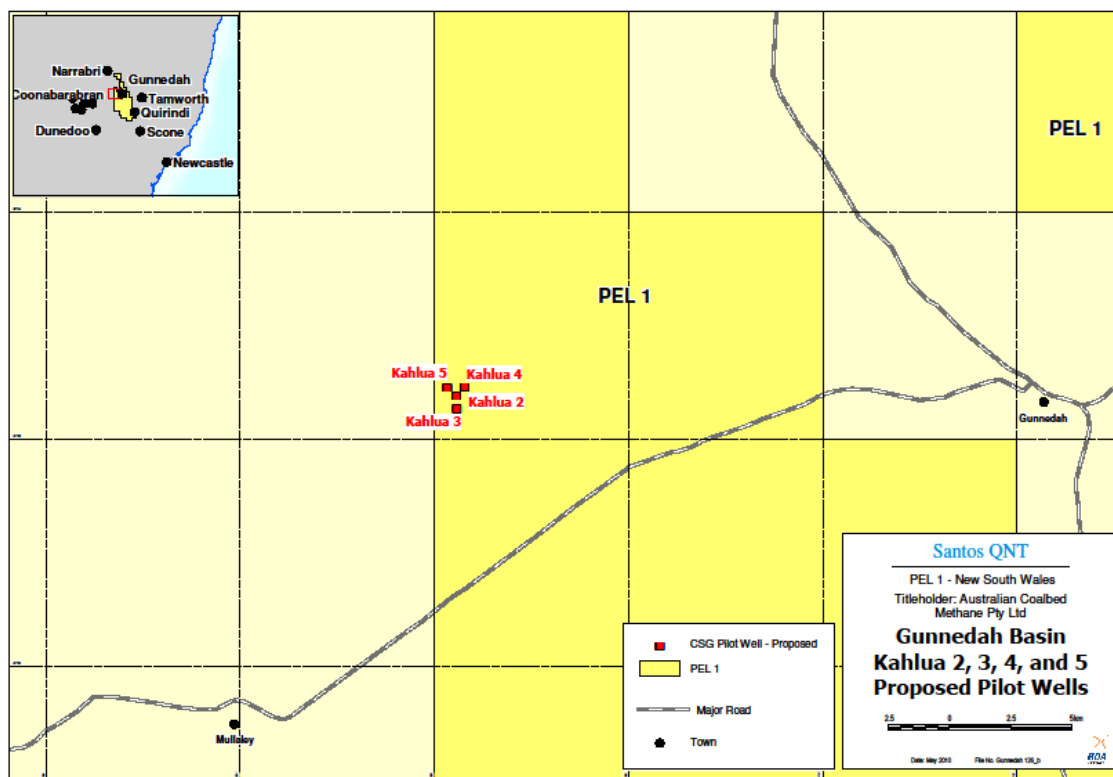
| Name     | Longitude       | Latitude        | LGA      | Nearest Town |
|----------|-----------------|-----------------|----------|--------------|
| Kahlua 2 | 150° 00' 35.95" | -30° 58' 59.47" | Gunnedah | Gunnedah     |

The Kahlua pilot site area is located on freehold land that is flat and has been previously disturbed by operating farm practices and petroleum drilling and completion activities. The Kahlua pilot area is situated approximately 22km west of Gunnedah and 17 km north east of Mullaley (direct line). The closest watercourse is Collygra Creek 3km east.

The proposed site is not located in:

- An area reserved or dedicated under the *National Parks and Wildlife Act 1974*;
- Land reserved or dedicated within the meaning of the *Crown Lands Act 1989* for preservation of other environmental protection purposes;
- A World Heritage Area;
- Environmental Protection Zones in environmental planning instruments;
- Lands protected under SEPP 14 – Coastal Wetlands;
- Lands protected under SEPP 26 – Littoral Rainforests;
- Land identified as wilderness under the *Wilderness Act 1987* or declared as wilderness under the *National Parks and Wildlife Act 1974*;
- Aquatic reserves dedicated under the *Fisheries Management Act 1994*;
- Wetland areas dedicated under the Ramsar Wetlands Convention;
- Land subject to a conservation agreement under the *National Parks and Wildlife Act 1974*;
- Western Lands Lease;
- Land identified as State Forest under the *Forestry Act 1916*; or
- Crown Land.

Figure 3.1: Kahlua Pilot Test Location



### 3.2 Kahlua Pilot Test – A conceptual plan

The Kahlua Pilot is an exploration test that will be undertaken by Santos QNT Pty. Ltd. as Operator, for and on behalf of the Titleholders of PEL 1.

The Kahlua Pilot will be the first coal seam gas pilot test in PEL 1, Gunnedah Basin NSW. The Pilot design is a central well surrounded by three outer wells typically equidistant apart. The Pilot is arranged in such way that the central well will test for gas and water whilst the outer wells will monitor pressure variation. The data collected will provide valuable information to assist optimisation of future appraisal activities in the area, especially relating to water quality, water rates, coal seam connectivity, directional permeability, well spacing and well design.

At a later stage the three outer wells will be converted to test wells to allow well to well pressure drawdown interference and hopefully promote eventual gas flow.

The Operator has elected to undertake the Kahlua Pilot Test subject to three Review of Environmental Factor (REF) documents.

#### **Review of Environmental Factors 1: Kahlua Pilot - Drill and Complete**

The first REF (Approved on 8 September 2010) covered the activities associated with drilling and completion of four pilot wells at Kahlua 2, 3, 4 and 5 to obtain information on the coal depths, seam sizes, continuity and quality to assess the CSG potential of the Gunnedah Basin in PEL 1. The REF covered the construction of associated leases, access tracks and a geotechnical investigation for the selection of the site for locating water management facilities. The activities associated with REF

1 are currently being completed by Santos in accordance with the approved documents.

### **Review of Environmental Factors 2: Kahlua Pilot – Connect, Water Handling Facility and Single-Well Test**

REF 2 involves a sixty day pilot test being undertaken at Kahlua 2. This involves the central well (Kahlua 2) being connected to the surface facilities, a water handling facility installed to manage incidental water volumes and the carrying out of testing of the well over a sixty day period (or until 10ML of water is produced if this occurs before 60 days). Testing will involve pumping water from the central well and possibly extracting incidental gas if gas is encountered. Hydraulic fracturing will not be used during the test.

On approval of REF 2 (this document), the following activities are proposed to be undertaken, as part of the Kahlua pilot program:

- Construct the surface facilities to connect and handle incidental water from the well site to the storage tank.
- Install underground flowlines and other equipment to allow the central well to flow water to the water management facility.
- Partial rehabilitation of the central pilot well lease area, in particular outside the fenced area containing well head and surface infrastructure.
- Construct at the site tanks with total of 10 megalitre capacity for managing water lifted from the well.
- The water that may be lifted from the central well is intended to be provided to Whitehaven Coal under agreement at their nominated licensed sites.
- Road tankers will transfer the water from the site via the existing all weather road access network.
- Install surface monitoring equipment at the surrounding pilot observation wells (Kahlua 3, 4 and 5) and the Shallow Aquifer Monitoring Bores (Kahlua SAMB 1 and Kahlua SAMB 2).

### **Review of Environmental Factors 3: Kahlua Pilot – Complete, Connect, Water Handling Facility Upgrade and Multi-Well Test**

On conclusion of the single well pilot test, a multi-well test may be performed. The multi-well test would involve completion of the remaining outer wells with a down hole pump and connection with flowlines to allow transport of fluids from the well head to the water management facility. Before all wells can be tested at once, it is envisaged water management facilities will be upgraded to handle additional incidental water volumes.

The following activities would be undertaken, as part of stage 3 of the Kahlua pilot program:

- The Operator plans then to remove suspended gauges from the three outer pilot wells and complete wells with a down hole pump.
- Connect the three remaining pilot wells to allow a multi-well pilot test.
- It is planned to increase water management capability at the site which may include Reverse Osmosis (RO) plant, a incidental water pond, a permeate pond and a brine pond which will allow for storage of water or brine, prior to it being transported to a licensed facility.
- Install surface flowlines and other equipment to allow the outer wells to flow water into the upgraded water management facility at the site for transport to the receipt point.

## 3.3 REF 2 Planned Activities

To assess the coal seam gas potential of the Gunnedah Basin in PEL 1 it is proposed to carry out a sixty day (or until 10ML of water is produced) single well Kahlua Pilot test at Kahlua 2 with associated monitoring to be carried out at Kahlua 3, 4 and 5. Santos proposes to undertake the testing activities in accordance with the activities described below.

Santos has contacted and negotiated an access, compensation and rehabilitation agreement with the affected landowner for the proposed activities. The proposed activities will have minimal impact on the property operations.

The number of employees present for the proposed activities is expected to be up to 20 persons. The hours of operation during the proposed activities will be on a 24-hour a day basis which has been negotiated with the landowner.

The proposed activities are temporary (not greater than 60 days) and will not have any long-term impact on the visual amenity of the area.

### 3.3.1 Surface Facilities

#### 3.3.1.1 Central Pilot Well

The central pilot well will be connected to a small separator, operating at low pressure (approximately 350kPag) that will separate any coal seam gas from the incidental water. The gas will be diverted to the flare and ignited safely. The incidental water will be connected to a small water tank that is open to atmosphere so that any small amount of remaining dissolved gas is released safely. The water will then be pumped through a buried flowline to the water handling facility. Figure 3.2 shows the layout of the proposed surface facilities.

The down hole pump and water transfer pump will be powered by a hydraulic power unit (HPU) using diesel fuel supplied from a small diesel storage tank. The HPU will incorporate a containment tray with capacity to contain all fluids to prevent ground contamination from leaks. The HPU will also be installed within a sound suppression enclosure. The diesel storage tank is a double wall (self contained) steel tank with a vent and conforms to the requirements of AS 1940 and AS 1692.

A Remote Operations Controller (ROC) powered by a solar panel and battery will control the surface facilities. Data will be transmitted via a Remote Telemetry Unit (RTU) through the Next G network to Santos offices to enable Operations personnel to remotely monitor and control the surface facilities. Surveillance cameras and gate sensors will also be installed to assist with remote monitoring and provide early warning of any unauthorised entry to site.

#### 3.3.1.2 Surrounding Pilot Wells

At the surrounding pilot wells (Kahlua 3, 4 and 5) the surface facilities will consist of a telemetry system to capture and transmit down hole pressure data back to the Santos offices. The existing lease and access tracks will be used for installation of the surface facilities. As the proposed activities to be completed at Kahlua 3, 4 and 5 for the single well pilot involves remote monitoring on existing well sites no potential impacts are likely to occur at these sites.

#### 3.3.1.3 Shallow Aquifer Monitoring Bores (SAMBs)

At the surrounding Shallow Aquifer Monitoring Bores (Kahlua SAMB 1 and Kahlua SAMB 2) the surface facilities will consist of a telemetry system to capture and transmit down hole pressure data back to the Santos offices. A supplementary

management plan was submitted to DPI-MR for the proposed SAMB activities and is not assessed in this REF.

#### *3.3.1.4 Water Handling Facility*

A suitable location for the water handling facilities has been identified adjacent to Kahlua 2 (see Figure 4.3), following a desktop and site investigation and drilling of 10 geotechnical test pits to depths of between 3 metres and 6 metres to ensure ground suitability.

During site preparation earthworks, there will be some soil disturbance as a level pad will need to be constructed to hold two 5ML lined panel tanks. The area to be disturbed will be approximately 100 by 60 metres.

Incidental water from the sixty day test at the central pilot well will be stored in two 5ML lined panel tanks. The tanks will be equipped with a high level trip to shutdown the down hole pump if a high level occurs in the tank, thereby mitigating against the risk of overflow. The tank level will be continuously monitored and transmitted via the Next G network to Santos offices so that any unexpected reduction in tank level, indicating a potential leak, can be managed promptly. Leak detection will also be installed under the tanks to detect any leakage from the tanks. The tanks will be located in an earthen contained area to contain the incidental water if any catastrophic failure occurs.

### **3.3.2 Incidental Water Management Scheme**

#### *3.3.2.1 Incidental Water Transport*

Incidental water will be pumped into 40,000L B-Double trucks for transportation away from the pilot site for disposal. The truck loading area will be located on the high side of the contained tank storage area so that any spillage that was to occur during transfer would drain back into the contained area to be salvaged.

It is expected that a maximum of five truck movements will be required per day, with trucking expected to occur only during daylight hours, Monday to Saturday. Wherever possible, truck movements will be scheduled outside of school bus pick-up / drop-off hours.

#### *3.3.2.2 Incidental Water Disposal*

The incidental water extracted from the Kahlua pilot will be transported to either Sunnyside Coal Mine or Rocglen Coal Mine, Whitehaven Coal Limited operated mines (licence numbers 90BL254691, 90BL255246 and 90BL255352). An agreement has been reached for Whitehaven Coal to receive the incidental water.

#### *3.3.2.3 Incidental Water Quantity*

The maximum expected incidental water flow rate from the central pumping well is 160 kL/day. The duration of the pilot test will be 60 days, or less if the total quantity of incidental water reaches 10ML before 60 days.

#### *3.3.2.4 Incidental Water Quality*

Table 3.2 shows the expected quality of incidental water extracted from the Kahlua pilot, however this may vary over time. Water quality testing will be undertaken on a regular basis (see Section 3.3.3) to ensure that the incidental water is within the limits of the Water Licence prior to discharge.

Table 3.2: Expected Incidental Water Quality

| Parameter                    | Kahlua Pilot |
|------------------------------|--------------|
| pH                           | 8            |
| Conductivity                 | 5 mS/cm      |
| Total Dissolved Solids (TDS) | 3,200 mg/L   |

### 3.3.3 Water Monitoring Activities

#### 3.3.3.1 Regional Bore Inventory

Private groundwater bores within a two kilometre radius of the pilot wells will be monitored on a regular basis. The groundwater bores will be monitored for water level and water quality and bore construction details will be collected.

The following in-field water quality parameters will be collected for all groundwater bores during testing:

- pH
- Temperature
- Dissolved Oxygen (DO)
- Redox (Eh)
- Electrical Conductivity (EC)

Selected groundwater bores will be sampled for a range of parameters and the samples analysed by a National Association of Testing Authorities (NATA) accredited laboratory. The samples will be analysed for the following water quality parameters:

- pH
- Electrical Conductivity
- Total Dissolved Solids (TDS)
- Alkalinity (total, bicarbonate, carbonate and hydroxide as calcium carbonate)
- Sulphate (SO<sub>4</sub>)
- Chloride (Cl)
- Cations: Calcium (Ca), Magnesium (Mg), Sodium (Na) and Potassium (K)
- Fluoride
- Nitrite and Nitrate (as N)
- Ammonia (as N)
- Total Phosphorus
- Dissolved Metals: Arsenic (As), Barium (Ba), Beryllium (Be), cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni), Lead (Pb), Vanadium (V), Zinc (Zn), Iron (Fe), Selenium (Se), Boron (B), Strontium (Sr), Molybdenum (Mo) and Mercury (Hg)
- Total Petroleum Hydrocarbons (TPH),
- Benzene, Toluene, ethylbenzene and total xylenes (BTEX)
- Total and Dissolved Organic Carbon (TOC/DOC)
- Ionic Balance
- Total Cyanide

### 3.3.3.2 *Incidental Water Quality*

The quality of the incidental water extracted during pilot testing will be monitored on a daily basis and the results provided to the New South Wales Industry and Investment and Office of Water on a weekly basis.

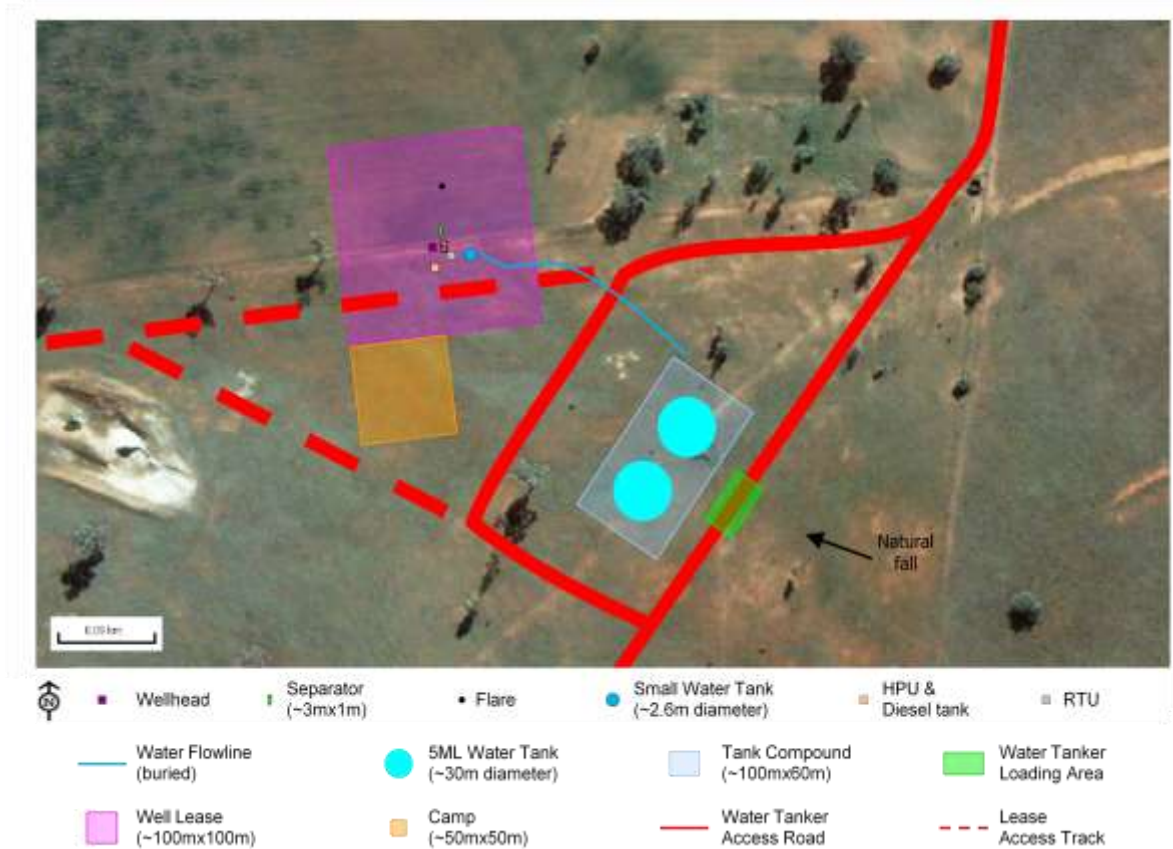
In-field water quality measurements will be recorded on a daily basis for the following parameters:

- pH
- Temperature
- Dissolved Oxygen (DO)
- Redox (Eh)
- Electrical Conductivity (EC)

Samples of incidental water will be collected on a weekly basis and sent to a National Association of Testing Authorities (NATA) accredited laboratory for analysis. The samples will be analysed for the parameters shown.

- pH
- Electrical Conductivity
- Total Dissolved Solids (TDS)
- Alkalinity (total, bicarbonate, carbonate and hydroxide as calcium carbonate)
- Sulphate (SO<sub>4</sub>)
- Chloride (Cl)
- Cations: Calcium (Ca), Magnesium (Mg), Sodium (Na) and Potassium (K)
- Fluoride
- Nitrite and Nitrate (as N)
- Ammonia (as N)
- Total Nitrogen as N (incl. NO<sub>x</sub> and TKN)
- Total Phosphorus and Reactive Phosphorus
- Dissolved Metals: Aluminium (Al), Arsenic (As), Barium (Ba), Beryllium (Be), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni), Lead (Pb), Vanadium (V), Zinc (Zn), Iron (Fe), Selenium (Se), Boron (B), Strontium (Sr), Molybdenum (Mo) and Mercury (Hg)
- Total Petroleum Hydrocarbons (TPH)
- Benzene, Toluene, ethylbenzene and total xylenes (BETEX)
- Total and Dissolved Organic Carbon (TOC/DOC)
- Ionic Balance
- Total Cyanide
- Blue Green Algae (Cyanobacteria Count)
- PCB including Aroclors
- Gross alpha and Gross beta with Potassium 40 correction

Figure 3.2: Proposed Layout of Surface Facility



### 3.4 Completion of REF 2 Activities

If at the time of completing the activities under REF 2 Santos choose not to proceed to REF 3, the Kahlua pilot wellbores will be plugged and abandoned and all land disturbances including all surface facility areas will be rehabilitated back to there pre-existing land use.

### 3.5 Justification of the Activity

A 60 day single well test of the Kahlua pilot is a necessary step in the ongoing exploration and evaluation of the hydrocarbon potential in PEL 1. Discovery of coal seam gas resources in the area has the potential to increase the state’s reserves and revenue from gas, and underpin future exploration or production in the region.

The proposed program consists of a 60 day single well pilot test. These procedures are required to define and identify commercially valuable reserves of coal seam gas. Santos is committed to undertake this work as part of its obligations under the NSW petroleum legislation and its obligations contained in the Farm-in Agreement entered into with Australian Coalbed Methane Pty Ltd.

### 3.6 Evaluation of Alternatives

There is no reasonable industry alternative to the monitoring method proposed in Section 3.3 if commercially useful amounts of coal seam gas are to be assessed within PEL 1. There is limited previous CSG monitoring in this area of the Gunnedah Basin for the purposes of petroleum exploration.

## 4 Regional Description

Unless otherwise stated the major source reference for this section is the Bioregions of New South Wales: their biodiversity, conservation and history in particular the Brigalow Belt South Bioregion (NSW National Parks and Wildlife Service, 2003).

Figure 4.1 shows the location of the Kahlua Pilot in relation to NSW and Gunnedah. Figure 4.2 shows the local residences in relation to the proposed Kahlua Pilot. Figure 4-3 shows the existing Kahlua 2 well site and access track as well as the proposed surface and water storage facilities areas.

Figure 4.1: Regional Map

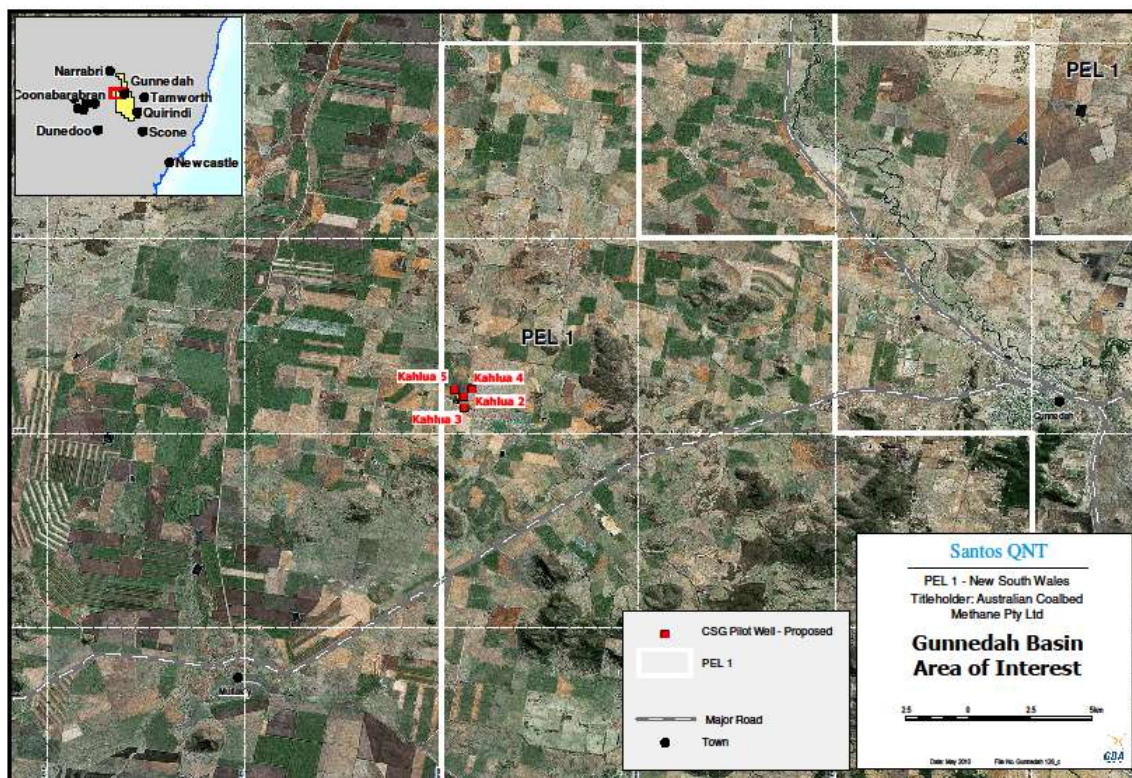


Figure 4.2: Aerial Photograph Showing the location of local residence

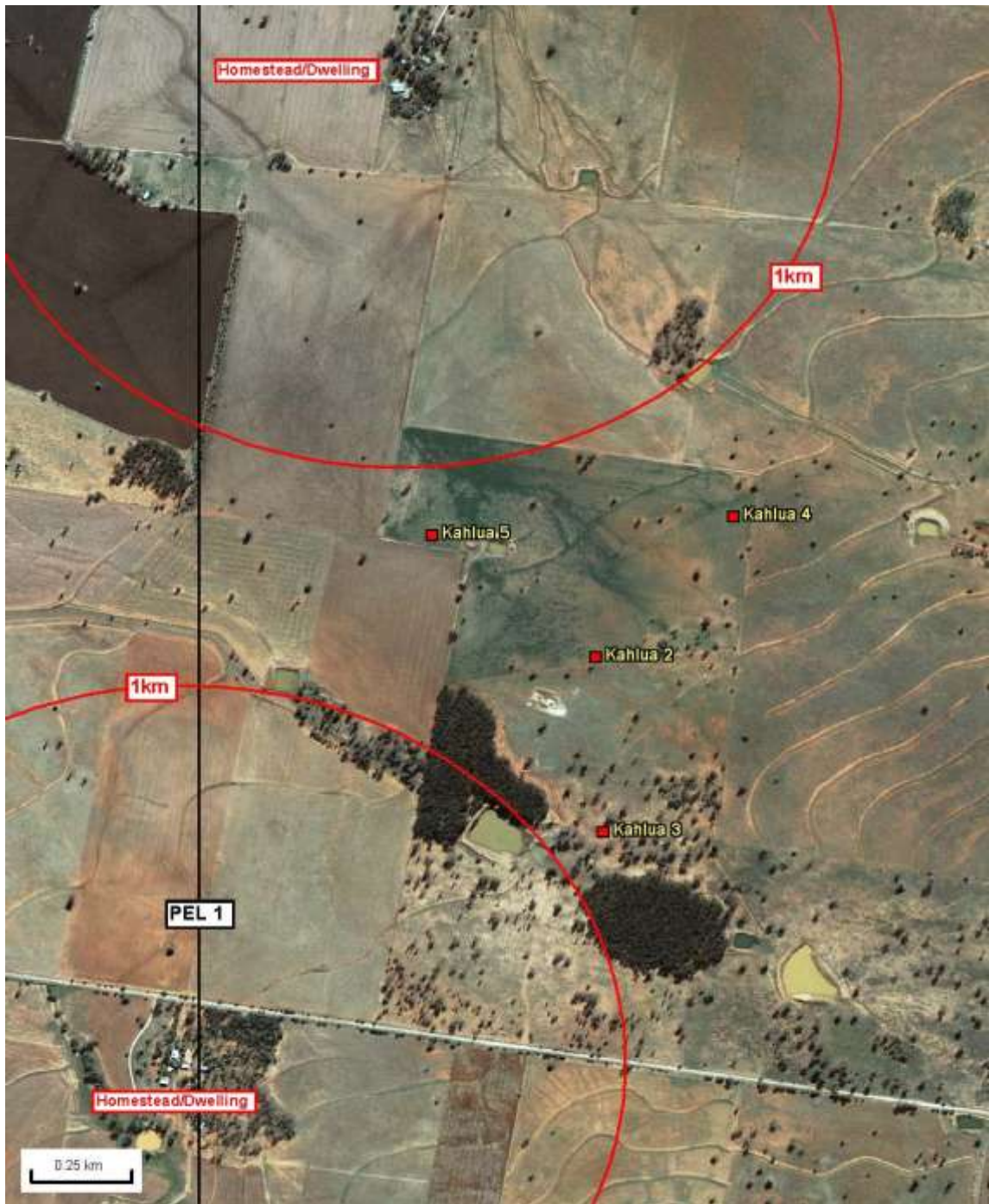


Figure 4.3: Aerial Photograph Kahlua 2 Well site and Water Storage Facilities



## 4.1 Bioregion

PEL 1 falls within the Brigalow Belt South Bioregion that extends from south of Dubbo in central-western NSW to mid-Queensland coast, of which about 20% is located in NSW. The towns of Baradine, Binnaway, Coonabarabran, Dubbo, Gunnedah, Merriwa, Moree and Narrabri occur within this bioregion. The nearest town to the proposed sites is Gunnedah 22 km east.

## 4.2 Climate

The bioregion is located with the eastern subhumid region of NSW. A subhumid climate, with no dry season and a hot summer, characterise the south-eastern section of the bioregion, while a generally dry subtropical climate dominates to the northwest. Minor patches to the southeast of the bioregion fall within the temperate zone with no dry season and a warm summer.

Situated between the tropical and temperate climatic zones, the Gunnedah region experiences very warm to hot summers and cool to mild winters. The town of Gunnedah, which is representative of the area, has average maximum temperatures varying from 34 degrees Celsius in January to 16.9 degrees Celsius in July, while average minima range from 18.3 degrees Celsius in January and to 3 degrees Celsius in July (BOM, 2010).

Rainfall in Gunnedah is higher in the summer months with an average annual rainfall of 618 millimetres (BOM, 2010).

## 4.3 Community – Social and Economic

### 4.3.1 Local Government Area

PEL 1, overlays three LGAs Narrabri, Gunnedah and Liverpool Plains. The planned activities are located solely within the Gunnedah LGA administered by the Gunnedah Shire Council.

The Gunnedah Shire was formed in 2004 by the amalgamation of Quirindi Shire, substantial parts of Parry and Murrundi Shires, and small parts of Gunnedah Shire. Located just 440km by Road from Sydney, the Gunnedah Shire covers an area of 5,994 square kilometres and has a population of 11,525 (ABS 2006).

### 4.3.2 Landuse

The proposed Kahlua Pilot is located in a region that has been used extensively for agricultural activities since the 1830s. Agricultural activities include mixed farming of sheep, cattle and grain crops with a gradually larger reliance on cattle. Sheep, beef cattle and grain farming are major rural land uses.

There are a number of operating coal mines located in PEL 1, however these are not within the immediate vicinity of the proposed Kahlua Pilot. Whitehaven's Sunnyside or Rocglen coal mine will be utilised for the disposal of incidental water from the single well Kahlua Pilot.

## 4.4 Cultural Heritage

### 4.4.1 Aboriginal Heritage

The Local Aboriginal Land Council for the area of interest is Red Chief Local Aboriginal Land Council based in the township of Gunnedah. For REF 1 Santos completed a search of the NSW DECCW Aboriginal Heritage Information Management System (AHIMS). Details of the results are not to be made available to the public. None of the sites identified in the AHIMS search are in close proximity to the planned sites (Santos 2010).

The proposed activities are away from the banks of any waterholes, creeks and ridgelines that are generally accepted as having a higher potential for the location of Aboriginal objects and places. The proposed activities will be undertaken on pastoral land that has been disturbed by clearing, grazing, cropping, general agricultural pursuits and petroleum activities.

An experienced Cultural Heritage Adviser has undertaken a Cultural Heritage Survey of the Kahlua Pilot test site. No items of Aboriginal Cultural Heritage were found and the impact of the proposed activity on Aboriginal Cultural Heritage will be nil (Santos 2010). Given the results of that survey the proposed activity in REF 2 (see Section 3.3) will not disturb or move an item of Aboriginal Cultural Heritage or destroy, damage or deface an item of Aboriginal Cultural Heritage. Accordingly, an Aboriginal Heritage Impact Permit (AHIP) under the *National Parks and Wildlife Act 1974* is not required.

As of the 30<sup>th</sup> September 2010 there were no Native Title claims over the proposed site location<sup>1</sup>.

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<sup>1</sup> See Map at [http://www.nntt.gov.au/Publications-And-Research/Maps-and-Spatial-Reports/Documents/Quarterly%20Maps/NSW\\_ACT\\_JBT\\_NTDA\\_Schedule.PDF](http://www.nntt.gov.au/Publications-And-Research/Maps-and-Spatial-Reports/Documents/Quarterly%20Maps/NSW_ACT_JBT_NTDA_Schedule.PDF)

#### 4.4.2 Non-Indigenous Cultural Heritage

For the Kahlua Pilot area a search of the Commonwealth register of National Estate sites found over 10 sites within the Gunnedah LGA (Santos 2010). While the search tool does not provide a specific location of each site, the majority of sites listed were most likely within town boundaries or Nature Reserves and National Parks. The proposed Kahlua Pilot area is not located within these locations.

The New South Wales Heritage Register for the Gunnedah LGA identified 1 item listed under the New South Wales *Heritage Act* and 29 items listed by Local Government and State agencies (Santos 2010). Like the National Register these items are usually located within town boundaries and therefore will be avoided during the proposed activities.

### 4.5 Flora and Fauna

The flora and fauna information presented below is based on an assessment completed for Santos by Alison Hunt and Associates Pty Ltd (AHA) and submitted as Appendix A of REF 1 (Santos 2010). The assessment was undertaken to describe the biodiversity values of the study area<sup>2</sup> in order to determine the likely potential impacts associated with the proposal using the framework provided by Part 5 of the EP&A Act, TSC Act, FM Act and Commonwealth EPBC Act and with reference to the *Threatened Species Assessment Guidelines: The Assessment of Significance* (DECC 2007) and *EPBC Act Policy Statement 1.1 – Significant Impact Guidelines: Matters of National Environmental Significance (MNES)* (DEH 2006).

For the assessment several tasks were undertaken by AHA including:

- A review of available literature and databases to assist with the identification of site values especially in relation to threatened species, populations and endangered ecological communities;
- Field investigations to ascertain the current site condition and the presence or likely presence of threatened or protected species;
- An impact assessment to determine the likely effects of the proposal on the ecology of the site with particular reference to threatened species, populations and / or ecological communities; and
- Preparation of preliminary recommendations to ameliorate and mitigate any impacts.

The NSW Department of Environment, Climate Change and Water (DECCW) Atlas of NSW Wildlife On-line database for records of threatened ecological communities, plants and animals together with the matters of conservation significance listed under the Environmental Protection and Biodiversity Conservation Act 1999 (Commonwealth) (EPBC Act) that are known or predicted to occur in the Kahlua Pilot area were searched based on a 20km radius around Kahlua 2 and therefore included any proposed location for the water storage facility within the Kahlua Pilot area.

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<sup>2</sup> For the flora and fauna assessment the sites plus access tracks are referred to as the 'study area'.

#### 4.5.1 Regional Vegetation

Native vegetation classes of the Western Slopes of NSW are characterised by *Western Slopes Grassy Woodlands* (also known as *Grassy White Box Woodlands*) on the fertile clay loam soils, *Western Slopes Grasslands* on alluvial outwash plains and deeply weathered basalt slopes with dark grey-brown clay soils and *Western Slopes Dry Sclerophyll Forests* which are found on shallow, sandy and infertile soils (Keith 2006). Four vegetation communities have been recorded within the Gunnedah local government area (LGA) (Gunnedah Shire Council 2005 / 2006) and these are:

*White Box Tall Woodland and Savannah Woodland* which is dominated by White Box (*Eucalyptus albens*) with co-dominant Yellow Box (*E. melliodora*), Blakely's Red Gum (*E. Blakelyi*) and Rough-barked Apple (*Angophora floribunda*). Other canopy species may include Silver-leaved Ironbark (*E. melanophloia*), Bimble Box (*E. populnea*) White Cypress Pine (*Callitris glaucophylla*) and Belah (*Casuarina cristata*). Grass species may include Red Grass (*Bothriochloa decipiens*), Windmill Grass (*Chloris truncate*) and Spear Grass (*Austrostipa scabra*). This community is found along the eastern boundary of the LGA.

*White Cypress Pine Tall Woodland and Shrub Woodland* which is widespread across the LGA is largely associated with soils derived from coarse sedimentary material. These communities vary from very poor scrubby woodland to considerable areas of millable timber. They are dominated by White Cypress Pine, with Narrow-leaved Ironbark (*E. crebra*), White Box, Yellow Box and Belah as co-dominants. Grasses also occur and these include Red Grass, Spear Grass and Barbed Wire Grass (*Cymbopogon refractus*).

*Yellow Box – White Box – Bimble Box Tall Woodland and Savannah Woodland* which occurs over large areas of the LGA has been extensively cleared for cropping and grazing. Dominant species vary with location with Bimble Box and Blakey's Red Gum occurring near stream channels. Other sub-dominants include Rough-barked Apple, Belah, Kurrajong (*Brachychiton populneus*), Wilga (*Geijera parviflora*) and Weeping Myall (*Acacia pendula*). Perennial and annual grasses occur in the understorey.

*Plains Grasses Dry Tussock Grassland* occurs on the black soil country which has been extensively cleared for cropping. Plains Grass (*Austrostipa aristiglumis*) is the dominant species which occurs in dense swards of plains grass with little or no competition from other species.

#### 4.5.2 Water Storage Site

The water storage site has been located in a modified environment that has been used for agricultural practices for over 50 years. Located adjacent to Kahlua 2 it will be located on the boundary of a paddock that is currently being cropped. Earthworks for the water storage tanks will be approximately 100 by 60 meters.

Access to the site has been constructed for the proposed activities (See Section 3.3).

#### 4.5.3 Fauna Habitat

The lack of structural diversity across the Kahlua Pilot area means that fauna habitat resources, such as trees, shrubs, rocky areas and fallen timber, are extremely limited and in general, habitat suitable for fauna would be limited to those common species of native and introduced fauna regularly found in disturbed areas, such as the Eastern Grey Kangaroo (*Macropus giganteus*), European Red Fox (*Vulpes vulpes*), Black Rat (*Rattus rattus*), House Mouse (*Mus musculus*), and domestic cats and dogs.

Species that forage over grasslands, such as birds of prey, may also frequent the area on occasion. Common bird species were recorded on the day (e.g. Galah (*Cacatua roseicapilla*) Australian Magpie (*Gymnorhina tibicen*) and Magpie Lark (*Grallina cyanoleuca*)).

Koala scats were also recorded under a paddock tree adjacent to Kahlua 3. The Koala is widely known from this area and is listed as a threatened species under the TSC Act. Habitat for reptiles is limited due to the absence of rocks and fallen timber, although there would be some habitat around and within the paddock trees and in adjacent areas.

Nearby farm dams would provide habitat for amphibians although it would be limited due to the lack of fringing vegetation and emergent aquatic vegetation.

#### 4.5.4 Commonwealth Environment Protection and Biodiversity Conservation Act 1999

Seven vegetation communities listed under the EPBC Act may occur in the locality (20 km radius) (Santos 2010). Of these only two have the potential to occur and these are White Box Yellow Box Blakely's Red Gum Woodland and Native Vegetation on Cracking Clay Soils on the Liverpool Plains, both of which are listed as Critically Endangered. The Kahlua pilot area is highly modified with the majority of the area comprising paddocks and consequently none of the EECs listed occur across the survey area (Santos 2010).

Predictive modelling indicates that 6 fauna, 4 flora and 7 migratory species listed under the EPBC Act have the potential to occur within the locality of the site (i.e. 20 km) and these are listed in REF 1 Appendix A Table 1 and Table 2 along with their likelihood of occurrence (Santos 2010). Those species for which potential habitat occurs include, Slender Darling-pea (*Swainsona murrayana*), Swift Parrot (*Lathamus discolor*), Superb Parrot (*Polytelis swainsonii*), Fork-tailed Swift (*Apus pacificus*), White-throated Needletail (*Hirundapus caudacutus*) and Greater Long-eared Bat (*Nyctophilus timoriensis*).

#### 4.5.5 NSW Threatened Species Conservation Act 1995

##### **Endangered Ecological Communities**

Fourteen (14) Endangered Ecological Communities (EEC) are listed under the TSC Act and as occurring within the Namoi CMA. Of these only three communities have the potential to occur and these are White Box Yellow Box Blakely's Red Gum Woodland, Fuzzy Box on alluvials of South West Slopes, Darling Riverine Plains and the Brigalow Belt South and Native Vegetation on Cracking Clay Soils on the Liverpool Plains. The Kahlua pilot area is highly modified with the majority of the area comprising paddocks and consequently none of the EECs listed occur across the study area (Santos 2010).

##### **Species**

A total of 21 threatened species listed under the TSC Act have been recorded within the locality and these are listed in REF 1 Appendix A Table 1 and Table 2, along with their likelihood of occurrence (Santos 2010). The survey area lacks the complexity required to provide habitat for a range of threatened species as pastures and crops generally have few refuge areas or foraging resources, especially for mammals and reptiles. The farm dams in adjacent areas lack habitat complexity and therefore provide few resources for waterbirds or amphibians. The fauna species most likely to use the area are those that are highly mobile and with large home ranges. Of these 21 species, 10 have the potential to forage across the site or occur in adjacent habitat.

Only one species was recorded on the day of assessment. Koala scats (*Phascolarctos cinereus*) were recorded under a paddock tree adjacent to the boundary of the Kahlua 3 drill site. The Koala is known from the Gunnedah LGA and a total of 129 records within a 20 km radius of the site are recorded on the DECCW database. It likely that Koala use the paddock trees and would move through the area during dispersal and during foraging (Santos 2010).

#### 4.5.6 RoTAP Species

Four *Rare or Threatened Australian Plants* (RoTAP) are listed as occurring within the Gunnedah LGA (Botanic Gardens Trust 2010). None of these species were recorded within the Kahlua Pilot area. All of these species are also listed as threatened under the TSC Act and hence those species for which habitat occurs have been considered under the TSC Act (Santos 2010).

#### 4.5.7 Declared Noxious Weeds

In NSW the identification, classification and control of noxious weeds is governed by the *Noxious Weeds Act 1993* (NW Act). Plants that have been declared as noxious weeds are classified into specific control classes in each Local Control Area. Those plants listed as Noxious Weeds for the Gunnedah LGA and that were recorded within the study area are listed in Table 4.1. It is likely that a number of other noxious weeds also occur within the Kahlua Pilot area but were not recorded on the day of assessment (Santos 2010).

Table 4.1: Noxious weeds recorded within the study area

| Botanic Name        | Common Name              | Noxious Weed Control Class |
|---------------------|--------------------------|----------------------------|
| Xanthium species    | Bathurst / Noogoora Burr | 4                          |
| Sclerolaena birchii | Galvanised Burr          | 4                          |
| Opuntia sp.         | Prickly Pear             | 4                          |
| Source: DPI 2010    |                          |                            |

The control requirements for:

**Class 4 - Locally Controlled Weeds:** Plants that pose a threat to primary production, the environment or human health, are widely distributed in an area to which the order applies and are likely to spread in the area or to another area. Legal requirements are that the growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local authority.

#### 4.5.8 Corridors and Connectivity

The Kahlua Pilot area is situated in an agricultural landscape and most of the adjacent lands have been cleared with only isolated pockets of remnant / regrowth bushland remaining within the broad valley area to the west of Gunnedah. In such landscapes, the road reserves and riparian vegetation provide important linear connections through the landscape. In this instance paddock trees are also important in providing stepping-stone habitat for the Koala and potentially for a number of bird species.

#### 4.5.9 SEPP 44 - Koala Habitat Protection

An assessment under *State Environment Planning Policy No. 44 – Koala Habitat Protection* (SEPP 44) is required as the Gunnedah LGA is listed under Schedule 1 of SEPP 44. This SEPP requires the identification and protection of core koala habitat within the LGA. Core Koala habitat means an area of land with a resident population of Koalas, evidenced by attributes such as breeding females (i.e. females with young) and recent sightings of and historical records of a population. Potential koala habitat means areas of native vegetation where the trees of the types listed in Schedule 2 of the Act, constitute at least 15% of the total number of trees in the upper or lower strata of the tree component.

The Gunnedah LGA is known for its extensive Koala population and the occurrence of Koala scats beneath a paddock tree would indicate that Koala are actively using the study area. Consequently the study area can be considered Core Koala Habitat and as such SEPP 44 requires that a site-specific individual Koala Plan of Management be prepared as Gunnedah Shire Council has not prepared a Core Koala Plan of Management for the LGA.

Notwithstanding the site evidence that Koala's are using the study area, no trees will be removed or fenced off during the proposed activities therefore and the Koala Management Plan which formed part of Stage 1 will be adhered to in Stage 2.

### 4.6 Protected Areas

No protected areas are located in the vicinity of the Kahlua Pilot and therefore will not be impacted by the proposed activities.

### 4.7 Geology

#### 4.7.1 Regional Geology

PEL 1 is located in the central portion of the Gunnedah Basin where Jurassic and Cretaceous Surat Basin sediments unconformably overlie Permo Triassic Gunnedah Basin sediments. The Gunnedah Basin, covers an area of more than 15,000 sq km and is defined in structural terms as being bounded to the east by the Hunter Mooki Thrust Fault System and the New England Fold Belt, and to the west by the Lachlan Fold Belt onto which the Gunnedah Basin sediments gradually onlap.

Metavolcanics, meta-sediments and minor ignimbritic volcanics of the Lachlan Fold Belt form much of the basement under the western part of western part of the Gunnedah Basin and the Rocky Glen Ridge. Widespread Late Carboniferous and Early Permian mafic lavas were succeeded by paralic-lacustrine environments with sediments of the Leard and Goonbri Formations deposited. This was followed by low energy fluvial conditions in which the coal measures of the Maules Creek Formation were deposited.

An Early Permian transgression then inundated the area and deposited shallow marine para-conglomerate, sandstone and siltstone of the Porcupine and lower Watermark Formations and culminating in the deposition of the upper Watermark Formation marine claystone.

The Black Jack Formation was deposited in a major delta system with a dominantly northeast sediment source from the New England region. A minor westerly provenance associated with the emergence of the Lachlan Fold Belt is also apparent. The New England provenance of the lower Black Jack Formation resulted in generally quartz lithic and arkosic sandstones with limited reservoir potential. The sandstones were deposited in a lower delta plain/marginal marine environment.

Deposition of the lower Black Jack Formation sediments was followed by an episode when marine conditions affected the Gunnedah Basin, with the deposition of sandstones of poor to fair reservoir quality. Deposition of the western derived quartzose sandstones was followed by very widespread coal swamp conditions depositing the thick Hoskissons Coal seam that is readily correlated across the Basin. The thickness of the Hoskissons Coal ranges from less than 1m in the west to more than 12m in the north and to 18m in the south-east.

Late Permian volcanic activity and tectonism to the east resulted in renewed deposition of more lithic sediments with an easterly provenance and consequently the upper Black Jack Formation has only limited potential for reservoir development. A period of tectonism, uplift and erosion of variable intensity throughout the Basin followed Late Permian deposition. The end of the Permian is marked by a major regional unconformity.

The Digby Formation is marked by a basal conglomerate that has been derived from the New England Fold Belt. This unit thickens towards the east and onlaps onto the older sediments and basement to the west. Reservoir quality is generally poor due to a tight sandstone matrix. Thick near-shore marine shales of the overlying Napperby Formation are considered a potential seal to any hydrocarbons reservoir in the Digby Formation.

A major period of uplift and erosion during the Late Triassic ended Gunnedah Basin deposition. Deposition of the Surat Basin sequence commenced during the Early Jurassic, preceded by lava flows, pyroclastics with intercalated claystones of the Garrawilla Volcanics (Nandewar Range). During the Tertiary period of tectonism, the Liverpool Ranges were formed by massive extrusions of basalts representing the last major depositional episode in PEL 1.

In the Triassic period, deposition of these alluvials continued forming beds of sandstones and mudstones. These outcrop in a belt which runs parallel to the Mooki and Goondiwindi fault regions, forming a non-marine wedge that was derived partly from the New England Tablelands.

Volcanic activity in the late Triassic or early Jurassic periods caused the eruption of basalts in the Mullaley district between Gunnedah and Coonabarabran. During the Tertiary period of tectonism, the Liverpool Ranges were formed by massive extrusions of basalts representing the last major depositional episode in PEL 1.

The present landscape is dominated by Quaternary sediments in the form of alluvial fans and outwash slopes that resemble the larger fans of the adjacent Darling Riverine Plains Bioregion to the west but are composed of coarser sediment and fan out at slightly steeper angles. The relative distribution of sediment from basalt or sandstone has a major impact on soil quality and vegetation.

The CSG bearing formations for the Gunnedah Project are the Permian coals of the Black Jack Group (Hoskissons Coal). The proposed Kahlua Single Well Pilot focuses on testing the Hoskissons Coal. The Hoskissons Coal is approximately 250 m and 325 m below ground in Kahlua.

Figure 4.4: Stratigraphy of the Gunnedah Basin

**Gunnedah Basin Lithostratigraphy**

| NEW STRATIGRAPHY<br>(Tadros 1993a, e; 1995 & herein) |        |                 |  |                   |                            |                                    | DEPOSITIONAL SYSTEMS<br>(modified from Tadros 1993b, Tadros & Hamilton 1991, Hamilton 1993a & herein) |  |
|--|--------|-----------------|--|-------------------|----------------------------|------------------------------------|---|--|
| PERIOD   |        | PALYNOLOGY ZONE | GROUP  | SUBGROUP          | FORMATION                  | MEMBER                             | SEAM  |  |
| TRIASSIC   | MIDDLE | PT2.2-PT3       |  |                   | GARRAWILLA VOLCANICS       |                                    |   | GARRAWILLA VOLCANICS                             |
|  |        |                 |  |                   | LEERIAH FORMATION          |                                    |   | NAPPERBY LACUSTRINE SYSTEM                       |
|  | EARLY  | PT1-PT2.1       |  |                   | DIGBY FORMATION            | ULINDA SANDSTONE                   |   |  |
|  |        |                 | BOMERA CONG.   |                   |                            |                                    |   |  |
| PERMIAN  | LATE   | PP5             | BLACK JACK GROUP   | NEA SUBGROUP      | TRINKEY FORMATION          | SPRINGFIELD C.M.                   | DOONA   | EASTERN FLUVIAL SYSTEM                           |
|  |        |                 |  |                   | WALLALA FORMATION          | CLIFT C.M.                         |   |  |
|  |        |                 |  | COOGAL SUBGROUP   | CLARE SANDSTONE            | BREEZA C.M.                        |   | LACUSTRINE & WESTERN FLUVIAL SYSTEMS             |
|  |        |                 |  |                   | STRALLEN SANDSTONE         | HOWES HILL C.M.                    |   | MONKING HILL GROUP SYSTEM                        |
|  |        |                 |  |                   | WARRILLA SANDSTONE         | CAROODA C.M.                       |   | ARKARILLA SPALLLOW MARINE SYSTEM                 |
|  | EARLY  | PP4.3           | MILLIE GROUP   | BROTHERS SUBGROUP | PAMBOOLA FORMATION         | MELVILLES C.M.                     | UPPER WATERMARK / LOWER BLACK JACK DELTA SYSTEMS  |  |
|  |        |                 |  |                   | WATERMARK FORMATION        |                                    |   |  |
|  |        |                 |  |                   | PORCUPINE FORMATION        |                                    | PORCUPINE-LOWER WATERMARK MARINE-SHELF SYSTEM   |  |
|  |        | PP3.2-PP3.3     | BELLATA GROUP  |                   | MAULES CREEK FORMATION     |                                    | BROWN   | LEARD-MAULES CREEK ALLUVIAL / LACUSTRINE SYSTEMS |
|  |        |                 |  |                   | GOCHBRI & LEARD FORMATIONS |                                    |   |  |
| PP2.1  |        |                 | BOGGABRI VOLCANICS, WERRIE BASALT, METAVOLCANICS & METASEDIMENTS |                   |                            | BOGGABRI VOLCANICS & WERRIE BASALT |   |  |

September 2007, GUNDAH 002a

### 4.7.2 Soils

The soils in the Gunnedah Shire are some of the most richly fertile in Australia. In 1976 they were categorised by the Department of Conservation and Management into six mapping units that are based on:

- surface cracking of the soil;
- soil texture;
- topography; and
- apparent erodability.

The six units, including the dominant soil types found within each, are summarised below.

## 1. Cracking Clay Soils

These are the dominant soils in the Gunnedah Shire.

The black earths, largely formed from the basaltic alluvium and colluvium derived from Werrie Basalt which outcrops to the east of Porcupine Lookout Ridge, are found primarily along the Mooki River. They have a uniformly textured profile of well structured clay, and vary in colour from a very dark grey (7.5 YR 3/1) and very dark brown (10 YR 2/2) to black (7.5 YR 2/1) when moist.

The surface soil comprises an organic matter layer (Ao) overlying the A1 horizon, which is a dark coloured, medium to light textured clay soil and has a depth of 2 to 10 centimetres. Its structure is crumb of fine block with a self mulching property. The A1 horizon graduates into a well structured medium to heavy clay B1 horizon with no apparent sign of the A2 horizon.

The B1 horizon shares a similar colour to the A1 and has a high degree of dense blocky aggregates in its structure. This graduates into the B2 horizon composed of yellowish-brown or grey-brown medium to heavy clay. The B2 horizon has a strong, coarse lenticular macrostructure with many large slickensides. The B3 graduates into colluvial and alluvial material at depth. The lower B1 and B2 horizons contain calcium carbonate nodules.

The black earths have a clay content of between 50 and 80 per cent. One of the prominent characteristics of this soil type is its extensive cracking during dry periods. This is due to a high volume of montmorillonite, an expanding lattice clay mineral which causes swelling and shrinkage on wetting and drying respectively.

The pH of these soils is neutral at the surface and becomes increasingly alkaline (pH 8 - 9) with depth. Fertility is naturally high although responses to some applied nutrients, especially nitrogen and zinc, can be expected after cropping.

In virgin black earths, well developed gilgais, with a vertical of 10-30 centimetres are associated with deeper soils. Gilgais occur in two distinct patterns depending on the topographical position:

- On gentle colluvial slopes of linear forms with a wavelength commonly in the range of 5 to 7 metres.
- On the broad near level plains taking the form of mounds crudely circular in plan, and varying from two to several metres in width.

This mapping unit also includes the red, brown and grey cracking clays. These have similar characteristics to the black earths but are not associated with gilgai formation.

## 2. Clay and Loam Soils

The loam textured soils are primarily associated with the Rangari Creek floodplain, while the clay soils have been formed along the Namoi River floodplain.

The clay soils appear to have a similar structure to the black earths and cracking clays, the difference being a thin band of recent alluvium on the surface which is subject to seasonal cracking. These soils graduate from black earths (heavy clays) next to the river, to brown medium to light clays along the perimeter of the floodplain.

The medium clay soils have weakly differentiated profiles and differ in colour from dark brown (7.5 YR 3/2 moist) to very dark brown (10 YR 2/2 moist). The A1 horizon consists of an earthy fabric with rounded peds and varies in depth from 5 to 20 centimetres according to the topography. The B horizon has an angular blocky structure with shiny smooth faced peds and ranges from medium to heavy clay with depth.

These soils have a medium to high level of fertility responding under various conditions to applications of phosphorus, sulphur and nitrogen. The surface pH of both soils are neutral, increasing with depth.

Some of these clays have a shrink-swell capacity ranging from 16.8 to 21.2 percent.

### 3. Duplex and 'Gravelly' Soils

The gravelly red brown earths form the dominant soil type in and around Gunnedah and are associated with the mesozoic sedimentary and volcanic rocks of the ridge systems in the Wean, Kelvin and Tambar Springs areas of the Shire.

They are characterised by a dark grey to brown (7.5 YR 4/1 to 7.5 YR 5/2 moist) sandy loam to loam A horizon, graduating into a reddish brown (5 YR 5/6 moist) clay B horizon, with gravel being present throughout the profile. Depending on topography, the A horizon varies in depth from 10 to 50 centimetres, and has a weak crumb to block structure which is hard when dry. The boundary between the A and B horizons is very clear and abrupt.

The B horizon varies in texture from medium clay along the ridges to a heavy, reddish brown clay to the east of Gunnedah. Its structure ranges from strong prismatic to block in the upper 15 centimetres to blocky as depth increases. Clay skins are well developed and peds separate easily. Carbonate nodules are present throughout.

These soils are very poor in terms of fertility and are of lesser value due to their porosity and high leaching qualities. They are likely to be deficient in phosphorus, nitrogen, sulphur and some trace elements. The pH ranges from mildly acid at the surface (pH 6 to 6.5) to alkaline at depth (pH 8 to 8.5).

They have a low to medium shrink-swell capacity ranging from 10 per cent at the surface to 11.2 per cent at 50 centimetres, 13.6 per cent at 100 centimetres and 16.4 per cent at 200 centimetres.

### 4. Clay Loams with Red Clay Subsoils

These soils are found around Gunnedah and to the west of the central ridge system with the major soil type being the Euchrozems.

Characteristically, the Euchrozem's colour graduates from red to reddish-brown and brown (2.5 YR 4/6 to 5 YR 4/4 to 7.5 YR 5/2 moist) and grades from a clay loam or light clay into a medium to heavy textured clay soil at depth. The A1 horizon is self mulching with a depth of 15 centimetres. The structure of the A1 changes from a weak to strong crumb structure at the surface to a fine to medium blocky structure at depth. The boundary between the A1 and B1 horizons is gradual with no evidence of an A2 horizon. The B2 horizon is more blocky in structure with smooth faced, dense peds. When moist the soil is moderately friable but becomes hard when dry. The B2 horizon is much larger than the B1 and often consists of gravelly clay. Some calcium carbonate nodules are evident in the B horizon.

The pH ranges from 6.5 at the surface to 7.8 to 8 at depth while the shrink-swell capacity is low to moderate ranging from about 11 per cent at the surface to 16 per cent at a depth of 1 metre.

### 5. Highly Erodible - Hard Setting Soils

These soils have been formed on Mandowa Mudstones, Lower Carboniferous, Baldwin and Caroda Formations North and West of the Keepit Catchment.

Their high degree of erodability is due to a slightly dispersible A2/B1 horizon. Where undisturbed, the A1 horizon is dark grey-brown to red-brown in colour varying from loamy sands to clay loams with a weak to blocky structure. These soils set hard

when dry and become moderately friable when moist. However the A1 is often eroded away leaving an exposed A2 or B1 horizon as the surface.

The Non-Calcic Brown Soils have no A2 horizon with the boundary between the A1 and B horizons being very distinct.

In the Red-Brown earths the A2 horizon is only weakly developed. The B horizon consists of a reddish brown to red clay having a moderate to strong blocky structure, often with a shiny smooth-faced ped fabric.

#### 6. Skeletal Soils

These soils are primarily found along the ridge crests and the steeper slopes with the major soil type being Lithosols. They contain large amounts of parent rock material and are usually very stony with soil depth ranging from 2 to 20 centimetres.

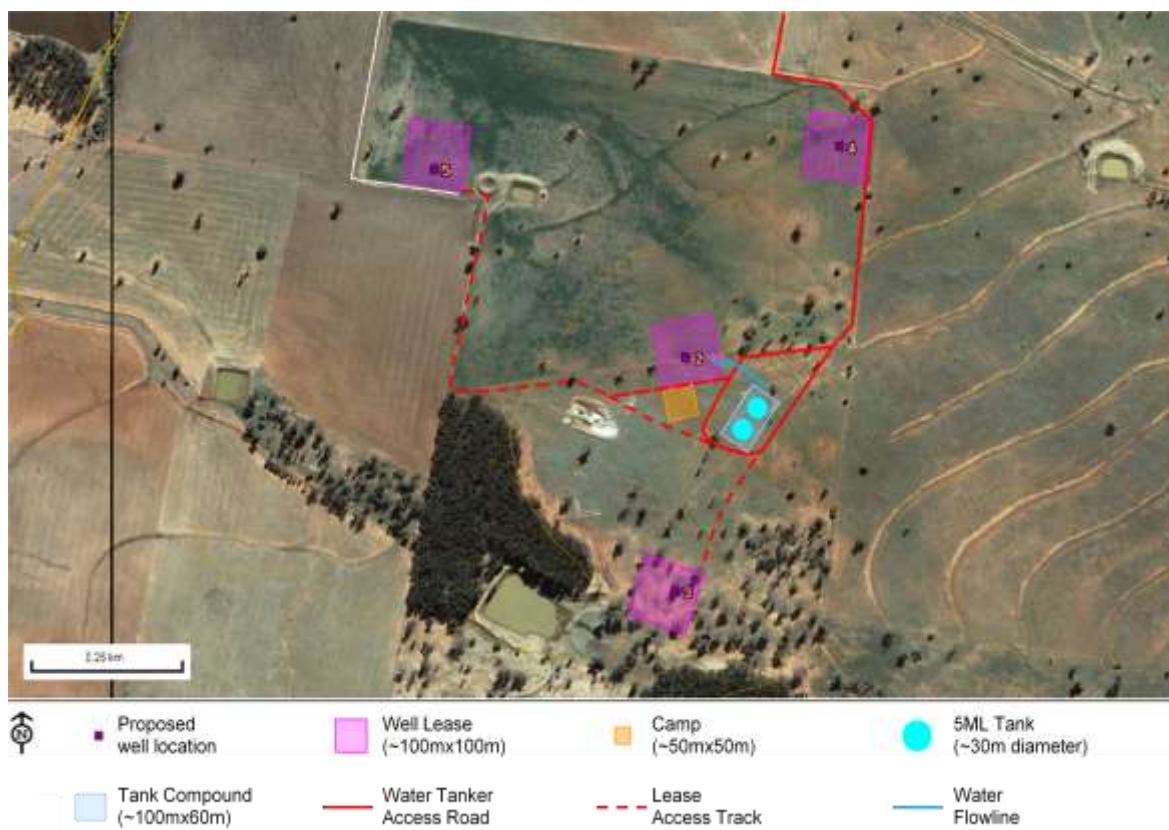
The soils at the proposed water storage site are likely to a combination of some or all-common soil types.

## 4.8 Topography

The Gunnedah Shire is situated 264 metres above sea level on the Liverpool Plain in the Namoi River Valley. The predominant topographical features are level flood plains of the Namoi and Mooki Rivers and Cox's Creek with 85% of the Shire having a land slope of less than 3 degrees. These plains are in long corridors that range from 15 to 40 kilometres across before the landform becomes slightly undulating. Three residual hill ridge systems rise from 300 to 500 metres above sea level but land slopes of greater than 15 degrees are found on only 1% of the Shire area.

Figure 4.5 shows the local topography of the Kahlua 2 site and the water storage facilities and truck loading area.

Figure 4.5: Kahlua Pilot Site Topography



## 4.9 Water Resources

### 4.9.1 Groundwater

Ground water in the Namoi catchment supports an irrigation industry worth in excess of \$380m as well as being the water supply for many towns and intensive industries such as feedlots. There are a total of 700 licence holders in the Namoi (NCMA 2010).

The groundwater sources include all water contained in the unconsolidated alluvial sediment aquifers associated with the Namoi River and its tributaries. Deep bores in the lower Namoi access the Great Artesian Basin water source (NCMA 2010).

It is expected that groundwater at the Kahlua pilot well sites and within surrounding areas will consist of both alluvial and hard rock aquifers. Alluvial aquifers are generally those that are closer to the surface and associated with more porous soil and unconsolidated rock materials. Depending on the topography and climate, they may be connected to surface water features and transmit waters to or receive waters from them. Alternatively, a hard rock aquifer is an aquifer where groundwater is stored and flows through very small (relatively) joints, pores, or fractures in bedrock. They generally yield less water than (alluvial) aquifers but in some cases may provide high yielding bores.

### 4.9.2 Hydrogeology

Golder Associates prepared the *Groundwater Impact Study – Kahlua Pilot Test* (full report is located in Appendix A) that details the hydrogeological setting of the Kahlua pilot test areas.

In summary, the hydrogeological setting for the Kahlua Pilot location is situated on an outcrop of the Gunnedah Basin. The Napperby Formation and Black Jack Group are hydrogeological systems of the area although both are considered to be poor aquifers. Little yield information and few water levels are available for the Napperby Formation or Black Jack Group around Kahlua.

The Narrabri and Gunnedah Formations are present to the west of the Kahlua sites, within Coxon Creek Valley and can be up to 140 m thick in the palaeochannel that lies to the west of the current river location.

The direction of groundwater flow in the Narrabri and Gunnedah Formations is north-northeast towards the Mooki River. The water table is very shallow in the area, near surface. A few bores are completed within the Black Jack Group and have water level between 10 and 16 m below ground level. The aquifers of the Black Jack Group are low yielding in this area and contain poor quality water with respect to the alluvial formations.

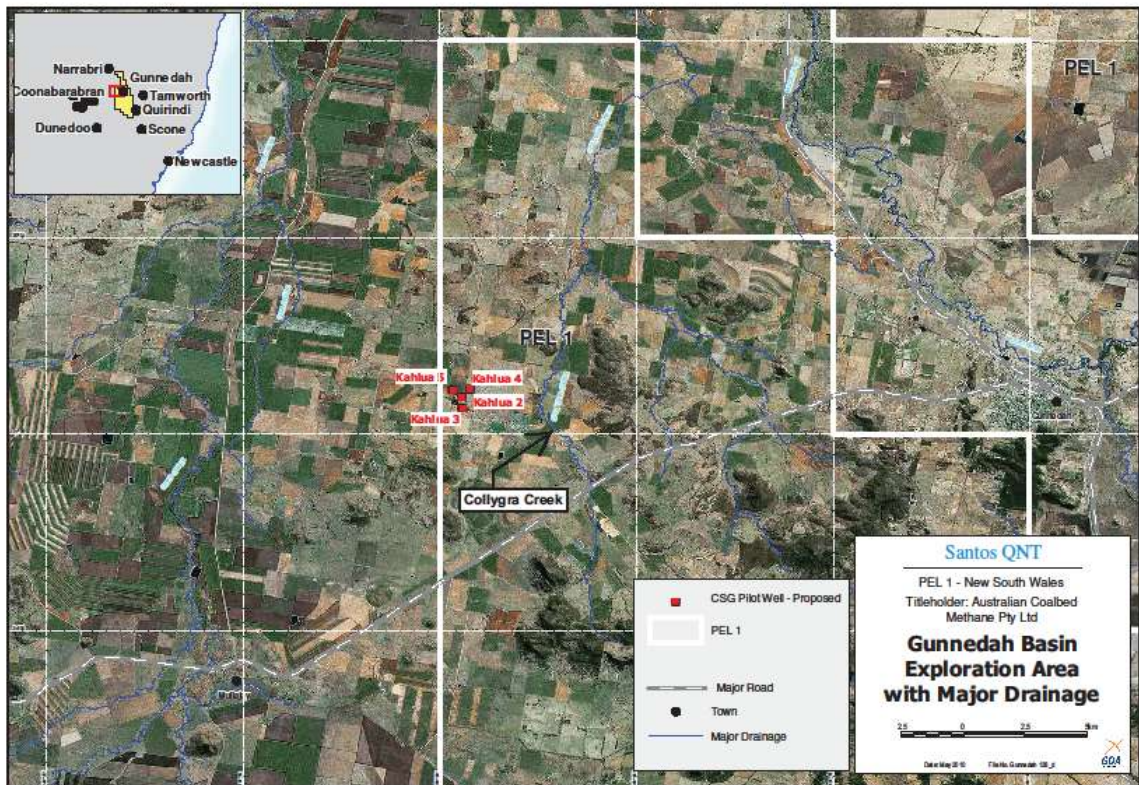
### 4.9.3 Surface Water

The permit PEL 1 overlies the Namoi catchment management area. The Namoi Catchment in northwest NSW is bounded by the Great Dividing Range in the east, the Liverpool Ranges and Warrumbungle Ranges in the south, and the Nandewar Ranges and Mt. 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 upstream of Boggabri. Stretching from Woolbrook in the east to Walgett on the western boundary the catchment is over 350 kilometres long (NCMA 2010).

The Kahlua Pilot area is located within the Mid Catchment Area – Bluevale sub-catchment. The Bluevale sub-catchment is located within the Liverpool Plains between Gunnedah and Boggabri. It covers an area of 1247km<sup>2</sup> and has elevations ranging from 886m on top of the Kelvin Hills to 240m ASL near Boggabri (NCMA 2010).

The Bluevale sub-catchment is dissected by the Namoi River. Main tributaries include Driggle Draggie Creek and Barbers Lagoon, north east of the Namoi River and Coochoonah, Collygra and Native Cat creeks and Deadmans Gully to the southeast (NCMA 2010). Collygra Creek is located 3km east of the proposed Kahlua Pilot (See Figure 4.6).

Figure 4.6: Major Surface Drainage



## 5 Environmental Impacts and Mitigation Measures

### 5.1 General

The following section addresses the potential and actual impacts of Santos' proposed operations in relation to this REF (see Section 3.3). As the proposed activities to be completed at Kahlua 3, 4 and 5 for the single well pilot involves remote monitoring no potential impacts are likely at these sites.

#### 5.1.1 EHSMS

Santos' EHSMS governs the methodology in which Santos conducts its business with regard to Safety and the Environment. There are 14 standards relevant to the Environment describing how the company will conduct its activities considering relevant legislation and industry best practice.

The activities will be undertaken in accordance with Santos' Environmental, Health and Safety Management System (EHSMS), the Australian Petroleum Production and Exploration Association Code of Environmental Practice – October 2008 (APPEA 2008) and the Schedule of Onshore Petroleum Exploration and Production Safety Requirements (DPI, 1992).

#### 5.1.2 Risk Assessment

A risk assessment was carried out to identify the potential environmental impacts associated with the proposed activities. Santos' Risk Matrix (see Appendix B) was used to determine the risk rating for each of the environmental elements identified as potentially being impacted. The risk ratings were determined prior to applying mitigation strategies and safeguards and then after considering measures to reduce risk. The unmitigated risk rating and residual risk ratings are both provided and ranged from a 1-3, which means that the risk identified can be managed through routine monitoring and procedures.

Table 5.1 shows the risk matrix including the management controls and performance management indicators that will be utilised by Santos during the drilling activities. The focus of environmental management is to avoid where possible, then minimise and mitigate any impacts.

## 5.2 Air Emissions

### 5.2.1 Existing Environment

The existing air quality is typical of a rural area with the majority of air emissions and pollutants arising from existing rural activities, namely:

- Stock grazing;
- Land clearing and soil preparation;
- Sowing and harvesting of crops;
- Vehicle and heavy machinery movements; and
- Bushfires and burn-offs.

## 5.2.2 Potential Impacts

The proposed activity has the potential to introduce additional air emissions arising from sources including:

- Vehicle movements to and from the sites; or
- Construction and rehabilitation of the proposed access tracks and well lease; or
- Testing of the well; or
- Operation of plant (such as temporary power generation); or
- Flaring of gas.

The air emissions are dust and greenhouse gases.

### 5.2.2.1 Dust

The dust generated by the mobilisation of the drilling and ancillary equipment travelling to and from a location will vary depending on road and weather conditions.

The Kahlua site has a bitumen road to the property entrance. The rig mobilisation, consisting up to 30 trailer loads, may require additional preparation of access ways to facilitate the safe entry of the drilling rig. Damage to any access roads will be repaired as soon as possible after occurrence to minimise any impact on the landholder or the public. It is not expected to have any significant impacts on roadside vegetation.

Internal roads on the property will be well-compacted roads therefore dust will not be a significant issue unless in extremely dry conditions. Due to the close proximity of the drill holes rig movements are minimised, decreasing dust generation. Where required dust suppression using a water cart will be used to reduce dust generation. Speed limits on rig traffic will be imposed to minimise dust when travelling on access roads within the Kahlua property. See Figure 4.3 for access road and lease layout.

Liaison with local homesteads that may be affected by rig traffic will take place, informing occupants of possible high traffic periods (i.e. during transport of the rig and equipment).

Santos will notify the Gunnedah Shire Council of the proposed start time of exploration drilling prior to its commencement and will liaise with the appropriate Council representatives should any repairs to Council roads be necessary.

### 5.2.2.2 Greenhouse Gasses

Operation of diesel fuelled vehicles and machinery will occur for the duration of the proposed activities (See Section 3.3). Accordingly there will be minimal emissions associated with the activities and they are not expected to impact on air quality or be a major contributor of greenhouse gases.

Gas bearing formations are targeted by the activities and the six day single well test may produce a small amount of gas with the incidental water. A number of safety precautions and contingencies including flaring of gas are therefore incorporated into the testing program in order to minimise any risk to personnel or plant on the site.

A gas water separator together with an appropriately sized and located flare will be installed prior to the commencement of testing operations. Any gas encountered during testing is automatically directed to the flare by a pressure control valve, where an ignition source will safely burn/flare the gas.

### 5.2.3 Mitigation Measures

To minimise impacts on air quality the following actions will be undertaken:

- Existing access tracks will be used.
- Minimise land disturbance for the water storage facilities area.
- Cover or stabilise any stockpiles.
- Water trafficked areas that produce dust if required.
- Speed restrictions will be enforced on internal site access tracks.
- Gas will be flared as a safety precaution during testing activities.

### 5.2.4 Residual Risk

Due to the air emission being proposed will be generated as a result of the petroleum activities being similar to the typical rural activities the likely impacts on air quality in the vicinity of the proposed site is negligible.

## 5.3 Community, Social and Economic

### 5.3.1 Existing Environment

The catchment has been used extensively for agricultural activities since the early 1800s. The main agricultural activities include sheep, beef cattle and grain crops. The particular area of the proposed drilling activities is largely rural. There is also number of coal mine operations within the broad region.

Santos has entered into a Land Access Agreement with the landowner in respect to land access conditions, compensation, rehabilitation and other matters as required under the *Petroleum (Onshore) Act 1991*. Consultation has involved the conducting of various land enquiries and meetings with the landowners in question. Further regular contact with landholders will be made as necessary. Other matters such as air quality, weeds, water, and noise are addressed in sections 5.2, 5.6 and 5.3.

The landscape in the region is dominated by broad views of rural properties, with scattered pastoral infrastructure such as bores, tanks, dams, fences, roads, homesteads and other buildings.

Water carting will occur using by 40,000L B-Double trucks between the Kahlua Pilot area and the local mine site for reuse. A maximum of five truck movements will be required per day, with trucking expected to occur during daylight hours, Monday to Saturday. Wherever possible, truck movements will be scheduled outside of school bus pick-up / drop-off hours and locations. The planned route does not take the heavy vehicles through town to get between sites.

### 5.3.2 Potential Impacts

The immediate landholder will experience the majority of potential social and economic impacts, as the largest disturbance will be on their property.

The potential direct impacts include disturbance to current farming activities, livestock, increased heavy vehicles or indirect impacts such as a result of a bushfire that may impact on pasture, farm assets, people as well as native flora, fauna and stock.

Most of the potential economic impacts are anticipated to be positive for the Gunnedah area including increased economic and employment opportunities within the Gunnedah Shire Council Area.

The visual impacts will include the work over rig onsite with associated shacks and vehicles (See Figure 3-2). Impacts will be temporary and insignificant and all rig equipment will be removed at the completion of the monitoring equipment installation program. The surface facilities at each well site and water management facility will remain on site for use as required during the Concept Plan Stage 3.

The hours of operation during testing will be on a 24 hour a day basis. The water carting activities will occur during the day Monday to Saturday.

The activities are temporary and will not have any long-term impact on the visual amenity of the area. The period of the activities to be undertaken will be up to 60 days or once 10 ML of incidental water is produced on site (see Section 3.3).

### 5.3.3 Mitigation Measures

To minimise impacts on landholders the following actions will be undertaken:

- Prior to the commencement of testing activities, the landholder is provided with a notice of the planned activities. The notification will also include immediate neighbours of the land on which the activities are to take place. Reasonable requests by landholders for rescheduling of activities will be considered.
- Ongoing contact will be maintained with the landholder to ensure that any concerns are immediately addressed.
- Internal access roads will be maintained in a condition satisfactory to the DII and Landholders until restoration of the area is completed.
- All sites are adequately fenced with a lockable gate and signs warning of potential danger of unauthorised access.
- Where possible, trucking is to occur during daylight hours, Monday to Saturday and will be scheduled outside of school bus pick-up / drop-off hours and locations.
- All sites have a cleared buffer outside the lease area to maintain an effective barrier against bushfires.
- The flare pit will be kept free of grass and leaf litter.
- A fire control water pump and hoses on site will be maintained.
- Liaison will occur with the local rural fire service officer.
- Fires on the surface of the land will be prohibited at the site.
- Hot work (e.g. welding) specific procedures will be in place.
- The area of land disturbance will be minimised subject to safety constraints.
- Santos will implement policies for local hiring and procurement of goods whenever possible to maximise local benefits.
- Sites will be kept in a neat and tidy state at all times.
- The site is not located near any tourist sites.

### 5.3.4 Residual Risk

With the implementation of the mitigations measures the likely impacts on the landholder and local community is negligible.

The activities are temporary and the area to be used is small relative to the surrounding agricultural area. Once the activities are completed and no longer required for assessment the disturbed land will be reinstated to that of the surrounding environment in agreement with the landholder.

There is a risk that the visual impact of the work over rig on site will not be acceptable to all stakeholders in the area, however the Kahlua 2 pilot site is not

located near any tourist sites, are largely out of site of neighbouring landholders, and the activities are of a temporary nature therefore the residual risk of visual impact is negligible.

## 5.4 Cultural Heritage

### 5.4.1 Existing Environment

The land where the proposed activities will be carried out has been previously disturbed and cleared. A search of the DECCW AHIMS database for the general area of the proposed drilling has been made (Santos 2010). No Aboriginal objects or places are recorded in close proximity (within 1km) of the proposed Kahlua Pilot area.

### 5.4.2 Potential Impacts

The potential impacts on cultural heritage include only the disturbance of unrecorded artefacts or sites.

### 5.4.3 Mitigation Measures

To minimise any potential impacts the following management measures will be implemented:

- Personnel, vehicles and equipment shall be restricted to designated work areas and access tracks.
- Aboriginal heritage issues and the potential for discovery of sites shall be covered in site inductions.

If a site is discovered during site preparation works, the following procedure shall be implemented:

**Step 1** Cease immediately all activities that could in any way interfere with or disturb the discovered site and/ or object.

**Step 2** Promptly report discovery to the Team Leader Cultural Heritage, the Cultural Heritage Coordinator or the Cultural Heritage Field Supervisor.

Santos Cultural Heritage personnel will advise of appropriate action to be followed in order for surface disturbance activities to recommence.

The discovery of cultural heritage on the site is recorded by Santos using the Discovery of Cultural Heritage Site Form.

### 5.4.4 Residual Risk

Based on the location of the proposed activities in a highly disturbed area, no impacts are expected on Aboriginal Cultural Heritage.

Due to the high level of disturbance over tens of years at the Kahlua property the likelihood of finding an in tact artefact or site in this area is remote.

## 5.5 Flora and Fauna

### 5.5.1 Existing Environment

With the exception of the construction of the water storage facilities, the proposed activities will be located on land that has been previously cleared for petroleum activities.

The water storage facilities area is located on land that has been previously cleared for rural activities and no native vegetation will be removed during construction.

### 5.5.2 Potential Impacts

The potential impacts on flora and fauna as a result of activities undertaken are:

- Direct Impacts:
  - Spread of weed seed and pest animals due to vehicle and equipment movement; or
  - Fauna mortality due to vehicle strike; or
- Indirect Impacts:
  - Noise impacts to fauna from the testing activities and fixed or mobile plant; or
  - Reduction in vegetation productivity due to dust deposition on leaves.

Santos concluded in REF 1 that an assessment under the NSW EP&A Act, including those species, populations and communities listed under the TSC Act that significant impacts are unlikely and that a Species Impact Statement is not required (Santos 2010). Similarly, it was concluded that MNES listed under the Commonwealth EPBC Act would not be significantly impacted and consequently it is unlikely to be considered a controlled action (Santos 2010).

The impacts of the proposed activities on flora and fauna are minor and temporary. The project would involve a period of testing of 60 days or less depending on the incidental water production (see Section 3.3). The footprint of the project would fall entirely within the existing Kahlua Pilot petroleum leases or cleared grazing lands (water storage facilities area) and would avoid the removal of any trees (See Figure 4.3).

Evidence of Koalas using the site area was made during the ecological assessment. However as there will be no tree removal or fencing off of eucalyptus trees during the proposed activities no site specific Koala Management Plan has been prepared for Stage 2.

There is a potential for the introduction of a new weed and pest species to the site via the movement of vehicles and plant. However as the movements will be on an existing road network this impact is assessed to be low.

### 5.5.3 Mitigation Measures

To minimise the potential impacts on fauna and flora the following actions will be implemented:

- Use previously disturbed areas for the water management facilities.
- All machinery operators and other on-site personal to attend an "Ice-breaker".
- The works area for the water management facilities (namely tank storage) should be surveyed and pegged to ensure that machinery remains in the designated works zone.
- Vehicle numbers and speed would be strictly limited to as required reduce the risk of fauna injuries.
- All Kahlua Pilot sites will remain fenced with temporary stock-proof fencing.
- General rubbish would be collected and removed off site to prevent it entering the waterway and causing harm to fauna.

- All vehicles coming from declared weed infested to non-declared weed areas are required to utilise vehicle washing facilities or any temporary washing facilities established for this purpose.
- All vehicle movements are restricted to defined areas agreed upon with the Landholder/s.
- Land disturbance is to be minimised to prevent the germination of weed seeds that may already exist in the soil.
- If a declared weed or weed of concern is discovered, it shall be monitored to ensure it does not spread from the area of infestation.
- All land disturbed by Santos is to be returned to a condition consistent with the adjacent area or to landholder requirements at the end of the rehabilitation process.

#### 5.5.4 Residual Risk

The minor and temporary nature of land disturbance from the proposal means that any impacts on flora and fauna are temporary and minor and will be managed to protect current values.

Santos has previously completed an assessment under the NSW EP&A Act, including those species, populations and communities listed under the TSC Act concluded that significant impacts are unlikely and that a Species Impact Statement is not required (Santos 2010). Similarly, it was concluded that MNES listed under the Commonwealth EPBC Act would not be significantly impacted and consequently it is unlikely to be considered a controlled action (Santos 2010).

Potential impacts on fauna exist in the form of interruption of Koala movement corridors, however as there will be no further clearing of trees for the proposed activities and the time for the testing will be 60 days or less (see Section 3.3) it is unlikely that fauna movement will be interrupted. It is not expected that there will be any long term impacts on flora.

The potential for the introduction of a new weed and pest species to the site via the entry of vehicles and plant is low. The need for washing and/or brushing down of the drilling rig, support vehicles and ancillary equipment will depend on the location from which the drilling contractor and other equipment will mobilise from.

## 5.6 Noise Emissions

### 5.6.1 Existing Environment

The existing background noise environment is typical of a rural area, with low levels of background noise dominated by natural sources (e.g. wind, animals and insects) and intermittent noise from vehicular traffic and agricultural activities.

The closest occupied residence to the proposed Kahlua Pilot are 1.1 km southwest of Kahlua 3, 1.3 km north and 2.1 km west Kahlua 5.

The environmental values adopted for the project are:

- The protection or enhancement of an environment conducive to the wellbeing of an individual, including the individual's opportunity to have sleep, relaxation and conversation without unreasonable interference from intrusive noise; and
- The protection or enhancement of an environment conducive to the wellbeing of the community or a part of the community, including its social and economic amenity.

## 5.6.2 Potential Impacts

The potential impacts as a result of activities undertaken are:

- Increased noise levels at sensitive receptors from additional noise sources including pump generators or intermittent noise sources such as vehicle and equipment movements, tank construction or earthworks.
- During the installation of the water tanks there will be intermittent noise from the use of rattle guns that is expected to be 85-90dB.

The duration of any noise impacts will be limited to the period that the activities are carried out (see Section 3.3).

## 5.6.3 Mitigation Measures

To minimise the potential impacts on noise the following actions will be implemented:

- Landholder notification will be given prior to commencement of activities;
- Appropriately informing potentially affected residences and other relevant parties in advance of any activities and providing those people with updated information as required;
- Equipment will be maintained so that noise levels remain constant;
- Complaints will be responded to in a timely manner;
- Noise monitoring may be undertaken on receipt of a non-vexatious complaint; and
- Where noise disturbance cannot be avoided, Santos will investigate alternative arrangements to suit the landholder.

## 5.6.4 Residual Risk

Potential impacts associated with noise are a function of the noise levels of sources, the dimensions of sources, distance to receptors, terrain and cover, topographic and climatic conditions, and the characteristics of the receptors.

An environmental indicator that will be utilised by Santos to determine whether noise objectives have been maintained is complaints, since maintenance of amenity is effectively the overriding objective.

The equipment used for the mobilisation and powering of the work over rig have mufflers installed on their respective power plants and prime movers. The proposed activities are located more than 1 km from the nearest residence, combined with the muffling of generators and the short term nature of the testing activity, operations are unlikely to create any significant noise impacts for neighbouring residents.

Through previous monitoring of Santos testing activities there is an understanding of the noise impact on the surrounding sensitive receptors. All sites are further than 1 km from the nearest landholder except the Kahlua homestead that is, and will remain unoccupied. Therefore it is unlikely that noise from the activities will impact the nearest sensitive receptor and thus the residual risk is negligible.

## 5.7 Soils, Land-Use and Terrain

### 5.7.1 Existing Environment

Land stability and erosion hazard is a function of soil type, topography, vegetative cover, rainfall intensity, and soil disturbance.

The soils in the vicinity of the sites are a valuable resource to the existing pastoral or agricultural interests of the landholder.

The proposed activities will involve earthworks within a defined footprint for the installation of temporary and/or permanent access tracks, workers accommodation camp and well leases.

The area is rural and there would be a variety of chemicals that could be stored and used through out the region. The drilling activities require the use of many chemicals and other hazardous substances (namely fuel). These goods will be transported and store on site for use.

### 5.7.2 Potential Impacts

The potential impacts as a result of activities undertaken are:

- Increase in the erosion potential of the land in areas that are subject to clearing or disturbance during the site establishment activities; or
- Increase in turbidity and suspended loads of waters through the erosion of sediments disturbed by the proposed activities; or
- Land contamination from hydrocarbon spillage (mainly lube oils and diesel fuel spills) from vehicles and mobile plant and equipment, storage and handling of fuels and chemicals; or access track or lease establishment activities may result in mobilisation of such contaminants off-site or increase the level of exposure of contaminants to workers; or
- The drilling activities will involve the generation of drilling fluids and waste oil and chemicals associated with these activities.

These impacts are limited to the area of disturbance required by the activities that are to be carried out (see Section 3.3).

### 5.7.3 Mitigation Measures

To minimise the potential impacts on soils and landuse the following actions will be implemented:

- All land disturbance activities will be discussed and agreed with the Landholder prior to commencement.
- Restricting the area to be disturbed to the minimum required for safe operations.
- The area of all disturbances will be determined and placed within Santos' Geographic Information System (GIS).
- Stockpiling top soil separately from other spoil so that it can be used in restoration activities.
- Erosion and sediment control structures are placed to minimise erosion of disturbed areas and prevent the contamination of land and waters.
- Implement an inspection and maintenance program for the erosion and sediment control features when installed.
- Return of natural/previous land contours.

- Reseeding if required in consultation with landholders.
- Removal of all imported spoil material.

To minimise the potential impacts of chemical and hazardous substances the following actions will be implemented:

- The amount of hazardous material stored and used on site shall be kept to the minimum practicable for the activities.
- Hazardous materials shall be transported, stored and handled in accordance with the requirements of relevant legislation (e.g. Road and Rail Transport (Dangerous Goods) Act 1997, Australian Dangerous Goods Code) and Australian Standard 1940.
- Fuels, lubricants and chemicals shall be stored and handled within containment areas (such as portable bunding) that are designed to prevent the release of spilt substances to the immediate neighbouring environment.
- A spill kit appropriate to operations of this size will be available at site.
- Material Safety Data Sheets and handling procedures for hazardous chemicals and materials shall be kept on site.

Spill response measures will include:

- Personnel shall be advised of the location and use of the spill containment equipment in the site induction.
- Spills or leaks shall be immediately reported to the senior Santos representative onsite and clean up actions initiated.
- In the event of a spill, the material shall be contained to the smallest area practicable.
- Spilt material and contaminated soils shall be treated on site with landholder acceptance or removed off-site for disposal at an appropriately licensed facility, as determined in consultation with DECCW and DPI-MR.
- Spills shall be reported in accordance with regulatory and licensing requirements. There is a duty to notify the appropriate regulatory authority (broadly, the DECCW or the local council) of pollution incidents where material harm to the environment is caused or threatened (see Section 2.1 for definition of material harm).

The information about a pollution incident required to be included in a notification consists of:

- The time, date, nature, duration and location of the incident.
- The nature, the estimated quantity or volume and the concentration of any pollutants involved.
- The circumstances in which the incident occurred (including the cause of the incident, if known).
- The action taken or proposed to be taken to deal with the incident and any resulting pollution or threatened pollution.
- Other information prescribed by the regulations.

#### 5.7.4 Residual Risk

Soil disturbance is necessary as a level pad is required for the water storage tanks. This will require topsoil to be removed and stockpiled for replacement during site rehabilitation. The area to be disturbed for the water storage tanks will be approximately 100 by 60 metres.

If imported material is required for the hard-stand area, it will be sourced from the local area and if required, permission will be obtained from the landholder prior to this being undertaken.

The proposed site has been previously disturbed by rural activities therefore the likely impact on the existing soils and land useability is considered low. Based on the current agricultural activities and previous restoration of sites in the area, the residual risk is negligible for ongoing erosion and land degradability beyond reinstatement of the site.

With the implementation of the mitigations measures the likely impacts of chemical and hazardous substances on land is negligible.

## 5.8 Waste

### 5.8.1 Existing Environment

Currently there is no waste disposal facility at the proposed sites.

The worksite will require the provision of systems for the management of sewage wastes. Personnel numbers can reach up to 10 during construction of surface facilities.

All industrial solid wastes created during operations will be collected in designated skips for eventual disposal to an appropriately licensed facility.

Topsoil will be respread over restored surfaces at final abandonment of the site to encourage revegetation of disturbed surfaces.

### 5.8.2 Potential Impacts

Potential beneficial uses of waste generated by activities include:

- Opportunity for reuse or recycling of valuable materials, compounds, and constituents that may otherwise become wastes and thereby be disposed of without obtaining maximum benefit from reuse or recycling. An example is scrap metal.

Potential adverse impacts of waste generated by activities include:

- Land or surface water pollution caused by release or spills of solid or liquid waste either directly to land or surface waters, or indirectly via storm water runoff to receiving waters from waste contaminated sites; or
- Groundwater contamination caused by release or spills of solid or liquid waste to land and subsequent transport of mobile or soluble waste constituents to the groundwater resource
- Littering caused by lack of suitable containment measures for general rubbish, scrap metal or other waste; or
- Odours caused by improper storage or treatment of putrescibles waste; or
- Illegal dumping of wastes generated on site including incidental water.

### 5.8.3 Mitigation Measures

Waste management measures include:

- Waste material (including domestic waste) shall be collected and stored in suitable bins to prevent loss and scavenging by stock, wildlife and feral animals.
- Where practicable, recyclable material (e.g. glass and cans, scrap metals, used chemical and fuel drums and timber pallets) shall be collected in designated skips for recycling.
- The waste bins shall be removed from the site as necessary following completion of drilling and their contents are to be deposited at a licensed waste management facility for appropriate disposal.
- Contractors are Pre-qualified under Santos' EHSMS and appropriately licensed.
- All wastes are to be transported in covered or sealed containers to prevent the loss of waste materials during transport.
- Waste shall be transported in accordance with appropriate standards and legislative requirements.
- All industrial waste materials including liquids and solids will be removed for reuse or disposed at an appropriate site.
- Santos Staff will be housed at accommodation in nearby towns.
- Construction contractors will be housed at accommodation in nearby towns.
- 'portaloos' will be provided at the site and maintained as required by a suitable contractor.
- The flare will also be fenced.
- Sumps containing waste fluids/cuttings shall be fenced off immediately following the rig moving off the premises.
- If a liner is used it will be removed, and depending on site conditions, cuttings may be disposed of a suitable location.
- A perimeter fence around the site will be considered at each site, if required to enclose all sumps etc.

### 5.8.4 Residual Risk

As all waste generated by the activities will be transported offsite for appropriate disposal there are no impacts expected on site.

## 5.9 Surface and Ground Water Resources

### 5.9.1 Existing Environment

There are no creeks or water bodies in the immediate vicinity of the proposed Kahlua pilot well sites that could be potentially affected if there are any spill incidents during the proposed activities. The closest surface water resource is Collygra Creek located 3km east of the proposed Kahlua pilot well sites.

As discussed in Section 3, groundwater intersected by the drilling activities will have been cased off and cemented to isolate them from the primary objective (namely coal seams). No water production will occur from outside of the coal seam zones during the proposed activities.

Aquifer monitoring facilities will be located at two shallow aquifer monitoring bores. Water level variation at these locations is predicted to be less than seasonal variation (See Appendix A).

Incidental water pumping up to a maximum of 10ML is proposed from within the targeted coal seams (see Section 3.3).

Water for the earth works activities will be sourced from a local dam or Council. A landholder agreement is in place for its use.

## 5.9.2 Potential Impacts

The potential impacts on surface water as a result of activities are:

- Increase in turbidity and suspended loads through the erosion of sediments disturbed by earthworks activities; or
- Increase in turbidity and suspended loads through the erosion of sediments from works adjacent to and within drainage lines and water courses; or
- Increase in turbidity and suspended loads through the erosion of sediments and the release of contaminants through flooding and inundation; or
- Increase in turbidity and suspended loads through incomplete rehabilitation of disturbed areas; or
- Increase in turbidity and suspended loads through erosion from storm water run-off from access tracks or well leases; or
- Decrease in water quality through the release of oils or other chemicals (including saline associated water) from leaks and spills and surface water run-off from well leases; or
- Decrease in water quality through the improper disposal of litter and other debris from wastes; or
- Lack of water supply through a decrease in water quality and reduced access to water resources (including shallow aquifers); or
- Decrease in environmental flows associated with the diversion of surface water or use of local water sources including shallow groundwater.

The potential impacts on groundwater as a result of activities are:

- Partial loss of shallow groundwater recharge as a result of alteration of topography; or
- Cross contamination of aquifers as a result interconnection of aquifers; or
- Contamination through the infiltration of water through contaminated soil and the subsequent migration of contaminants. This may result from uncontrolled spills and leaks of fuels or chemicals; or
- Partial loss of shallow groundwater resources and environmental flows into surface water bodies such and watercourses and lakes.

Golder Associates completed a detailed assessment of potential impacts on water resources and their use that may arise from undertaking the proposed single well pilot test. A full copy of the assessment report is attached as Appendix A.

The extraction of CSG is linked to groundwater extraction (as incidental water). Initially groundwater extraction is necessary to decrease water pressure in the coal seams and allows the liberation of the CSG. Incidental water is typically produced through the whole CSG production. The proposed extraction rates for the Kahlua single well pilot test will not exceed 0.16ML/d and the predicted drawdown in the upper aquifers, in particular the Napperby Formations at Kahlua, is negligible (Appendix A). Overall Golder Associates concluded that the potential likely impacts from the proposed activities are negligible.

### 5.9.3 Mitigation Measures

To minimise the potential impacts on water resources the following actions will be implemented:

- Installation of groundwater monitoring wells with surface monitoring facilities at two shallow aquifer locations adjacent to the pilot to monitor coal seam pressures at Kahlua 3, 4 and 5 (See Section 3.3.3).
- The maintenance and cleaning of vehicles and other equipment and plant will be carried out in areas from where the resultant contaminants cannot be released into any waters.
- Waste water removed from site will be managed by a contractor licensed to carry and handle water.
- Bunding of all areas storing or handling fuel, fuel using equipment, and chemicals, in line with Australian Standard 1940 – 1993; The Storage and Handling of Flammable and Combustible Liquids
- Where applicable maintenance of roads, drains, bund walls, contour and diversion banks, will occur. All drainage structures are to be maintained for the life of the development.
- During rehabilitation, diversion banks and ripping along the contour will be completed to prevent the concentration and momentum of water flow as required.
- Tanker loading area will be on the high side of the water storage facilities to ensure that any spills drain into the contained area.

### 5.9.4 Residual Risk

With the implementation of the mitigations measures the likely impacts on surface and groundwater resources due to the activities is negligible.

## 5.10 Cumulative Environmental Impacts

The proposed activities are temporary in nature and each site will be restored to enable previous land-uses to continue into the future. The mitigation measures outlined will ensure that there are no significant cumulative environmental impacts.

Table 5.1: Risk Assessment for the Proposed Activities

| Aspect        | Potential Impacts  | UMRR <sup>3</sup> | Management Controls  | RRR <sup>4</sup> | Performance Indicator   | Records   |
|---------------|--|-------------------|--|------------------|---|---|
| Air Emissions | <ul style="list-style-type: none"> <li>• Combustion exhausts from the flare (during testing);</li> <li>• Fugitive emissions from (vehicles); and</li> <li>• Dust emissions from earthworks and vehicular activity.</li> <li>• Fugitive emissions from vehicles used during appraisal activities are anticipated to be minor due to the small scale of activities planned.</li> <li>• Other minor sources of air emissions include exhaust fumes from earthmoving and transport equipment.</li> <li>• These sources are likely to be negligible in the context of existing activities including grazing and transport within the area.</li> </ul> | 1                 | <ul style="list-style-type: none"> <li>• Ignite gas produced as part of the testing program. Flare gas</li> <li>• Reducing the speed of vehicles on field roads.</li> <li>• Watering of roads when appropriate or when agreed.</li> <li>• Investigating dust complaints and responding appropriately.</li> </ul> | 1                | <ul style="list-style-type: none"> <li>• Minimal complaints from Landholders regarding dust impacts.</li> <li>• Amicable resolution of complaints.</li> </ul> | <ul style="list-style-type: none"> <li>• All complaints made by the Landholder and any subsequent actions are to be recorded in the Complaints Register.</li> </ul> |

<sup>3</sup> UMRR = Unmitigated Risk Rating

<sup>4</sup> RRR = Residual Risk Rating

| Aspect                          | Potential Impacts   | UMRR <sup>3</sup> | Management Controls   | RRR <sup>4</sup> | Performance Indicator   | Records   |
|---------------------------------|---|-------------------|---|------------------|---|---|
| Community – Social and Economic | <ul style="list-style-type: none"> <li>• Direct impact upon landholder amenity.</li> </ul>  | 1                 | <ul style="list-style-type: none"> <li>• Land requirements and locations for infrastructure will be discussed with the Landholder.</li> <li>• Where practical infrastructure will be located within previously disturbed areas.</li> <li>• Land requirements will be minimised to that required for safe operations.</li> <li>• Land no longer required for normal operations will be rehabilitated and where practical returned to its previous use in consultation with the Landholder.</li> </ul>  | 1                | <ul style="list-style-type: none"> <li>• All land disturbed by Santos is to be returned to a condition consistent with the adjacent area and in consultation with the landholder.</li> </ul>                      | <ul style="list-style-type: none"> <li>• Santos records contracts with landholders.</li> </ul>            |
| Bushfire                        | <ul style="list-style-type: none"> <li>• Threat to the community, flora and fauna or sensitive areas.</li> </ul>  | 1                 | <ul style="list-style-type: none"> <li>• Maintain a cleared buffer outside the lease area (flare pit) to maintain an effective barrier against bushfires.</li> <li>• The flare pit will be kept free of grass and leaf litter.</li> <li>• A fire control water pump and hoses on site will be maintained.</li> <li>• Liaison will occur with the local rural fire service officer.</li> <li>• Fires on the surface of the land will be prohibited.</li> <li>• Hot work (e.g. welding) specific procedures will be in place.</li> <li>• Diesel machinery will be utilised for all activities.</li> </ul> | 1                | <ul style="list-style-type: none"> <li>• No fires occur as a result of the proposed activities.</li> </ul>  | <ul style="list-style-type: none"> <li>• Incident notification records.</li> </ul>                        |
| Cultural Heritage               | <ul style="list-style-type: none"> <li>• Indigenous heritage. Site or artefact of indigenous culture may be inadvertently damaged.</li> <li>• Non-Indigenous Heritage: Sites or artefacts of non-indigenous settlement may be inadvertently damaged.</li> </ul> | 1                 | <ul style="list-style-type: none"> <li>• The proposed activities will occur in previously cleared/disturbed areas.</li> <li>• If a site is discovered during site preparation works, the following procedure shall be implemented:</li> <li>• Step 1 Cease immediately all activities that could in any way interfere with or disturb the discovered site and/ or object.</li> <li>• Step 2 Promptly report discovery</li> </ul>  | 1                | <ul style="list-style-type: none"> <li>• Cultural heritage clearance completed prior to ground disturbance.</li> <li>• No indigenous or non-indigenous sites are disturbed by the proposed activities.</li> </ul> | <ul style="list-style-type: none"> <li>• Records of any cultural heritage site are maintained.</li> </ul> |

| Aspect          | Potential Impacts   | UMRR <sup>3</sup> | Management Controls   | RRR <sup>4</sup> | Performance Indicator  | Records   |
|-----------------|---|-------------------|---|------------------|--|---|
|                 |   |                   | <p>to the Team Leader Cultural Heritage, the Cultural Heritage Coordinator or the Cultural Heritage Field Supervisor.</p> <ul style="list-style-type: none"> <li>• DO NOT disturb or collect anything from the site. Santos Cultural Heritage personnel will advise of appropriate action to be followed in order for surface disturbance activities to recommence.</li> <li>• The discovery of cultural heritage on the site is recorded by Santos using the Discovery of Cultural Heritage Site Form.</li> </ul>  |                  |  |   |
| Flora and Fauna | <ul style="list-style-type: none"> <li>• Threatened flora or fauna or sensitive areas impacted by the proposed activities.</li> </ul>                                   | 1                 | <ul style="list-style-type: none"> <li>• Use of areas already disturbed.</li> <li>• No unplanned or unapproved damage to flora and fauna.</li> <li>• Restoration of disturbed areas to commence as soon as practical.</li> </ul>  | 1                | <ul style="list-style-type: none"> <li>• Ongoing monitoring to assess the success and integrity of construction and rehabilitation measure and ensure appropriate follow-up rehabilitation measures is implemented.</li> </ul> | <ul style="list-style-type: none"> <li>• Santos will maintain records during construction and operation of all monitoring and assessment activities.</li> </ul> |
| Weed Management | <ul style="list-style-type: none"> <li>• Introduction or spread of weeds through the movement of earthworks equipment, work over rig and/or general traffic.</li> </ul> | 1                 | <ul style="list-style-type: none"> <li>• All vehicles coming from declared weed infested to non-declared weed areas are required to utilise vehicle washing facilities or any temporary washing facilities established for this purpose.</li> <li>• All vehicle movements are restricted to defined areas agreed upon with the Landholder/s.</li> <li>• Land disturbance is to be minimised to prevent the germination of weed seeds that may already exist in the soil.</li> <li>• If a declared weed or weed of concern is discovered, it shall be monitored to ensure it does not spread from the area of infestation.</li> <li>• All land disturbed by Santos is to be returned to a condition</li> </ul> | 1                | <ul style="list-style-type: none"> <li>• Identify and document areas of new weed infestations in the Incident Management System.</li> </ul>  | <ul style="list-style-type: none"> <li>• Vehicle Hygiene Records.</li> </ul>  |

| Aspect                      | Potential Impacts   | UMRR <sup>3</sup> | Management Controls   | RRR <sup>4</sup> | Performance Indicator   | Records   |
|-----------------------------|---|-------------------|---|------------------|---|---|
|                             |   |                   | consistent with the adjacent area or to landholder requirements at the end of the rehabilitation process.   |                  |   |   |
| Noise Emissions             | <ul style="list-style-type: none"> <li>Increased noise at a sensitive receptor.</li> </ul>  | 2                 | <ul style="list-style-type: none"> <li>Landholder notification will be given prior to commencement of activities.</li> <li>Equipment will be maintained so that noise levels remain constant.</li> <li>Complaints will be responded to in a timely manner.</li> <li>Where noise disturbance cannot be avoided, Santos will investigate alternative arrangements to suit the landholder.</li> <li>The equipment used for the mobilisation and powering of pumps have mufflers installed on their respective power plants and prime movers.</li> <li>The proposed activities are a distance of greater than 1km to the nearest occupied dwelling in any direction.</li> </ul> | 1                | <ul style="list-style-type: none"> <li>All noise complaints will be recorded in the Complaints Register.</li> <li>Amicable resolution of complaints</li> </ul>  | <ul style="list-style-type: none"> <li>Maintenance carried out on equipment is to be recorded.</li> <li>Complaints Register.</li> </ul> |
| Soils, Land Use and Terrain | <ul style="list-style-type: none"> <li>Soil erosion from the disturbed land.</li> <li>Incident or accident that may result in a release of fuel, oils or other chemicals maintenance fluids to the ground.</li> </ul> | 2                 | <ul style="list-style-type: none"> <li>All activities associated with land disturbance will be discussed with the Landholder prior to commencement.</li> <li>The area of all disturbances will be determined, surveyed and placed within Santos' Geographic Information System (GIS).</li> <li>Construction and use of erosion control devices.</li> </ul>  | 1                | <ul style="list-style-type: none"> <li>The sites are rehabilitated upon completion of the activities.</li> </ul>  | <ul style="list-style-type: none"> <li>Records of disturbance are maintained within Santos' GIS.</li> </ul>                             |
| Waste                       | <ul style="list-style-type: none"> <li>Contaminated land by the incorrect disposal of wastes or sewage on site.</li> </ul>  | 3                 | <ul style="list-style-type: none"> <li>No waste will be disposed of on site.</li> <li>General and recyclable wastes (including glass, paper and plastic) generated will be transported to landfill and recycling facilities on a routine</li> </ul>   | 1                | <ul style="list-style-type: none"> <li>Post construction checks to ensure all waste has been appropriately removed and disposed of.</li> <li>Operational checks to establish that all waste has been appropriately removed</li> </ul> | <ul style="list-style-type: none"> <li>Waste management records.</li> <li>Complaints register.</li> </ul>                               |

| Aspect                             | Potential Impacts   | UMRR <sup>3</sup> | Management Controls  | RRR <sup>4</sup> | Performance Indicator  | Records  |
|------------------------------------|---|-------------------|--|------------------|--|--|
|                                    |   |                   | basis.<br><ul style="list-style-type: none"> <li>Sewage will be collected by licensed contractor for off-site disposal.</li> <li>Waste is disposed of at appropriate end point.</li> <li>All waste management non-compliances are managed in the Incident Management System.</li> </ul>  |                  | from the operational areas, or correctly stored and waiting for removal.   |  |
| Surface and Ground Water Resources | <ul style="list-style-type: none"> <li>Incident or accident that may result in a release of fuels, soils or other chemicals maintenance fluids to the ground.</li> <li>Transport of sediments disturbed by erosion of soils during construction activities.</li> <li>Spill during the production, storage, transfer or trucking of incidental water to the ground.</li> </ul> | 2                 | <ul style="list-style-type: none"> <li>Water removed from site will be managed by a contractor licensed to carry and handle water.</li> <li>Bunding of all areas storing or handling fuel, fuel using equipment, and chemicals, in line with Australian Standard 1940 – 1993: The Storage and Handling of Flammable and Combustible Liquids.</li> <li>Where applicable maintenance of roads, drains, bund walls, contour and diversion banks, will occur. All drainage structures are to be maintained for the life of the development.</li> <li>During rehabilitation, diversion banks and ripping along the contour will be completed to prevent the concentration and momentum of water flow as required.</li> <li>Testing procedures to ensure good oilfield practice.</li> <li>During rehabilitation, diversion banks and ripping along the contour will be completed to prevent the concentration and momentum of water flow as required.</li> </ul> | 1                | <ul style="list-style-type: none"> <li>No incidents where substances are released to surface or groundwater causing contamination.</li> <li>Diversion mechanisms in place, regularly checked and maintained to redirect natural stormwater movement where required.</li> </ul> | <ul style="list-style-type: none"> <li>Records of spills, leaks and associated clean ups are to be managed using the Incident Management System.</li> <li>Maintenance carried out to remedy any erosion and water channelling is to be recorded using the Incident Management System.</li> <li>Records of water storage inspections to be maintained.</li> </ul> |

## 5.11 Clause 228 Checklist

Clause 228 of the EP&A Regulation states that for the purpose of Part 5 of the EP&A Act the following factors are to be taken into account concerning the impact of an activity on the environment. These factors are considered below.

Table 5.2: Clause 228 Checklist

| Factor  | Positive/Negative Impact |
|---|--------------------------|
| <p><i>Any environmental impact on the community</i></p> <p>The proposed site lies approximately 22 km west of Gunnedah. Minor short term impacts such as increase local traffic would be experienced. Safeguards proposed in Section 5 and Table 5.1 would minimise these impacts.</p>  | Short term negative      |
| <p><i>Any transformation of a locality</i></p> <p>There would be localised and non-permanent visual impact on the immediate vicinity of the hole for the duration of the programme. Safeguards proposed in Section 5 and Table 5.1 would minimise these impacts.</p>  | Short term negative      |
| <p><i>Any environmental impact on the ecosystems of the locality</i></p> <p>The area of proposed activities is highly disturbed, no environmental impacts of the ecosystems of the locality would occur as a result of the project.</p>   | Nil                      |
| <p><i>Any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality</i></p> <p>During drilling there may be a reduction in these values due to affecting visual amenity. Given the short term nature of activities and the safeguards/mitigation detailed in Section 5 and Table 5.1 the potential for a reduction is considered negligible.</p>   | Nil                      |
| <p><i>Any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations</i></p> <p>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 occur near the proposal area.</p> | Nil                      |
| <p><i>Any impact on the habitat of protected fauna (within the meaning of the National Parks and Wildlife Act 1974)</i></p> <p>The proposal would not significantly impact on the habitat of protected fauna.</p>   | Nil                      |
| <p><i>Any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air</i></p> <p>The proposal would not endanger any species of animal, plant or other form of life, whether living on land, in water or in the air.</p>  | Nil                      |

| Factor   | Positive/Negative Impact  |
|--|---------------------------|
| <p><i>Any long-term effects on the environment</i></p> <p>The proposal would have no long-term effects on the environment</p>  | Nil                       |
| <p><i>Any degradation of the quality of the environment</i></p> <p>There is potential for minor short term environmental degradation due to visual or dust impacts. Safeguards proposed in Section 5 and Table 5.1 would minimise these impacts.</p>   | Minor short term negative |
| <p><i>Any risk to the safety of the environment</i></p> <p>The proposal may result in short term potential risks to the safety of the environment due to incidents and spills. The likelihood and consequence of an incident occurring would be reduced through the application of Santos's EHSMS Standards and mitigation proposed in Section 5.</p>          | Minor short term negative |
| <p><i>Any reduction in the range of beneficial uses of the environment</i></p> <p>The footprint of activities for the proposal would not result in any reduction in the range of beneficial use of the environment.</p>  | Nil                       |
| <p><i>Any pollution of the environment</i></p> <p>The proposal may result in short term potential risk of pollution of the environment due to incidents and spills. The likelihood and consequence of an incident occurring would be reduced through the application of Santos's EHSMS Standards and mitigation proposed in Section 5.</p>                     | Nil                       |
| <p><i>Any environmental problems associated with the disposal of waste</i></p> <p>All waste generated by the activities will be collect and removed from site for disposal at approved landfill sites. Given the short term of the propose activity waste production will be minimal.</p>  | Nil                       |
| <p><i>Any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply</i></p> <p>Resources required for the proposal are not in limited supply in the area.</p>   | Nil                       |
| <p><i>Any cumulative environmental effect with other existing or likely future activities</i></p> <p>The proposed activities are temporary in nature and each site will be restored to enable previous land-uses to continue into the future. The mitigation measures outlined will ensure that there are no significant cumulative environmental impacts.</p> | Nil                       |

## 6 Conclusions

The Kahlua single well pilot test is a necessary step in evaluating the hydrocarbon potential of PEL 1. Discovery of coal seam gas resources in this area has the potential to increase the state's reserves and revenue from gas and underpin future exploration or production in the region.

A Land Access Agreement is in place for the landholder where the proposed Kahlua Pilot is located and that agreement addresses matters of access, compensation and rehabilitation. Santos will communicate with neighbouring landholders so as to identify any concerns with regard to planned activities.

The proposed activities have associated potential environmental impacts, which are common to exploration activities such as those carried out elsewhere in the Gunnedah Basin. It is considered that the potential impacts can be successfully mitigated with the application of the management strategies outlined in this document. The strategies are consistent with the APPEA Code of Environmental Practice and are typical of good hydrocarbon field practice.

With the implementation of the management measures outlined in Section 5, it is expected that:

- Impacts on landholders will be minimal;
- Impacts to air quality will be minor, localised and insignificant;
- Adverse effects on water resources will be minimal during drilling;
- Off-site impacts to soils will be avoided and on-site impacts will be minor and temporary;
- The potential noise impacts will be short term, and no threatened species or communities are likely to be impacted;
- There will be no significant use of, or impact to, natural resources;
- Impacts on the community and visual amenity will be insignificant and short term, particularly as the sites are in a sparsely populated area;
- Impacts to known heritage places or sites will be avoided;
- Disturbances to pastoral and agricultural land use will be minor and short term and managed in consultation with affected landholder(s); and
- There will be no significant cumulative environmental impacts.

## 7 References

- Australian Bureau of Statistics (ABS) (2006), Commonwealth of Australia Census Data 2006, Information downloaded on May 6, 2010 at <http://www.abs.gov.au/websitedbs/d3310114.nsf/home/Census+data>
- Australian Petroleum Production and Exploration Association (APPEA) (2008), Code of Environmental Practice October 2008, Published by the APPEA Canberra ACT.
- Botanic Gardens Trust (2010), PlantNET - The Plant Information Network System of Botanic Gardens Trust, Sydney, Australia (version 2). <http://plantnet.rbg Syd.nsw.gov.au>. Accessed May 2010.
- Bureau of Metrology (BOM) (2010), Average Monthly Climate Statistics for the Township of Gunnedah, downloaded May 5, 2010 at: [http://www.bom.gov.au/climate/averages/tables/cw\\_055023.shtml](http://www.bom.gov.au/climate/averages/tables/cw_055023.shtml)
- Commonwealth of Australia (2010), National Native Title Tribunal Register. Retrieved May 6, 2010, from National Native Title Tribunal: <http://www.nntt.gov.au/register/>
- Department of Environment, Water, Heritage and the Arts (DEWHA), 2006, EPBC Policy Statement 3.5, Nationally Threatened Species and Ecological Communities Guidelines Department of the Environment and Heritage, May, downloaded 8<sup>th</sup> April, 2008, at <http://www.environment.gov.au/epbc/publications/box-gum.html>
- DEWHA (2010b), Search the Australian Heritage Database. Retrieved May 2010 from Department of the Environment, Water, Heritage and the Arts: <http://www.environment.gov.au/cgi-bin/ahdb/search.pl>
- Department of Primary Industries (DPI) (1992), Schedule of Onshore Petroleum Exploration and Production Safety Requirements, published by NSW Department of Primary Industries.
- DPI (2010), Noxious Weeds Declarations, downloaded May 2010 from: <http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/noxweed>
- Lampert, G & Short, A. (2004), Namoi River Styles Report - River Styles, Indicative, Geomorphic Condition and Geomorphic Priorities for River Conservation and Rehabilitation in the Namoi Catchment, Department of Infrastructure Planning and Natural Resources.
- Namoi Catchment Management Authority (NCMA) (2010), Namoi Catchment Management Area. Website accessed on May 5 2010: <http://www.namoi.cma.nsw.gov.au/>
- New South Wales Parks and Wildlife Service (NSWPWS) (2003), The Bioregions of New South Wales- their biodiversity, conservation and history, NSW National Parks and Wildlife Service, Hurstville.
- NSW Department of Planning (2010), NSW Heritage Register. Retrieved May 2010, from Heritage Branch NSW: [http://www.heritage.nsw.gov.au/07\\_subnav\\_04.cfm](http://www.heritage.nsw.gov.au/07_subnav_04.cfm)
- Santos QNT Pty Ltd (Santos) 2010, Review of Environmental Factors Kahlua Pilot Wells - Drilling and Completions - PEL 1 Gunnedah Basin. Prepared by Santos QNT Pty Ltd and submitted to the DII.

### **Further reading:**

Petroleum Exploration Licence (PEL) 1 Licence Instrument

DPI - Mineral Resources Division (2006), Guidelines for Review of Environmental Factors, June, NSW Department of Primary Industries.

## Appendix A.

### Groundwater Impact Study – Kahlua Pilot Test – Golder Associates



## Appendix B.

Pickanjinnie Pad Wells Compliance Noise  
Measurements Report Number 20-2014R14 17  
November 2010 URS Pty Ltd



## Appendix C.

### Santos Group Risk Assessment Matrix

| <b>Santos Group Risk Matrix</b> |  |   |   |   |  |
|---------------------------------|--|---|---|---|--|
| <b>Consequences</b>             |  |   |   |   |  |
| <b>Consequence Type</b>         | <b>Negligible</b>  | <b>Minor</b>  | <b>Moderate</b>   | <b>Major</b>  | <b>Critical</b>  |
| <b>Health and Safety</b>        | Minor injury - first aid treatment   | Injury requiring medical treatment with no lost time  | Injury requiring medical treatment, time off work and rehabilitation  | Permanent disabling injury and/or long term off work  | Fatality   |
| <b>Natural Environment</b>      | Negligible impact on fauna/flora, habitat, aquatic ecosystem or water resources. Incident reporting according to routine protocols | Impact on fauna, flora and/or habitat but no negative effects on ecosystem. Requires immediate regulator notification | Short term impact on sensitive environmental features (e.g. gibber plain). Triggers regulatory investigation. | Long term impact of regional significance on sensitive environmental features (e.g. wetlands). Likely to result in regulatory intervention/action | Destruction of sensitive environmental features. Severe impact on ecosystem. Regulatory & high level Government intervention/action. |
| <b>Reputation</b>               | Minimal impact to reputation   | Some impact on business reputation  | Moderate to small impact on business reputation.  | Significant impact on business reputation and/or national media exposure.   | Critical impact on business reputation /or international media exposure  |
| <b>Financial</b>                | Financial loss from \$0 to \$500,000   | Financial loss from \$500,000 to \$5 Million.   | Financial loss from \$5 Million to \$50 Million   | Financial loss from \$50 Million to \$100 Million   | Financial loss in excess of \$100 Million  |

|   |  | Consequences |       |          |       |          |
|---|--|--------------|-------|----------|-------|----------|
| Consequence Type  |  | Negligible   | Minor | Moderate | Major | Critical |
|   |  | I            | II    | III      | IV    | V        |
| <b>Almost Certain</b><br>Is expected to occur in most circumstances |  | A            | 2     | 3        | 4     | 5        |
| <b>Likely</b><br>Could occur in most circumstances                  |  | B            | 1     | 3        | 3     | 4        |
| <b>Possible</b><br>Has occurred here or elsewhere                   |  | C            | 1     | 2        | 3     | 3        |
| <b>Unlikely</b><br>Hasn't occurred yet but could                    |  | D            | 1     | 1        | 2     | 2        |
| <b>Remote</b><br>May occur in exceptional circumstances             |  | E            | 1     | 1        | 1     | 1        |

|  | Risk Level | Guideline for Risk Management                                  |
|--|------------|--|
|  | 5          | Immediate action or suspend activity. Notify VP. RMP by 1 week |
|  | 4          | Allocate manager responsibility, notify VP - RMP by 2 weeks    |
|  | 3          | Allocate manager responsibility - RMP by 1 month               |
|  | 2          | Manage by specific monitoring of controls. RMP by 3 months     |
|  | 1          | Manage by routine procedures and regular monitoring            |