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12 January 2023

Santos Reference: NSW22-02

NSW Resources Regulator
Mining Act Inspectorate
PO Box 344
Hunter Region Mail Centre NSW 2310

Dear Resources Regulator,

Application to conduct exploration activities for assessable prospecting operations, PEL 1 – Kahlua Pilot Reactivation including a Guideline Review of Environmental Factors

Santos QNT Pty Ltd (Santos) as Operator of PEL 1 held by Santos and Australian Coalbed Methane Pty Limited has prepared the attached application to conduct exploration activities for assessable prospecting operations and a Guideline Review of Environmental Factors in accordance with Section 5.5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), clause 171 of the *Environmental Planning and Assessment Regulation* 2021 (EP&A Regulation) and the ESG2: Guideline for Preparing a Review of Environmental Factors (DISRD, 2015a).

Santos are seeking to carry out the Kahlua Pilot Reactivation within PEL 1.

The following information is attached in support of the application:

- Attachment 1 – ESF4 Application to conduct exploration activities for assessable prospecting operations;
- Attachment 2 – Plans; and
- Attachment 3 – Guideline Review of Environmental Factors;

An ESF2 Rehabilitation completion and/or review of rehabilitation cost estimate and/or notification of mine or petroleum site closure and supporting rehabilitation cost estimate which contemplated the Kahlua Pilot Reactivation was submitted to NSW Resources Regulator on 12 September 2022 (application reference MAAG0014844). These documents have not been resubmitted with this application.

Please contact [redacted] on [redacted] or [redacted] should you have any further enquiries.

Santos

Yours sincerely,

Team Leader - Environment
Santos

Kahlua Pilot Reactivation

Review of Environmental Factors

Santos

December 2022

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	0	[redacted]	[redacted]		[redacted]		19/12/22

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Executive Summary

Santos QNT Pty Ltd (Santos) proposes to carry out the Kahlua Pilot Reactivation at a site located on Lot 6 DP586978 in Marys Mount about 20 kilometres west of Gunnedah, NSW.

The site contains existing coal seam gas exploration infrastructure including four exploration wells (Kahlua (K) 2, K3, K4 and K5), access tracks, water storage and gas flaring infrastructure.

The purpose of the proposed activity is to continue exploration and appraisal activities at the site utilising the existing coal seam gas exploration infrastructure. It includes some minor additional civil and construction works including installation of buried gas and water gathering and power cables, upgrade of the gas flare, establishment of central power generation infrastructure and 65 kilolitre diesel storage, followed by workovers and completions, and appraisal activities.

The proposed activity is planned be carried out from early 2023. The civil and construction works, and workovers and completions, would occur collectively over about three months. The appraisal activities would then continue for up to two years following the commencement of production through to late 2024/early 2025. It is intended that the period of approximately two years of appraisal activities would be continuous, however maintenance or downtime may occur that could result in a lengthier overall program.

The water produced from each of the four wells would flow through the water gathering line network to the existing central water storage infrastructure, consisting of two, 5 mega litre tanks located near well K2, where it would be temporarily stored. The two water holding tanks would be periodically emptied, with the water transported to the water treatment facility at Santos' Leewood property, about 20 kilometres south of Narrabri, which operates under a separate activity approval and environment protection licence. Alternately, the produced water may be provided to a third party for beneficial reuse subject to a successful application for a resource recovery order and exemption under the *Protection of the Environment Operations (Waste) Regulation 2014*. Produced water would be managed in accordance with the *Exploration Code of Practice: Produced Water Management, Storage and Transfer*.

The volume of water produced would vary over time and be greater at the start of appraisal as the wells are depressurised, reducing as appraisal continues. Indicatively, daily water production could vary between 6 kilolitres and 24 kilolitres and with peaks in the order of 48 kilolitres in the early stages. Irrespective of the daily rate of water production, the total volume of water produced during appraisal is estimated to be about 9 megalitres per year.

Decommissioning and rehabilitation would be carried out once the gas infrastructure reaches the end of its operational life. Decommissioning and rehabilitation would be carried out in consultation with the landholder and in accordance with the relevant guidelines including the *Exploration Code of Practice: Rehabilitation* and the *Code of Practice for Coal Seam Gas Well Integrity*.

Coal seam gas exploration at the site is authorised under petroleum exploration licence (PEL) 1, held by Australian Coalbed Methane Proprietary Limited (Pty Ltd) and Santos. The proposed activity is classified as an assessable prospecting operation and therefore requires an activity approval under the *Petroleum (Onshore) Act 1991*.

The purpose of this Review of Environmental Factors (REF) is to assess the potential impacts of the proposed activity under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and in accordance with the NSW Department of Planning and Environment guideline *ESG2: Guideline for preparing a Review of Environmental Factors*.

As one of Australia's most significant domestic gas suppliers, Santos has partnered with many local communities, providing jobs and business opportunities while safely and sustainably developing Australia's natural gas resources and powering Australian industries and households. Santos is committed to engaging with landholders and other key stakeholders who may be impacted by our projects or operations. Stakeholder identification and consultation for the Kahlua project has been undertaken to meet the requirements associated with a 'medium impact activity' as per the *Exploration Code of Practice: Community Consultation*. Santos will continue to carry out stakeholder and community consultation activities in the region in relation to the planning and conduct of activities in accordance with the relevant guidelines.

Using EGS2 guidance, the environmental assessment of the proposed activity as reported herein found that all assessed environmental disciplines returned impacts ranked as low adverse, with cultural heritage being negligible. The total impact of the proposed activity based on the classification of individual impacts has been found to be low adverse. The assessment found that the proposed activity would comply with all minimal impact considerations within the NSW *Aquifer Interference Policy* (DPIE 2012).

In addition, the potential risk of significant impact on Matters of National Environmental Significance were assessed using applicable Commonwealth Government guidelines. Of the matters of national environmental significance that were identified:

– The identified wetlands of international importance were listed as being in the order of 1,000 kilometres from the site of the proposed activity. Given this very large separation distance, the potential impact of the proposed activity on the identified wetlands is negligible.
– The proposed activity was found to not have a significant impact on biodiversity including threatened species and ecological communities.
– In relation to the NSW *Aquifer Interference Policy*, predicted impacts are expected to be minor or negligible, and temporary, and are therefore unlikely to result in reduction in the current and future utility of affected aquifers. As such, the impacts are not considered to represent a 'significant impact', and therefore, are interpreted not to require referral under the EPBC Act water trigger.

Overall, the potential impacts on matters of national environmental significance were assessed as low.

Notwithstanding the assessment findings, Santos champions leading practice environmental and social governance, and therefore, has committed to the range of management and mitigation safeguards as described in Appendix I.

In summary, this REF has assessed the potential impacts of the proposed activity under Part 5 of the *Environmental Planning and Assessment Act 1979* and in accordance with *ESG2: Guideline for preparing a Review of Environmental Factors* (DPIE 2015).

As the site of the proposed activity has been disturbed previously for the establishment of the existing gas exploration infrastructure, the proposed activity would involve relatively limited additional disturbance at the site and would largely represent a continuation of the use of existing and approved infrastructure. As such, the total impact of the proposed activity based on the classification of individual impacts has been found to be low adverse.

The proposed activity would not be likely to have a significant impact on the environment or a significant impact on a matter of national environmental significance.

Accordingly, an environmental impact statement or species impact statement are not required under the *Environmental Planning and Assessment Act 1979* and a referral is not required under the *Environment Protection and Biodiversity Conservation Act 1999*.

This conclusion has been arrived at with due consideration to the principles of ecologically sustainable development and the environmental factors under the *Environmental Planning and Assessment Regulation 2021* which have been summarised in and responded to in Appendix A of this REF.

Abbreviations

ABN	Australian Business Number
AHD	Australian Height Datum
AHIMS	Aboriginal Heritage Information Management System
AHIP	Aboriginal heritage impact permit
AS	Australian Standard
dBA	Decibel A Scale
BC Act	Biodiversity Conservation Act 2016 (NSW)
BOM	Bureau of Meteorology
BSAL	Biophysical strategic agricultural land
CH	Cultural heritage
CO2-e	Carbon dioxide equivalent emissions
COVID	Coronavirus (COVID-19) pandemic
CSG	Coal seam gas
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CU	Cumulative
DCCEE&W	Australian Department of Climate Change, Energy, the Environment and Water
DECC	NSW Department of Environment and Climate Change
DECCW	NSW Department of Environment, Climate Change and Water
DOI	NSW Department of Industry
DP	Deposited Plan
DPE	NSW Department of Planning and Environment
DPI	NSW Department of Primary Industries
DPIE	NSW Department of Planning, Industry and Environment (now renamed as NSW Department of Planning and Environment)
EP&A Act	Environmental Planning and Assessment Act 1979 (NSW)
EPA	NSW Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Cth)
EPL	Environmental Protection Licences
GDE	Groundwater Dependent Ecosystems
ICNG	Interim Construction Noise Guideline
ID	Identification number
IDE	Inflow dependent ecosystems
IEO	Index of Education and Occupation
IER	Index of Economic Resources
IRSD	Index of Relative Socio-Economic Disadvantage
LAeq	Equivalent Continuous Sound Pressure Level
LALC	Local Aboriginal Land Council
LDAR	Gas Leak Detection and Repair
LEP	Local Environmental Plan
LGA	Local government area
LLS	Local Land Services
MDB	Murray Darling Basin
MEG	Department of Regional NSW, Mining, Exploration and Geoscience
MGA	Map Grid of Australia
MNES	Matters of national environmental significance under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999.
MP	Member of Parliament
NA	Not Applicable
NML	Noise management level
NPfI	Noise Policy for Industry

NSW	New South Wales
OEH	Office Of Environment and Heritage
OOHW	Outside of hours works
PEL	Petroleum exploration licence
POEO Act	Protection of the Environment Operations Act 1997 (NSW)
REF	Review of environmental factors
SAMBs	Shallow aquifer monitoring bores
SEED	Sharing and Enabling Environmental Data portal
SEIFA	Socio-Economic Indexes for Areas
SEPP	State environmental planning policy
SSD	State significant development
SSI	State Significant Infrastructure
TBA	To be announced
TFNSW	Transport for NSW
UTM	Universal Transverse Mercator
WA	Waste and resources

Contents

Table index

Figure index

Appendices

1. Introduction

1.1 Overview

Santos QNT Pty Ltd (Santos) proposes to carry out the Kahlua Pilot Reactivation at a site located on Lot 6 DP586978 in Marys Mount about 20 kilometres west of Gunnedah, NSW.

The site contains existing coal seam gas exploration infrastructure including four exploration wells (Kahlua (K) 2, K3, K4 and K5), access tracks, water storage and gas flaring infrastructure.

The purpose of the proposed activity is to continue exploration and appraisal activities at the site utilising the existing coal seam gas exploration infrastructure. It includes some minor additional civil and construction works including installation of buried gas and water gathering and power cables, upgrade of the gas flare, establishment of central power generation infrastructure and 65 kilolitre diesel storage, followed by workovers and completions, and appraisal activities.

Coal seam gas exploration at the site is authorised under petroleum exploration licence (PEL) 1, held by Australian Coalbed Methane Proprietary Limited (Pty Ltd) and Santos.

The proposed activity is classified as an assessable prospecting operation and therefore requires an activity approval under the *Petroleum (Onshore) Act 1991*.

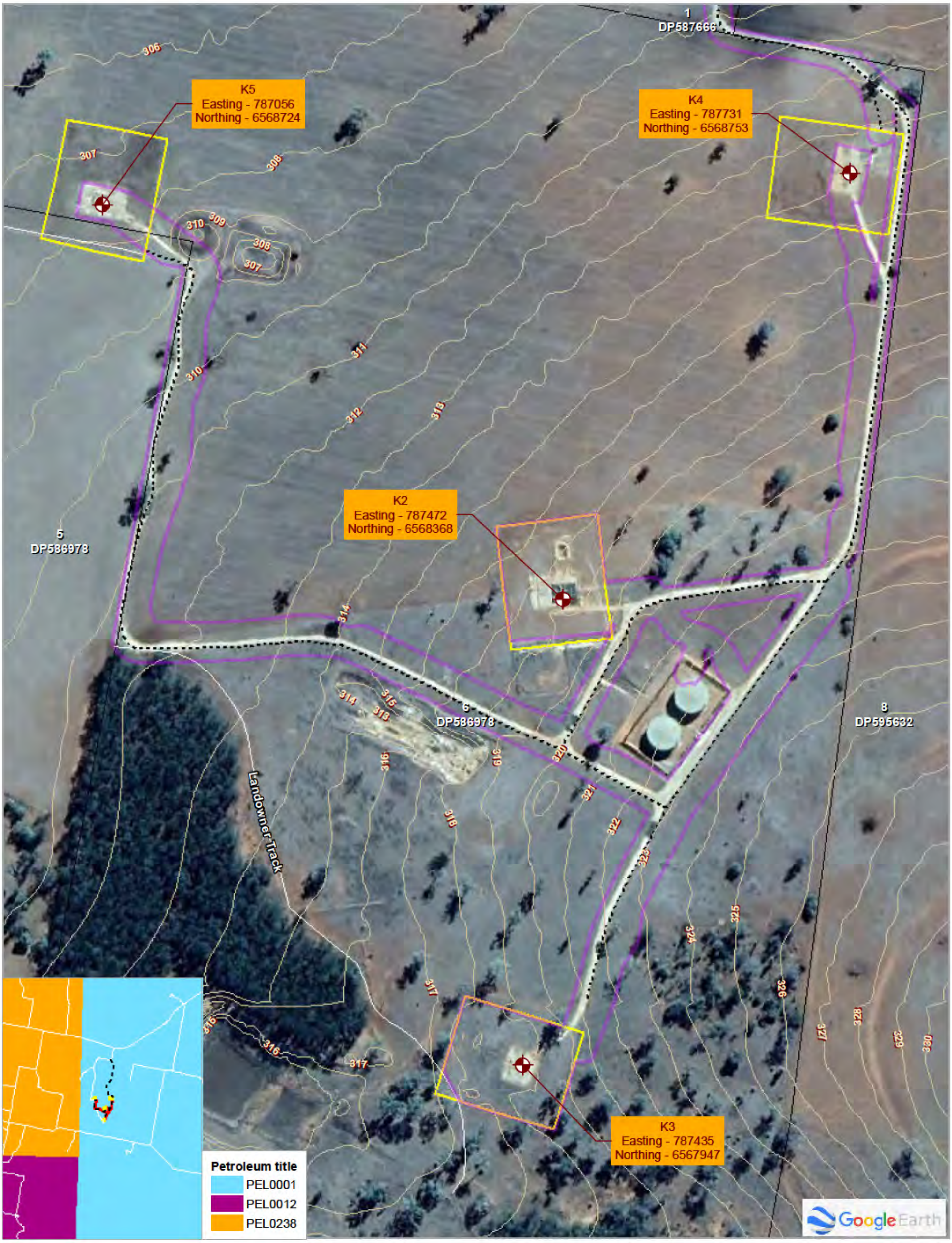
The site of the proposed activity and infrastructure layout is shown in Figure 1.1.

1.2 Purpose and structure

The purpose of this Review of Environmental Factors (REF) is to assess the potential impacts of the proposed activity under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and in accordance with the NSW Department of Planning and Environment guideline *ESG2: Guideline for preparing a Review of Environmental Factors* (DPIE 2015).

The structure and content of this Review of Environmental Factors is as follows:

– Section 2 — description of the proposed activity including stakeholder consultation
– Section 3 — statutory context including application of laws, regulations and instruments
– Section 4 — description of the existing environment and potential impacts of the proposed activity
– Section 5 — conclusion including determination of significant impact on the environment.



LEGEND

- Pilot well
- Construction Disturbance Zone
- Well pad
- Existing access track
- Roads
- Contours (1m)
- Cadastre

Paper Size ISO A4

0 50 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Santos
Kahlua Pilot

Project No. **2122463**
Revision No. **0**
Date **15/12/2022**

Proposal location

FIGURE 1.1

G:\21\22463\GIS\Maps\Deliverables\Kahlua_Pilot\21_22463_Z184_REF_KahluaPilot_ProposalLocation.mxd
Print date: 15 Dec 2022 - 16:09

Data source: Pilot wells, gathering lines and well pads, Santos 2020. General topo - NSW LPI DTDB 2015. Cadastre - NSW LPI DCDB 2017. Contours - NSW Spatial Services 2011. Mining titles - NSW DPIE 2019. Aerial imagery - Google Earth Pro (image date 13/08/2018, image extracted 04/09/2020). Created by: eibbertson

2. Proposed activity

2.1 Activity description

The proposed activity at the site would involve the following:

– Minor civil and construction works, including:
  - installation of buried gathering (gas and water) lines and power cables
  - upgrade of the existing gas flaring infrastructure at well pad K2
  - establishment of central power generation infrastructure at well pad K2
  - establishment of a 65 kilolitre diesel fuel storage at well pad K2.
– Workovers and completions of four existing gas exploration wells (K2, K3, K4 and K5).
– Appraisal activities including water and gas production from all four wells and gas flaring (K2 only).
– Decommissioning and rehabilitation activities.

The proposed activity is necessary for the continued exploration and appraisal of gas in PEL1.

The site of the proposed activity contains existing and approved coal seam gas exploration infrastructure as described in Section 1.1. As far as reasonably practicable, the proposed activity would be contained to areas that have already been disturbed through the establishment of this infrastructure. As such, the proposed activity may be largely characterised as a brown field activity that would likely result in no additional impacts on the environment at the proposed site.

2.2 Timing and duration

The proposed activity is planned be carried out from early 2023. The civil and construction works, and workovers and completions, would occur collectively over about three months. The appraisal activities would then continue for up to two years following the commencement of production through to late 2024/early 2025.

Civil and construction work and related activities would be carried out within the hours of operation and exceptions currently permitted under EPL 20351, which are reproduced below.

> *L4.1 Standard construction hours*
>
> *Unless otherwise specified by any other condition all construction activities are:*
>
> *a) restricted to between the hours of 7:00am and 6:00pm Monday to Friday;*
>
> *b) restricted to between the hours of 8:00am and 1:00pm Saturday; and*
>
> *c) not to be undertaken on Sundays or Public Holidays.*
>
> *L4.2 Exceptions to standard construction hours*
>
> *The following may be carried out outside of the hours permitted by Condition L4.1:*
>
> *a) Construction work that causes LAeq(15minute) noise levels that are:*
>
> *(i) no more than 5dB above rating background level at any residence not subject to a private negotiated agreement, in accordance with the Interim Construction Noise Guideline (DECC, 2009); and*
>
> *(ii) no more than the noise management levels specified Table 3 of the Interim Construction Noise Guideline (DECC, 2009) at other sensitive land uses.*
>
> *b) The delivery of plant, equipment and materials which is required to be delivered outside of the standard construction hours by Police and/or other authorities; and*
>
> *c) Emergency work to avoid loss of life, damage to property and/or environmental harm.*

2.3 Workforce and access

The workforce at the site of the proposed activity at any one time would total about 50 workers. It is planned for the workforce to be accommodated in Gunnedah and/or Boggabri and travel to the site each day in four-wheel drive vehicles via the existing road network and the access tracks at the site. It is not planned that there would be a persistent onsite workforce during appraisal activities, however, the site would be visited by a small number of workers for monitoring operations and maintenance activities.

2.4 Equipment and materials

Equipment that would be used on site would indicatively include various heavy vehicles, excavators, rollers, water carts, mobile cranes, drilling rigs, pumps, and generators.

Materials that would be transported to site would include prefabricated sections of gathering lines, HDPE pipe, power cables and equipment, components for the upgrade of the gas flare, central power generation infrastructure, principally a diesel generator, and the diesel fuel storage tank.

The civil and construction works have the potential to generate surplus excavated material. As far as practicable, all excavated material would be reused during backfilling, however, there remains the potential for there to be a relatively small volume of surplus excavated material.

The approach to managing waste materials is discussed in section 4.7.

2.5 Services and utilities

The services and utilities that would be required include power, water, and sewage.

Power required during the civil and construction works, and the workovers and completions, would be generated on site by diesel-powered generators. Power requirements during appraisal activities would be supplied from central power generation infrastructure at well pad K2.

Water would be required during civil and construction works, primarily for dust control purposes. Water would be delivered to site by water cart as required, depending on site conditions.

Water would also be required for workovers. The volume of water required would nominally be in the order of 50,000 to 80,000 litres per workover. Potential water sources could include existing farm dams in the region and/or existing or new groundwater bores.

All water take required for the proposed activity would be suitably licensed under the *Water Management Act 2000* and, in the case of existing farm dams or groundwater bores, agreements with the relevant owners and licence holders of those water sources.

Sewage services would be provided by portable amenities situated on site with sewage waste being routinely collected by suitably licensed waste management contractors.

2.6 Civil and construction

Installation of gathering lines and power cables would be by open trenching. The corridor for these works would be nominally 17 metres in width and 2 kilometres in length. The dimensions of the open trench within this corridor would be in the order of 1 metre wide and 1 metre deep.

As trenching progresses, the excavated material would be temporarily stockpiled within the construction corridor adjacent to the trench. Topsoil would be excavated first and stockpiled separately, followed by subsoil, so the existing soil profile may be reinstated during backfilling.

Sections of gathering lines and power cables would be progressively delivered to site, strung out and joined, and placed into the open trench. Excavated material would be progressively backfilled and lightly compacted over the installed gathering lines and power cables.

The upgrade of the existing gas flare at well K2 would be necessary to flare additional gas generated from wells K3, K4 and K5, once they are tied in. The flare would be designed in accordance with all relevant Australian and industry standards. As the site is largely cleared, it is not expected that additional clearing or other disturbance would be needed.

The central power generation infrastructure and diesel fuel storage tank would largely be prefabricated and would be delivered to site with some construction activities to be performed to establish the equipment.

2.7 Workovers and completions

The existing gas exploration wells are described in Table 2.1 and mapped in Figure 1.1.

Workover of wells K2, K3, K4 and K5 would include investigative activities such as wireline logging and diagnostic injection testing to determine the existing condition of the wells and reservoir connectivity. Workovers will include cleanout of the wellbores, jetting and perforation of the production casing across the coal seams, and completion activities such as the installation of pumps, gauges, automatic level controls and telemetry at each of the wells. The workover activities would involve rigless activities prior to the rig arrival and workovers through the use of a single workover rig at each of the well sites.

The favourable geology within the project area also lends itself to the use of lateral and incline drilling techniques to release the gas; therefore, hydraulic fracturing is not proposed as part of the project.

All workovers and completions would be carried out in accordance with relevant standards including the *Code of Practice for Coal Seam Gas Well Integrity* (NSW Government 2012a) and the draft *Code of Practice Construction, Operation and Decommissioning Petroleum Wells* (NSW Government).

Table 2.1 Gas exploration wells

Exploration well	Coordinates (MGA Zone 55)	Target formation	Drill depth (mbgs[a])
K2	E 787472 N 6568368	Black Jack Group	695.0
K3	E 787435 N 6567947	Black Jack Group	402.5
K4	E 787731 N 6568753	Black Jack Group	409.2
K5	E 787056 N 6568724	Black Jack Group	290–300

[a] metres below ground surface

2.8 Appraisal activities

Appraisal activities would involve the operation of wells K2, K3, K4 and K5 for a period of approximately two years. It is intended that the period of approximately two years of appraisal activities would be continuous, however maintenance or downtime may occur that could result in a lengthier overall program.

The water produced from each of the four wells would flow through the water gathering line network to the existing central water storage infrastructure, consisting of two, 5 mega litre tanks located near well K2, where it would be temporarily stored. The two water holding tanks would be periodically emptied, with the water transported to the water treatment facility at Santos' Leewood property, about 20 kilometres south of Narrabri, which operates under a separate activity approval (DOI 2015a) and environment protection licence (NSW EPA 2019). Alternately, the produced water may be provided to a third party for beneficial reuse subject to a successful application for a resource recovery order and exemption under the *Protection of the Environment Operations (Waste) Regulation 2014*. Produced water would be managed in accordance with the *Exploration Code of Practice: Produced Water Management, Storage and Transfer* (NSW Government 2012b).

The volume of water produced would vary over time and be greater at the start of appraisal as the wells are depressurised, reducing as appraisal continues. Indicatively, daily water production could vary between 6 kilolitres and 24 kilolitres and with peaks in the order of 48 kilolitres in the early stages. Irrespective of the daily rate of water production, the total volume of water produced during appraisal is estimated to be about 9 megalitres per year.

Water quality within the target formation has been characterised by sampling and laboratory analysis, and is characterised by alkaline pH values, and higher electrical conductivity and total dissolved solids when compared to water in overlying alluvial formations used for agricultural purposes under licence. Laboratory analytical results are provided in Appendix C.

Gas produced from each of the four wells would flow through the gas gathering lines to the upgraded gas flare near well K2, where the gas would be flared continuously. It is estimated that the median gas production rate would be in the order of 480 thousand standard cubic feet per day, up to a probable maximum in the order of 820 thousand standard cubic feet per day. Gas composition data collected to date indicates the gas contains about 4 per cent carbon dioxide.

2.9 Decommissioning and rehabilitation

Decommissioning and rehabilitation would be carried out once the gas infrastructure reaches the end of its operational life. Decommissioning and rehabilitation would be carried out in consultation with the landholder and in accordance with the relevant guidelines including the *Exploration Code of Practice: Rehabilitation* (NSW Government 2012c) and the *Code of Practice for Coal Seam Gas Well Integrity* (NSW Government 2012a).

2.10 Stakeholder consultation

2.10.1 Overview

As one of Australia’s most significant domestic gas suppliers, Santos has partnered with many local communities, providing jobs and business opportunities while safely and sustainably developing Australia’s natural gas resources and powering Australian industries and households. Santos is committed to engaging with landholders and other key stakeholders who may be impacted by our projects or operations.

Santos has carried out stakeholder engagement regarding its gas exploration program in the Gunnedah Basin since 2008. Santos established and operated a Shopfront in Gunnedah for nine years from 2009 through until September 2018 to provide information to the community. Santos had a strong presence in the Gunnedah area during this period, with involvement in local events and representation on several community groups.

From late 2018, the exploration and appraisal work program in PEL 1 and 12 was reduced as part of a wider contiguous exploration project, comprising multiple prospecting titles, where PEL 238 and the Narrabri Gas Project became the focus for Santos’ NSW operations. While resources were realigned to meet delivery commitments for the Narrabri Gas Project, relationships with key stakeholders in the Gunnedah area have been maintained. From March 2020 through until January 2022, participation in community events was limited due to COVID-19 restrictions. During this period, Santos continued to provide information through the Santos website, activity updates in local newspapers, and a monthly activity update newsletter emailed to key stakeholders. Santos has offered an enquiry email address and telephone number during this time.

Santos has developed a specific community and stakeholder engagement plan for the proposed activity. The objectives of the stakeholder engagement plan are to:

– Increase overall awareness and understanding of the CSG industry
– Keep landholders, neighbours, residents, local council and relevant government agencies informed of the activity and progress
– Consider the interests of stakeholders in the project design and implementation
– Identify key issues or concerns for stakeholders and the community and address these through the environmental assessment process
– Provide timely, accurate and credible information to stakeholders and the broader community.

Stakeholder identification and consultation has been undertaken to meet the requirements associated with a ‘medium impact activity’ as per the *Exploration Code of Practice: Community Consultation* (Department of Regional NSW 2022). A summary of stakeholder engagement is summarised in the following sections.

Santos will continue to carry out stakeholder and community consultation activities in the region in relation to the planning and conduct of activities in accordance with the relevant guidelines including *Exploration Code of*

Practice: Community Consultation (Department of Regional NSW 2022) and *Exploration Guideline: Petroleum Land Access* (Department of Industry, July 2015).

2.10.2 Stakeholders

The following stakeholders have been identified for the activity based on the 'medium impact' determination for the activity:

- Landholder and residents/tenants of the site of the activity
- Gomeroi Native Title claimants
- Local government – Gunnedah Shire Council
- NSW Government local Member of Parliament – Member for Tamworth
- Community and Environment Groups
  - Mullaley Gas and Pipeline Accord
  - SOS Liverpool Plains
  - Lock the Gate Alliance
  - The Wilderness Society
  - NSW Farmers
  - General community
- Landholders, residents and businesses within 5km of the activity
  - Local contractors/service providers
  - Resource Title Holders
- Local Aboriginal Land Council
  - Red Chief LALC
  - Walhollow LALC
- State government
  - Various state government ministerial offices
  - Department of Regional NSW, Mining, Exploration and Geoscience (MEG)
  - NSW Environment Protection Authority (EPA)
  - North West Local Land Services (LLS)
- Santos has also identified and engaged with the following additional stakeholders:
  - Local Chamber of Commerce – Gunnedah Chamber of Commerce

No mineral or coal titles overlie or directly adjoin the site, however engagement will be undertaken with Namoi Mining Pty Ltd that hold the licence for EL5183 which is located approximately 5 kilometres to the east of the activity area.

2.10.3 Broad consultation activities

Santos uses a wide range of consultation tools to engage with various stakeholders as part of its overall community engagement program for its activities within PEL 1. This includes:

- Responding to correspondence / submissions regarding our activities
- Providing general information through the Santos website
- Daily presence at the Santos shopfront in Narrabri
- Media announcements
- Activity updates in local newspapers
- A monthly activity update newsletter emailed to key stakeholders

- A quarterly activity update to landowners
- An enquiry email address and telephone number on Fact Sheets
- Community site tours to Santos' operations in the Narrabri Gas Project area
- Community information sessions
- Direct engagement with landholders
- Information stands at local agricultural shows and relevant community events.

Santos delivered a Gunnedah Community Information Session on the 23 June 2022 and again on 2 November 2022. The intent of these sessions was to provide information and address any concerns on the proposed seismic program, Kahlua reactivation and the CSG industry more broadly. Santos advertised these community information sessions in the local newspaper and directly notified key stakeholders about the event. The sessions were well attended with more than 50 people visiting each day.

Santos has also hosted an information stand at AgQuip which is held near Gunnedah annually for each event held over the past eleven years. Santos had a stand at AgQuip from 16 to 18 August 2022, with representatives able to provide feedback on various aspects of the Narrabri Gas Project and Gunnedah exploration program including the proposed Kahlua work. More than 400 people attended the Santos stand over the three days.

2.10.4 Activities under stakeholder engagement plan

Table 2.2 identifies specific engagement that has occurred under the stakeholder engagement plan for the activity, identifying the relevance of the stakeholder to the impact level of the activity. Table 2.3 demonstrates that the community consultation in the form of actions / events and meetings has exceeded the requirements for the medium impact activity as prescribed in the *Exploration Code of Practice: Community Consultation* (Department of Regional NSW 2022).

Table 2.2 Consultation / Engagement Activities under stakeholder engagement plan

Stakeholder		Details of Engagement
Mandatory Stakeholder Engagement for Medium Impact Activity		
Landholder and residents / tenants of the site of the activity	Neighbouring private landowners	A letter advising of the activity and an Activity Overview will be sent to neighbouring landholders. Any update will be included in the monthly activity update which will be distributed to landholders that have subscribed to Santos updates.
Local Government	Gunnedah Shire Council	A presentation was provided to Gunnedah Shire Council on 15 June 2022 in relation to the activity in the Shire. Written notification of the activity would be sent to the General Manager and a face-to-face meeting arranged if required.
NSW Government local Member of Parliament	Member for Tamworth	Santos met with the local MP at an event on 16 March where upcoming exploration activities, were discussed. Additional information was sent to the local MP's office on 18 March. The local MP was advised of the Community Information Session on 23 June 2022. We will continue to update the local MP and his office regarding proposed activities.
Community and Environment Groups	– Mullaley Gas and Pipeline Accord, – SOS Liverpool Plains, – Lock The Gate Alliance (North West), – The Wilderness Society (Newcastle)	A letter was emailed to local relevant groups on 24 June 2022 to advise of the activity. A number of members of Mullaley Gas and Pipeline Accord and Knitting Nanas attended the Gunnedah Community Information Session held on the 23 June 2022. The monthly activity update will be provided to these groups on a regular basis.
	NSW Farmers	A meeting was held with NSW Farmers on 31 May 2022 to discuss the CSG industry and Santos' activities in NSW. Following this meeting, Santos sent an email on 24 June 2022 advising of the activity. NSW Farmers' contact will be included to the monthly activity update distribution list.

	General community	Santos held Gunnedah Community Information Sessions on the 23 June 2022 and 2 November 2022 to provide information and address any concerns on the proposed exploration program. Approximately 50 people attended each session, including some directly affected landholders and community members who oppose the CSG industry. Santos had a stand at AgQuip from 16 to 18 August 2022, with representatives able to provide feedback on the proposed Kahlua re-activation. More than 400 people attended the Santos stand over the three days.
Landholders, residents and businesses within 5km of the activity	Local contractors & service providers	Updates included in the monthly activity update.
	Resource title holders	All resource title holders are consulted as required.
	Private landholders	Many private landholders within 5km of the operating area have been engaged through the community information sessions, along with phone calls to landholders. Correspondence will be mailed in 2023.
Local Aboriginal Land Council	Red Chief LALC	Letters were sent to the Red Chief LALC 8 August and 7 September 2022 advising of the activity. This was followed up in August with phone calls to relevant contacts. The monthly activity update will be provided on a regular basis.
NSW Government	MEG	Multiple meetings have been held with the MEG including a session on 7th July 2022 to discuss the activity and further follow up sessions.
	EPA	A meeting with the EPA was held on 7th July 2022 to discuss the activity.
	North-West LLS	Written notification of the activity was sent to the General Manager on 17 June 2022 and a face-to-face meeting would be arranged if required. Updates on Project information would be included in the monthly activity update.
Additional Stakeholder Engagement Completed		
Local Chamber of Commerce	Gunnedah Chamber of Commerce	Written notification of the activity was sent to the Secretary on 17 June 2022 and a briefing for members will be arranged at a future meeting if required. The monthly activity update will be provided to these groups on a regular basis.

2.10.5 Engagement outcomes

Table 2.3 identifies the issues raised and the outcomes of engagement with the stakeholders identified in Table 2.2.

Table 2.3 Outcomes of engagement under stakeholder engagement plan

Stakeholder		Issues Raised	How/where issue is addressed
Mandatory Stakeholder Engagement for Medium Impact Activity			
Landholder and residents / tenants of the site of the activity	Neighbouring private landowners	Positive feedback on gaining better geological information. Negative feedback in relation to gas exploration activities recommencing in Gunnedah area.	Provision of background information with landholder letters. Continue to provide regular updates through various sources including direct engagement, Gunnedah Times newspaper, monthly activity updates, website, enquiry phone and email address.
Local Government	Gunnedah Shire Council	No issues raised	N/A

NSW Government local Member of Parliament	Member for Tamworth	Concerns raised about exploration activities in the Gunnedah region.	CSIRO research information provided to the local MP's office detailing how water aquifers are protected during CSG activities. Commitment to ongoing engagement with the local MP to clarify members concerns and address issues where possible.
Community and Environment Groups	– Mullaley Gas and Pipeline Accord – SOS Liverpool Plains – Lock The Gate Alliance (North West) – The Wilderness Society (Newcastle)	A number of members of Mullaley Gas and Pipeline Accord and Knitting Nanas attended the Gunnedah Community Information Session held on the 23 June 2022 to raise general concerns relating to the CSG industry.	Continue to provide regular updates through various sources including Gunnedah Times newspaper, monthly activity updates, website, enquiry phone and email address and letter relating to specific activities.
	NSW Farmers	No issues raised about the Kahlua reactivation but have members opposed to CSG development in the Gunnedah area.	Commitment to ongoing engagement with NSW Farmers to clarify members concerns and address issues where possible.
	General community	General concerns relating to CSG development including groundwater impacts and general opposition to fossil fuel development.	Continue to provide regular updates through various sources including Gunnedah Times newspaper, monthly activity updates, website, enquiry phone and email address and letter relating to specific activities.
Landholders, residents and businesses within 5km of the activity	Local contractors & service providers	No issues raised	N/A
	Resource title holders	No issues raised	N/A
Local Aboriginal Land Council	Red Chief LALC	No issues raised	N/A
NSW Government	MEG	No issues raised	N/A
	EPA	No issues raised	N/A
	North West LLS	No issues raised	N/A
Additional Stakeholder Engagement Completed			
Local Chamber of Commerce	Gunnedah Chamber of Commerce	No issues raised	N/A

2.10.6 Future and ongoing consultation activities

Santos will continue the broad consultation program prior to and during the proposed activity. Further specific consultation for the proposed activity will occur prior to the activity commencing. These activities are identified in Table 2.4.

Table 2.4 Proposed engagement prior to activity commencing

Consultation Activity	Description
Face to face meeting/briefing	Meetings with key stakeholders will continue to provide information, answer questions, identify issues of concern and provide timely responses to questions. Santos will continue to meet and discuss the seismic program with landholders and respond to any concerns raised.

Consultation Activity	Description
	Written notice will be provided to all landholders in proximity to the activity a minimum of 21 days prior to commencement.
Community Site Tours	Community Site Tours to visit operational sites in PEL 238 are conducted by request and are advertised at the Community Shopfront and on the Santos Narrabri Gas Project website so community from the broader area can see activities on-ground.
Narrabri Shopfront	The Santos shopfront will continue to provide a face-to-face opportunity for community members to ask questions and seek information on our activities.
Communication tools	The generic email and a contact telephone number will be referenced on Santos' website and external printed documentation.
Website	Website will be maintained and regularly updated with information.
Brochures and fact sheets	Brochures and fact sheets will be regularly reviewed and updated, and new publications will be produced as required.
Media Updates	Media releases on key announcements will continue.
Social Media	Santos' Facebook and Twitter pages are able to provide information via social media channels as required
Attendance at community events and agricultural shows	Santos will continue to attend community events such as agricultural shows, AgQuip, industry events and other relevant community events

2.10.7 Stakeholder complaint and conflict management

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

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

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

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

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

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

3. Statutory context

3.1 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) is the principal law regulating development in NSW. It establishes a regime for the making and determination of development applications, including assessment of environmental impacts. It also provides for the making of environmental planning instruments that place further controls on development including various local environmental plans (LEPs) and State environmental planning policies (SEPPs).

The EP&A Act defines development as any use of land, subdivision, building, work, demolition, or any other act, matter or thing controlled by an environmental planning instrument.

The EP&A Act further defines a number of types of development, including:

– Division 4.3 – Local and regional development
– Division 4.7 – State significant development (SSD)
– Division 5.1 – Activities by determining authorities
– Division 5.2 – State significant infrastructure (SSI).

Activities under Division 5.1 are generally those carried out by or on behalf of a public authority. A public authority in this case becomes the prescribed determining authority for the activity. In its consideration of an activity, a prescribed determining authority must examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment.

As discussed in section 3.2, the proposed activity requires an activity approval under the *Petroleum (Onshore) Act 1991*. The NSW Resources Regulator would be required to comply with the requirements of Division 5.1 of the EP&A Act in providing any such activity approval.

3.2 Petroleum (Onshore) Act 1991

The *Petroleum (Onshore) Act 1991* regulates petroleum exploration and production in NSW. The Act provides for the granting of various petroleum titles including the following:

– Division 2 – Petroleum exploration licences
– Division 3 – Petroleum assessment leases
– Division 5 – Petroleum production leases.

Division 2, Section 31A of the Act states that the holder of a petroleum exploration licence (PEL) must seek an activity approval for any assessable prospecting operation on land over which the licence is granted. Section 3 of the Act states an assessable prospecting operation is defined as any prospecting operation that is not exempt development as defined under the EP&A Act.

Santos is acting on behalf of the titleholders of PEL 1, which applies to land including the site of the proposed activity (DPIE 2019). The proposed activity classifies as an assessable prospecting operation and therefore requires an activity approval under the EP&A Act.

3.3 Water Management Act 2000

The *Water Management Act 2000* provides for the sustainable and integrated management of water resources within NSW. The Act provides for the making of water sharing plans, which set out rules for taking surface water and groundwater, and the granting of water access licences.

There are two water sharing plans relevant to the proposed activity:

– *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020*

– *Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020.*

The *Water Management (General) Regulation 2018* identifies a number of exemptions from the licensing requirements of the Act. Section 21 of the regulation states a person is exempt from requiring an access licence in relation to the taking of water from a water source if specified in any provision of Part 1 of Schedule 4 of the regulation. Part 1 of Schedule 4 includes any person lawfully engaged in an aquifer interference activity including taking of water for exploration for petroleum provided the taking of water is less than or equal to 3 mega litres in a given year.

The Act also regulates aquifer interference activities and other controlled activities where they affect the quantity or flow of water, including development, or removal or deposition of material.

The assessment and approval process for aquifer interference activities is set out in the NSW Aquifer Interference Policy (DPI 2012). The policy contains minimal impact considerations that may be applied to determine whether an aquifer interference activity will have minimal impact.

The policy states that the potential impacts of petroleum exploration activities on groundwater are to be assessed under the EP&A Act. The application of the EP&A Act is discussed in section 3.1 and potential impacts on groundwater have been assessed in section 4.4.2.

The proposed activity would involve groundwater take that would require a water access licence under these plans. Specifically, it would involve extraction of an estimated 9 megalitres per year from the Gunnedah-Oxley Basin MDB Groundwater Source under the *Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020*. This groundwater source is significantly under-allocated, and an allocation of this size would be readily available.

As discussed in section 4.4, the proposed activity would result in negligible, if any, induced flow in overlying aquifers, and accordingly, water access licenses for these aquifers are not needed.

As discussed in section 2, water would also be required for workovers in the order of 50,000 to 80,000 litres per workover. Potential water sources could include existing farm dams in the region and/or existing or new groundwater bores. All water take required for the proposed activity would be suitably licensed under the *Water Management Act 2000* and, in the case of existing farm dams or groundwater bores, agreements with the owners and licence holders.

3.4 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) aims to protect, restore, and enhance the quality of the environment. It prescribes offences mainly regarding pollution of the environment and establishes a regime for the licensing of certain scheduled activities.

Santos is the holder of EPL 20351 for the scheduled activity of petroleum exploration, assessment, and production (NSW EPA 2020). The licence applies to the existing coal seam gas exploration infrastructure and would require minor amendments for the proposed activity.

Santos is also the holder of EPL 20350 for the scheduled activity of petroleum exploration, assessment, and production (NSW EPA 2019). Condition A.32 of the licence states that it also applies to the operation of the existing produced water treatment facility at Leewood as described in the activity approval under the *Petroleum (Onshore) Act 1991* (DOI 2015a).

As discussed in section 2, produced water may be transported to the existing water treatment facility at Santos' Leewood property near Narrabri. Condition L3.4 of EPL 20350 was amended on 24 November 2022 to authorise the receipt of the produced water.

3.5 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the principal Commonwealth environment law. It protects the following nine matters of national environmental significance (MNES):

- world heritage properties
- national heritage places
- wetlands of international importance
- listed threatened species and ecological communities
- migratory species protected under international agreements
- Commonwealth marine areas
- the Great Barrier Reef Marine Park
- nuclear actions (including uranium mines)
- a water resource, in relation to coal seam gas or large coal mining development.

The EPBC Act also protects other matters including the environment in general where an action is on, or will affect, Commonwealth land, or where it is proposed by a Commonwealth agency.

An action that is likely to have a significant impact on matters of national environmental significance must be referred to the Minister responsible for the administration of the EPBC Act. After receiving a referral, the Minister decides whether the action is a controlled action.

Potential impacts on matters of national environmental significance are assessed in section 4.13. The proposed activity is not likely to have a significant impact on a matter of national environmental significance and is not on Commonwealth land or proposed by a Commonwealth agency. As such, the proposed activity does not need to be referred under the EPBC Act.

3.6 State Environmental Planning Policy (Resources and Energy) 2021

State Environmental Planning Policy (Resources and Energy) 2021 aims to provide for the management and development of mining, petroleum, and extractive industries. It establishes a gateway process to assess the impact of State significant mining and coal seam gas development on strategic agricultural land and its associated water resources.

The gateway assessment process is detailed in Division 4 of the policy. Section 2.29 provides that an application for a gateway certificate in respect of proposed mining or petroleum development on strategic agricultural land is to be made to the Gateway Panel.

Proposed mining or petroleum development is defined with reference to Schedule 1, section 6 of *State Environmental Planning Policy (Planning Systems) 2021* as follows:

> *6 Petroleum (oil and gas)*
>
> *(1) Development for the purpose of petroleum production.*
>
> *(2), (3) (Repealed)*
>
> *(4) Development for the purpose of petroleum related works (including pipelines and processing plants) that—*
>
> *(a) is ancillary to or an extension of another State significant development project, or*
>
> *(b) has a capital investment value of more than $30 million.*
>
> *(4A) This clause does not apply to coal seam gas development on or under land within a coal seam gas exclusion zone or land within a buffer zone (within the meaning of clause 9A of State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007).*

(5) In this clause, petroleum production has the same meaning as it has in State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007.

With regard to clause 6(5), petroleum production is defined in section 2.2 of *State Environmental Planning Policy (Resources and Energy) 2021* as follows:

petroleum production means the recovery, obtaining or removal of petroleum pursuant to a production lease under the Petroleum (Onshore) Act 1991 or a production licence under the Petroleum (Submerged Lands) Act 1982, and includes—

(a) the construction, operation and decommissioning of associated petroleum related works, and

(b) the drilling and operation of wells, and

(c) the rehabilitation of land affected by petroleum production.

petroleum related works means any works, structures or equipment that are ancillary or incidental to petroleum production and includes all works, structures and equipment that a production lease under the Petroleum (Onshore) Act 1991, or a production licence under the Petroleum (Submerged Lands) Act 1982, entitles the lease or licence holder to construct, maintain or execute.

The proposed activity does not classify as development for the purpose of petroleum production or petroleum related works as it would be carried out pursuant to a petroleum exploration licence and not a petroleum production lease or petroleum production licence.

As such, the gateway assessment process does not apply to the proposed activity.

Section 2.8 of the policy states that development for petroleum exploration may be carried out without development consent under Part 4 of the EP&A Act. Petroleum exploration is defined by the policy as including prospecting pursuant to a petroleum exploration licence. The proposed activity is development for the purpose of petroleum exploration and accordingly may be carried out without development consent under Part 4 of the EP&A Act. It must nonetheless comply with the requirements of Division 5.1 of the EP&A Act as discussed in section 3.1.

Section 2.12 of the policy states that coal seam gas development is prohibited in certain exclusion zones and buffer zones. Exclusion zones include residential zones, future residential growth areas, rural village land and critical industry cluster land. Buffer zones include any land within two kilometres of a residential zone, future residential growth area or rural village land. The site of the proposed activity is not within the above listed exclusion or buffer zones.

3.7 Gunnedah Local Environmental Plan 2012

The *Gunnedah Local Environmental Plan 2012* is the principal local planning instrument administered by Gunnedah Shire Council. The plan specifies permitted and prohibited development and land use zones throughout the Gunnedah local government area.

The site of the proposed activity is zoned as RU1 Primary Production under the plan. The proposed activity is permitted with consent within this zone. As discussed in section 3.6, the proposed activity is permissible without development consent under Part 4 of the EP&A Act.

4. Environmental assessment

4.1 Overview

The site of the proposed activity is located on Lot 6 DP586978 in Marys Mount about 20 kilometres west of Gunnedah, NSW. The site contains existing coal seam gas exploration infrastructure including four exploration wells (K2, K3, K4 and K5), access tracks between the wells, and water storage and gas flaring infrastructure located at well K2. The surrounding land is predominantly cleared for agriculture and related activities with isolated patches of native vegetation. The nearest residences to the site not leased by Santos are approximately 1 to 2 kilometres away to the west, south-west and south-east (refer Figure 4.1). It is noted that a homestead located approximately 1,100 metres north of the site is leased by Santos and was therefore not considered a sensitive receptor.

The site is relatively flat with elevations above sea level ranging between about 307 metres in the north-west to 323 metres AHD in the south-east, with an average gradient of about one degree. Soils in the region are mapped as a mosaic of vertosols, ferrosols and chromosols — with primarily vertosols mapped at the site itself. There are no known instances of problematic soil properties such as salinity or potential acid sulfate soils at the site.

The climate at the site of the proposed activity has been characterised based on data collected at the weather station in Gunnedah (BOM 2020). Monthly rainfall averages about 50 mm with lows of about 40 mm during the drier months and highs of about 80 mm during wetter months. The average maximum temperature is about 25 degrees, ranging between lows of 16 degrees and highs of 32 degrees. Wind speed as recorded at 9 am averages nine kilometres per hour.

It should be noted that the site is partially mapped as biophysical strategic agricultural land (BSAL) under *State Environmental Planning Policy (Resources and Energy) 2021*. The actual presence and potential impacts on BSAL are discussed in section 4.5. The site is not within, or in close proximity to, any other sensitive land as defined under *ESG2: Guideline for preparing a Review of Environmental Factors* (DPIE 2015) including any conservation areas, drinking water catchments, environmentally sensitive areas, Aboriginal heritage protection areas, historic or natural heritage protection areas or community land.

As discussed in section 3.6, the site is not within an exclusion zone or buffer zone under *State Environmental Planning Policy (Resources and Energy) 2021*.

4.2 Air quality

4.2.1 Existing environment

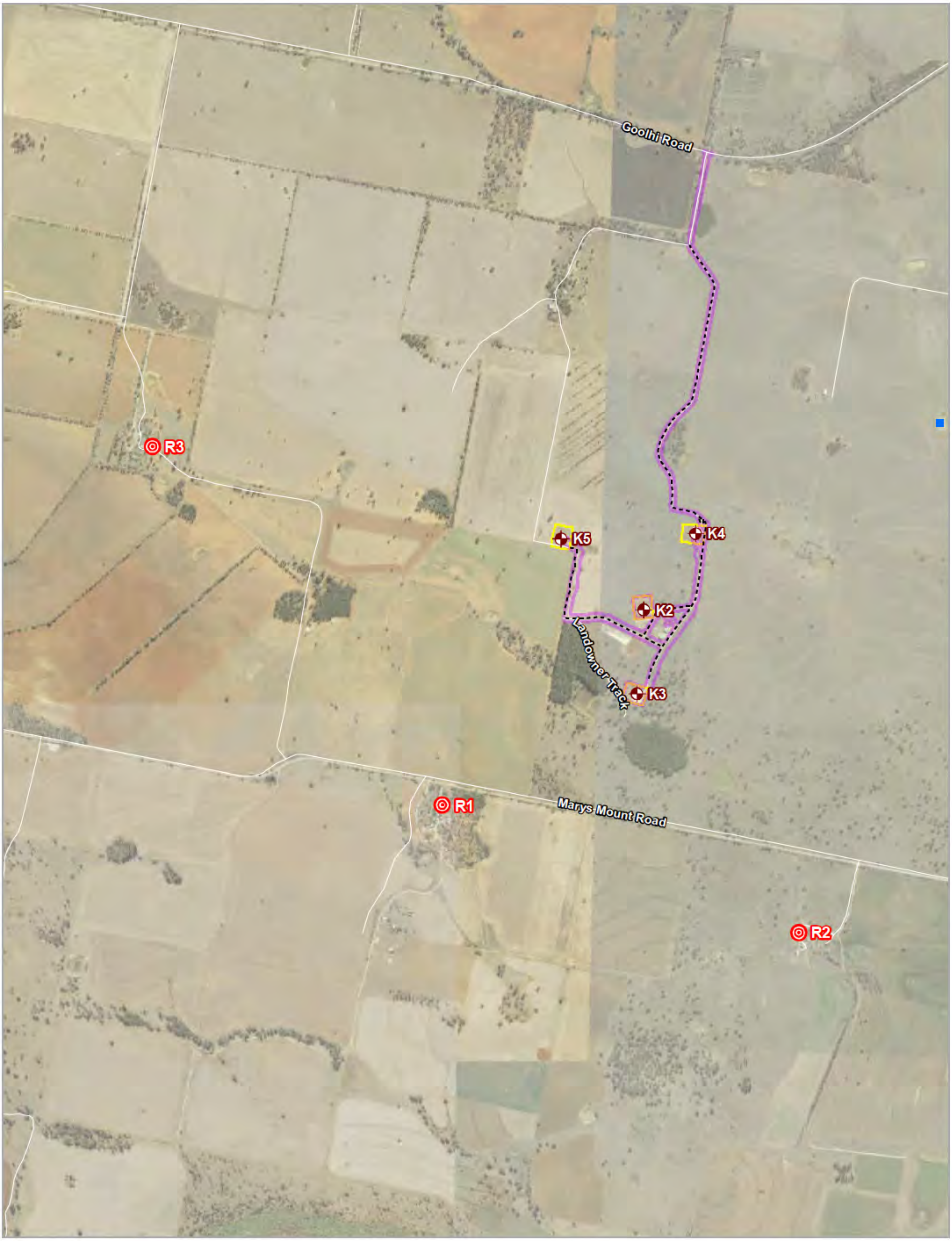
Existing air quality at the site of the proposed activity and surrounding region is expected to be relatively good given the surrounding rural agricultural land uses of grazing and cropping. A search of the National Pollutant Inventory did not return any major sources of pollution in the region (Australian Government 2020a). A review of one year of publicly available air quality data at Gunnedah indicated the air quality was generally good as reflected in the average air quality index score of 63 (DPIE 2020a).

The proposed activity is situated in a relatively remote setting in a largely rural and agricultural region and accordingly there are relatively few sensitive receivers surrounding the site.

The identified sensitive receivers are listed in Table 4.1 and shown in Figure 4.1.

Table 4.1 Sensitive receivers

Sensitive receiver	X coordinate (UTM)	Y coordinate (UTM)	Distance from site	Direction from site
R1	786,462	6,567,387	1,080 m	South-west
R2	788,250	6,566,748	1,400 m	South-east
R3	785,005	6,569,188	2,000 m	West



LEGEND
- Pilot well
- Well pad
- Existing access track
- Roads
- Sensitive receiver
- Construction Disturbance Zone
- Water tank

Paper Size ISO A4
0 250 500
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Santos
Kahlua Pilot

Sensitive receivers

Project No. 2122463
Revision No. 0
Date 15/12/2022

FIGURE 4.1

G:\21\22463\GIS\Maps\Deliverables\Kahlua_Pilot\21_22463_Z185_REF_KahluaPilot_SensitiveReceivers.mxd
Print date: 15 Dec 2022 - 16:12

Data source: Sensitive receivers, GHD 2020. Pilot wells, gathering lines and well pads, Santos 2020. Water tank, Geoscience NSW. General topo - NSW LPI DTDB 2015. Aerial imagery courtesy of SIXMaps, State Government of NSW Spatial Services, 2011-2016 © Department of Customer Service 2020. Created by: ebbertson

4.2.2 Potential impacts

The proposed activity would have very limited potential to generate emissions to air that would have a material impact at the identified sensitive receivers. Civil and construction works would include some small-scale excavation and stockpiling for the installation of gathering lines and movement of vehicles and equipment on access tracks that could generate dust. The operation of vehicles and equipment would also generate some small quantities of exhaust emissions.

Based on the limited potential for nuisance air quality emissions, separation distances to the nearest sensitive receivers, and measures proposed in section 4.2.3, potential impacts on air quality would be low.

4.2.3 Proposed measures

ID	Proposed measure
A1	Carry out water-based dust suppression as required.
A2	Implement on site speed limits to minimise dust generation.
A3	Water, cover or otherwise stabilise stockpiled excavated material.
A4	Maintain plant and equipment
A5	Turn off plant and equipment when not in use

4.3 Greenhouse gas

4.3.1 Existing environment

Australia's greenhouse gas emissions are quantified on an annual basis through the Emissions and Energy Reporting system under the *National Greenhouse and Energy Reporting Act 2007*. They are estimated at 510.1 million tonnes of carbon dioxide equivalent emissions (CO2-e) according to the Quarterly Update of Australia's National Greenhouse Gas Inventory (September 2020; DCCEE&W 2020).

4.3.2 Potential impacts

The greenhouse gas emissions from the proposed activity have been assessed in accordance with the *National Greenhouse and Energy Reporting (Measurement) Determination 2008* under the *National Greenhouse and Energy Reporting Act 2007*. The greenhouse gases considered included carbon dioxide, methane and nitrous oxide. The sources of greenhouse gas emissions that were considered included general leaks, emissions from well operations, emissions from gas flaring, emissions from the reservoir and operation of generators. Technical assumptions that formed the basis greenhouse gas assessment are documented in detail in Appendix D.

The estimated greenhouse gas emissions from the proposed activity are listed in Table 4.2. The total greenhouse gas emissions inventory is 36,489 tonnes CO_2-e over two years, or about 18,245 tonnes CO_2-e per year — about 0.004 per cent of Australia's annual inventory.

Proposed measures to minimise greenhouse gas emissions are provided in section 4.3.3. In the context of Australia's annual inventory, and with the implementation of the proposed measures, it is considered that the potential impacts of greenhouse gas emissions would be low.

Table 4.2 Greenhouse gas

Source	Emissions (tonnes CO_2-e)
Flaring	31,478
Production related emissions (including well workovers)	95
Reservoir CO_2 release	1,259
Diesel use – operation of power plant	3,542

Source	Emissions (tonnes CO_2-e)
Diesel use – operation of generators during site establishment	100
Diesel use – Transport	14
Total	36,489

4.3.3 Proposed measures

ID	Proposed measure
G1	Consider energy efficiency in the procurement of goods and services.
G2	Implement a Gas Leak Detection and Repair (LDAR) program for all gas process plant and equipment on the premises.

Due to the remote location of this pilot away from potential beneficial end users the production gas is to be flared locally. Alternate options to flaring have been explored and assessed for implementation however none are currently feasible. Alternate flaring options development is to be continued and assessed for implementation over the pilot operation period.

4.4 Water resources

A specialist groundwater assessment has been carried out for the proposed activity.

The specialist groundwater assessment included a review of existing information, including data collected during prior pilot tests, development of a conceptual groundwater model, and prediction of potential groundwater impacts using numerical modelling techniques.

The complete assessment is provided in Appendix E and its key findings are summarised here.

4.4.1 Existing environment

4.4.1.1 Groundwater

The existing geology at the site of the proposed activity was characterised with reference to well completion reports from prior exploration and appraisal activities. The geological stratigraphy determined from the well completion report for well K2 is reproduced below in Table 4.3.

Table 4.3 Stratigraphic column

Formation	Depth (bgl)	Depth (AHD)
Alluvium	4 m	317.4
Napperby Formation	12 m	309.4
Digby Formation	174 m	147.4
– Ulinda Sandstone	174 m	147.4
– Bomera Conglomerate	180 m	141.4
Black Jack Group	210 m	111.4
– Trinkey Formation	210 m	111.4
– Wallala Formation	234 m	87.4
Breeza Coal Measure	268 m	53.4
– Benelabri Formation	273 m	48.4
Hoskissons Coal Measure	301 m	20.05
– Arkarula Formation	309 m	12.45

Formation	Depth (bgl)	Depth (AHD)
– Pamboola Formation	338 m	-16.6
Melvilles Coal Measure	347 m	-25.6
Millies Group	384 m	-62.6
– Watermark Formation	384 m	-62.6
– Porcupine Formation	534 m	-212.6
Bellata Group	600 m	-278.6
– Maules Creek Formation	600 m	-278.6
Maules Creek Coal Measure	600 m	-278.6
– Leard Formation	678 m	-356.6

A conceptual groundwater model was developed based on an interpretation of the stratigraphy of the site. A conceptual groundwater model is a simplified representation of a groundwater system and is based on geological, geophysical, hydrological, and hydrogeochemical information. The development of an appropriate conceptual model is one of the most important steps in any successful modelling study.

The potential aquifer units identified in the conceptual model were as follows:

- Quaternary alluvium — Narrabri Formation and Gunnedah Formation
- Sandstone units — Napperby Formation and Digby Formation.

With regard to the quaternary alluvium within Narrabri Formation and Gunnedah Formation, these aquifer units were not considered present at the site of the proposed activity but about 4 kilometres to the west and more than 130 metres above the target Hoskissons Coal Measure within the Black Jack Group.

With regard to the Sandstone units within the Napperby Formation and Digby Formation, the main potential aquifer unit identified was the Ulinda Sandstone, which was considered to be present at the site and about 110 to 120 metres above the target Hoskissons Coal Measure.

The hydraulic properties of the potential aquifer units were then characterised with reference to existing literature and data collected during prior pilot tests. The hydraulic properties of the quaternary alluvium within the Narrabri Formation and Gunnedah Formation were considered well documented within the existing literature having a relatively high hydraulic conductivity. It was noted that the hydraulic properties of the deeper bedrock were less well documented, however it was considered that those deeper formations had considerably less conductivity.

Groundwater levels within potential aquifer units were analysed using data from a network of shallow aquifer monitoring bores (SAMBs 1 and 2) established as a condition of the prior pilot tests. The SAMBs target the potential aquifer units in the Napperby and Digby Formations above the target Hoskissons Coal Seam. The SAMB1 and SAMB2 monitoring wells comprise nested monitoring facilities with groundwater level sensors installed at three different levels. SAMB1 is located near Kahlua 4, while SAMB 2 is located around 800 m to the north of Kahlua 4 near the decommissioned (cemented) and abandoned Kahlua 1 pilot well.

The results of the analysis of groundwater levels indicated a significant hydraulic barrier between the shallower, higher value aquifer units and the target Hoskissons Coal Measure. More specifically, there would be on average over 120 metres of intervening strata including:

- Benelabri Formation — 26 metres of sandstone and mudstone
- Breeza Coal Measures — 3 metres of tuff with coal fragments
- Wallala Formation — 31 metres of sandstone and conglomerate
- Trinkey Formation — 28 metres of tuff with coal bands.

Water quality within the potential aquifer units was characterised with reference to the state data (NSW Government 2011), data from the Kahlua 2 well established by Santos, and through a literature review (Lavitt 1999). It was found that the quaternary alluvium contained generally fresh groundwater with some brackish/saline characteristics in the shallower Narrabri Formation and fresher characteristics in the deeper Gunnedah Formation within the alluvium. In other, deeper, potential aquifer units including the Napperby and Digby formations, groundwater was observed to be fresh to slightly brackish. Groundwater in coal formations, including the target Hoskissons Coal Measure in particular, was far more saline than other formations.

The marked difference in water quality, in particular between the target Hoskissons Coal Measure and shallower aquifers, provided further evidence of the significant hydraulic barrier.

A review of registered bores within about six kilometres of the site of the proposed activity was carried out. The registered bores identified within about 2 kilometres of the site were:

– GW026532 — 1.74 km south-east — Water supply — Napperby Formation
– GW027074 — 1.87 km south-east — Unknown use — Napperby Formation
– GW027071 — 1.75 km north-east — Irrigation — Napperby Formation
– GW027072 — 1.94 km north-east — Irrigation — Digby Formation
– GW027073 — 1.46 km north-east — Irrigation — Digby Formation.

The likely aquifer units targeted by these bores was appraised based on bore depth and the conceptual groundwater model. As shown above, the bores in proximity to the site of the proposed activity were considered to target the Napperby Formation or Digby Formation. As discussed above, these formations are separated from the target Hoskissons Coal Measure by on average over 120 metres of intervening strata that form a significant hydraulic barrier.

A review of potential groundwater-surface water interactions identified that regional waterways including Mooki River and Coxs Creek were likely to be connected to alluvial aquifers however groundwater is generally significantly deeper than the beds of the waterways particularly in reaches where groundwater extraction was occurring. WaterNSW monitoring bore data to the west of the site of the proposed activity indicated groundwater depths in the alluvial aquifers at about 14 metres below ground level. It was therefore considered that the interactions would more typically involve the waterways recharging the alluvial aquifers, particularly after rainfall.

A number of potential groundwater dependent ecosystems (GDEs) and inflow dependent ecosystems (IDEs) were identified within about 10 kilometres from the site of the proposed activity. The identified GDEs and IDEs were typically vegetation communities that generally classified as low to moderate potential for groundwater dependence, and a subset with high potential, that would typically rely on the relatively shallow potential aquifer units. There were no high priority GDEs as listed under the relevant water sharing plan within 10 km of the site.

4.4.1.2 Surface water

There are no mapped minor or major watercourses in or near the site of the proposed activity. The nearest minor watercourses are Quia Creek about 8 kilometres to the west and Collygra Creek about 3 kilometres to the east. The nearest major watercourse is the Namoi River about 20 kilometres to the north-east. Some minor ephemeral drainage lines connecting a series of farm dams are situated about 100 metres south-west and 250 metres north-east of the site.

4.4.2 Potential impacts

The potential impacts of the proposed activity include the following and are considered below:

– potential change in groundwater hydraulic pressure (drawdown)
– potential change in groundwater quality and quantity
– potential change in groundwater availability on GDEs and/or IDEs
– potential change in surface water quality or availability.

Produced water management is discussed separately in section 2.

4.4.2.1 Potential change in groundwater hydraulic pressure (drawdown)

The potential for drawdown was assessed using a numerical model on the conservative assumption of an extraction rate of 24 kilolitres per day each day over two years. The model then produced a predicted drawdown at each of the registered bores in the vicinity of the site of the proposed activity.

In general, the depth of the target Hoskissons Coal Measure and the significant hydraulic barrier between it and the shallower aquifers significantly mitigated the transmission of changes in groundwater pressure. The predicted drawdown was contained to the Hoskissons Coal Measure and adjacent formations within the Black Jack Group, of which the Hoskissons Coal Measure is a part, and accordingly negligible drawdown was predicted in the shallower, higher value aquifers including the sandstone units of the Napperby and Digby formations and Quaternary alluvium of the Narrabri and Gunnedah formations. Negligible drawdown was therefore predicted in surrounding groundwater bores.

The results indicate that the potential drawdown resulting from the proposed activity would comply with the minimal impact considerations of the *Aquifer Interference Policy* (DPIE 2012). As such, no impacts on water levels and/or water quality at sensitive receptors including existing water supply bores which target shallower units is predicted.

4.4.2.2 Potential change in groundwater quality and quantity

As discussed above, the potential for drawdown were predicted to be constrained to the Hoskissons Coal Measure and adjacent formations within the Black Jack Group. Accordingly, the potential drawdown and concomitant potential for mixing of groundwater from the lower value deeper aquifers into the higher value shallow sandstone and alluvial aquifers is negligible.

It should also be noted that in the event of even minimal drawdown within one of the higher value shallow aquifers, the downward hydraulic gradient would tend towards the deeper aquifers and prevent any such mixing.

The results indicate that the potential impacts on water quality from the proposed activity would comply with the minimal impact considerations of the *Aquifer Interference Policy* (DPIE 2012).

4.4.2.3 Potential changes in water availability on GDEs and/or IDEs

As discussed above, the potential drawdown was predicted to be constrained to the Hoskissons Coal Measure and adjacent formations within the Black Jack Group, with negligible drawdown in the shallower high value aquifers or any formations that occur at outcrop. As such, the potential for a change in water availability (impact) of the proposed activity on GDEs and/or IDEs was considered negligible.

The results indicate that the potential impacts on GDEs and IDEs from the proposed activity would comply with the minimal impact considerations of the *Aquifer Interference Policy* (DPIE 2012).

4.4.2.4 Potential change in surface water or availability

The potential impacts of the proposed activity on waterways and drainage would be limited as no diversion is proposed and activities limits. Potential changes in water quality are limited to the potential for erosion and sedimentation associated with earthworks and accidental leaks or spills for fuels or chemical storage.

Based on the limited and temporary nature of ground disturbance proposed, the proximity of the activity to surface waters, the limited volumes of fuel or other chemicals at the site, and the measures proposed in section 4.4.3, potential impacts on waterways would be low.

4.4.3 Proposed measures

ID	Proposed measure
W1	Implement a groundwater monitoring program including: – Daily monitoring of extraction rates/groundwater levels in pilot wells – Review of groundwater level data from all available NSW state monitoring points within 10 km of the Kahlua site at 12 months and at completion – Reporting of results of review findings to NSW Office of Water as required
W2	Carry out the activity in accordance with relevant standards including the *Code of Practice for Coal Seam Gas Well Integrity* (NSW Government 2012a)
W3	Erosion and sediment controls in place where appropriate

ID	Proposed measure
W4	Vehicles and machinery would be properly maintained and routinely inspected to minimise the risk of fuel/oil leaks
W5	Spill kits appropriate to products used in the machinery and vehicles would be available during the proposed activity
W6	Spills of fuel, oil, chemicals, or the like would be cleaned immediately, and the environmental manager for the activity would be notified of the location of the incident, extent of the incident and type of material spilled.
W7	Light vehicles would be refuelled off-site

4.5 Soils and land use

4.5.1 Existing environment

The site of the proposed activity is Lot 6 DP586978 in Marys Mount about 20 kilometres west of Gunnedah, NSW. The site contains existing coal seam gas infrastructure including exploration wells connecting access tracks and central water storage and gas flaring infrastructure. The surrounding land is predominantly cleared for agriculture with isolated patches of native vegetation. The nearest residences to the site are in the order of 1 to 2 kilometres away to the west, south-west and south-east, as shown in Figure 4.1.

The site gently slopes from the south-east to the north-west. Elevations above sea level range between about 307 metres in the north-west to 323 metres AHD in the south-east. Soils in the region are mapped as a mosaic of vertosols, ferrosols and chromosols — with primarily vertosols mapped at the site itself. There are no known instances of problematic soil properties such as salinity or potential acid sulfate soils at the site.

The site is partially mapped as Biophysical Strategic Agricultural Land (BSAL) under *State Environmental Planning Policy (Resources and Energy) 2021*. BSAL is defined as land with high quality soil and water resources able to sustain a high level of productivity. A total of 2.8 million hectares of BSAL has been mapped across NSW (NSW Government 2020a).

Due to the broad scale of BSAL mapping, there may be circumstances where it does not accurately reflect its presence or absence at the given location. Accordingly, a site verification process has been established as a precursor to the gateway assessment process under *State Environmental Planning Policy (Resources and Energy) 2021*.

As discussed in section 3.6, the gateway assessment process does not apply to the proposed exploration and appraisal activity, and accordingly, neither does the site verification process. However, for the purposes of this environmental assessment it has been assumed that BSAL mapping at the site is accurate. The extent of mapped BSAL at the site is shown in Figure 4.2.

Regardless of the extent of BSAL, land and soil capability mapping of NSW classifies the site as being class 3 land, defined within the assessment scheme (NSW Government 2012e) as:

> *High capability land: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.*

Accordingly, all of the land at the site is considered to be of relatively high agricultural capability.

The existing uses of agricultural land at the site and surrounding region are predominantly cropping with smaller areas of grazing on modified pastures (Australian Government 2020b).

LEGEND

- Pilot well
- Well pad
- Existing access track
- Roads
- Watercourse
- Contours (1m)
- Construction Disturbance Zone
- Biophysical Strategic Agricultural Land

Australian soil classification

- Vertosols

Paper Size ISO A4

0 50 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Santos
Kahlua Pilot

Topography and soils

Project No.	2122463
Revision No.	0
Date	15/12/2022

FIGURE 4.2

G:\21\22463\GIS\Maps\Deliverables\Kahlua_Pilot\21_22463_Z186_REF_KahluaPilot_TopographySoils.mxd
Print date: 15 Dec 2022 - 16:07

Data source: Pilot wells, gathering lines and well pads, Santos 2020. SALBiophysical, DPIE 2020. Soil and Land Resources of the Liverpool Plains Catchment, DPIE 2012. Contours and watercourse, DPIE 2015. Australian Soil Classification (ASC) - OEH 2013. General topo - NSW LPI DTDB 2015. Cadastre - NSW LPI DCDB 2017. Contours - NSW Spatial Services 2011. Aerial imagery - Google Earth Pro (image date 13/08/2018, image extracted 04/09/2020). Created by: elbbertson

4.5.2 Potential impacts

The ongoing appraisal activities would largely represent a continuation of the use of existing and approved infrastructure at the site. The proposed activity may involve some additional works with minimal disturbance. The proposed activity would therefore have limited impacts on existing land uses and property values.

As discussed in section 2.10, the proposed activity would be carried out in consultation with the existing landholder, which would serve to further minimise potential impacts on land use.

The proposed activity would involve some temporary and small-scale excavation that would have no long-term impacts on the topography and stability of the site. Given the site is relatively flat, and the soils are not mapped as dispersive, and are therefore not prone to erosion, it is considered that erosion and sedimentation would be readily controlled by standard measures.

The potential impacts of the proposed activity on agricultural land, including BSAL, have been assessed in the following subsection in accordance with the requirements for a Level 2 Agricultural Impact Statement, which are set out in the *Strategic Regional Land Use Policy Guideline for Agricultural Impact Statements at the Exploration Stage* (NSW Government 2015). The assessed impact of the proposed activity on soils and land use, including BSAL, is considered low.

4.5.2.1 Strategic agricultural land

As discussed in section 4.5.1, the site of the proposed activity is partly mapped as BSAL.

As discussed in section 2, as far as reasonably practicable, the proposed activity would be confined to areas that have already been disturbed through the establishment of existing and approved onshore gas exploration infrastructure. As such, the potential for the proposed activity to have a significant impact on the strategic agricultural land is intrinsically low.

A worst-case scenario for the purpose of assessing potential impacts on strategic agricultural land would be that the construction corridor for the installation of gathering lines would be entirely outside areas that have already been disturbed. In this scenario, an area of agricultural land totalling about 2.3 hectares would be directly impacted by excavation and/or compaction. About 1.95 hectares of this area of additional disturbance would be on land mapped as BSAL — or about 0.001 per cent of mapped BSAL within the Gunnedah local government area.

The land that would be directly disturbed during the minor civil and construction works would be limited and, following the works, would be restored to a state such that cropping could resume. Accordingly, there is not expected to be any significant or lasting impact to agricultural land.

Proposed measures to rehabilitate impacted agricultural land are included in section 4.5.3.

4.5.2.2 Sensitive agricultural activities

The existing use of agricultural land at the site and surrounding region are predominantly cropping with smaller areas of grazing on modified pastures (Australian Government 2020b).

No nearby sensitive agricultural activities have been identified, including intensive plant agriculture such as orchards and vineyards, intensive livestock agriculture and/or breeding.

4.5.2.3 Agricultural biosecurity

The proposed activity would involve the use of vehicles and equipment, which would have the potential to create vectors for noxious weeds or plant diseases. The excavation of soil at the site would also present a risk of mobilising soil borne plant diseases such as *Phytopthora*.

As all vehicles and equipment would access the site via existing roads, remaining within areas that have either been previously disturbed or are immediately adjacent to previously disturbed land, the potential for the spread of weeds and disease into agricultural areas would be limited. Proposed measures to prevent the spread of weeds and disease are nonetheless included in section 4.5.3.

The approach to weed management at the site is discussed in section 4.9.

4.5.2.4 Accounting for the take of water

The potential impacts of the proposed activity on groundwater are predicted to be negligible as discussed in section 4.4.2. Accordingly, the proposed activity is not expected to significantly affect the availability or reliability of water and would be readily licensed in the water trading market. Monitoring and reporting will be undertaken in accordance with the existing and any future *Water Management Act 2000* approvals relevant to the Kahlua pilot reactivation.

As discussed above, all water take required for the proposed activity would be suitably licensed under the *Water Management Act 2000* and, in the case of water extraction from existing farm dams or groundwater bores, agreements with any existing owners and licence holders.

4.5.2.5 Consultation

Consultation regarding agricultural land would be carried out as described in section 2.10

4.5.3 Proposed measures

ID	Proposed measure
S1	Carry out the proposed activity in consultation with the landholder and through the development of a land access and compensation agreement.
S2	Stockpile topsoil separately so that the soil profile is maintained when backfilled.
S3	Manage stockpiled material in accordance with standard sediment and erosion control management measures.
S4	Carry out decommissioning and rehabilitation in consultation with the landholder and in accordance with the relevant guidelines including the *Exploration Code of Practice: Rehabilitation* (NSW Government 2012c).
S5	Vehicles and machinery would be properly maintained and routinely inspected to minimise the risk of fuel/oil leaks.
S6	Spill kits appropriate to products used in the machinery and vehicles would be available during the proposed activity.
S7	Spills of fuel, oil, chemicals or the like would be cleaned immediately, and the environmental manager for the activity would be notified of the location of the incident, extent of the incident and type of material spilled.
S8	Light vehicles would be refuelled off-site.

4.6 Noise and vibration

4.6.1 Existing environment

The proposed activity is situated in a relatively remote setting in a largely rural and agricultural region, and accordingly, there are relatively few sensitive receivers surrounding the site. A residential dwelling is situated approximately 1,100 m to the north, located within the same lot as the Kahlua site. This lot is leased by Santos, with the dwelling uninhabited. Considering this, it will not be considered part of the scope of this assessment.

The identified sensitive receivers are listed in Table 4.4 and shown in Figure 4.1.

Table 4.4 Sensitive receivers

Sensitive receiver	Distance from site	Direction from site
R1	1.1 km	South-west
R2	1.4 km	South-east
R3	2.0 km	West

In lieu of background noise monitoring, background noise levels for this assessment are assumed to be the minimum background noise levels presented in Table 2.1 of the Noise Policy for Industry (NPfI) (NSW EPA 2017) and are presented below in Table 4.5.

Table 4.5 Background noise

Period	Background noise
Day (7 am – 6 pm)	35
Evening (6 pm – 10 pm)	30
Night (10 pm – 7 am)	30

4.6.2 Potential impacts

The relevant construction and operational noise limits are provided in conditions L3 and L4 from EPL 20531 and are prepared in accordance with the *Interim Construction Noise Guideline* (ICNG) (EPA 2009) for the assessment of impacts from construction, including workovers, and the *Noisy Policy for Industry* (EPA 2017) for the assessment of operations including appraisal. Whilst the *Construction Noise Guideline* is currently in preparation with the NSW EPA, and a *Draft Construction Noise Guideline* was previously issued for public consultation, the ICNG is the relevant construction noise guideline in force at the time of this assessment, from which the noise criteria and assessment methodology is based off. It is noted that no construction noise limit for construction activities during standard hours is provided; as such, a noise management level (NML) is provided to manage noise impacts during this period.

The adopted noise criteria for the proposed activity are summarised below in Table 4.6. Noise management levels have also been provided for construction works occurring within standard construction hours, which are included in this assessment to assess where reasonable and feasible management measures should be implemented during standard construction hours. These are based on the NML in accordance with the *Interim Construction Noise Guideline (DECC, 2009)* (ICNG), and are also provided in Table 4.6.

Table 4.6 Noise criteria

<table>
<tr><th>Activity</th><th colspan="2">Period</th><th>Criterion (dBA)</th></tr>
<tr><td>Construction</td><td colspan="2">Standard hours - NML</td><td>45[a]</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">Outside of hours works (OOHW)</td><td>Day</td><td>40[b]</td></tr>
<tr><td>Evening and night</td><td>35</td></tr>
<tr><td>Operations</td><td colspan="2">Day, evening and night</td><td>35</td></tr>
</table>

[a] Monday to Friday 7 am – 6 pm, Saturday 8 am – 1 pm

[b] 40 dBA when outside standard hours but within the day period of 7 am – 6 pm

Construction noise impacts were modelled which included workover operations and trenched gathering line installation. The predicted noise levels at the identified sensitive receivers during these works under worst-case noise enhancing conditions are summarised in Table 4.7. Exceedances of the noise limits outside standard construction hours in the day, evening and night periods were predicted, due to the use of the workover rig, with the airpacks circulating downhole, and the primary jet. An exceedance of the night-time criteria is also predicted during standard meteorological conditions from the same equipment.

It is recommended that a negotiated agreement is sought with the exceeding receivers R2 and R3 for works involving the workover rig outside of standard construction hours. It is predicted that construction noise levels are compliant with the adopted NML inside standard construction hours.

Table 4.7 Construction noise

<table>
<tr><th colspan="2" rowspan="2">Activity</th><th rowspan="2">Noise criterion, dBA</th><th colspan="3">Noise level, dBA</th></tr>
<tr><th>R1</th><th>R2</th><th>R3</th></tr>
<tr><td rowspan="2">Workover operations</td><td>VENITA 29 Workover Rig, Airpacks circulating downhole</td><td rowspan="2">Standard hours: 45 NML
OOHW day: 40
OOHW evening and night: 35</td><td>44</td><td>41</td><td>35</td></tr>
<tr><td>Tripping operations overbalance only</td><td>30</td><td>27</td><td>21</td></tr>
</table>

Activity		Noise criterion, dBA	Noise level, dBA		
			R1	R2	R3
	Circulating with rig Mud pumps only (no air packs)		32	29	23
	VENITA 29 Workover Rig, Silvent primary jet		44	41	35
Trenched gathering line installation			35	32	26

The noise impacts of appraisal operations were modelled that included operation of diesel generator power unit, well head drive motors, and the use of a pilot flare. Operational traffic impacts were also included in the assessment, through the assessment of water truck noise along internal access roads. The predicted noise levels at the identified sensitive receivers during these works under standard and noise enhancing conditions are summarised in Table 4.8. As shown, operational noise would comply with the noise criteria at all receptors and during all periods.

Table 4.8 Operational noise

Operational noise source	Weather conditions	Noise limit, dB(A)	Receiver ID, dB(A)		
			R1	R2	R3
Diesel generator power unit	Standard	35	0	0	0
	Noise enhancing		0	0	0
Well head drive motors	Standard		0	0	3
	Noise enhancing		5	0	9
Water truck	Standard		11	8	13
	Noise enhancing		15	13	17
Pilot flare	Standard		14	7	18
	Noise enhancing		19	12	23
Total	Standard		16	11	19
	Noise enhancing		21	16	24

Given the limited duration and intensity of the predicted noise impacts and the measures proposed in section 4.2.3 it is considered that potential noise impacts would be low.

The noise and vibration assessment is documented in further detail in Appendix F.

4.6.3 Proposed measures

ID	Proposed measure
N1	Site inductions for the work crew would include the specific noise issues and mitigation measures required for the site.
N2	Incorporate the use of two-way radios over loudspeakers when communicating across longer distances
N3	Maximise the distance between plant and equipment and sensitive receivers where practicable. For example, vehicle movements and generator storage would be located as far as practical from sensitive receivers.
N4	The use of broadband reversing alarms.
N5	Use quieter and lower vibration emitting construction methods where available.
N6	Vehicles, plant and equipment would be regularly maintained and kept in good operating condition.
N7	Where feasible and reasonable, reducing the number of plant and equipment used during the out of hours periods to reduce noise emission levels.

ID	Proposed measure
N8	Scheduling noisier activities during recommended standard construction hours and minimise the use of heavy machinery during the out of hours periods.

4.7 Waste and resources

4.7.1 Existing environment

The existing waste and resources facilities in the region include Gunnedah Shire Council Waste Management Service and Gunnedah Community Recycling Centre.

Other waste and resources facilities further afield include Narrabri Waste Management Facility and Tamworth Waste Management Facility, plus a number of rural transfer stations.

4.7.2 Potential impacts

The predicted waste inventory from the proposed activity is summarised in Table 4.9.

The proposed activity will involve well workover activities which will include the generation of the waste products outlined in Table 4.9.

Table 4.9 Waste inventory

Activity	Waste	Volume
Civil and construction	General construction waste[a]	10 m^3
	Sewage and greywater	50 m^3
	General solid waste[b]	10 m^3
Workovers and completions	General construction waste[a]	10 m^3
	Wellbore solids	50 m^3
	Workover fluid	70 m^3
Appraisal activities	Produced water	25 m^3/day

[a] Includes waste such as offcut or excess gathering lines or removed components of existing gas flare or gas wells.
[b] Includes general solid waste generated by the workforce such as waste packaging.

All waste generated by the proposed activity would be classified in accordance with the *Waste Classification Guidelines* (EPA 2014) and would be transported and reused, recycled or disposed of by suitably licensed waste contractors and waste management facilities.

The predicted volumes of waste that would be generated would be relatively small and it is expected that there would be sufficient capacity at regional waste management facilities.

The largest waste stream from the proposed activity would be produced water which water would be produced progressively over two years of appraisal activities. As discussed in section 2, produced water would be sent to the produced water treatment facility at Leewood or a third party for beneficial reuse subject to receiving a resource recovery order and exemption. To reduce on site risk, the storage of up to 10 mega litres of produced water would be in holding tanks that have been designed to Australian standards and subject to integrity testing. The holding tanks would also be routinely emptied and would have telemetry installed that would trigger an automated response in the unlikely event of a loss of containment.

General construction waste and other general solid waste would be stored on site in suitable containers and routinely collected. Surplus excavated material would be temporarily stockpiled and watered or covered as necessary prior to collection and disposal. Sewage and greywater would be contained in portable amenities and would be routinely collected.

Overall, the potential impacts concerning waste and resources are considered to be low.

4.7.3 Proposed measures

ID	Proposed measure
WA1	All waste generated by the proposed activity must be classified in accordance with the *Waste Classification Guidelines* (EPA 2014) and transported and reused, recycled or disposed of by suitably licensed waste contractors and facilities.
WA2	General construction waste and other general solid waste stored on site must be held in suitable containers and regularly collected for disposal.
WA3	Produced water would be stored in accordance with relevant Australian standards.

4.8 Hazardous materials

4.8.1 Existing environment

The site of the proposed activity contains existing gas exploration infrastructure with the potential to contain hazardous materials including natural gas that may have accumulated in the existing gas wells, and potentially, residual drill cuttings, drilling fluids and/or other chemicals remaining on site from prior activities. It should be noted that the drilling fluids utilised are inert and low toxicity substances — composed primarily of water (70 to 80 per cent) with most of the remainder being weighting agents, typically bentonite clay, and some minor additives including biocide to prevent the accumulation of bacteria. A review of the site rehabilitation reports for the wells K2, K3, K4 and K5 indicates that drill cuttings were to be removed from site and the drilling sumps were to be drained (Santos 2011a; 2011b; 2011c; 2011d). Remnant drill cuttings and drilling fluids are therefore not expected to be present.

4.8.2 Potential impacts

The proposed activity would include appraisal activities that would necessarily involve the storage of gas within the wells and gathering lines and combustion of gas at the flare. The gas volume that would be stored at any one time would be relatively low as it would be continuously flared for the duration of appraisal activities. Further, the gas wells would be able to be remotely shut-in to stop the flow of gas in the event of fire or other hazardous incident at the site.

The proposed activity would also involve a 65 kilolitre diesel fuel storage. Diesel is classified as a dangerous good for the purpose of transport, storage and handling. It is highly flammable and can sustain a pool fire in the event of a spill. Potential hazards posed by the diesel fuel storage all relate to a loss of containment that could be caused by a number of events including failure of the fuel storage structure, collision of a vehicle with the storage, natural hazards such as a bushfire compromising the storage structure, or a spill from the storage or tanker during refilling.

The potential impacts of such a loss of containment would include the potential harm to people and property, particularly if the diesel becomes ignited, as well as harm to the environment, which would principally be potential contamination of soil and/or groundwater.

The risk of a loss of containment of diesel would be inherently low as the diesel fuel storage would be suitably designed to Australian standards and bunded to contain spills. Additional measures are discussed below that would further mitigate the potential impacts of a spill.

As the proposed activity would be limited to workovers and completions, minimal drill cuttings and fluids will be generated (refer Table 4.9).

The potential for combustion of gas at the gas flare to cause a bushfire would be low given the engineering controls including sterile and exclusion zones as discussed in section 2.6.

Overall, the potential impacts concerning hazardous materials would be low.

4.8.3 Proposed measures

ID	Proposed measure
H1	The diesel fuel storage would be designed and operated in accordance with all relevant Australian standards. The diesel fuel storage would be situated within an appropriately bunded area to contain spills. Appropriate signage, fencing/bollards and speed limits would also be put in place to further mitigate risks of spills.
H2	All chemicals and dangerous goods would be transported, stored and handled in line with all relevant Australian standards including *AS1940:2017 The storage and handling of flammable and combustible liquids* and the *Australian Code for the Transport of Dangerous Goods by Road & Rail Edition 7.6, 2018*.
H3	If a spill is identified on site it would be immediately acted upon including stopping the spill at its source and carrying out measures to contain and remediate the spill affected area. All statutory notifications would be carried out in accordance with the requirements of the *Protection of the Environment Operations Act 1997*. A trigger action response plan would be included in the environmental management plan.
H4	An emergency response procedure is to be developed for the event of a spill.

4.9 Biodiversity and biosecurity

A specialist biodiversity assessment has been carried out for the proposed activity.

The specialist biodiversity assessment included a database and literature review, field surveys for flora and fauna, likelihood of occurrence assessment, and assessment of impacts including determining their significance under the NSW *Biodiversity Conservation Act 2016* (BC Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The complete assessment is provided in Appendix G and its key findings are summarised here.

4.9.1 Existing environment

As discussed above, the site of the proposed activity contains existing coal seam gas exploration infrastructure and the surrounding land is predominantly cleared. The areas immediately in and around the site are cropped. Some vegetation has re-established but is primarily exotic shrubs and grasses with occasional native grasses of shrubs including Wilga, and scattered paddock trees, including White Box, Bimble Box and White Cypress Pine. A number of priority weeds are also present including African Boxthorn and Common Pear.

The site of the proposed activity has limited habitat value, primarily due to past clearing. A low diversity of fauna was recorded during field surveys; principally bird species such as raptors, woodland birds and parrots typical of rural landscapes on the Liverpool Plains.

A total of 45 threatened fauna species have been previously recorded or are otherwise expected to occur in the locality of the site. The majority of these species are highly mobile and the site is unlikely to provide important habitat. Hollow-dependent species like microbats, arboreal mammals or birds may utilise tree hollows, a number of which are present, and potential impacts to such species have been considered in general. Two threatened fauna species were recorded: grey-crowned babbler and koala, which are discussed further below.

The grey-crowned babbler is vulnerable under the BC Act and not listed under the EPBC Act. The grey-crowned babbler was recorded about two kilometres north of the site and is likely to utilise paddock trees at the site as well as grassland for foraging. The site is not likely to be used for breeding as the species nests in groups requiring larger patches of vegetation.

The koala is listed as endangered under the BC Act and EPBC Act. Numerous koala scats were identified under a number of paddock trees at the site of the proposed activity. While koalas were not observed in any paddock trees at the time of the survey, they have frequently been observed in and around the site and accordingly were considered likely to occur at times.

A full list of threatened fauna and their likelihood of occurrence is provided in Appendix G.

No threatened flora species were recorded during field surveys. Nine threatened flora species have previously been recorded or are predicted to occur in the general locality. A likelihood of occurrence assessment was carried out based on the local conditions of the site and concluded that, of these nine species, two would have potential to occur within the grassland areas or at the bases of the identified paddock trees: bluegrass, listed as vulnerable under the BC Act and EPBC Act, and slender darling pea, also listed as vulnerable under the BC Act and EPBC Act.

A full list of threatened flora and their likelihood of occurrence is provided in Appendix G.

4.9.2 Potential impacts

The potential impacts of the proposed activity on biodiversity would be avoided in the first instance through its layout and the avoidance of mature native trees including hollow-bearing trees and koala feed trees in particular. As such, the limited biodiversity values that are present at the site would be maintained meaning the residual impacts would be inherently low.

Vegetation that would likely be removed as a result of the proposed activity may include some cropped areas and predominantly exotic groundcover. The removal of this vegetation would have some very limited impact in terms of its potential value as foraging habitat for various fauna species including birds and microbats. Any such loss of habitat value would be only temporary as the areas to be disturbed would be reinstated at the end of construction.

As stated above, mature native trees would be avoided which would largely prevent impacts to threatened species including grey-crowned babbler and koala. The evidence, in the form of scats, of the presence of the koala suggests it has persisted despite the establishment of the existing exploration infrastructure, prior pilot tests, and the carrying out of agricultural activities.

The movement of vehicles and machinery around the site of the proposed activity would also have the potential to cause fauna injury or mortality in the event of a strike. This potential risk would be readily managed through the implementation of the proposed measures below.

The proposed activity could also create indirect impacts on fauna such as noise and vibration that may deter fauna from utilising the site. Given the limited habitat value of the site, and the presence of woodland patches in the vicinity, potential impacts on fauna would be limited.

An assessment of significance of impact for grey-crowned babbler and koala has been carried out and is provided in full in Appendix G. It has concluded that a significant impact is unlikely.

Potential impacts on threatened flora are limited given that no such species were recorded during field surveys at the site. While bluegrass and slender darling pea have the possibility of occurring, the lack of local records of these species at the site or their detection during the field surveys as well as the limited extent of the proposed activity means any potential impacts would be very limited. An assessment of significance of impact for blue grass and slender darling pea has been carried out and concluded that a significant impact is unlikely. The assessments of significance for blue grass and slender darling pea are provided in full in Appendix G.

4.9.3 Proposed measures

ID	Proposed measure
B1	Provide all workers with a site induction on the biodiversity values of the site.
B2	Have a suitably qualified ecologist undertake a pre-clearance site survey of paddock tress that may be impacted by the proposed works and inspect fallen timber for fauna as required.
B3	Implement measures to avoid impacts to mature native trees including marking out tree protection zones and preventing any disturbance or compaction of those zones.
B4	If any habitat features such as hollow logs are present in the disturbance area relocate them to a nearby area that would not be disturbed prior to the disturbance.
B5	Backfill or cover any open trenches at the completion of each work period to prevent injury to fauna. Check any covered trenches at the start of each work period.
B6	If any threatened fauna or flora are identified within the area of the works notify the environmental representative and do not carry out works in that area until approved.
B7	Implement weed hygiene protocols to prevent introduction and/or spread of weeds.
B8	Manage weeds in accordance with the requirements of the *Biosecurity Act 2015* and additional requirements for any Weeds of National Significance.

4.10 Community impacts

4.10.1 Existing environment

The site of the proposed activity is situated at Marys Mount in the Gunnedah local government area (LGA). The nearest regional centres are Gunnedah about 20 kilometres to the east and Boggabri about 30 kilometres to the north within the Narrabri LGA. Demographic and economic statistics for the Gunnedah LGA and the Narrabri LGA are provided in Table 4.10.

The demographics include the Socio-Economic Indexes for Areas (SEIFA) including Index of Relative Socio-Economic Disadvantage (IRSD), Index of Education and Occupation (IEO) and Index of Economic Resources (IER). The scores relate to the decile in which the LGA sits — where a score of 1 indicates the lowest decile and a score of 10 indicates the highest decile.

As shown, the Gunnedah LGA and Narrabri LGA have relatively similar demographic and economic characteristics including population, dwellings, workforce, businesses and key employment industries. The LGAs have similar SEIFA scores with Narrabri LGA showing a slightly better score on the IEO and Gunnedah LGA showing a slightly better score on the IER.

Table 4.10 Key statistics

Demographic	Gunnedah LGA	Narrabri LGA
Population	12,661	13,231
Dwellings	4,528	4,634
Workforce	7,660	7,920
Businesses	1,562	1,752
Key employment industries	—	—
– Agriculture, forestry and fishing	13.8%	19.6%
– Mining	13.7%	5.5%
– Health care and social assistance	10.2%	10.1%
– Retail trade	8.0%	9.0%
– Education and training	7.8%	6.9%
– Construction	5.1%	5.9%
– Manufacturing	5.0%	3.1%
– Accommodation and food services	6.8%	6.2%
– Other	29.7%	33.8%
Unemployment	5.5%	6.0%
IRSD	4	4
IEO	3	4
IER	6	5

4.10.2 Potential impacts

As discussed in section 2.3, the workforce at the site of the proposal at any one time would total about 50 workers. As far as practicable, existing contractors in the region would be engaged to carry out the works, however, there is potential that specialist contractors from further afield may be required for some aspects of the proposed activity. The workforce would be accommodated at their existing place of residence, or alternately accommodation in Gunnedah and/or Boggabri.

A workforce of this size, whether sourced from the region or further afield, would not be likely to have a substantial adverse effect on the regional community including demographic structure, community identity or availability of community resources and services. Accordingly, the potential social and economic impacts of the proposed activity are considered to be low.

The aesthetic impact of the proposed activity would be limited to disruption caused by the presence of equipment and the workforce at the site during civil and construction works and during workovers and completions. These activities would only occur for about one month of the 24 month duration of the proposed activity. These impacts would potentially be experienced by nearby residences, and to a lesser extent, users of the surrounding road network. Based on a review of aerial imagery, views toward the site of the proposed activity from nearby residences would be at least partially screened by existing vegetation. Due to their short duration and the relatively large distance to visual receivers these aesthetic impacts are considered to be low.

The ongoing appraisal activities would largely represent a continuation of the use of existing and approved infrastructure at the site and would therefore have minimal aesthetic impacts. The reactivation of the flare would have potential to generate some level of light spill at night, but this would not be expected to materially affect nearby visual receivers due to separation distance.

Other potential impacts of the project that could have a social or economic dimension include potential impacts on air quality (see section 4.2) and noise and vibration (see section 4.6). The limited scale of these impacts mean they would not be likely to have an adverse social impact.

The proposed activity including the presence of an additional workforce in the region would have the potential to generate economic benefits by creating additional demand for the services of local businesses including in the construction, retail trade, and accommodation and food services sectors that make up a substantial proportion of the regional economy.

4.10.3 Proposed measures

ID	Proposed measure
C1	Carry out stakeholder consultation as described in section 2.10.
C2	Carry out the proposed activity in consultation with the landholder.
C3	Implement policies for local hiring and procurement of goods and services to maximise the potential for regional economic benefits.

4.11 Cultural heritage

A specialist Aboriginal heritage due diligence assessment has been carried out for the proposed activity. The assessment included a desktop review, site based visual inspection and appraisal in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (DECCW 2010) and *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in New South Wales* (OEH 2011). The complete assessment is provided in Appendix H and its key findings are summarised here.

4.11.1 Existing environment

Aboriginal heritage

The first stage of the Aboriginal heritage due diligence assessment was to determine whether or not the proposed activity could classify as a low impact activity for which there would be a defence under the *National Parks and Wildlife Act 1974*. In making this appraisal of the proposed activity both the nature of the activity and the site were considered. In summary, while the site of the proposed activity has been subject to previous disturbance, the proposed activity involves construction and civil works that would potentially affect areas of land that have not been disturbed to the extent that would eliminate potential for Aboriginal heritage. Accordingly, it was determined that the proposed activity would not classify as a low impact activity and further assessment was required in accordance with the due diligence code.

The next stage of the Aboriginal heritage due diligence assessment was to determine whether the proposed activity would disturb the ground surface or culturally modified trees. As already established, the proposed activity would disturb the ground surface. Further, there are a number of mature native paddock trees at the site that would have the potential to be culturally modified. As discussed in section 4.9, potential impacts to mature native paddock trees would be avoided.

A search of the Aboriginal Heritage Information Management System (AHIMS) was made over a broad search area of about 30 km by 40 km. The search returned 65 records of Aboriginal sites within this area, mainly artefact scatters and culturally modified trees and a relatively smaller number of grinding grooves and isolated finds, however none of these Aboriginal sites were in or near the site of the proposed activity. A literature review was carried out to identify any other sources of information that may provide some other evidence of Aboriginal sites in the area but did not return anything further. The landforms at the site were also considered for features that would be considered archaeologically sensitive such as ridgelines and waterways. The site of the proposed activity was found to be flat with no major waterways in the vicinity. Accordingly, the site was not considered to be part of a landform that is archaeologically sensitive.

The site area was assessed via pedestrian transects. The wells and access tracks are already extant, as is a large quarry area likely used to win the material used for access track establishment. Beyond these areas of high disturbance, the land was either ploughed or covered in chest high weeds / vegetation. It is also relevant that there was a lot of standing water at the time of the assessment, which precluded walking through some areas such as the ploughed paddocks. This completed the due diligence process.

Non-Aboriginal heritage

There are no non-Aboriginal cultural heritage items near the site of the proposed activity on the following local, national and international heritage databases (NSW Government 2020b):

- Local heritage register under Gunnedah Local Environmental Plan 2012
- State heritage register under *Heritage Act 1977*
- National heritage list under EPBC Act
- Commonwealth heritage list
- World heritage list.

The nearest non-Aboriginal cultural heritage items to the site of the proposed activity are local and state heritage items situated in the township of Gunnedah about 20 kilometres to the east.

4.11.2 Potential impacts

Aboriginal heritage

The Aboriginal heritage due diligence assessment did not identify any Aboriginal sites. It was therefore concluded that no Aboriginal sites would be harmed by the proposed activity and that an Aboriginal Heritage Impact Permit (AHIP) would not be required for the proposed activity.

A number of measures are nonetheless proposed to address residual risk of impact.

Non-Aboriginal heritage

As there are no non-Aboriginal heritage items near the site no impacts are predicted.

4.11.3 Proposed measures

ID	Proposed measure
CH1	Work crews will receive site inductions that include the contents of the Unanticipated Finds Protocol and a cultural heritage awareness component to assist them in recognising Aboriginal artefacts and make them aware of legislative protections of Aboriginal objects under the *National Parks and Wildlife Act 1974*. The Unexpected Finds Protocol is provided as Appendix 2 to Appendix H. Guidance on Aboriginal artefact identification is in Appendix 3 to Appendix H.
CH2	If during works, however, Aboriginal artefacts or skeletal material are noted, all work should cease and the procedures in the Unanticipated Finds Protocol should be followed. The Unexpected Finds Protocol is provided as Appendix 2 to Appendix H.

4.12 Traffic and transport

4.12.1 Existing environment

The existing road network surrounding the site of the proposed activity includes the local roads Quia Road and Goolhi Road to the north, Collygra Road to the east, Marys Mount Road to the south and Grain Valley Road to the west. The major roads in the region of the proposed activity include Oxley Highway running from Coonabarabran to Gunnedah, Kamilaroi Highway from Gunnedah to Narrabri via Boggabri, and Newell Highway from Narrabri to Coonabarabran.

The existing traffic volumes on the local roads are expected to be low as these roads would mainly provide access for local residents. The existing traffic volumes on Oxley Highway and Kamilaroi Highway would be significantly greater as highways connecting a number of regional localities and providing for movement of freight. Traffic count data indicates about 3,000 vehicle movements per day on Oxley Highway near Gunnedah with about 80 per cent light vehicles and 20 per cent heavy vehicles (TFNSW 2020). A similar volume is expected on Kamilaroi Highway.

4.12.2 Potential impacts

The proposed activity would generate relatively few vehicle movements on the external road network. Each day during civil and construction works, and workovers and completions, there would be in the order of 25 two-way light vehicle movements for transport of the workforce and 5 to 10 two-way heavy vehicle movements of equipment and materials.

It is planned that the workforce would travel to site from Gunnedah and/or Boggabri. The roads that would likely be used from Gunnedah would include Quia Road and Goolhi Road. The roads that would likely be used from Boggabri would include Kamilaroi Highway or Grain Valley Road as well as Quia Road and Goolhi Road. Movements of equipment and materials may be delivered from further afield but would follow similar routes in the vicinity of the site.

During appraisal activities, the main source of vehicle movements would be the transport of produced water to the existing produced water treatment facility at Leewood and/or to a third party for beneficial reuse under a Resource Recovery Order and Exemption, which would be sought under the *Protection of the Environment Operations (Waste) Regulation 2014*.

At an average water production of about 24 kilolitres per day, and assuming a storage vehicle with a holding capacity of 10,000 litres, in the order of 20 vehicle movements would be required per week of water production. It should be noted that the central water storage at the site would have a capacity of 10 mega litres, or about one year of water production, meaning that weekly transport would not be essential, and transport may occur on a monthly or lengthier basis, and potentially use higher volume storage vehicles. The likely route for storage vehicles leaving the site of the proposed activity would be via Goolhi Road, Kamilaroi Highway and Newell Highway.

The predicted vehicle movements would be well within the capacity of the existing road network and would not be expected to significantly affect the level of service or safety conditions. As such, the potential impacts of the proposed activity on transportation would be low.

4.12.3 Proposed measures

ID	Proposed measure
T1	Develop and implement a traffic management plan for the proposed activity.

LEGEND
Kahlua Site
Leewood Site
Water Haulage Route
Roads

Paper Size ISO A4
0 5 10
Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Santos
Kahlua Pilot

Project No. 2122463
Revision No. 0
Date 30/08/2022

Produced water haulage route

FIGURE 4.3

G:\21\22463\GIS\Maps\Deliverables\Kahlua_Pilot\21_22463_Z189_REF_KahluaPilot_HaulageRoutes.mxd
Print date: 15 Dec 2022 - 16:08

Data source: General topo - NSW LPI DTDB 2015. Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: eibbertson

4.13 Matters of national environmental significance

4.13.1 Existing environment

A search using the protected matters search tool was carried out to identify matters of national environmental significant under the EPBC Act in the region of the proposed activity, including a one kilometre buffer zone around the site. The search identifies listed World Heritage Properties, National Heritage Places, Wetlands of International Importance, the Great Barrier Reef Marine Park, Commonwealth Marine Areas, Listed Threatened Ecological Communities, Listed Threatened Species and Listed Migratory Species.

The matters of national environmental significance that were identified included the following:

– 3 wetlands of international importance
– 6 threatened ecological communities
– 26 listed threatened species
– 9 migratory species.

No world heritage properties or national heritage places were identified.

The complete protected matters search record is provided in Appendix B.

As the proposed activity is for gas exploration, it is also considered that protection of water resources (from coal seam gas development and large coal mining development) are a relevant matter of national environmental significance under the EPBC Act.

4.13.2 Potential risk of significant impact on Matters of National Environmental Significance

The potential risk of significant impact on Matters of National Environmental Significance were assessed using the following Commonwealth Guidelines:

– Commonwealth Department of the Environment (DoE) (2013). *Matters of National Environmental Significance. Significant Impact Guidelines 1.1.*
– Commonwealth Department of Climate Change, Energy, the Environment and Water (DECCEEW) (2022). *Significant Impact Guidelines 1.3 – Coal seam gas and large coal mining developments – impacts on water resources*.

The identified wetlands of international importance were listed as being in the order of 1,000 kilometres from the site of the proposed activity. Given this very large separation distance, the potential impact of the proposed activity on the identified wetlands is negligible.

As discussed in section 4.7, the proposed activity would not have a significant impact on biodiversity including threatened species and ecological communities under the EPBC Act.

As discussed in section 4.4.2 in relation to the NSW *Aquifer Interference Policy*, predicted impacts are expected to be minor or negligible, and temporary, and are therefore unlikely to result in reduction in the current and future utility of affected aquifers. As such, the impacts are not considered to represent a ‘significant impact’, and therefore, are interpreted not to require referral under the EPBC Act water trigger.

Overall, the potential impacts on matters of national environmental significance would be low.

4.14 Cumulative impacts

4.14.1 Existing environment

An assessment of cumulative impacts was undertaken using the guidance from *Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions* (European Commission 1999).

The method included a review of publicly available information from the NSW Department of Planning's major projects website returned a number of projects in the region of the proposed activity. The identified major projects that may have cumulative impacts with the proposed activity are summarised in Table 4.11.

Gunnedah Quarry, while not a major project, was also included due to its proximity to the site.

Table 4.11 Major projects

Project	Status	Distance
Gunnedah Coal Handling and Preparation Plant	Existing	20 km
Gunnedah Waste Facility	Proposed	20 km
Gunnedah Quarry	Existing	7 km

Gunnedah Coal Handling and Preparation Plant is an existing facility about 20 kilometres east of the site of the proposed activity. The facility is approved to process up to 3 million tonnes per annum and dispatch up to 4.1 million tonnes per annum. It operates 24 hours per day, 7 days per week. The environmental assessment indicates movement of coal and rejects may occur on Kamilaroi Highway, Torrens Road, Quia Road and Black Jack Road (Whitehaven Coal 2020b). Whitehaven have sought approval for a life of operations extension until 2 October 2026. The previous approved operational expiration date was October 2022 (Whitehaven Coal 2022).

Gunnedah Waste Facility is a proposed resource recovery facility and waste transfer station about 20 kilometres east of the site of the proposed activity. It is planned that the facility would handle up to 250,000 tonnes per annum. Secretary's environmental assessment requirements were published on 7 August 2020. At the time of writing, a Submissions Report had been lodged with the NSW Department of Planning and Environment.

Gunnedah Quarry is an existing blue metal quarry about 7 kilometres south-west of the site. The quarry is approved for the extraction of up to 360,000 tonnes per annum. It is understood that product may be transported via Barker Road, Marys Mount Road, Goolhi Road, Quia Road, Blackjack Road, Kamilaroi Highway and Oxley Highway (Gunnedah Shire Council 2015). Gunnedah Quarry have since received approval to operate as a (non-putrescible) solid waste landfill, and as such, will be receiving waste.

4.14.2 Potential impacts

Due to the limited scale of the proposed activity and its separation distance from the projects listed above, it is generally not expected that significant cumulative impacts would occur. There would be some potential for interaction between traffic generated by the proposed activity and the other projects — particularly on sections of Quia Road, Goolhi Road and Kamilaroi Highway that may be utilised by vehicles, including heavy vehicles, travelling to and from the Gunnedah Coal Handling and Preparation Plant and/or Gunnedah Quarry.

While it is unlikely that significant cumulative impacts would result, an additional proposed measure has been provided to monitor and adapt the traffic management plan as necessary if any issues arise.

Other initiatives that may be undertaken as part of preparing the traffic management plan include:

- consultation with Gunnedah Shire Council to ensure that general signposting of construction access roads is appropriate and provides adequate warning of heavy vehicle and construction activity
- review signposted and non-signposted speed restrictions along the road network and where necessary, provide additional signposting of speed limitations associated with project activities
- advise local road users of scheduled construction activities, and road closures, and alternative routes as required
- consultation with school bus services to identify routes and determine the most appropriate response to minimising the potential for traffic impacts
- manage the transportation of construction materials to maximise vehicle movement efficiencies, in consultation with Gunnedah Shire Council, as appropriate
- ensuring that appropriate permits are in place for over dimension vehicle movements as applicable
- project induction training for truck and vehicle operators.

Overall, the potential for cumulative impacts to occur is considered to be low.

4.14.3 Proposed measures

ID	Proposed measure
CU1	Consult with Gunnedah Shire Council during the development of the traffic management plan to ensure the proposed routes are suitable and that the content of the plan is appropriate and complete.

4.15 Summary of impacts

The NSW Department of Planning and Environment guideline *ESG2: Guideline for preparing a Review of Environmental Factors* (DPIE 2015) states that the REF must summarise the impacts of the activity and consider the total impact of the activity based on the classification of individual impacts as low, medium or high adverse, negligible or positive.

As such, a summary of impacts of the activity including their predicted ranking is provided in Table 4.12. All rankings in Table 4.12 relate to low adverse, with cultural heritage being negligible.

The total impact of the proposed activity based on the classification of individual impacts has been found to be low adverse.

Table 4.12 Summary of impacts

Impact	Size	Scope	Intensity	Duration	Confidence	Resilience	Reversible	Ability to manage or mitigate	Compliance	Public interest	Further information required	Ranking
Air quality	Small	Localised	Low	Short	High	Low	High	High	High	High	None	Low
Greenhouse gas	Small	Localised	Low	Long	High	Low	Low	Low	High	High	None	Low
Water resources	Small	Localised	Low	Long	High	Low	Low	Medium	High	High	Monitoring	Low
Soils and land uses	Small	Localised	Medium	Long	High	Low	Medium	Medium	High	High	None	Low
Noise and vibration	Small	Localised	Low	Long	High	Low	High	Medium	Medium	High	None	Low
Waste and resources	Small	Localised	Low	Short	High	Medium	Medium	High	High	Moderate	None	Low
Hazardous materials	Small	Localised	Low	Short	High	Low	Medium	High	High	High	None	Low
Biodiversity and biosecurity	Small	Localised	Low	Short	High	Low	Medium	Medium	High	High	None	Low
Community impacts	Small	Localised	Low	Short	High	Medium	Medium	Medium	High	High	None	Low
Cultural heritage	—	—	—	—	—	—	—	—	—	—	—	Negligible
Traffic and transport	Small	Localised	Low	Short	High	Medium	High	High	High	Medium	None	Low
Cumulative impact	Small	Localised	Low	Short	High	Medium	Medium	Medium	High	Medium	None	Low

5. Conclusion

This Review of Environmental Factors has assessed the potential impacts of the proposed activity under Part 5 of the *Environmental Planning and Assessment Act 1979* and in accordance with *ESG2: Guideline for preparing a Review of Environmental Factors* (DPIE 2015).

The site of the proposed activity has been disturbed previously for the establishment of the existing gas exploration infrastructure. The proposed activity would involve relatively limited additional disturbance at the site and would largely represent a continuation of the use of existing and approved infrastructure. The total impact of the proposed activity based on the classification of individual impacts has been found to be low adverse.

The proposed activity would not be likely to have a significant impact on the environment or a significant impact on a matter of national environmental significance.

Accordingly, an environmental impact statement or species impact statement are not required under the *Environmental Planning and Assessment Act 1979* and a referral is not required under the *Environment Protection and Biodiversity Conservation Act 1999*.

This conclusion has been arrived at with due consideration to the principles of ecologically sustainable development and the environmental factors under the *Environmental Planning and Assessment Regulation 2021* which have been summarised in and responded to in Appendix A.

A statement of commitments consolidating the proposed measures is provided in Appendix I.

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Santos 2011c, Well Rehabilitation Report - Kahlua 4 on PEL1, Gunnedah Area- INW11/20330- RP0005461, https://search.geoscience.nsw.gov.au/report/RE0003554

Santos 2011d, Well Rehabilitation Report - Kahlua 5 on PEL1, Gunnedah Area-INW11/20325-RP0005462, https://search.geoscience.nsw.gov.au/report/RE0003555

TFNSW 2020, Traffic Volume Viewer, https://www.rms.nsw.gov.au/about/corporate-publications/statistics/traffic-volumes/aadt-map/

Whitehaven Coal 2020a, Sunnyside Mine, https://whitehavencoal.com.au/our-business/our-assets/sunnyside-mine/

Whitehaven Coal 2020b, Gunnedah CHPP, https://whitehavencoal.com.au/our-business/our-assets/gunnedah-chpp/

Whitehaven Coal (2022). Whitehaven CHPP Life Extension Modification Report. https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=DA0079-2002-MOD-4%2120220512T013929.072%20GMT

Appendix A

Statutory consideration

Environmental factors – Clause 171(2) *EP&A Act Regs 2021* checklist

Factor	Consideration
(a) any environmental impact on a community,	The potential impacts of the proposed activity have been found to be generally low and accordingly would not have a significant environmental impact on a community.
(b) any transformation of a locality	The proposed activity would largely represent a continuation of the use of existing and approved infrastructure it and would therefore not result in the transformation of a locality.
(c) any environmental impact on the ecosystems of the locality	The potential impacts of the proposed activity have been found to be generally low and accordingly would not have a significant environmental impact on ecosystems.
(d) any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality	The proposed activity would largely represent a continuation of the use of existing and approved infrastructure it and would not reduce the aesthetic, recreational, scientific or other environmental quality of the locality.
(e) 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	The site of the proposed activity is not considered to have any special values that would be materially impacted by the activity.
(f) any impact on the habitat of protected animals (within the meaning of the *Biodiversity Conservation Act 2016*)	The potential impacts of the proposed activity have been found to be generally low and accordingly would not have a significant environmental impact on animal habitat.
(g) any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air	The potential impacts of the proposed activity have been found to be generally low and would not result in the endangering or any species of animal, plant or other lifeform.
(h) any long-term effects on the environment	The potential impacts of the proposed activity have been found to be generally low and no long-term effects have been predicted.
(i) any degradation of the quality of the environment	The potential impacts of the proposed activity have been found to be generally low and accordingly are not predicted to result in degradation of the quality of the environment.
(j) any risk to the safety of the environment	The potential impacts of the proposed activity have been found to be generally low and accordingly would not have a significant impact on the safety of the environment.
(k) any reduction in the range of beneficial uses of the environment	The potential impacts of the proposed activity have been found to be generally low and accordingly would not have a significant impact on the range of beneficial uses.
(l) any pollution of the environment	The potential impacts of the proposed activity have been found to be generally low and are not expected to result in any pollution of the environment. Any spills would be immediately acted upon as described in section 4.8.
(m) any environmental problems associated with the disposal of waste	The proposed activity would generate a relatively small volume of waste. There are not anticipated to be any environmental problems with the disposal of the waste.
(n) any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply	The proposed activity would have relatively limited demand on resources none of which are expected to become in short supply.
(o) any cumulative environmental effect with other existing or likely future activities	The potential cumulative impacts of the proposed activity have been found to be generally low. Measures have been proposed in section 4.14 to avoid any such impacts.
(p) any impact on coastal processes and coastal hazards, including those under projected climate change conditions.	The proposed activity would not affect any coastal processes or coastal hazards.

Factor	Consideration
(q) applicable local strategic planning statements, regional strategic plans or district strategic plans made under the Act, Division 3.1	The proposed activity would not affect any applicable local strategic planning statements, regional strategic plans or district strategic plans made under the Act, Division 3.1.
(r) other relevant environmental factors	The proposed activity would not affect any other relevant environmental factors.

Appendix B

Desktop searches

Australian Government
Department of Climate Change, Energy, the Environment and Water

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 16-Dec-2022

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	3
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	6
Listed Threatened Species:	26
Listed Migratory Species:	9

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	2
Commonwealth Heritage Places:	None
Listed Marine Species:	16
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	1
Key Ecological Features (Marine):	None
Biologically Important Areas:	None
Bioregional Assessments:	1
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar Wetlands) [Resource Information]

Ramsar Site Name	Proximity	Buffer Status
Banrock station wetland complex	900 - 1000km upstream from Ramsar site	In feature area
Riverland	900 - 1000km upstream from Ramsar site	In feature area
The coorong, and lakes alexandrina and albert wetland	1000 - 1100km upstream from Ramsar site	In feature area

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.
Status of Vulnerable, Disallowed and Ineligible are not MNES under the EPBC Act.

Community Name	Threatened Category	Presence Text	Buffer Status
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered	Community may occur within area	In feature area
Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia	Endangered	Community may occur within area	In feature area
Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland	Critically Endangered	Community likely to occur within area	In feature area
Poplar Box Grassy Woodland on Alluvial Plains	Endangered	Community likely to occur within area	In feature area
Weeping Myall Woodlands	Endangered	Community may occur within area	In feature area
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	Community likely to occur within area	In feature area

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text	Buffer Status
BIRD			
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour may occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
Calyptorhynchus lathami lathami South-eastern Glossy Black-Cockatoo [67036]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat may occur within area	In feature area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat may occur within area	In feature area
Polytelis swainsonii Superb Parrot [738]	Vulnerable	Species or species habitat may occur within area	In feature area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area	In feature area
MAMMAL			

Scientific Name	Threatened Category	Presence Text	Buffer Status
Chalinolobus dwyeri			
Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Dasyurus maculatus maculatus (SE mainland population)			
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat may occur within area	In feature area
Nyctophilus corbeni			
Corben's Long-eared Bat, South-eastern Long-eared Bat [83395]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)			
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Endangered	Species or species habitat known to occur within area	In feature area
Pteropus poliocephalus			
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour may occur within area	In feature area
PLANT			
Androcalva procumbens			
[87153]	Vulnerable	Species or species habitat may occur within area	In feature area
Cadellia pentastylis			
Ooline [9828]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Dichanthium setosum			
bluegrass [14159]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Lepidium aschersonii			
Spiny Pepper-cress [10976]	Vulnerable	Species or species habitat may occur within area	In feature area
Lepidium monoplocoides			
Winged Pepper-cress [9190]	Endangered	Species or species habitat may occur within area	In feature area
Swainsona murrayana			
Slender Darling-pea, Slender Swainson, Murray Swainson-pea [6765]	Vulnerable	Species or species habitat likely to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Thesium australe			
Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area	In feature area
Vincetoxicum forsteri listed as Tylophora linearis			
[92384]	Endangered	Species or species habitat likely to occur within area	In feature area
REPTILE			
Aprasia parapulchella			
Pink-tailed Worm-lizard, Pink-tailed Legless Lizard [1665]	Vulnerable	Species or species habitat may occur within area	In feature area
Hemiaspis damelii			
Grey Snake [1179]	Endangered	Species or species habitat may occur within area	In feature area
Uvidicolus sphyrurus			
Border Thick-tailed Gecko, Granite Belt Thick-tailed Gecko [84578]	Vulnerable	Species or species habitat may occur within area	In feature area

Listed Migratory Species

[Resource Information]

Scientific Name	Threatened Category	Presence Text	Buffer Status
Migratory Marine Birds			
Apus pacificus			
Fork-tailed Swift [678]		Species or species habitat likely to occur within area	In feature area
Migratory Terrestrial Species			
Hirundapus caudacutus			
White-throated Needletail [682]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Motacilla flava			
Yellow Wagtail [644]		Species or species habitat may occur within area	In feature area
Myiagra cyanoleuca			
Satin Flycatcher [612]		Species or species habitat may occur within area	In feature area
Migratory Wetlands Species			
Actitis hypoleucos			
Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area	In feature area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area	In feature area

Other Matters Protected by the EPBC Act

Commonwealth Lands [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Commonwealth Land Name	State	Buffer Status
Commonwealth Trading Bank of Australia		
Commonwealth Land - Commonwealth Trading Bank of Australia [15451]	NSW	In buffer area only
Commonwealth Land - Commonwealth Trading Bank of Australia [13300]	NSW	In buffer area only

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text	Buffer Status
Bird			
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area	In feature area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area	In feature area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area	In feature area
Chalcites osculans as Chrysococcyx osculans Black-eared Cuckoo [83425]		Species or species habitat likely to occur within area overfly marine area	In feature area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area overfly marine area	In feature area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat may occur within area	In feature area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat likely to occur within area overfly marine area	In feature area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat may occur within area overfly marine area	In feature area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Motacilla flava			
Yellow Wagtail [644]		Species or species habitat may occur within area overfly marine area	In feature area
Myiagra cyanoleuca			
Satin Flycatcher [612]		Species or species habitat may occur within area overfly marine area	In feature area
Neophema chrysostoma			
Blue-winged Parrot [726]		Species or species habitat may occur within area overfly marine area	In feature area
Rostratula australis as Rostratula benghalensis (sensu lato)			
Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area overfly marine area	In feature area

Extra Information

EPBC Act Referrals

[Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Not controlled action				
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed	In feature area

Bioregional Assessments

SubRegion	BioRegion	Website	Buffer Status
Namoi	Northern Inland Catchments	BA website	In feature area

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

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Appendix C

Laboratory analytical results

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1122381**	Page	: 1 of 9
Client	: **SANTOS LTD**	Laboratory	: Environmental Division Brisbane
Contact	: [redacted]	Contact	: [redacted]
Address	: GPO BOX 1010 LEVEL 22, 32 TURBOT STREET BRISBANE QLD, AUSTRALIA 4001	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: [redacted]	E-mail	: [redacted]
Telephone	: [redacted]	Telephone	: [redacted]
Facsimile	: ----	Facsimile	: [redacted]
Project	: 117626001	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 879002-405		
C-O-C number	: ----	Date Samples Received	: 26-OCT-2011
Sampler	: [redacted]	Issue Date	: 02-NOV-2011
Site	: Gunnedah		
		No. of samples received	: 1
Quote number	: BN/107/11 V3	No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

NATA

WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Jonathon Angell	Inorganic Coordinator	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane External Subcontracting
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
Luke Evans	Microbiologist	Brisbane Microbiological
Matt Frost	Senior Organic Chemist	Brisbane Organics
Pabi Subba	Senior Organic Chemist	Sydney Organics
Scott Beddoes	Trace Water Section Supervisor	WB Water Lab Brisbane

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **Field Observations and Measurements submitted to the laboratory by external samplers and appearing in this report are not covered by ALS' NATA Accreditation.**
- **Microbiological Comment: Samples for microbiological testing were received at the laboratory outside of the recommended 24 hour holding period. It may be informative to record this fact.**
- **MW002 is ALS's internal code and is equivalent to AS4276.3.1.**
- **Standard anions by IC (ED009-X): LOR for Bromide on sample GUN_K2_BORE_W (EB1122381001) raised due to matrix interference.**

Analytical Results

Sub-Matrix: WATER			Client sample ID	GUN_K2_BORE_W	----	----	----	----
			Client sampling date / time	24-OCT-2011 13:30	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1122381-001	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.11**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**6080**	----	----	----	----
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	**4040**	----	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**19**	----	----	----	----
EA161: Residual Alkali								
Residual Alkali	----	0.01	meq/L	**6.11**	----	----	----	----
EA165: CO2 - Free and Total								
Free Carbon Dioxide as CO2	85540-96-1	1	mg/L	**2**	----	----	----	----
Total Carbon Dioxide as CO2	85540-96-1	1	mg/L	**201**	----	----	----	----
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	<0.200	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**3360**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**3360**	----	----	----	----
ED040F: Dissolved Major Anions								
Sulfate as SO4 2-	14808-79-8	1	mg/L	**4**	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**209**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**6**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**1**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**1600**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**35**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**1.65**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----

Analytical Results

Sub-Matrix: WATER			Client sample ID	GUN_K2_BORE_W	----	----	----	----
			Client sampling date / time	24-OCT-2011 13:30	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1122381-001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.514**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.014**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**0.968**	----	----	----	----
Tin	7440-31-5	0.001	mg/L	<0.001	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	**0.01**	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Boron	7440-42-8	0.05	mg/L	<0.05	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.13**	----	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**2.05**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.002**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.740**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.021**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**1.20**	----	----	----	----
Tin	7440-31-5	0.001	mg/L	<0.001	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.008**	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.06**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**1.44**	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----

Analytical Results

Sub-Matrix: WATER			Client sample ID	GUN_K2_BORE_W	----	----	----	----
			Client sampling date / time	24-OCT-2011 13:30	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1122381-001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG052F: Dissolved Silica by ICPAES								
Silica	7631-86-9	0.1	mg/L	**14.5**	----	----	----	----
EK010/011: Chlorine								
Chlorine - Free	----	0.2	mg/L	<0.2	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**2.1**	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**1.52**	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.02**	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.02**	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**3.2**	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**3.2**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.06**	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	----	0.01	mg/L	**0.02**	----	----	----	----
EK084: Un-ionized Hydrogen Sulfide								
Unionized Hydrogen Sulfide	----	0.1	mg/L	<0.1	----	----	----	----
EK085M: Sulfide as S2-								
Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	----	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**73.1**	----	----	----	----
Total Cations	----	0.01	meq/L	**70.9**	----	----	----	----
Ionic Balance	----	0.01	%	**1.62**	----	----	----	----
EN67: Field Tests								
Electrical Conductivity (Non Compensated)	----	1	µS/cm	**6090**	----	----	----	----
pH	----	0.01	pH Unit	**7.96**	----	----	----	----
Redox Potential	----	0.1	mV	**-46**	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	GUN_K2_BORE_W	----	----	----	----
			Client sampling date / time	24-OCT-2011 13:30	----	----	----	----
				EB1122381-001	----	----	----	----
EN67: Field Tests - Continued								
Temperature	----	0.1	°C	**28.1**	----	----	----	----
Field Dissolved Oxygen	----	0.1	mg/L	**1.68**	----	----	----	----
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	<1	----	----	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**47**	----	----	----	----
EP033: C1 - C4 Hydrocarbon Gases								
Methane	74-82-8	10	µg/L	**5120**	----	----	----	----
Ethene	74-85-1	10	µg/L	<10	----	----	----	----
Ethane	74-84-0	10	µg/L	<10	----	----	----	----
Propene	115-07-1	10	µg/L	<10	----	----	----	----
Propane	74-98-6	10	µg/L	<10	----	----	----	----
Butene	25167-67-3	10	µg/L	<10	----	----	----	----
Butane	106-97-8	10	µg/L	<10	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	----	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	----	----	----	----
Acenaphthene	83-32-9	1.0	µg/L	<1.0	----	----	----	----
Fluorene	86-73-7	1.0	µg/L	<1.0	----	----	----	----
Phenanthrene	85-01-8	1.0	µg/L	<1.0	----	----	----	----
Anthracene	120-12-7	1.0	µg/L	<1.0	----	----	----	----
Fluoranthene	206-44-0	1.0	µg/L	<1.0	----	----	----	----
Pyrene	129-00-0	1.0	µg/L	<1.0	----	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	----	----	----	----
Chrysene	218-01-9	1.0	µg/L	<1.0	----	----	----	----
Benzo(b)fluoranthene	205-99-2	1.0	µg/L	<1.0	----	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	----	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	----	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	----	----	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	----	----	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	----	----	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----

Analytical Results

Sub-Matrix: WATER			Client sample ID	GUN_K2_BORE_W	----	----	----	----
			Client sampling date / time	24-OCT-2011 13:30	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1122381-001	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons - Continued								
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft								
C6 - C10 Fraction	----	20	µg/L	<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	----	20	µg/L	<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ Total Xylenes	1330-20-7	2	µg/L	<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L	<1	----	----	----	----
EP117: Alcohols								
Ethanol	64-17-5	50	µg/L	<50	----	----	----	----
MW002: Heterotrophic Plate Count								
Heterotrophic Plate Count (22°C)	----	1	CFU/mL	**2500**	----	----	----	----
Heterotrophic Plate Count (36°C)	----	1	CFU/mL	**3200**	----	----	----	----
SAMP02: Observations (performed by external sampler)								
Santos Suite	----	-	--	**Sutie C,B and X**	----	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.1	%	**24.2**	----	----	----	----
2-Chlorophenol-D4	93951-73-6	0.1	%	**58.4**	----	----	----	----
2.4.6-Tribromophenol	118-79-6	0.1	%	**59.0**	----	----	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.1	%	**69.4**	----	----	----	----
Anthracene-d10	1719-06-8	0.1	%	**87.4**	----	----	----	----
4-Terphenyl-d14	1718-51-0	0.1	%	**75.8**	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	**106**	----	----	----	----
Toluene-D8	2037-26-5	0.1	%	**102**	----	----	----	----
4-Bromofluorobenzene	460-00-4	0.1	%	**101**	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	CAS Number	Recovery Limits (%) Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10.0	64.1
2-Chlorophenol-D4	93951-73-6	11.3	122.9
2.4.6-Tribromophenol	118-79-6	11.7	144.0
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	19.9	122.8
Anthracene-d10	1719-06-8	23.3	125.8
4-Terphenyl-d14	1718-51-0	20.3	134.5
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66.1	137.9
Toluene-D8	2037-26-5	79.2	119.6
4-Bromofluorobenzene	460-00-4	74.2	118.0

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

QUALITY CONTROL REPORT

Work Order	: **EB1122381**	Page	: 1 of 16
Client	: **SANTOS LTD**	Laboratory	: Environmental Division Brisbane
Contact	: [redacted]	Contact	: [redacted]
Address	: GPO BOX 1010 LEVEL 22, 32 TURBOT STREET BRISBANE QLD, AUSTRALIA 4001	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: [redacted]	E-mail	: [redacted]
Telephone	: [redacted]	Telephone	: [redacted]
Facsimile	: ----	Facsimile	: [redacted]
Project	: 117626001	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: Gunnedah		
C-O-C number	: ----	Date Samples Received	: 26-OCT-2011
Sampler	: [redacted]	Issue Date	: 02-NOV-2011
Order number	: 879002-405		
		No. of samples received	: 1
Quote number	: BN/107/11 V3	No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

NATA

WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Jonathon Angell	Inorganic Coordinator	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane External Subcontracting
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
Luke Evans	Microbiologist	Brisbane Microbiological
Matt Frost	Senior Organic Chemist	Brisbane Organics
Pabi Subba	Senior Organic Chemist	Sydney Organics
Scott Beddoes	Trace Water Section Supervisor	WB Water Lab Brisbane

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA005P: pH by PC Titrator (QC Lot: 2017942)									
EB1122059-003	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	9.95	9.95	0.0	0% - 20%
EB1122407-001	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	7.38	7.26	1.6	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 2017939)									
EB1121992-001	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	1580	1580	0.1	0% - 20%
EB1122057-002	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	2740	2750	0.4	0% - 20%
EA015: Total Dissolved Solids (QC Lot: 2017932)									
EB1122290-001	Anonymous	EA015H: Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	7290	7430	1.9	0% - 20%
EB1122342-002	Anonymous	EA015H: Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	7070	7050	0.3	0% - 20%
ED009: Anions (QC Lot: 2020005)									
EB1121924-001	Anonymous	ED009-X: Bromide	24959-67-9	0.010	mg/L	0.605	0.600	0.8	0% - 20%
EB1122467-003	Anonymous	ED009-X: Bromide	24959-67-9	0.010	mg/L	<0.100	<0.100	0.0	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 2017938)									
EB1121992-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	664	666	0.2	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	664	666	0.2	0% - 20%
EB1122057-002	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	202	202	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	202	202	0.0	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 2018203)									
EB1122381-001	GUN_K2_BORE_W	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	4	4	0.0	No Limit
EB1122395-007	Anonymous	ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	12	12	0.0	0% - 50%
ED045G: Chloride Discrete analyser (QC Lot: 2018209)									
EB1122381-001	GUN_K2_BORE_W	ED045G: Chloride	16887-00-6	1	mg/L	209	209	0.0	0% - 20%
EB1122395-007	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	145	145	0.0	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 2018204)									
EB1122381-001	GUN_K2_BORE_W	ED093F: Calcium	7440-70-2	1	mg/L	6	6	0.0	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	1	1	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	1460	1440	1.7	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	35	35	0.0	0% - 20%
EB1122395-007	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	39	39	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	27	27	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	64	64	0.0	0% - 20%

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
ED093F: Dissolved Major Cations (QC Lot: 2018204) - continued									
EB1122395-007	Anonymous	ED093F: Potassium	7440-09-7	1	mg/L	2	2	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2018190)									
EB1122262-015	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	0.0011	0.0011	0.0	0% - 50%
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.013	0.013	0.0	0% - 50%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.008	0.008	0.0	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.001	<0.001	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	2.36	2.35	0.4	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.008	0.008	0.0	No Limit
		EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.021	0.021	0.0	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.04	0.04	0.0	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.0	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EB1122262-025	Anonymous	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	0.0018	0.0019	0.0	0% - 50%
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.018	0.018	0.0	0% - 50%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	0.015	0.016	0.0	0% - 50%
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.005	0.005	0.0	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Lithium	7439-93-2	0.001	mg/L	0.004	0.004	0.0	No Limit
		EG020A-F: Manganese	7439-96-5	0.001	mg/L	2.79	2.81	0.9	0% - 20%
		EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.016	0.016	0.0	0% - 50%
		EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.072	0.075	4.1	0% - 50%
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.03	0.02	0.0	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2018190) - continued									
EB1122262-025	Anonymous	EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 2018191)									
EB1122262-015	Anonymous	EG020B-F: Strontium	7440-24-6	0.001	mg/L	0.200	0.201	0.6	0% - 20%
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EB1122262-025	Anonymous	EG020B-F: Strontium	7440-24-6	0.001	mg/L	0.167	0.177	6.0	0% - 20%
		EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 2017782)									
EB1122262-016	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0020	0.0019	0.0	0% - 50%
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.014	0.015	0.0	0% - 50%
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.037	0.038	0.0	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.005	0.004	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.020	0.020	0.0	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.021	0.021	0.0	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.014	0.012	11.8	0% - 50%
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	0.006	0.006	0.0	No Limit
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	2.46	2.43	1.4	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.020	0.020	0.0	0% - 20%
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.325	0.325	0.0	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	5.41	5.38	0.7	0% - 20%
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	0.02	0.01	0.0	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.0	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	6.40	6.13	4.3	0% - 20%
EB1122262-031	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0386	0.0398	3.0	0% - 20%
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.007	0.007	0.0	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	0.004	0.004	0.0	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.032	0.032	0.0	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.001	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.454	0.441	2.7	0% - 20%
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.177	0.174	1.8	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.022	0.023	0.0	0% - 20%
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	0.045	0.046	0.0	0% - 20%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	39.5	39.7	0.4	0% - 20%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.355	0.345	2.8	0% - 20%
		EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	<0.001	0.0	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EG020T: Total Metals by ICP-MS (QC Lot: 2017782) - continued									
EB1122262-031	Anonymous	EG020A-T: Zinc	7440-66-6	0.005	mg/L	5.42	5.34	1.6	0% - 20%
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	6.56	6.54	0.2	0% - 20%
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	<0.05	0.0	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	15.9	15.5	2.9	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 2017783)									
EB1122262-016	Anonymous	EG020B-T: Strontium	7440-24-6	0.001	mg/L	0.135	0.135	0.0	0% - 20%
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EB1122262-031	Anonymous	EG020B-T: Strontium	7440-24-6	0.001	mg/L	1.52	1.56	2.8	0% - 20%
		EG020B-T: Uranium	7440-61-1	0.001	mg/L	0.002	0.002	0.0	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 2018192)									
EB1122262-016	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 2021544)									
EB1122326-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EB1122535-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 2017943)									
EB1122407-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	0.0	No Limit
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 2018222)									
EB1122381-001	GUN_K2_BORE_W	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	1.52	1.47	3.3	0% - 20%
EB1122388-010	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 2018206)									
EB1122381-001	GUN_K2_BORE_W	EK057G: Nitrite as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EB1122395-007	Anonymous	EK057G: Nitrite as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 2018221)									
EB1122381-001	GUN_K2_BORE_W	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.02	0.02	0.0	No Limit
EB1122388-010	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.01	0.01	0.0	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 2018613)									
EB1122304-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.5	0.5	0.0	No Limit
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 2018614)									
EB1122304-001	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.04	0.02	46.8	No Limit
EB1122333-001	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.03	0.03	0.0	No Limit
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 2018208)									
EB1122381-001	GUN_K2_BORE_W	EK071G: Reactive Phosphorus as P	----	0.01	mg/L	0.02	0.02	0.0	No Limit
EB1122395-007	Anonymous	EK071G: Reactive Phosphorus as P	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EK085M: Sulfide as S2- (QC Lot: 2021135)									
EB1122277-004	Anonymous	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	0.0	No Limit
EB1122637-005	Anonymous	EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	<0.1	0.0	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
				Laboratory Duplicate (DUP) Report					
EP002: Dissolved Organic Carbon (DOC) (QC Lot: 2019429)									
EB1122342-001	Anonymous	EP002: Dissolved Organic Carbon	----	1	mg/L	588	596	1.2	0% - 20%
EP005: Total Organic Carbon (TOC) (QC Lot: 2019424)									
EB1122342-005	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	26	25	6.7	0% - 20%
EP033: C1 - C4 Hydrocarbon Gases (QC Lot: 2023466)									
EM1112093-001	Anonymous	EP033: Methane	74-82-8	10	µg/L	<10	<10	0.0	No Limit
		EP033: Ethene	74-85-1	10	µg/L	<10	<10	0.0	No Limit
		EP033: Ethane	74-84-0	10	µg/L	<10	<10	0.0	No Limit
		EP033: Propene	115-07-1	10	µg/L	<10	<10	0.0	No Limit
		EP033: Propane	74-98-6	10	µg/L	<10	<10	0.0	No Limit
		EP033: Butene	25167-67-3	10	µg/L	<10	<10	0.0	No Limit
		EP033: Butane	106-97-8	10	µg/L	<10	<10	0.0	No Limit
EM1112020-001	Anonymous	EP033: Methane	74-82-8	10	µg/L	10	10	0.0	No Limit
		EP033: Ethene	74-85-1	10	µg/L	<10	<10	0.0	No Limit
		EP033: Ethane	74-84-0	10	µg/L	<10	<10	0.0	No Limit
		EP033: Propene	115-07-1	10	µg/L	<10	<10	0.0	No Limit
		EP033: Propane	74-98-6	10	µg/L	<10	<10	0.0	No Limit
		EP033: Butene	25167-67-3	10	µg/L	<10	<10	0.0	No Limit
		EP033: Butane	106-97-8	10	µg/L	<10	<10	0.0	No Limit
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QC Lot: 2021328)									
EB1122381-001	GUN_K2_BORE_W	EP075(SIM): Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	0.0	No Limit
		EP075(SIM): Naphthalene	91-20-3	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Chrysene	218-01-9	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Benzo(b)fluoranthene	205-99-2	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	<1.0	0.0	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2020012)									
EB1122379-001	Anonymous	EP080: C6 - C9 Fraction	----	20	µg/L	60	100	50.8	No Limit
EB1122376-002	Anonymous	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.0	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2021327)									

Sub-Matrix: **WATER**

Laboratory Duplicate (DUP) Report

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 2021327) - continued									
EB1122381-001	GUN_K2_BORE_W	EP071: C15 - C28 Fraction	----	100	µg/L	<100	<100	0.0	No Limit
		EP071: C10 - C14 Fraction	----	50	µg/L	<50	<50	0.0	No Limit
		EP071: C29 - C36 Fraction	----	50	µg/L	<50	<50	0.0	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft (QC Lot: 2020012)									
EB1122379-001	Anonymous	EP080: C6 - C10 Fraction	----	20	µg/L	50	80	34.7	No Limit
		EP080: C6 - C10 Fraction minus BTEX (F1)	----	20	µg/L	50	80	46.2	No Limit
EB1122376-002	Anonymous	EP080: C6 - C10 Fraction	----	20	µg/L	<20	<20	0.0	No Limit
		EP080: C6 - C10 Fraction minus BTEX (F1)	----	20	µg/L	<20	<20	0.0	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft (QC Lot: 2021327)									
EB1122381-001	GUN_K2_BORE_W	EP071: >C10 - C16 Fraction	----	100	µg/L	<100	<100	0.0	No Limit
		EP071: >C16 - C34 Fraction	----	100	µg/L	<100	<100	0.0	No Limit
		EP071: >C34 - C40 Fraction	----	100	µg/L	<100	<100	0.0	No Limit
EP080: BTEXN (QC Lot: 2020012)									
EB1122379-001	Anonymous	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.0	No Limit
		EP080: Sum of BTEX	----	1	µg/L	<1	<1	0.0	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.0	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.0	No Limit
		EP080: Total Xylenes	1330-20-7	2	µg/L	<2	<2	0.0	No Limit
EB1122376-002	Anonymous	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.0	No Limit
		EP080: Sum of BTEX	----	1	µg/L	<1	<1	0.0	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.0	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.0	No Limit
		EP080: Total Xylenes	1330-20-7	2	µg/L	<2	<2	0.0	No Limit
EP117: Alcohols (QC Lot: 2021321)									
EB1122408-001	Anonymous	EP117: Ethanol	64-17-5	50	µg/L	2810	2900	3.0	0% - 20%

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA005P: pH by PC Titrator (QCLot: 2017942)								
EA005-P: pH Value	----	0.01	pH Unit	----	7 pH Unit	100	98	102
EA010P: Conductivity by PC Titrator (QCLot: 2017939)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	4000 µS/cm	102	93	107
EA015: Total Dissolved Solids (QCLot: 2017932)								
EA015H: Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	<5	2000 mg/L	97.0	80	120
ED009: Anions (QCLot: 2020005)								
ED009-X: Bromide	24959-67-9	0.01	mg/L	<0.010	0.5 mg/L	99.0	71	119
ED037P: Alkalinity by PC Titrator (QCLot: 2017938)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	106	88	112
ED040F: Dissolved Major Anions (QCLot: 2018203)								
ED040F: Sulfate as SO4 2-	14808-79-8	1	mg/L	<1	----	----	----	----
ED045G: Chloride Discrete analyser (QCLot: 2018209)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	96.7	70	128
ED093F: Dissolved Major Cations (QCLot: 2018204)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 2018190)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	96.0	81	125
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	91.4	86	124
EG020A-F: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	114	86	130
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	92.0	89	117
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	102	88	127
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	91.3	88	116
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	90.9	86	115
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	96.9	91	113
EG020A-F: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-F: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	90.0	85	119
EG020A-F: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	95.3	91	113
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	93.7	88	115
EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	0.100 mg/L	95.9	86	122

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EG020F: Dissolved Metals by ICP-MS (QCLot: 2018190) - continued								
EG020A-F: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	93.7	89	130
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	94.0	81	113
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	91.6	86	120
EG020A-F: Boron	7440-42-8	0.05	mg/L	<0.05	0.50 mg/L	102	70	129
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.50 mg/L	95.3	84	124
EG020F: Dissolved Metals by ICP-MS (QCLot: 2018191)								
EG020B-F: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	91.0	87	119
EG020B-F: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS (QCLot: 2017782)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.500 mg/L	97.7	70	128
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.100 mg/L	101	78	120
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.100 mg/L	117	80	130
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.100 mg/L	98.0	84	114
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.100 mg/L	99.8	86	124
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.100 mg/L	98.4	86	122
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.200 mg/L	99.3	70	130
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.100 mg/L	95.8	70	130
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	----	----	----	----
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.100 mg/L	96.0	84	124
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.100 mg/L	98.0	70	130
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.100 mg/L	94.8	86	121
EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	0.100 mg/L	103	70	130
EG020A-T: Tin	7440-31-5	0.001	mg/L	<0.001	0.100 mg/L	99.8	72	130
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.100 mg/L	97.8	76	120
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.200 mg/L	96.2	81	123
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.500 mg/L	103	76	129
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.500 mg/L	99.8	70	130
EG020T: Total Metals by ICP-MS (QCLot: 2017783)								
EG020B-T: Strontium	7440-24-6	0.001	mg/L	<0.001	0.500 mg/L	100	86	115
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
EG035F: Dissolved Mercury by FIMS (QCLot: 2018192)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.010 mg/L	87.9	84	116
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2021544)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.0100 mg/L	91.4	80	116
EK010/011: Chlorine (QCLot: 2020819)								
EK010: Chlorine - Free	----	0.2	mg/L	<0.2	----	----	----	----
EK040P: Fluoride by PC Titrator (QCLot: 2017943)								

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High
EK040P: Fluoride by PC Titrator (QCLot: 2017943) - continued								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	10 mg/L	107	85	115
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2018222)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	0.5 mg/L	87.0	70	129
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2018206)								
EK057G: Nitrite as N	----	0.01	mg/L	<0.01	0.5 mg/L	109	78	126
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2018221)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	100	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2018613)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	10.0 mg/L	80.2	70	115
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2018614)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	4.2 mg/L	92.1	76	117
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2018208)								
EK071G: Reactive Phosphorus as P	----	0.01	mg/L	<0.01	0.5 mg/L	107	81	121
EK085M: Sulfide as S2- (QCLot: 2021135)								
EK085: Sulfide as S2-	18496-25-8	0.1	mg/L	<0.1	0.5 mg/L	110	80	120
EP002: Dissolved Organic Carbon (DOC) (QCLot: 2019429)								
EP002: Dissolved Organic Carbon	----	1	mg/L	<1	5 mg/L	81.2	78	114
EP005: Total Organic Carbon (TOC) (QCLot: 2019424)								
EP005: Total Organic Carbon	----	1	mg/L	<1	5 mg/L	97.5	78	114
EP033: C1 - C4 Hydrocarbon Gases (QCLot: 2023466)								
EP033: Methane	74-82-8	10	µg/L	<10	27.92 µg/L	93.3	86	108
EP033: Ethene	74-85-1	10	µg/L	<10	50.29 µg/L	92.0	87	111
EP033: Ethane	74-84-0	10	µg/L	<10	53.91 µg/L	93.5	87	111
EP033: Propene	115-07-1	10	µg/L	<10	74.71 µg/L	94.0	86	112
EP033: Propane	74-98-6	10	µg/L	<10	72.91 µg/L	93.4	87	111
EP033: Butene	25167-67-3	20	µg/L	<20	98.63 µg/L	94.2	87	113
EP033: Butane	106-97-8	20	µg/L	<20	103.19 µg/L	94.4	87	113
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 2021328)								
EP075(SIM): Naphthalene	91-20-3	0.2	µg/L	----	0.5 µg/L	77.6	58.6	119
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Acenaphthylene	208-96-8	0.2	µg/L	----	0.5 µg/L	80.5	63.6	114
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Acenaphthene	83-32-9	0.2	µg/L	----	0.5 µg/L	78.3	62.2	113
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Fluorene	86-73-7	0.2	µg/L	----	0.5 µg/L	84.6	63.9	115
		1	µg/L	<1.0	----	----	----	----

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 2021328) - continued								
EP075(SIM): Phenanthrene	85-01-8	0.2	µg/L	----	0.5 µg/L	90.5	62.6	116
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Anthracene	120-12-7	0.2	µg/L	----	0.5 µg/L	95.3	64.3	116
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Fluoranthene	206-44-0	0.2	µg/L	----	0.5 µg/L	94.8	63.6	118
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Pyrene	129-00-0	0.2	µg/L	----	0.5 µg/L	96.0	63.1	118
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Benz(a)anthracene	56-55-3	0.2	µg/L	----	0.5 µg/L	92.6	64.1	117
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Chrysene	218-01-9	0.2	µg/L	----	0.5 µg/L	90.2	62.5	116
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Benzo(b)fluoranthene	205-99-2	0.2	µg/L	----	0.5 µg/L	85.7	61.7	119
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Benzo(k)fluoranthene	207-08-9	0.2	µg/L	----	0.5 µg/L	95.9	61.7	117
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Benzo(a)pyrene	50-32-8	0.2	µg/L	----	0.5 µg/L	92.8	63.3	117
		0.5	µg/L	<0.5	----	----	----	----
EP075(SIM): Indeno(1.2.3.cd)pyrene	193-39-5	0.2	µg/L	----	0.5 µg/L	92.7	59.9	118
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Dibenz(a.h)anthracene	53-70-3	0.2	µg/L	----	0.5 µg/L	93.6	61.2	117
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Benzo(g.h.i)perylene	191-24-2	0.2	µg/L	----	0.5 µg/L	95.6	59.1	118
		1	µg/L	<1.0	----	----	----	----
EP075(SIM): Sum of polycyclic aromatic hydrocarbons	----	1	µg/L	<1.0	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2020012)								
EP080: C6 - C9 Fraction	----	20	µg/L	<20	160 µg/L	98.7	69	135
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2021327)								
EP071: C10 - C14 Fraction	----	50	µg/L	<50	2000 µg/L	83.5	58.9	131
EP071: C15 - C28 Fraction	----	100	µg/L	<100	2500 µg/L	120	73.9	138
EP071: C29 - C36 Fraction	----	50	µg/L	<50	2000 µg/L	82.0	62.7	131
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft (QCLot: 2020012)								
EP080: C6 - C10 Fraction	----	20	µg/L	<20	185 µg/L	96.9	64	136
EP080: C6 - C10 Fraction minus BTEX (F1)	----	20	µg/L	<20	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft (QCLot: 2021327)								
EP071: >C10 - C16 Fraction	----	100	µg/L	<100	2500 µg/L	70.8	58.9	131
EP071: >C16 - C34 Fraction	----	100	µg/L	<100	3500 µg/L	82.6	73.9	138
EP071: >C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
		50	µg/L	----	1500 µg/L	106	62.7	131

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
				Result	Concentration	LCS	Low	High
EP080: BTEXN (QCLot: 2020012)								
EP080: Benzene	71-43-2	1	µg/L	<1	10 µg/L	91.0	76	124
EP080: Toluene	108-88-3	2	µg/L	<2	10 µg/L	106	71	123
EP080: Ethylbenzene	100-41-4	2	µg/L	<2	10 µg/L	122	73	125
EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	20 µg/L	108	70.4	129
EP080: ortho-Xylene	95-47-6	2	µg/L	<2	10 µg/L	105	72	124
EP080: Total Xylenes	1330-20-7	2	µg/L	<2	----	----	----	----
EP080: Sum of BTEX	----	1	µg/L	<1	----	----	----	----
EP117: Alcohols (QCLot: 2021321)								
EP117: Ethanol	64-17-5	50	µg/L	<50	100 µg/L	84.5	73	121

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	Spike Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High
ED009: Anions (QCLot: 2020005)							
EB1121924-002	Anonymous	ED009-X: Bromide	24959-67-9	5 mg/L	88.0	70	130
ED045G: Chloride Discrete analyser (QCLot: 2018209)							
EB1122385-001	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	96.0	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 2018190)							
EB1122262-017	Anonymous	EG020A-F: Aluminium	7429-90-5	0.500 mg/L	92.0	70	130
		EG020A-F: Arsenic	7440-38-2	0.100 mg/L	95.8	70	130
		EG020A-F: Beryllium	7440-41-7	0.100 mg/L	102	70	130
		EG020A-F: Barium	7440-39-3	0.500 mg/L	92.0	70	130
		EG020A-F: Cadmium	7440-43-9	0.100 mg/L	95.7	70	130
		EG020A-F: Chromium	7440-47-3	0.100 mg/L	91.4	70	130
		EG020A-F: Cobalt	7440-48-4	0.100 mg/L	90.2	70	130
		EG020A-F: Copper	7440-50-8	0.200 mg/L	93.8	70	130
		EG020A-F: Lead	7439-92-1	0.100 mg/L	89.1	70	130
		EG020A-F: Manganese	7439-96-5	0.100 mg/L	# Not Determined	70	130
		EG020A-F: Molybdenum	7439-98-7	0.100 mg/L	92.4	70	130
		EG020A-F: Nickel	7440-02-0	0.100 mg/L	93.6	70	130
		EG020A-F: Selenium	7782-49-2	0.100 mg/L	96.9	70	130
		EG020A-F: Tin	7440-31-5	0.100 mg/L	91.0	70	130
		EG020A-F: Vanadium	7440-62-2	0.100 mg/L	92.6	70	130
		EG020A-F: Zinc	7440-66-6	0.200 mg/L	91.3	70	130
		EG020A-F: Boron	7440-42-8	0.500 mg/L	90.1	70	130
EG020T: Total Metals by ICP-MS (QCLot: 2017782)							
EB1122262-017	Anonymous	EG020A-T: Arsenic	7440-38-2	1.000 mg/L	119	70	130
		EG020A-T: Beryllium	7440-41-7	0.100 mg/L	123	70	130
		EG020A-T: Barium	7440-39-3	1.000 mg/L	81.4	70	130
		EG020A-T: Cadmium	7440-43-9	0.500 mg/L	107	70	130
		EG020A-T: Chromium	7440-47-3	1.000 mg/L	94.8	70	130
		EG020A-T: Cobalt	7440-48-4	1.000 mg/L	102	70	130
		EG020A-T: Copper	7440-50-8	1.000 mg/L	99.3	70	130
		EG020A-T: Lead	7439-92-1	1.000 mg/L	89.0	70	130
		EG020A-T: Manganese	7439-96-5	1.000 mg/L	# Not Determined	70	130
		EG020A-T: Nickel	7440-02-0	1.000 mg/L	98.6	70	130
		EG020A-T: Vanadium	7440-62-2	1.000 mg/L	88.0	70	130
		EG020A-T: Zinc	7440-66-6	1.000 mg/L	104	70	130

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	Spike Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High
EG035F: Dissolved Mercury by FIMS (QCLot: 2018192)							
EB1122262-019	Anonymous	EG035F: Mercury	7439-97-6	0.010 mg/L	77.9	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 2021544)							
EB1122376-001	Anonymous	EG035T: Mercury	7439-97-6	0.010 mg/L	100	70	130
EK040P: Fluoride by PC Titrator (QCLot: 2017943)							
EB1122381-001	GUN_K2_BORE_W	EK040P: Fluoride	16984-48-8	6.1 mg/L	114	70	130
EK055G: Ammonia as N by Discrete Analyser (QCLot: 2018222)							
EB1122388-001	Anonymous	EK055G: Ammonia as N	7664-41-7	0.4 mg/L	94.2	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 2018206)							
EB1122395-002	Anonymous	EK057G: Nitrite as N	----	0.4 mg/L	84.8	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 2018221)							
EB1122388-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	78.8	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 2018613)							
EB1122304-002	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	84.6	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 2018614)							
EB1122304-002	Anonymous	EK067G: Total Phosphorus as P	----	1.0 mg/L	104	70	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 2018208)							
EB1122395-002	Anonymous	EK071G: Reactive Phosphorus as P	----	0.4 mg/L	104	70	130
EK085M: Sulfide as S2- (QCLot: 2021135)							
EB1122381-001	GUN_K2_BORE_W	EK085: Sulfide as S2-	18496-25-8	1.0 mg/L	80.0	70	130
EP033: C1 - C4 Hydrocarbon Gases (QCLot: 2023466)							
EM1112093-002	Anonymous	EP033: Methane	74-82-8	27.92 µg/L	90.2	70	130
		EP033: Ethene	74-85-1	50.29 µg/L	83.5	70	130
		EP033: Ethane	74-84-0	53.91 µg/L	89.0	70	130
		EP033: Propene	115-07-1	74.71 µg/L	82.1	70	130
		EP033: Propane	74-98-6	72.91 µg/L	88.7	70	130
		EP033: Butene	25167-67-3	98.63 µg/L	83.9	70	130
		EP033: Butane	106-97-8	103.19 µg/L	88.5	70	130
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 2021328)							
EB1122381-001	GUN_K2_BORE_W	EP075(SIM): Acenaphthene	83-32-9	2 µg/L	88.2	70	130
		EP075(SIM): Pyrene	129-00-0	2 µg/L	104	70	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2020012)							
EB1122376-001	Anonymous	EP080: C6 - C9 Fraction	----	40 µg/L	113	70	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2021327)							
EB1122381-001	GUN_K2_BORE_W	EP071: C10 - C14 Fraction	----	200 µg/L	110	74	150
		EP071: C15 - C28 Fraction	----	250 µg/L	132	77	153

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	Spike Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High
EP080/071: Total Petroleum Hydrocarbons (QCLot: 2021327) - continued							
EB1122381-001	GUN_K2_BORE_W	EP071: C29 - C36 Fraction	----	200 µg/L	115	67	153
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft (QCLot: 2020012)							
EB1122376-001	Anonymous	EP080: C6 - C10 Fraction	----	40 µg/L	115	70	130
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft (QCLot: 2021327)							
EB1122381-001	GUN_K2_BORE_W	EP071: >C10 - C16 Fraction	----	250 µg/L	88.0	74	150
		EP071: >C16 - C34 Fraction	----	350 µg/L	120	77	153
		EP071: >C34 - C40 Fraction	----	150 µg/L	86.7	67	153
EP080: BTEXN (QCLot: 2020012)							
EB1122376-001	Anonymous	EP080: Benzene	71-43-2	10 µg/L	106	70	130
		EP080: Toluene	108-88-3	10 µg/L	102	70	130
EP117: Alcohols (QCLot: 2021321)							
EB1122408-002	Anonymous	EP117: Ethanol	64-17-5	100 µg/L	# Not Determined	70	130

INTERPRETIVE QUALITY CONTROL REPORT

Work Order	: **EB1122381**	Page	: 1 of 13
Client	: SANTOS LTD	Laboratory	: Environmental Division Brisbane
Contact	: [redacted]	Contact	: [redacted]
Address	: GPO BOX 1010 LEVEL 22, 32 TURBOT STREET BRISBANE QLD, AUSTRALIA 4001	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: [redacted]	E-mail	: [redacted]
Telephone	: [redacted]	Telephone	: [redacted]
Facsimile	: ----	Facsimile	: [redacted]
Project	: 117626001	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Site	: Gunnedah		
C-O-C number	: ----	Date Samples Received	: 26-OCT-2011
Sampler	: [redacted]	Issue Date	: 02-NOV-2011
Order number	: 879002-405		
		No. of samples received	: 1
Quote number	: BN/107/11 V3	No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

The following report summarises extraction / preparation and analysis times and compares with recommended holding times. Dates reported represent first date of extraction or analysis and precludes subsequent dilutions and reruns. Information is also provided re the sample container (preservative) from which the analysis aliquot was taken. Elapsed period to analysis represents number of days from sampling where no extraction / digestion is involved or period from extraction / digestion where this is present. For composite samples, sampling date is assumed to be that of the oldest sample contributing to the composite. Sample date for laboratory produced leachates is assumed as the completion date of the leaching process. Outliers for holding time are based on USEPA SW 846, APHA, AS and NEPM (1999). A listing of breaches is provided in the Summary of Outliers.

Holding times for leachate methods (excluding elutriates) vary according to the analytes being determined on the resulting solution. For non-volatile analytes, the holding time compliance assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These soil holding times are: Organics (14 days); Mercury (28 days) & other metals (180 days). A recorded breach therefore does not guarantee a breach for all non-volatile parameters.

Matrix: **WATER**

Evaluation: ✘ = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural GUN_K2_BORE_W	**24-OCT-2011**	---	24-OCT-2011	----	**27-OCT-2011**	24-OCT-2011	✘
EA010P: Conductivity by PC Titrator							
Clear Plastic Bottle - Natural GUN_K2_BORE_W	**24-OCT-2011**	---	21-NOV-2011	----	**27-OCT-2011**	21-NOV-2011	✓
EA015: Total Dissolved Solids							
Clear Plastic Bottle - Natural GUN_K2_BORE_W	**24-OCT-2011**	----	----	----	**27-OCT-2011**	31-OCT-2011	✓
ED009: Anions							
Clear Plastic Bottle - Natural GUN_K2_BORE_W	**24-OCT-2011**	----	----	----	**28-OCT-2011**	21-NOV-2011	✓
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural GUN_K2_BORE_W	**24-OCT-2011**	---	07-NOV-2011	----	**27-OCT-2011**	07-NOV-2011	✓
ED040F: Dissolved Major Anions							
Clear Plastic Bottle - Natural GUN_K2_BORE_W	**24-OCT-2011**	---	21-NOV-2011	----	**27-OCT-2011**	21-NOV-2011	✓
ED045G: Chloride Discrete analyser							
Clear Plastic Bottle - Natural GUN_K2_BORE_W	**24-OCT-2011**	---	21-NOV-2011	----	**27-OCT-2011**	21-NOV-2011	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural GUN_K2_BORE_W	**24-OCT-2011**	---	31-OCT-2011	----	**27-OCT-2011**	31-OCT-2011	✓
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Nitric Acid; Filtered GUN_K2_BORE_W	**24-OCT-2011**	---	21-APR-2012	----	**28-OCT-2011**	21-APR-2012	✓
EG020T: Total Metals by ICP-MS							
Clear Plastic Bottle - Nitric Acid; Unfiltered GUN_K2_BORE_W	**24-OCT-2011**	**28-OCT-2011**	21-APR-2012	✓	**28-OCT-2011**	21-APR-2012	✓

Work Order : EB1122381
Client : SANTOS LTD
Project : 117626001

Matrix: **WATER**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method *Container / Client Sample ID(s)*	*Sample Date*	*Extraction / Preparation* *Date extracted*	*Due for extraction*	*Evaluation*	*Analysis* *Date analysed*	*Due for analysis*	*Evaluation*
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Nitric Acid; Filtered GUN_K2_BORE_W	**24-OCT-2011**	---	21-NOV-2011	----	**31-OCT-2011**	21-NOV-2011	✓
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Nitric Acid; Unfiltered GUN_K2_BORE_W	**24-OCT-2011**	----	----	----	**02-NOV-2011**	21-NOV-2011	✓
EK010/011: Chlorine							
Clear Plastic Bottle - Natural GUN_K2_BORE_W	**24-OCT-2011**	----	----	----	**28-OCT-2011**	24-OCT-2011	✗
EK040P: Fluoride by PC Titrator							
Clear Plastic Bottle - Natural GUN_K2_BORE_W	**24-OCT-2011**	---	21-NOV-2011	----	**27-OCT-2011**	21-NOV-2011	✓
EK055G: Ammonia as N by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid GUN_K2_BORE_W	**24-OCT-2011**	---	21-NOV-2011	----	**28-OCT-2011**	21-NOV-2011	✓
EK057G: Nitrite as N by Discrete Analyser							
Clear Plastic Bottle - Natural GUN_K2_BORE_W	**24-OCT-2011**	---	26-OCT-2011	----	**27-OCT-2011**	26-OCT-2011	✗
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid GUN_K2_BORE_W	**24-OCT-2011**	---	21-NOV-2011	----	**28-OCT-2011**	21-NOV-2011	✓
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid GUN_K2_BORE_W	**24-OCT-2011**	**28-OCT-2011**	21-NOV-2011	✓	**28-OCT-2011**	21-NOV-2011	✓
EK067G: Total Phosphorus as P by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid GUN_K2_BORE_W	**24-OCT-2011**	**28-OCT-2011**	21-NOV-2011	✓	**28-OCT-2011**	21-NOV-2011	✓
EK071G: Reactive Phosphorus as P by discrete analyser							
Clear Plastic Bottle - Natural GUN_K2_BORE_W	**24-OCT-2011**	---	26-OCT-2011	----	**27-OCT-2011**	26-OCT-2011	✗
EK084: Un-ionized Hydrogen Sulfide							
Clear Plastic Bottle - Zinc Acetate/NaOH GUN_K2_BORE_W	**24-OCT-2011**	----	----	----	**02-NOV-2011**	31-OCT-2011	✗
EK085M: Sulfide as S2-							
Clear Plastic Bottle - Zinc Acetate/NaOH GUN_K2_BORE_W	**24-OCT-2011**	----	----	----	**31-OCT-2011**	31-OCT-2011	✓
EP002: Dissolved Organic Carbon (DOC)							
Amber DOC Filtered- Sulfuric Preserved GUN_K2_BORE_W	**24-OCT-2011**	----	----	----	**28-OCT-2011**	21-NOV-2011	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation: Date extracted	Extraction / Preparation: Due for extraction	Extraction / Preparation: Evaluation	Analysis: Date analysed	Analysis: Due for analysis	Analysis: Evaluation
EP005: Total Organic Carbon (TOC)							
Amber TOC Vial - Sulfuric Acid GUN_K2_BORE_W	**24-OCT-2011**	**----**	----	----	**28-OCT-2011**	21-NOV-2011	✓
EP033: C1 - C4 Hydrocarbon Gases							
Amber VOC Vial - Sulfuric Acid GUN_K2_BORE_W	**24-OCT-2011**	**----**	----	----	**01-NOV-2011**	07-NOV-2011	✓
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons							
Amber Glass Bottle - Unpreserved GUN_K2_BORE_W	**24-OCT-2011**	**31-OCT-2011**	31-OCT-2011	✓	**31-OCT-2011**	10-DEC-2011	✓
EP080/071: Total Petroleum Hydrocarbons							
Amber Glass Bottle - Unpreserved GUN_K2_BORE_W	**24-OCT-2011**	**31-OCT-2011**	31-OCT-2011	✓	**31-OCT-2011**	10-DEC-2011	✓
Amber VOC Vial - Sulfuric Acid GUN_K2_BORE_W	**24-OCT-2011**	**31-OCT-2011**	07-NOV-2011	✓	**31-OCT-2011**	07-NOV-2011	✓
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft							
Amber Glass Bottle - Unpreserved GUN_K2_BORE_W	**24-OCT-2011**	**31-OCT-2011**	31-OCT-2011	✓	**31-OCT-2011**	10-DEC-2011	✓
Amber VOC Vial - Sulfuric Acid GUN_K2_BORE_W	**24-OCT-2011**	**31-OCT-2011**	07-NOV-2011	✓	**31-OCT-2011**	07-NOV-2011	✓
EP080: BTEXN							
Amber VOC Vial - Sulfuric Acid GUN_K2_BORE_W	**24-OCT-2011**	**31-OCT-2011**	07-NOV-2011	✓	**31-OCT-2011**	07-NOV-2011	✓
EP117: Alcohols							
Amber VOC Vial - Sulfuric Acid GUN_K2_BORE_W	**24-OCT-2011**	**----**	----	----	**31-OCT-2011**	07-NOV-2011	✓
MW002: Heterotrophic Plate Count							
Sterile Plastic Bottle - Sodium Thiosulfate GUN_K2_BORE_W	**24-OCT-2011**	**---**	25-OCT-2011	----	**26-OCT-2011**	25-OCT-2011	×

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alcohols by HS-GC-MS	EP117	1	6	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	2	16	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
C1 - C4 Gases	EP033	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	18	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity by PC Titrator	EA010-P	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	8	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	15	**13.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	2	15	**13.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Organic Carbon	EP002	1	9	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	7	**14.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Dissolved	ED040F	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	2	15	**13.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	1	**100.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
pH by PC Titrator	EA005-P	2	13	**15.4**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	16	**12.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfide as S2-	EK085	2	13	**15.4**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	2	20	**10.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	9	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	2	19	**10.5**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	2	12	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite B	EG020B-T	2	12	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	1	6	**16.7**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	2	15	**13.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH - Semivolatile Fraction	EP071	1	1	**100.0**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Volatiles/BTEX	EP080	2	18	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Alcohols by HS-GC-MS	EP117	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Alkalinity by PC Titrator	ED037-P	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	16	**6.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
C1 - C4 Gases	EP033	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	2	18	**11.1**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity by PC Titrator	EA010-P	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	8	**12.5**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	15	**6.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	15	**6.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Control Samples (LCS) - Continued							
Dissolved Organic Carbon	EP002	2	9	**22.2**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	7	**14.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	15	**6.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
pH by PC Titrator	EA005-P	2	13	**15.4**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	16	**6.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfide as S2-	EK085	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	9	**11.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite B	EG020B-T	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Organic Carbon	EP005	2	6	**33.3**	**10.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	15	**6.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH - Semivolatile Fraction	EP071	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Volatiles/BTEX	EP080	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Alcohols by HS-GC-MS	EP117	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	16	**6.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
C1 - C4 Gases	EP033	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Chlorine	EK010	1	2	**50.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Conductivity by PC Titrator	EA010-P	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	8	**12.5**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	15	**6.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	15	**6.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Dissolved Organic Carbon	EP002	1	9	**11.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	7	**14.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Anions - Dissolved	ED040F	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	15	**6.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	16	**6.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Sulfide as S2-	EK085	1	13	**7.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	1	20	**5.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	9	**11.1**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	19	**5.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Metals by ICP-MS - Suite B	EG020B-T	1	12	**8.3**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Total Organic Carbon	EP005	1	6	**16.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	15	**6.7**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH - Semivolatile Fraction	EP071	1	1	**100.0**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
TPH Volatiles/BTEX	EP080	1	18	**5.6**	**5.0**	✓	NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Alcohols by HS-GC-MS	EP117	1	6	**16.7**	**5.0**	✓	ALS QCS3 requirement
Ammonia as N by Discrete analyser	EK055G	1	16	**6.3**	**5.0**	✓	ALS QCS3 requirement
C1 - C4 Gases	EP033	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	1	18	**5.6**	**5.0**	✓	ALS QCS3 requirement
Dissolved Mercury by FIMS	EG035F	1	8	**12.5**	**5.0**	✓	ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	15	**6.7**	**5.0**	✓	ALS QCS3 requirement
Fluoride by PC Titrator	EK040P	1	7	**14.3**	**5.0**	✓	ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	**5.0**	**5.0**	✓	ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	1	15	**6.7**	**5.0**	✓	ALS QCS3 requirement
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	1	**100.0**	**5.0**	✓	ALS QCS3 requirement
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	16	**6.3**	**5.0**	✓	ALS QCS3 requirement
Standard Anions -by IC (Extended Method)	ED009-X	1	19	**5.3**	**5.0**	✓	ALS QCS3 requirement
Sulfide as S2-	EK085	1	13	**7.7**	**5.0**	✓	ALS QCS3 requirement
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	9	**11.1**	**5.0**	✓	ALS QCS3 requirement
Total Mercury by FIMS	EG035T	1	19	**5.3**	**5.0**	✓	ALS QCS3 requirement
Total Metals by ICP-MS - Suite A	EG020A-T	1	12	**8.3**	**5.0**	✓	ALS QCS3 requirement
Total Phosphorus as P By Discrete Analyser	EK067G	1	15	**6.7**	**5.0**	✓	ALS QCS3 requirement
TPH - Semivolatile Fraction	EP071	1	1	**100.0**	**5.0**	✓	ALS QCS3 requirement
TPH Volatiles/BTEX	EP080	1	18	**5.6**	**5.0**	✓	ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
pH by PC Titrator	EA005-P	WATER	APHA 21st ed. 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Conductivity by PC Titrator	EA010-P	WATER	APHA 21st ed., 2510 B This procedure determines conductivity by automated ISE. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Dissolved Solids (High Level)	EA015H	WATER	APHA 21st ed., 2540C A gravimetric procedure that determines the amount of `filterable` residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Hardness as CaCO3	EA065	WATER	APHA 21st ed., 2340 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Residual Alkali	EA161	WATER	In House (Calculation)
Free and Total CO2	EA165-P	WATER	APHA 21st ed., CO2-D. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Standard Anions -by IC (Extended Method)	ED009-X	WATER	APHA 21st ed., 4110. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Alkalinity by PC Titrator	ED037-P	WATER	APHA 21st ed., 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Major Anions - Dissolved	ED040F	WATER	APHA 21st ed., 3120. The 0.45um filtered samples are determined by ICP/AES for Sulfur and/or Silcon content and reported as Sulfate and/or Silica after conversion by gravimetric factor.
Chloride by Discrete Analyser	ED045G	WATER	APHA 21st ed., 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	Major Cations is determined based on APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises the 0.45um filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Sodium Absorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2) Total Hardness is calculated based on APHA 21st ed., 2340 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	Method	Matrix	Method Descriptions
Dissolved Metals by ICP-MS - Suite B	EG020B-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite B	EG020B-T	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45 um filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Mercury by FIMS	EG035T	WATER	AS 3550, APHA 21st ed. 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Silica (Total Dissolved) by ICPAES	EG052F	WATER	APHA 21st ed., 4500-SiO2. Silica (Total) determined by calculation from Silicon by ICPAES.
Chlorine	EK010	WATER	In-house (DPD colourimetry)
Fluoride by PC Titrator	EK040P	WATER	APHA 21st ed., 4500 F--C CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ammonia as N by Discrete analyser	EK055G	WATER	APHA 21st ed., 4500-NH3 G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite as N by Discrete Analyser	EK057G	WATER	APHA 21st ed., 4500-NO2- B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrate as N by Discrete Analyser	EK058G	WATER	APHA 21st ed., 4500-NO3- F. Nitrate is reduced to nitrite by way of a cadmium reduction column followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	APHA 21st ed., 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Cadmium Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	APHA 21st ed., 4500-Norg D. 25mL water samples are digested using a traditional Kjeldahl digestion followed by determination by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	APHA 21st ed., 4500-Norg / 4500-NO3-. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	APHA 21st ed., 4500-P B&F This procedure involves sulphuric acid digestion of a 100mL sample to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Analytical Methods	Method	Matrix	Method Descriptions
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	APHA 21st ed., 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with othophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Un-ionized Hydrogen Sulfide	EK084	WATER	APHA 21st ed., 4500-S2- H. Sulfide in the sample is reported as the ionised / unionised fractions by the use of a nomograph and the initial pH. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Sulfide as S2-	EK085	WATER	APHA 21st ed., 4500-S2- D Sulfide species present in water samples are immediately precipitated when collected in pretreated caustic/zinc acetate preserved sample containers. After the supernatant is discarded, the resultant precipitate is then coloured using methylene blue indicator and measured using UV-VIS detection at 664nm. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Ionic Balance by PCT DA and ICPAES	EN055 - DA	WATER	APHA 21st Ed. 1030F. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Field Tests (performed by external sampler)	EN67-B02	WATER	Field determinations as per methods described in APHA or supplied by client. The analysis is performed in the field by non-ALS samplers. ALS NATA accreditation does not apply for this service.
Dissolved Organic Carbon	EP002	WATER	APHA 21st ed., 5310 B. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Total Organic Carbon	EP005	WATER	APHA 21st ed., 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
C1 - C4 Gases	EP033	WATER	Technical Guidance for the Natural Attenuation Indicators: Methane, Ethane, and Ethene, US EPA - Region 1, EPA New England, July 2001. Automated static headspace, dual column GC/FID. A 12 mL sample is pipetted into a 20 mL headspace vial containing 3g of sodium chloride and sealed. Each sample is equilibrated with shaking at 40 degrees C for 10 minutes prior to analysis by GC/FID using a pair of PLOT columns of different polarity.
TPH - Semivolatile Fraction	EP071	WATER	USEPA SW 846 - 8015A The sample extract is analysed by Capillary GC/FID and quantification is by comparison against an established 5 point calibration curve of n-Alkane standards. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
TPH Volatiles/BTEX	EP080	WATER	USEPA SW 846 - 8260B Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. Alternatively, a sample is equilibrated in a headspace vial and a portion of the headspace determined by GCMS analysis. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Alcohols by HS-GC-MS	* EP117	WATER	In House. A 10 mL aliquot of sample is mixed with 4 g of sodium chloride, equilibrated at 80 degrees C for 10 minutes and the headspace analysed by GCMS in the selected ion monitoring mode.
Heterotrophic (Total) Plate Count @ 22C and 36C	MW002	WATER	AS4276.3.1- 2007
Field Observations	SAMP-02	WATER	Field Observations provided by Samplers and recorded on ALS report. NATA accreditation does not apply to this service.
Sulphate Reducing Bacteria (Water)	SRB-WAT	WATER	Sulphate Reducing Bacteria analysis of water matrices conducted by Subcontracting Laboratory

Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	APHA 21st ed., 4500 Norg - D; APHA 21st ed., 4500 P - H. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)
Digestion for Total Recoverable Metals	EN25	WATER	USEPA SW846-3005 Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2)

Preparation Methods	Method	Matrix	Method Descriptions
Separatory Funnel Extraction of Liquids	ORG14	WATER	USEPA SW 846 - 3510B 500 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (1999) Schedule B(3) (Appdx. 2). ALS default excludes sediment which may be resident in the container.
Volatiles Water Preparation	ORG16-W	WATER	A 5 mL aliquot or 5 mL of a diluted sample is added to a 40 mL VOC vial for sparging.

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EG020F: Dissolved Metals by ICP-MS	EB1122262-017	Anonymous	**Manganese**	7439-96-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EG020T: Total Metals by ICP-MS	EB1122262-017	Anonymous	**Manganese**	7439-96-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EP117: Alcohols	EB1122408-002	Anonymous	**Ethanol**	64-17-5	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**
- **For all matrices, no Laboratory Control outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

Matrix: **WATER**

Method	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EA005P: pH by PC Titrator						
Clear Plastic Bottle - Natural GUN_K2_BORE_W	----	----	----	27-OCT-2011	24-OCT-2011	**3**
EK010/011: Chlorine						
Clear Plastic Bottle - Natural GUN_K2_BORE_W	----	----	----	28-OCT-2011	24-OCT-2011	**4**
EK057G: Nitrite as N by Discrete Analyser						
Clear Plastic Bottle - Natural GUN_K2_BORE_W	----	----	----	27-OCT-2011	26-OCT-2011	**1**
EK071G: Reactive Phosphorus as P by discrete analyser						

Matrix: **WATER**

Method Container / Client Sample ID(s)	Extraction / Preparation Date extracted	Due for extraction	Days overdue	Analysis Date analysed	Due for analysis	Days overdue
EK071G: Reactive Phosphorus as P by discrete analyser - Analysis Holding Time Compliance						
Clear Plastic Bottle - Natural GUN_K2_BORE_W	----	----	----	27-OCT-2011	26-OCT-2011	**1**
EK084: Un-ionized Hydrogen Sulfide						
Clear Plastic Bottle - Zinc Acetate/NaOH GUN_K2_BORE_W	----	----	----	02-NOV-2011	31-OCT-2011	**2**
MW002: Heterotrophic Plate Count						
Sterile Plastic Bottle - Sodium Thiosulfate GUN_K2_BORE_W	----	----	----	26-OCT-2011	25-OCT-2011	**1**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

CHAIN OF CUSTODY DOCUMENTATION

Santos
We have the energy.

CLIENT: Santos Ltd	SAMPLER: [redacted]
ADDRESS / OFFICE: Santos Place, Level 22, 32 Turbot Street, Brisbane QLD 4000	MOBILE: [redacted]
PROJECT MANAGER (PM): [redacted]	PHONE:
PROJECT ID: 117626001	EMAIL INVOICE TO: [redacted]
SITE: Gunnedah	EMAIL REPORT TO: [redacted]
RESULTS REQUIRED: Standard Turn Around QUOTE: EN/039/10 Addendum	**Notes:** PLEASE ANALYSE APPROPRIATE SAMPLES FIRST TO ENSURE THAT HOLDING TIMES ARE NOT BREACHED

Note: Please provide results in SRA ENVT SANTOS format

FOR LABORATORY USE ONLY	COMMENTS / HANDLING / STORAGE OR DIPOSAL:
COOLER SEAL (circle appropriate)	Please store samples for 3 weeks prior to disposal
Intact: Yes No N/A	
SAMPLE TEMPERATURE	
CHILLED: Yes No	

SAMPLE INFORMATION (note: S = Soil, W=Water) — CONTAINER INFO

Field Measurements (ALS Code EN6702) — Serial No (SAMP2):

Field Observations (ALS Code SAMP2) — Surface Water / Groundwater

Lab Analysis

ID	SAMPLE ID	MATRIX	DATE	Time	Type / Code	#Bot	pH	EC (µS/cm)	Field DO (mg/L)	Temp (°C)	Redox (mV)	Turbidity (NTU)	Water Lvl (mbgl)	Dam Level	Flow	Clarity	Algae	Hydrocarbon	Vol Pumped (L)	Clarity	Colour	Odour	Sample Type	Rainfall	Santos Suite C	Santos Suite B	Santos Suite X	LAB QC extra Volume
1	GUN K2_BORE W	W	24/10/11	1330		21	7.96	6090	1.68	28.1	-46														X	X	X	X

SPLIT BATCH
Test C14 - C16
Assoc. Batch No.
EB1122384

Environmental Division
Brisbane
Work Order
EB1122381
Telephone : +61-7-3243 7222

HT

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
Name: [redacted]	Date: 24/10/11	Name: [redacted]	Date: 26/10/11	Con' Note No:
Of: Golder Associates	Time: 500 pm	Of: ALS	Time: 13:45	Transport Co:
Name:	Date:	Name:	Date:	
Of:	Time:	Of:	Time:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserveed Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bad for Acid Sulphate Soils; B = Unpreserved Bag.

Analyte	unit	LOR	ANZG (2018) - Freshwater - 95% level of species protection	ADWG 2011 Health (v3.5 updated 2018)	ANZECC / ARMCANZ (2000) short-term irrigation	GUN_K2_BORE_W
pH Value	pH Unit	0.01	6.5-8.0	6.5-8.5	6.0-9.0	8.1
Electrical Conductivity @ 25°C	µS/cm	1	30-350		Crop specific	6080
Total Dissolved Solids @180°C	mg/L	5	20 - 234	1200	Crop specific	4040
Total Hardness as CaCO3	mg/L	1			<60	19
Residual Alkali	meq/L	0.01				6.11
Free Carbon Dioxide as CO2	mg/L	1				2
Total Carbon Dioxide as CO2	mg/L	1				201
Bromide	mg/L	0.01				<0.200
Hydroxide Alkalinity as CaCO3	mg/L	1				<1
Carbonate Alkalinity as CaCO3	mg/L	1				<1
Bicarbonate Alkalinity as CaCO3	mg/L	1			No guideline	3360
Total Alkalinity as CaCO3	mg/L	1			No guideline	3360
Sulfate as SO4 2-	mg/L	1				4
Chloride	mg/L	1			175->700	209
Calcium	mg/L	1			No guideline	6
Magnesium	mg/L	1			No guideline	1
Sodium	mg/L	1			115 - >460	1600
Potassium	mg/L	1			No guideline	35
Aluminium (filtered)	mg/L	0.01	0.055		20	<0.01
Arsenic (filtered)	mg/L	0.001	0.013	0.01	20	<0.001
Beryllium (filtered)	mg/L	0.001		0.06	0.5	<0.001
Barium (filtered)	mg/L	0.001		2	No guideline	1.65
Cadmium (filtered)	mg/L	0.0001	0.0002	0.002	0.05	<0.0001
Chromium (filtered)	mg/L	0.001	0.001		1	<0.001
Cobalt (filtered)	mg/L	0.001			0.1	<0.001
Copper (filtered)	mg/L	0.001	0.0014	2	5	<0.001
Lead (filtered)	mg/L	0.001	0.0034	0.01	5	<0.001
Lithium (filtered)	mg/L	0.001			2.5	0.514
Manganese (filtered)	mg/L	0.001	1.9	0.5	10	0.014
Molybdenum (filtered)	mg/L	0.001		0.05	0.05	<0.001
Nickel (filtered)	mg/L	0.001	0.011	0.02	2	<0.001
Selenium (filtered)	mg/L	0.01		0.01	0.05	<0.01
Strontium (filtered)	mg/L	0.001			No guideline	0.968
Tin (filtered)	mg/L	0.001			No guideline	<0.001
Uranium (filtered)	mg/L	0.001		0.017	0.1	<0.001
Vanadium (filtered)	mg/L	0.01			0.5	0.01
Zinc (filtered)	mg/L	0.005	0.008		5	<0.005
Boron (filtered)	mg/L	0.05	0.37	4	0.5-15	<0.05
Iron (filtered)	mg/L	0.05	0.3		10	0.13
Aluminium	mg/L	0.01	0.055		20	<0.01
Arsenic	mg/L	0.001	0.013	0.01	20	<0.001
Beryllium	mg/L	0.001		0.06	0.5	<0.001
Barium	mg/L	0.001		2	No guideline	2.05
Cadmium	mg/L	0.0001	0.0002	0.002	0.05	<0.0001
Chromium	mg/L	0.001	0.001		1	<0.001
Cobalt	mg/L	0.001			0.1	<0.001
Copper	mg/L	0.001	0.0014	2	5	0.002
Lead	mg/L	0.001	0.0034	0.01	5	<0.001
Lithium	mg/L	0.001			2.5	0.74
Manganese	mg/L	0.001	1.9	0.5	10	0.021
Molybdenum	mg/L	0.001		0.05	0.05	<0.001
Nickel	mg/L	0.001	0.011	0.02	2	<0.001
Selenium	mg/L	0.01		0.01	0.05	<0.01
Strontium	mg/L	0.001			No guideline	1.2

Analyte	unit	LOR	ANZG (2018) - Freshwater - 95% level of species protection	ADWG 2011 Health (v3.5 updated 2018)	ANZECC / ARMCANZ (2000) short-term irrigation	GUN_K2_BORE_W
Tin	mg/L	0.001			No guideline	<0.001
Uranium	mg/L	0.001		0.017	0.1	<0.001
Vanadium	mg/L	0.01			0.5	<0.01
Zinc	mg/L	0.005	0.008		5	0.008
Boron	mg/L	0.05	0.37	4	0.5-15	0.06
Iron	mg/L	0.05	0.3		10	1.44
Mercury	mg/L	0.0001		0.001	0.002	<0.0001
Silica	mg/L	0.1			No guideline	14.5
Chlorine	mg/L	0.2		5	No guideline	<0.2
Fluoride	mg/L	0.1		1.5	2.0	2.1
Ammonia as N	mg/L	0.01	0.013		Crop specific as N (25-105)	1.52
Nitrite (as N)	mg/L	0.01		0.91		<0.01
Nitrate (as N)	mg/L	0.01		11.29	Crop specific as N (25-105)	0.02
Nitrite + Nitrate as N	mg/L	0.01				0.02
Total Kjeldahl Nitrogen as N	mg/L	0.1				3.2
Total Nitrogen as N	mg/L	0.1	0.25		25-105	3.20
Total Phosphorus as P	mg/L	0.01	0.02		0.8-12	0.06
Reactive Phosphorus as P	mg/L	0.01				0.02
Unionized Hydrogen Sulfide	mg/L	0.1				<0.1
Sulfide as S2-	mg/L	0.1				<0.1
Total Anions	meq/L	0.01				73.1
Total Cations	meq/L	0.01				70.9
Ionic Balance	%	0.01				1.62
Electrical Conductivity (NonCompensated)	µS/cm	1	30-350			6090.00
Field pH	pH Unit	0.01	6.5-8.0			8.0
Field Redox Potential	mV	0.1				-46
Field Temperature	°C	0.1				28.1
Field Dissolved Oxygen	mg/L	0.1				1.68
Dissolved Organic Carbon	mg/L	1				<1
Total Organic Carbon	mg/L	1				47
Methane	mg/L	0.01				5.12
Ethene	mg/L	0.01				<0.01
Ethane	mg/L	0.01				<0.01
Propene	mg/L	0.01				<0.01
Propane	mg/L	0.01				<0.01
Butene	mg/L	0.01				<0.01
Butane	mg/L	0.01				<0.01
Naphthalene	mg/L	0.001	0.016			<0.001
Acenaphthylene	mg/L	0.001				<0.001
Acenaphthene	mg/L	0.001				<0.001
Fluorene	mg/L	0.001				<0.001
Phenanthrene	mg/L	0.001				<0.001
Anthracene	mg/L	0.001				<0.001
Fluoranthene	mg/L	0.001				<0.001
Pyrene	mg/L	0.001				<0.001
Benz(a)anthracene	mg/L	0.001				<0.001
Chrysene	mg/L	0.001				<0.001
Benzo(b)fluoranthene	mg/L	0.001				<0.001
Benzo(k)fluoranthene	mg/L	0.001				<0.001
Benzo(a)pyrene	mg/L	0.0005		0.00005		**<0.0005**
Indeno(1.2.3.cd)pyrene	mg/L	0.001				<0.001

Analyte	unit	LOR	ANZG (2018) - Freshwater - 95% level of species protection	ADWG 2011 Health (v3.5 updated 2018)	ANZECC / ARMCANZ (2000) short-term irrigation	GUN_K2_BORE_W
Dibenz(a.h)anthracene	mg/L	0.001				<0.001
Benzo(g.h.i)perylene	mg/L	0.001				<0.001
Sum of polycyclic aromatic hydrocarbons	mg/L	0.0005				<0.0005
C6 - C9 Fraction	mg/L	0.02				<0.02
C10 - C14 Fraction	mg/L	0.05				<0.05
C15 - C28 Fraction	mg/L	0.1				<0.1
C29 - C36 Fraction	mg/L	0.05				<0.05
C10 - C36 Fraction (sum)	mg/L	0.05				<0.05
C6 - C10 Fraction	mg/L	0.02				<0.02
C6 - C10 Fraction minus BTEX (F1)	mg/L	0.02				<0.02
>C10 - C16 Fraction	mg/L	0.1				<0.1
>C16 - C34 Fraction	mg/L	0.1				<0.1
>C34 - C40 Fraction	mg/L	0.1				<0.1
>C10 - C40 Fraction (sum)	mg/L	0.1				<0.1
Benzene	mg/L	0.001	0.95	0.001		<0.001
Toluene	mg/L	0.002		0.8		<0.002
Ethylbenzene	mg/L	0.002		0.3		<0.002
meta- & para-Xylene	mg/L	0.002				<0.002
ortho-Xylene	mg/L	0.002				<0.002
Total Xylenes	mg/L	0.002		0.6		<0.002
Ethanol	mg/L	0.05	1.4			<0.05
Heterotrophic Plate Count (22°C)	CFU/mL	1				2500
Heterotrophic Plate Count (36°C)	CFU/mL	1				3200

Notes:
Freshwater criteria for TDS is the upland rivers range for south east Australia (ANZECC ARMCANZ, 2000)

Appendix D

Greenhouse gas report

Kahlua Pilot Reactivation

Greenhouse gas assessment

Santos

December 2022

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	0	[redacted]	[redacted]		[redacted]		15/12/22

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Contents

Table index

1. Introduction

Santos QNT Pty Ltd (Santos) proposes to carry out the Kahlua Pilot Reactivation at a site located on Lot 6 DP586978 in Marys Mount about 20 kilometres west of Gunnedah, NSW.

The site contains existing coal seam gas exploration infrastructure including four exploration wells (Kahlua (K) 2, K3, K4 and K5), access tracks, water storage and gas flaring infrastructure.

The purpose of the proposed activity is to continue exploration and appraisal activities at the site utilising the existing coal seam gas exploration infrastructure. It includes some minor additional civil and construction works including installation of buried gas and water gathering, power cables, upgrade of the gas flare, establishment of central power generation infrastructure and 65 kilolitre diesel storage, followed by workovers and completions, and appraisal activities.

This report provides a greenhouse gas assessment of the proposed activity.

2. Assessment methodology

The assessment estimates Scope 1 greenhouse gas (GHG) emissions associated with the Kahlua Pilot Reactivation Project.

Scope 1 emissions are the release of greenhouse gases into the atmosphere as a direct result of an activity, or series of activities (including ancillary activities) that constitute the facility. These are considered to be 'direct' emissions.

Factors used as input to calculations are from the following sources:

– *National Greenhouse and Energy Reporting (Measurement) Determination 2008* as amended (Commonwealth of Australia) (NGER Measurement Determination)
– American Petroleum Institute (API) Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry[1].

Given that the facility is not connected to the mains power, there are no Scope 2 emissions associated with the project.

Scope 3 emissions are indirect greenhouse gas emissions other than scope 2 emissions that are generated in the wider economy. They occur as a consequence of the activities of a facility, but from sources not owned or controlled by that facility's business — such as greenhouse gas emissions from the use of product gas by industry. Product gas would be flared as part of the proposed activity, emissions from which are accounted for as Scope 1, and would therefore not create any such downstream Scope 3 emissions for Santos. Other scope 3 emissions, such as those embodied in production of purchased goods and services, would be outside of the operational control of the proposed activity and are unlikely to be significant. Accordingly, Scope 3 emissions have not been considered further in this assessment.

Per requirements of the ESG2 guideline, an initial, high-level quantitative GHG assessment was undertaken, considering major emissions during well appraisal operations, restricted to the following sources:

– flaring
– combustion for electricity generation (operation of equipment)
– venting of reservoir carbon dioxide (CO_2)
– well workovers
– general leaks.

The GHG emission estimates associated with pilot reactivation and combustion of diesel fuel for the project were calculated in accordance with the current techniques set out in the NGER Measurement Determination.

2.1 Greenhouse gases considered

The greenhouse gases considered in this assessment and the corresponding global warming potential (GWP) for each GHG are listed in Table 2.1. The GWPs from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report[2] were used in this assessment for consistency with the IPCC guidelines.

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[1] **https://www.api.org/~/media/files/ehs/climate-change/2009_ghg_compendium.ashx**
[2] IPCC, 2014: *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* **https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf** (Box 3.2 Table 1 Examples of emission metric values from WGI)

Table 2.1 Greenhouse gases and 100-year global warming potentials

Greenhouse gas	Global warming potential
Carbon dioxide (CO_2)	1
Methane (CH_4)	28
Nitrous Oxide (N_2O)	265

3. Calculation of GHG emissions

GHG emissions from the pilot reactivation were calculated. Several assumptions were used for the process calculations including that the pilot reactivation appraisal work will be operating for two years. The remaining assumptions used in estimating the emissions are outlined in Table 3.1.

Table 3.1 Greenhouse gas emissions assumptions

Source	Assumptions
Flaring	Most of the natural gas from the project is flared. Emissions from flaring were estimated as per section 3.86 of the NGER Measurement Determination.
Production related emissions (including well workovers)	Production related emissions were estimated in accordance with the API Compendium section 5.7.1. Emission sources included well workovers, compressor starts, compressor blowdowns, gas gathering pipeline blowdowns, pressure relief valves and gas gathering pipeline mishaps (dig-ins). General leaks from the project were estimated using a fixed leak factor. The total quantity of natural gas produced was estimated as 11,014 tonnes. This was based on four wells operating for 365 days per year for two years at 205 MSCFD (5,800 m^3/day) each well.
Reservoir CO_2 release	Carbon dioxide is present in the coal seam gas at an average composition of 4 mol % (maximum 6 mol %). This carbon dioxide gas is released to atmosphere. The quantity released was based on four wells operating for 365 days per year for two years at 205 MSCFD each well.
Diesel use – operation of generators	During civil and construction works, and workovers and completions, electricity would be generated by diesel generators. The estimated fuel use was 36.8 kL diesel. During operations, each well would be provided electricity from a central power plant. The estimated fuel use was 1,307 kL diesel. Emissions were estimated using the stationary fuel emission factors from the NGER Measurement Determination.
Diesel use – Transport	It was assumed that the construction workforce would be primarily stationed in Gunnedah and/or Boggabri and travel to site in diesel 4WD vehicles. The workforce was estimated to make 1,080 trips over construction and the two-year duration of the project, with a total estimated diesel use of 5 kL. Emissions were estimated using the transport fuel emission factors from the NGER Measurement Determination. Transport emissions during operations would be negligible.

4. Assessment results

4.1 Estimated project emissions

The estimated greenhouse gas emissions are presented in Table 4.1. The majority of the emissions (96%) are from flaring of the gas, followed by release of reservoir carbon dioxide.

Table 4.1 Greenhouse gas emissions for the 2-year pilot testing

Source	Emissions (tonnes CO_2-e)
Flaring	31,478
Production related emissions (including well workovers)	95
Reservoir CO_2 release	1,259
Diesel use – operation of power plant	3,542
Diesel use – operation of generators during site establishment	100
Diesel use – Transport	14
Total (tonnes CO_2-e)	**36,489**

4.2 Impact assessment

Australia GHG emissions are estimated to be 510.1 Mt CO2-e.[3] Compared with the estimated GHG of 0.036Mt CO_2-e for the two years of pilot testing, the impact of increases in annual greenhouse gas emissions is considered to be minor in the context of Australia's greenhouse gas emissions as a whole.

[3] Quarterly Update of Australia's National Greenhouse Gas Inventory: September 2020

5. Conclusion

The pilot testing at Kahlua would result in 0.036Mt CO_2-e for the two years or 0.018Mt CO_2-e per year it will be operating. The annual emissions from the pilot testing is approximately 0.004% of Australia's annual GHG emissions, which is considered to be negligible.

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Appendix E

Groundwater report

Australasian Groundwater & Environmental Consultants

Report on

Kahlua Pilot Reactivation Groundwater Assessment

Prepared for
Santos QNT Pty Ltd

Project No. SAN5001.001
July 2022

ageconsultants.com.au

ABN 64 080 238 642

Document details and history

Document details

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Table of contents

Table of contents

List of figures

Table of contents

List of tables

List of appendices

Kahlua Pilot Reactivation Groundwater Assessment

1 Introduction

1.1 Background

Santos QNT Pty Ltd (Santos) engaged Australasian Groundwater and Environmental Consultants (AGE) to prepare a Review of Environmental Factors (REF) to assess the potential impacts of the project under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and in accordance with NSW Department of Planning, Industry and Environment (DPIE) guideline *ESG2: Guideline for preparing a Review of Environmental Factors*. This report assesses the potential impacts of the proposed activity on groundwater.

The Kahlua Pilot (referred to hereafter as 'the Project') is located approximately 25 kilometres west of Gunnedah in north-western NSW (Figure 1.1). The pilot consists of four wells (Kahlua 2, 3, 4 and 5) drilled by Santos in 2010. In late 2011, Santos carried out a single well production test of Kahlua 2 for a period of 90 days. Golder Associates (Golder Associates, 2010) prepared the original groundwater impact study (GWIS) for the 2011 pilot test. The objectives of the Golder Associates (2010) report was to identify and assess potential groundwater impacts and develop groundwater impact mitigation measures from the proposed pilot test. This REF includes a re-evaluation the 2010 pilot test assessment and the 2011 well production test in order to assess the likely impacts of the Project, further details of which are provided in Section 2.

Accordingly, information from Golder Associates (2010) was used as an input for project conceptualisation, along with hydraulic data from the 2011 pilot test, plus the currently proposed pilot test groundwater abstraction schedule. Further, a number of applicable legislative amendments have occurred since the previous GWIS was completed which have been considered herein.

1.2 Objectives

The primary objective of this assessment was to assess potential groundwater impacts from reactivation of the Kahlua Pilot wells for a period of up to 24 months with reference to applicable regulatory guidance for NSW and Australia.

1.3 Scope of works

To meet the objective outlined above, the following scope of work was completed:

- A desktop review of existing information, including Golder Associates (2010) and the original REF (Santos 2010).
- Review of the revised Kahlua Pilot infrastructure and proposed extraction schedule.
- Review of applicable groundwater legislation and policies, including:
  - The NSW Aquifer Interference Policy.
  - Amendments to the Water Management (General) Regulations.
  - Water sharing plans (NSW Murray-Darling Basin Porous Rock Groundwater Sources 2020 and Namoi Alluvial Groundwater Sources 2020).
  - The Commonwealth EPBC Act – i.e., the so called 'water trigger'.
- Review of Santos and public database/information.
- Review and interpretation of data collected from the 2011 Kahlua pilot test, including:
  - An analytical drawdown assessment of the available data to establish hydraulic parameters for the aquifer systems.
  - A review of available groundwater quality data to inform water treatment requirements.

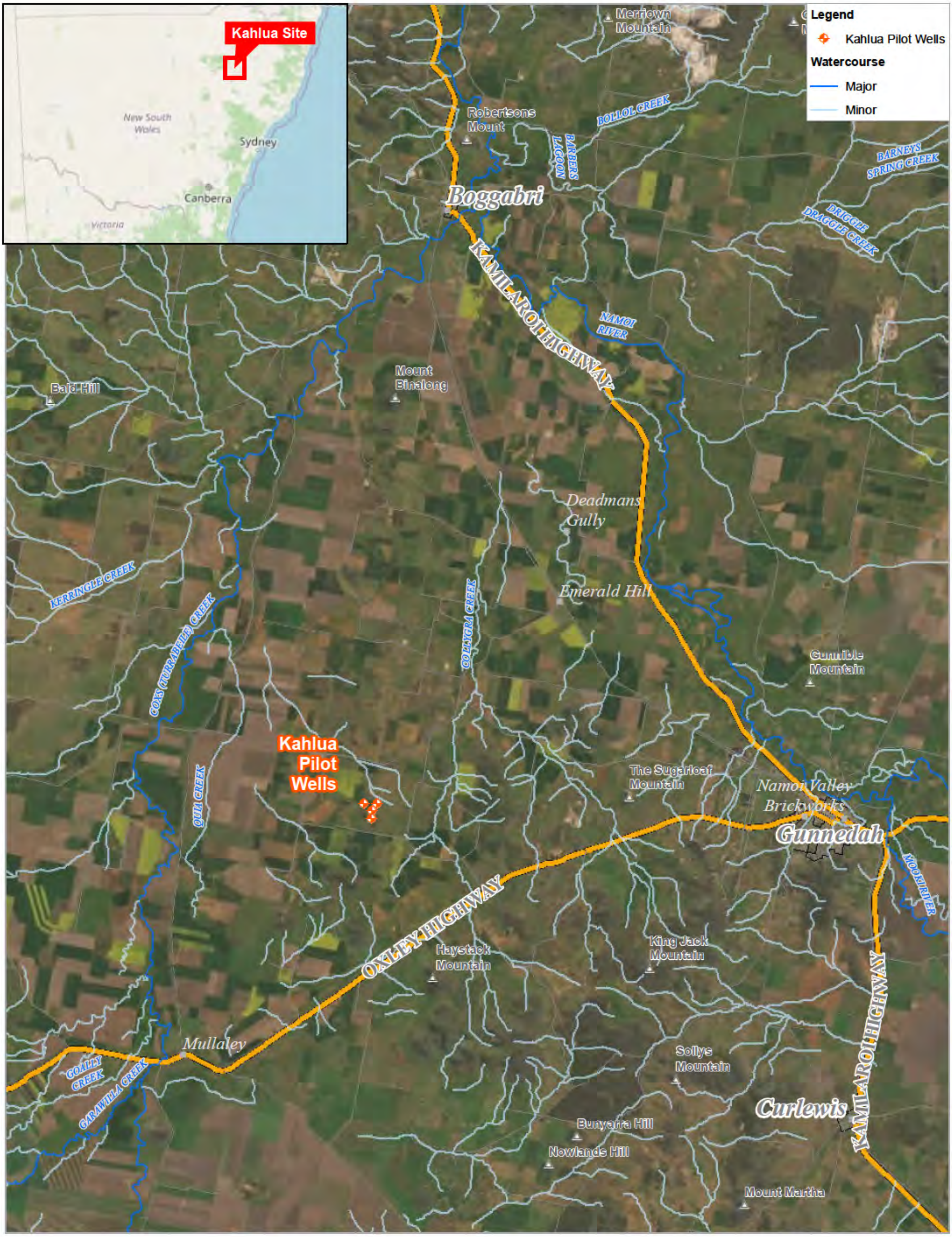
- Development of a conceptual groundwater model to assess the potential effect on groundwater resources from the Kahlua pilot test.
- Forward prediction of potential groundwater impacts using a relatively simple numerical modelling approach and contextualising their significance relative to the criteria for assessing groundwater impacts in NSW (i.e., the NSW Aquifer Interference Policy minimal impact considerations).
- Preparation of this report to document the groundwater assessment findings.

A number of the initial tasks outlined above including re-interpretation of the 2011 pilot test and preparation of a number of maps and other report figures were undertaken by GHD Pty Ltd (GHD). AGE's input was therefore primarily focussed on undertaken the groundwater impact assessment and interpretation of the results (reported in Sections 6, 7 and 8).

1.4 Report structure

This report is structured as follows:

- Section 2 presents a description of the proposed Kahlua Pilot Reactivation Project (the Project).
- Section 3 presents a summary of regulatory framework of relevance to this assessment.
- Section 4 presents a summary of the existing hydrogeological environment in the Project area.
- A hydrogeological conceptual model of the Project area is presented Section 5.
- Section 6 presents a summary of the predicted groundwater impacts of the Project.
- Appropriate mitigation and monitoring measures are identified in Section 7.
- Overall study conclusions are presented in Section 8.



Paper Size ISO A4

0 2 4 6 8 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Santos
Kahlua Pilot test
Groundwater Assessment

Project No. **2122463**
Revision No. **-**
Date **07/04/2021**

Site Location

FIGURE 1-1

G:\21\22463\GIS\Maps\Deliverables\21_22463_Z181_SiteOverview.mxd
Print date: 07 Apr 2021 - 09:46

Data source: Topology Basemap: LPI NSW Govt. Web Service; Bores: Santos, 08/05/2020; Waterways: GeoScience NSW, NSW Govt, 14/05/2020; © OpenStreetMap (and) contributors, CC-BY-SA
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Created by: eibbertson

2 Project description

As shown in Figure 1.1 the Project site is situated on the Liverpool Plains; an area of predominantly agricultural land underlain by the following groundwater sources under the NSW Water Management Act 2000 (WM Act):

- NSW Murray Darling Basin Porous Rock Groundwater Sources – Gunnedah-Oxley Basin MDB Groundwater Source.
- Namoi Alluvial Groundwater Sources – Upper Namoi Zone 2, Coxs Creek (Mullaley to Boggabri) Groundwater Source (located about 4 kilometres to the west northwest of the project).

Existing infrastructure at the Project site (Figure 2.1) includes four well pads each with a single well (Kahlua 2 to Kahlua 5), wellhead infrastructure and access tracks, along with two central water storage tanks and a gas flare at Kahlua 2. As shown in Figure 2.1 two shallow aquifer monitoring bores (SAMBs) were also installed near Kahlua 4 (SAMB1) and around 800m to the north (SAMB 2). Summary details for each monitoring and extraction well is provided in Table 2.1. As shown the SAMB1 and SAMB2 monitoring wells comprise nested monitoring facilities with groundwater level sensors installed at three different levels above the Hoskissons Coal Seam targeted by the Project. The Kahlua 1 core hole located about 1.5 kilometres north of the pilot well set was drilled in 2008 and has since been decommissioned (cemented) and abandoned. Kahlua wells 2 to 5 and the two SAMBs were installed in 2010 and 2011 respectively.

Based on the well completion and suspension reports located on the Government's DiGS database, Kahlua 2 is the only pilot well currently fitted with dewatering infrastructure (pumping/abstraction equipment).

Additional activities which would be carried out prior to reactivating the pilot would comprise:

- Downhole wireline logging.
- Installing well equipment such as pumps, gauges, auto level control and telemetry.
- Completion of gathering lines under, or adjacent to, existing access tracks to minimise disturbance.
- Upgrading the existing flare.

The Project would then be operated for a period of up to 24 months to confirm potential long term gas yields.

During operation of the reactivated pilot, produced water will be temporarily stored in the two on-site water storage tanks (refer Figure 2.1) before being trucked to Santos's Leewood Property located about 20 kilometres south of Narrabri, or to a third party for beneficial reuse, subject to securing required approvals and/or licencing.

Table 2.1 Kahlua Pilot existing drillhole summary

Well ID	Drill date	Ground Surface (m AHD)	Total drill depth (m bgl)	Screen Location (m bgl)	Lithology at Screen	Source
Kahlua 2	13/12/2010	317.4	695.0	301.4 to 309.0	Hoskissons Coal	DiGS website and MinView website
Kahlua 3	28/11/2010	318.5	402.5	306.7 to 316.2	Hoskissons Coal	DiGS website and MinView website
Kahlua 4	10/11/2010	313.7	409.2	290 to 300	Hoskissons Coal	DiGS website and MinView website
Kahlua 5	18/11/2010	307.6	410.2	302 to 310.6	Hoskissons Coal	DiGS website and MinView website
Monitoring well SAMB 1 – Slot 3 (at Kahlua 4) – GW970106	03/05/2011	313.27	215.0	103 to 106 175 to 178 195 to 198	Napperby Fm Digby Fm Trinkey Fm coal	URS (2012)
Monitoring well SAMB 2 – Slot 3 (at Kahlua 1)	21/04/2011	294.4	186	85 to 88 141 to 144 158 to 161	Napperby Fm Digby Fm Trinkey Fm coal	URS (2012)

Santos
Kahlua Pilot test
Groundwater Assessment

Project No. 2122436
Revision No. -
Date 07/04/2021

Kahlua Pilot infrastructure

FIGURE 2-1

G:\21\22463\GIS\Maps\Deliverables\21_22463_Z182_KahluaWells_SAMBBores.mxd
Print date: 07 Apr 2021 - 09:39

Data source: Imagery: LPI NSW Govt; Bores: Santos, 08/05/2020; Waterways: GeoScience NSW, NSW Govt, 14/05/2020; © Department of Customer Service 2020. Created by: eibbertson

Forecasted average pumping rates during CSG production range between 6 and 24 m^3/day (2 to 8.8 ML/yr) for the first 24 months of production. Temporary (short term) pumping rates of up to 47.7 m^3/day are also forecasted during the early stages of the production whilst water is being removed from storage in the target coal seams and water pressures are reducing allowing liberation of the coal seam gas (Figure 2.2). As shown in Figure 2.2 after this initial dewatering or depressurisation phase water extraction rates typically gradually decline whilst conversely gas production gradually increases. Long term, gas production would eventually begin to decline slowly. However, this would occur well beyond the lifetime of the Project which is intended to confirm initial gas production rates once target water pressures have been achieved.

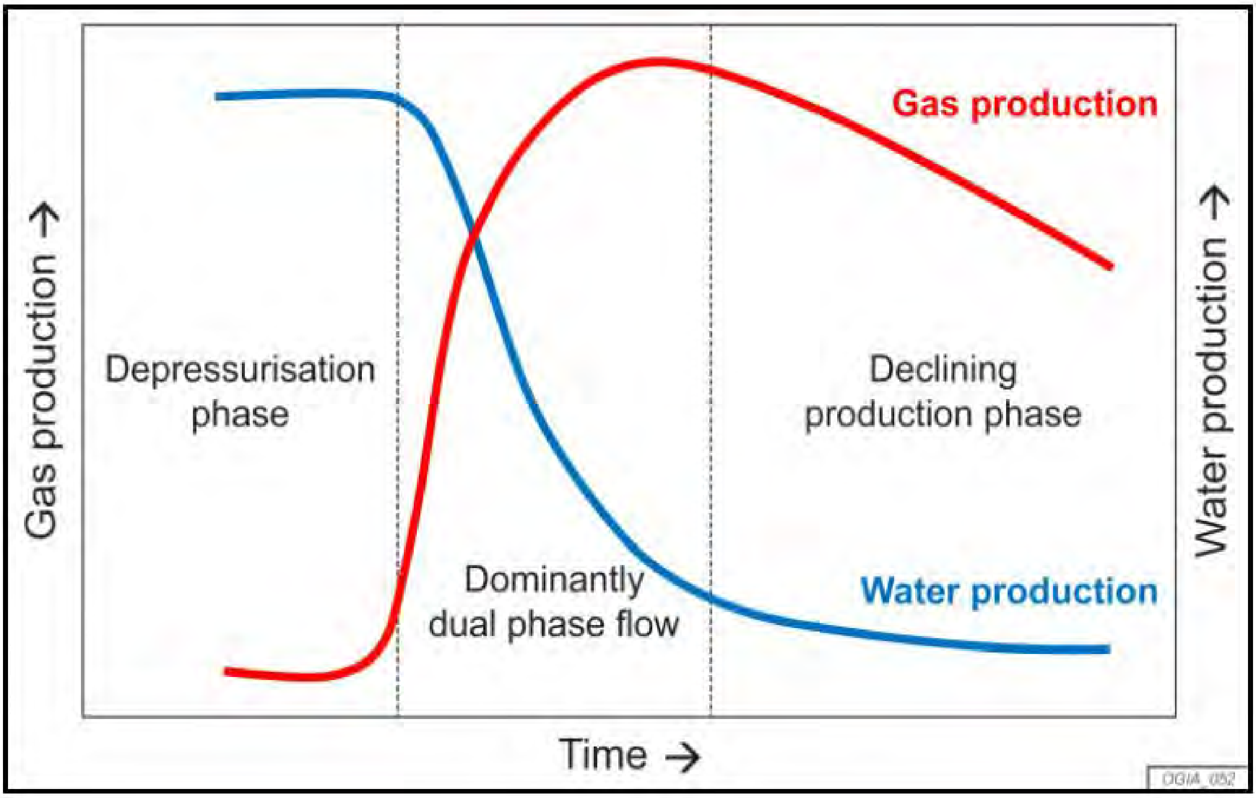


Figure 2.2 Typical gas and water flow profile during CSG production (OGIA, 2021)

3 Regulatory framework

3.1 Water Management Act 2000

Most water access licences are issued under the NSW Water Management Act 2007 (WM Act). There may still be some licences current under the NSW *Water Act 1912* that have not yet been converted into licences and/or approvals under the WM Act.

Objectives of the WM Act are to provide for the sustainable and integrated management of the water sources of the state for the benefit of both present and future generations. Water sharing plans (WSPs) made under the WM Act define the rules for sharing water between consumptive users and the environment.

3.1.1 Water sharing plans

A WSP is a statutory water management instrument prepared under the WM Act. The WSPs set the rules for sharing water between environmental needs and water users, and between different types of water users including town supply, rural domestic supply, stock watering, industry, and irrigation. WSPs also set rules for water trading, which is the buying and selling of water licences and annual water allocations.

WSPs are specific to aquifer systems, which in turn, usually correspond to a Groundwater Management Area (GMA) or to a surface water system. A licence is required to access water resources regulated under a WSP, with a request made directly to DPIE-Water if the water resource is not fully allocated. Where the allocation under a WSP is fully allocated, as is often the case, DPIE-Water may place an embargo on the issue of new water allocation licenses. In this case, purchasing an existing water access license and/or annual entitlements is the only mechanism for access to water resources under a fully allocated WSP. Even in this case, authorisation may be required by DPIE-Water or the Natural Resources Access Regulator (NRAR).

Where no WSP is in place, the access to water is managed under the NSW *Water Act 1912*. With reference to the Kahlua pilot, WSPs cover all groundwater sources being intersected or potentially affected by the project.

The WSPs relevant to the Kahlua pilot are:

- The Water Sharing Plan for the NSW Murray-Darling Basin Porous Rock Groundwater Resources 2020.
- The Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020.

These WSPs are discussed in more detail below.

3.1.1.1 Water Sharing Plan for the NSW Murray-Darling Basin Porous Rock Groundwater Sources 2020 (WPH, 2020a)

These water resources are located within the NSW portion of the Murray Darling Basin and include porous rock aquifers not included in any other water sharing plan. They also include unmapped alluvial sediments overlying porous rock groundwater sources and fractured rock sediments that occur within the porous rock aquifers.

There are four groundwater sources listed within the plan, including the Gunnedah-Oxley Basin (GOB) Murray-Darling Basin (MDB) Groundwater Source, which is located beneath the Project site.

The GOB groundwater source covers an outcrop area of 1,128,000 hectares with a sub-crop area of 2,860,000 hectares. It includes the Permian, Triassic, Cretaceous and Tertiary rocks associated with the Gunnedah Basin. At the Kahlua pilot, this includes thin quaternary alluvium and outcropping Napperby Formation at ground surface. The Napperby Formation continues to depths of at least 695 metres below ground surface (m bgl) where the Leard Formation was identified in Kahlua 2 (refer Section 4.3). The Hoskissons Coal, which is present at the location of the pilot well screens, is located at depths of 301 m to 309 m bgl at Kahlua 2.

Details of the current water use entitlement in this water sharing plan are summarised in Table 3.1. A large volume of water remains currently unassigned, meaning that there is water available for allocation to the project under a controlled water allocation order or by trading in the water market.

Table 3.1 Groundwater allocation – Murray-Darling Basin Porous Rock Groundwater Sources 2020

Water allocations	Volume (ML/yr)
Long term average annual extraction limit	127,500
Water access licences	23,109
Domestic and stock	5,778
Local water utilities	480
Salinity and water table management licenses	13,985
Total water allocated	43,352
Percent of groundwater source currently allocated	34 %

There are also water sharing rules for the GOB, with the project needing to be assessed against these rules. The rules relate to:

- The availability and access to water
- Trading of licenced water
- Minimising impacts on surrounding groundwater receptors and environmental features such as:
  - Existing groundwater bores
  - Sources of contamination
  - High priority groundwater dependent ecosystems
  - Groundwater dependent culturally significant sites
  - Replacing existing groundwater bores with new bores.

A comparison of the project and associated groundwater impacts against these water sharing rules is provided in Section 6.4.

3.1.1.2 Water sharing plan for the Namoi Alluvial Groundwater Sources 2020 (WPH, 2020)

This WSP includes all water contained in Cenozoic unconsolidated alluvial sediments aquifers associated with the Namoi River and its tributaries, including the Coxs, Mooki, and Peel Rivers. The Namoi River is one of the Murray-Darling Basin's major NSW sub-catchments, covering a total area of about 42,000 square kilometres.

There are 13 groundwater sources listed within this WSP, of which 12 are characterised as "Zones". The Namoi Alluvium zones pertaining to the Project site include:

- Zone 2: Coxs Creek (Mullaley to Boggabri) Groundwater Source, located west of the site
- Zone 3: Mooki Valley (Breeza to Gunnedah) Groundwater Source, located east of the site
- Zone 4: Namoi Valley (Keepit Dam to Gin's Leap) Groundwater Source, located north of the site.

Details of the current water entitlements for the above zones are summarised in Table 3.2. The resource is currently fully allocated and in recent years there have been available water determinations of less than 100 per cent because the use has exceeded the extraction limits.

Table 3.2 Groundwater allocation - Namoi Alluvial Groundwater Sources 2020

Water allocations	Volume (ML/yr)
Zone 2	
Long term average annual extraction limit	7,327
Aquifer access licences	7,141
Domestic and stock	127
Local water utilities	59
Total water allocated	7,327
Percent of groundwater source currently allocated	100 %
Zone 3	
Long term average annual extraction limit	17,499
Aquifer access licences	17,101
Domestic and stock	199
Local water utilities	198
Total water allocated	17,498
Percent of groundwater source currently allocated	100 %
Zone 4	
Long term average annual extraction limit	26,121
Aquifer access licences	21,032
Domestic and stock	421
Local water utilities	4,660
Total water allocated	26,113
Percent of groundwater source currently allocated	100 %

3.2 Water Management (General) Regulation 2018

The NSW *Water Management (General) Regulation 2018* identifies several exemptions from the licensing requirements of the WM Act. Section 21 of the regulation states a person is exempt from requiring an access licence in relation to the taking of water from a water source if specified in any provision of Part 1 of Schedule 4 of the regulation. Part 1 of Schedule 4 includes any person lawfully engaged in an aquifer interference activity including taking of water for exploration for petroleum provided the taking of water is less than or equal to 3 ML in a given year.

Section 38 of the regulation identifies several exemptions from licensing requirements for water supply work approval under the WM Act. These include any water supply work used for the purpose of prospecting or fossicking for minerals or petroleum under the *Petroleum (Onshore) Act 1991*. Water supply works are defined in the WM Act include, but are not limited to, a water bore for the purpose of taking water from a source or a tank for the purpose of storing water. The project would therefore be exempt from water supply work approval for such works.

3.3 Commonwealth Water Act 2007

The key piece of Commonwealth legislation relating to water is the Commonwealth *Water Act 2007*. The primary objectives of the *Water Act 2007* are to:

- Manage the Murray-Darling Basin (the Basin) resources in the national interest.
- Promote use and management of the Basin water resources in a way that optimises economic, social, and environmental outcomes.
- Return to environmentally sustainable levels of extraction.
- Protect, restore, and provide for the ecological values and ecosystem services of the Murray-Darling Basin.
- Subject to the above, maximise the economic returns to the Australian community.

Part 2, Division 1 of the Act specifies that the Basin resource will be managed by the Commonwealth Basin Plan 2012 (Basin Plan), which the NSW Government is party to.

3.3.1 Water resource plans

Like the regime under the WM Act, the *Water Act 2007* and Basin Plan provide for the making of water resource plans that set out limits on water take. Under the current arrangements, state governments are responsible for developing water resource plans that comply with the requirements of the *Water Act* 2007 and Basin Plan, which are then submitted for accreditation by the Commonwealth Murray-Darling Basin Authority.

The NSW Government has prepared its water sharing plans in accordance with these requirements, in particular aligning rules for water take, and accordingly, an assessment against these rules is taken to meet the requirements of the *Water Act 2007* and Basin Plan.

3.4 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the principal Commonwealth environment law. It protects nine matters of national environmental significance:

- world heritage properties
- national heritage places
- wetlands of international importance
- listed threatened species and ecological communities
- migratory species protected under international agreements
- Commonwealth marine areas
- the Great Barrier Reef Marine Park
- nuclear actions (including uranium mines)
- a water resource, in relation to coal seam gas or coal mining.

An action that is likely to have a significant impact on matters of national environmental significance must be referred to the Minister responsible for the administration of the EPBC Act. After receiving a referral, the Minister decides whether the action is a controlled action.

The key matter of national environmental significant relevant to this assessment is a water resource, in relation to coal seam gas or coal mining — also termed “the water trigger”.

Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments - impacts on water resources have been developed to assist parties who propose to take an action to which the water trigger applies to determine whether it is likely to have a significant impact.

Accordingly, an assessment of whether the project is likely to have a significant impact with regard to the water trigger, including consideration of the guideline, is provided in Section 8.1.3.

3.5 Policies and Guidelines

3.5.1 NSW Aquifer Interference Policy

Although the WM Act has provision for aquifer interference approvals, this system is not yet in place. Instead, while the take of water from aquifer interference is governed by the WM Act, the approvals are generally governed through the NSW EP&A Act in accordance with the NSW Aquifer Interference Policy.

The NSW Aquifer Interference Policy (AIP) (NOW, 2012) was finalised in September 2012 and clarifies the water licensing and approval requirements for aquifer interference activities in NSW. The AIP adopts the definition of aquifer interference from the WM Act, which includes:

- The penetration of an aquifer
- The interference with water in an aquifer
- The obstruction of flow of water in an aquifer
- The taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations
- The disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.
- The AIP also indicates that an activity with the potential to contaminate groundwater is considered to be an aquifer interference activity.

The AIP states that aquifer interference approval will not be granted unless the "Minister is satisfied that adequate arrangements are in force to ensure that there will be no more than minimal harm to any water source, or its dependent ecosystems, as a consequence of being interfered with" by the activities the approval relates to. To this end, the AIP sets out "minimal impact considerations" that set a standard as to what can be considered "minimal harm".

Accordingly, an assessment of whether the project would have more than minimal harm under the AIP, including assessment against minimal impact considerations, is provided in Section 6.4.

3.5.2 Other guidance and policies

There are a number of the other NSW and Australian policy and guidance documents that provide additional clarity on the definitions of key terms used in the groundwater impact assessment framework outlined above. These include terms such as:

- Beneficial use potential
- Environmental values
- Water quality objectives

The guidelines also include threshold criteria that facilitate a quantitative pathway for defining the above terms.

The relevant guidance and policies are presented in Appendix A and detail the purpose of the document and how they have been applied to the assessment of impacts against the aforementioned regulatory framework.

4 Existing environment

4.1 Topography and drainage

As shown in Figure 1.1 the Project site lies within the surface water catchment of Cox's creek and hence the topography falls gradually from around 315 m Australian Height Datum (AHD) at the site itself to around 270 mAHD in the vicinity of Cox's Creek around 10 km to the northwest. Cox's creek flows from south to north-west of the Project area and discharges into the Namoi River around 20 km north of the site close to Boggabri. Other minor surface water courses of relevance to the Project are shown in Figure 1.1.

4.2 Climate

Bureau of Meteorology (BOM) weather stations in the vicinity of the Project area are listed in Table 4.1 and include three stations in and around Gunnedah (055023, 055202, 055024) and a fourth station at Quirindi (055049).

The nearest weather station to the Project site is the Gunnedah Airport Weather Station (station 055202), located approximately 23 kilometres to the east. The Gunnedah Resource Centre Weather Station (station 055024) is the only station close to the project site that has evaporation data.

Table 4.1 BOM Weather Stations

Data	Gunnedah Pool (055023)	Gunnedah Airport NSW (055202)	Gunnedah Resource Centre NSW (055024)	Quirindi (055049)
Rainfall	Yes	Yes	Yes	Yes (Post Office)
Temperature	Yes	Yes	Yes	Yes
Evaporation	No	No	Yes	No
Approximate distance from Kahlua pilot site	38.5 km east	23.1 km north-east	42.2 km east	86.7 km south-east

Long-term monthly and annual averages for temperature, rainfall, and evaporation data at the four weather stations can be summarised as follows:

- Monthly average temperature maximums range from 16°C in July (with a diurnal range of 1.6°C to 17.4°C per day) to 34.8°C in January (with a diurnal range of 18.0°C to 34.8°C per day).
- Monthly rainfall averages range from 33.8 millimetres in April to 73.7 millimetres in December, with annual rainfall averages (for the four weather stations) of between 520.8 and 675.1 millimetres. The annual average rainfall using data from all four weather stations was 610.6 millimetres.
- Monthly evaporation averages range from 57 millimetres in June to 241.8 millimetres in December, with an annual average of 1,783.4 millimetres. Therefore, the long-term monthly evaporation rates are consistently higher than the long-term monthly rainfall rates.

4.3 Geological setting

4.3.1 Regional geology

As shown in Figure 4.1 the geology at outcrop in the Project site is dominated by the Napperby Formation. Volcanic intrusives and other igeneous rock types including the Garrawilla Volcanics are also mapped in the Project area. To the north-east and north-west, however, the outcrop geology in lower lying areas close to Cox's creek and the Namoi River is dominated by Quaternary colluvium and alluvium which overlies the consolidated bedrock strata.

The regional geological setting of the Project area can be summarised as:

- The Gunnedah Basin around the Kahlua pilot generally dips to the south-west with outcrops observed to the north-east.
- The Kahlua pilot is located on an outcrop of the Napperby Formation.
- The Black Jack Group of the Permian sequence was reached at a depth of 159 metres at Kahlua 1.
- Variable thicknesses of the bedrock surfaces underlying the Quaternary alluvium of the Narrabri and Gunnedah Formations are present in the valleys to the east and west of the Kahlua pilot.
- Volcanic intrusions are noted around the project site.

Other key observations presented in Figure 4.1 are the southeast to northwest trending outcrops of the Lower Black Jack Group stratigraphy and the Watermark Formation (underlying the Black Jack Group). Not shown is the Brothers Subgroup, which directly underlies the Hoskissons Coal Seam, outcropping about 12 kilometres to west of the Kahlua pilot with surficial width of up to 4 kilometres. This outcrop occurs prior to the intersection of the unconsolidated Quaternary alluvial systems associated with the Mooki and Namoi Rivers. Based on this information, the dip in the Hoskissons Coal Seam between outcrop and the Kahlua pilot is estimated to be approximately 1.4 degrees, in an east-southeast direction.

Lithological logs for WaterNSW groundwater monitoring wells shown are presented in Appendix C and are summarised in Table 4.2. The data presented indicates that the alluvial deposits beneath Coxs and Quia Creeks are between approximately 38 metres and 124 metres thick. As shown in Figure 4.1 these units are not mapped as being present at the Project site.

Interpretation of the geological log for GW093068 suggests that the Clare Sandstone is located at depths of 255 to 267 m bgl (4 metres AHD to 16 metres AHD), and the Hoskissons Coal Seam at 276 m bgl to 283 m bgl (-12 metres AHD to -5 metres AHD). This results in a lithological separation between the Hoskissons Coal Seam and the base of the alluvium at this location of 156 metres.

Table 4.2 WaterNSW groundwater monitoring well log summary

Well ID	Date	Latitude	Longitude	Distance to closest Kahlua pilot well (km)	Elevation (m AHD)	Drill depth	Depth to Bedrock (m bgl)
GW036676	1/12/1986	-30.938347	149.84465	16.06	277.5	86	> 86
GW036495	1/03/1984	-30.9445	149.887	11.99	271.2	38	>38
GW036543	1/11/1984	-31.008431	149.826702	17.37	284.2	105	> 105
GW036499	1/04/1984	-30.946763	149.901977	10.56	269.4	71	> 71
GW036496	1/03/1984	-30.941208	149.860867	14.48	274	54.2	54.2
GW036544	1/12/1984	-30.947319	149.908366	9.97	268.2	84	> 84
GW036545	1/12/1984	-30.947874	149.924755	8.51	269.8	80	80
GW036497	1/03/1984	-30.946486	149.918644	9.10	269.7	82.3	> 82.3
GW036515	1/09/1984	-30.011103	149.860295	108.32	278.6	126.5	124
GW093068	27/03/2014	-30.9467	149.9022	10.55	271	309.4	123
GW093067*	8/02/2014	-30.961	150.0019	2.14	287.27	171	33

Note: *The slotted interval for GW093067 is 144 to 147 m and 153 to 159 m across the coal seam.

4.3.2 Site Stratigraphy

As previously noted, Kahlua 2 to Kahlua 5 were drilled after completion of Golder Associates (2010). The well completion reports provided in Appendix B provide summaries of depths to key stratigraphic units intersected during well installation. Lithological information from Kahlua 2 is presented in Table 4.3. Key points to note are:

- Consistent with the regional mapping only a thin layer of Quaternary material is logged at the surface and is not associated with or connected to the alluvial deposits associated with the Coxs and/or Quia Creeks.
- The Hoskissons Coal Seam is located at approximately 300 m bgl, or around 20 metres AHD.

Table 4.3 Kahlua 2 stratigraphy summary

Formation name	Formation surface	
	(m bgl)	(m AHD)
Alluvium	4	317.4
Napperby Fm	12	309.4
Digby Fm	**174**	**147.4**
Ulinda Sandstone	*174*	*147.4*
Bomera Conglomerate	*180*	*141.4*
Black Jack Group	**210**	**111.4**
Trinkey Fm	210	111.4
Wallala Fm	234	87.4
Breeza CM	268	53.4
Benelabri Fm	273	48.4
Hoskissons CM	301.35	20.05
Arkarula Fm	308.95	12.45
Pamboola Fm	338	-16.6
Melvilles CM	347	-25.6
Millies Group	**384**	**-62.6**
Watermark Fm	384	-62.6
Porcupine Fm	534	-212.6
Bellata Group	**600**	**-278.6**
Maules Creek Fm	600	-278.6
Maules Creek CM	600	-278.6
Leard Fm	678	-356.6
Total Depth	**695**	**-373.6**

To provide an understanding of the dip of key stratigraphic units at the Kahlua pilot site, Table 4.4 presents the depth of key stratigraphic units. The data indicates that there is a predominantly south-west dip across the site. Extrapolation of the dip to the west results in an estimated geological separation between the base of the alluvial strata associated with Cox's creek and the Hoskissons Coal Seam of over 300 m.

Table 4.4 Depth of top intersection for key stratigraphic units at the Kahlua pilot

Formation	Unit	Kahlua 3	Kahlua 4	Kahlua 5	Average
Napperby Formation	m bgl	12	24	18	18
	m AHD	***310.5***	***293.7***	***293.6***	***299.3***
Digby Formation	m bgl	177.0	168	180	175.0
	m AHD	***145.5***	***149.7***	***131.6***	***142.3***
Trinkey Formation	m bgl	226	197	214	212.3
	m AHD	***96.5***	***120.7***	***97.6***	***104.9***
Hoskissons Coal Seam	m bgl	310	292	303.5	301.8
	m AHD	***12.5***	***25.7***	***8.1***	***15.4***

Notes: m bgl: metres below ground level, m AHD: metres above Australian Height Datum.

Conceptual geological cross-sections highlighting the inter-relationships between the key geological units described above are presented in Figure 4.2 and Figure 4.3. Cross-section locations are presented in Figure 4.1. It is noted that the depth of key stratigraphic units beneath the alluvial areas has been extrapolated using information from the Kahlua pilot site.

4.3.3 Structural geology

As shown in Figure 4.1 three separate faults are shown in the regional geological mapping in close proximity to the Project site as follows:

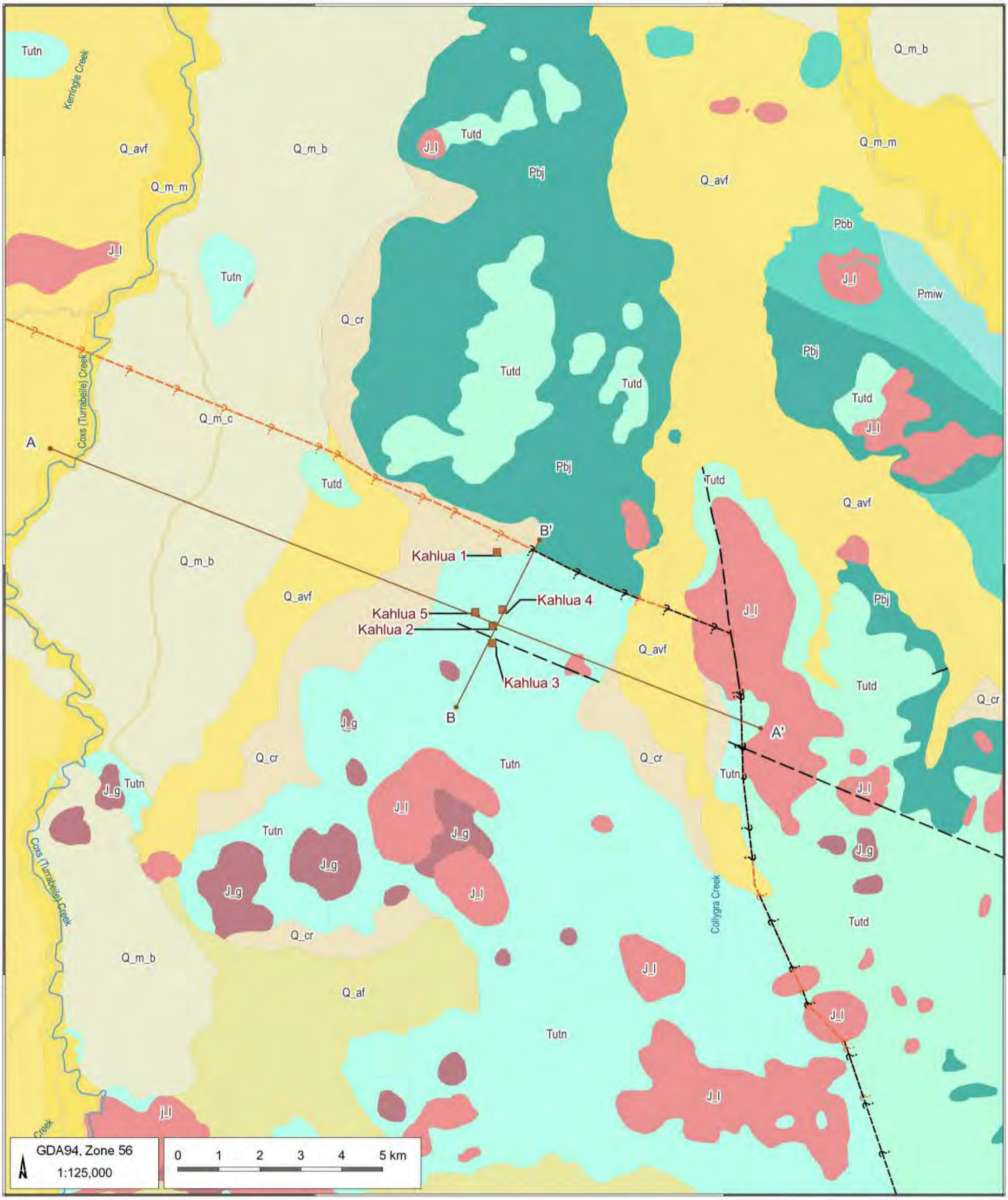
- A south-east to north-west trending fault around two kilometres to the north-east of the Kahlua 2 bore;
- A further south-east to north-west trending fault around just south of the Kahlua 2 bore and to the north of the Kahlua 3 bore; and
- A north to south trending fault around six kilometres east of the Kahlua 2 bore.

It should be noted that minor faults, characterised by displacements in the tens rather than hundreds of meters, are not commonly shown on regional maps, which suggests that all of these faults are potentially significant features. The effects of the fault to the north-east of the pilot site can be clearly seen in the geological mapping. In fact reference to meta data included on the digital mapping indicates that the presence of this fault has been inferred based on the mapped geology. The Napperby Formation is mapped at outcrop in the area to the south of the fault whilst the older Black Jack Group is mapped to the north. As shown in Figure 4.3 based on the observed dip of the strata at the Project site then top of the Black Jack Group is expected to be around 125 metres below ground immediately south of the fault and at outcrop to the north which suggests a fault throw or displacement of around 125 metres.

Similarly, the effects of the north-south trending fault to the east are also evident in the geological mapping which shows the older Digby Formation at outcrop to the east of the fault and the younger Napperby Formation at outcrop to the west. As shown in Figure 4.2 the Digby Formation is expected to be at around 60 metres below ground level immediately west of the fault and at outcrop to the east, which suggests a displacement of around 60 m in this case.

It would appear, therefore, that the Kahlua site comprises a downthrown block bounded by faults to the north and east. Consequently, the Hoskissons coal seam is not present at or close to outcrop, or at subcrop (beneath the mapped superficial deposits), anywhere within this block.

The extent of the Kahlua block may be further constrained by south-east to north-west trending fault immediately to the south of Kahlua 2. However, this fault was not picked up during drilling at the pilot site and its effects are also not evident in the geological mapping which suggests it may be characterised by relatively minor displacements, compared to the other local faults.



LEGEND

- Kahlua bores

Cenozoic Sedementary Province

- Q_af - Alluvial floodplain deposits
- Q_avf - Alluvial fan deposits
- Q_cr - Colluvial and residual deposits
- Q__m_b - Marra Creek Formation - back plain facies
- Q__m_c - Marra Creek Formation - channel facies
- Q__m_m - Marra Creek Formation - meander plain facies

Permian Mesozoic Igneous Province

- J__g - Garrawilla Volcanics
- J__l - Glenrowan Intrusives

Permo Triassic Basin

- Tutn - Napperby Formation
- Tutd - Digby Formation
- Pbj - Black Jack Group
- Pbb - Brothers Subgroup
- Pmiw - Watermark Formation
- Cross section location

Structures

- Fault, position approximate
- Fault, inferred (geological mapping)
- FAult, inferred (AGE)

Kahlua Pilot Reactivation Groundwater Assessment (SAN5001.001)

Regional surface geology

AGE

DATE 14/07/2022

FIGURE No: **4.1**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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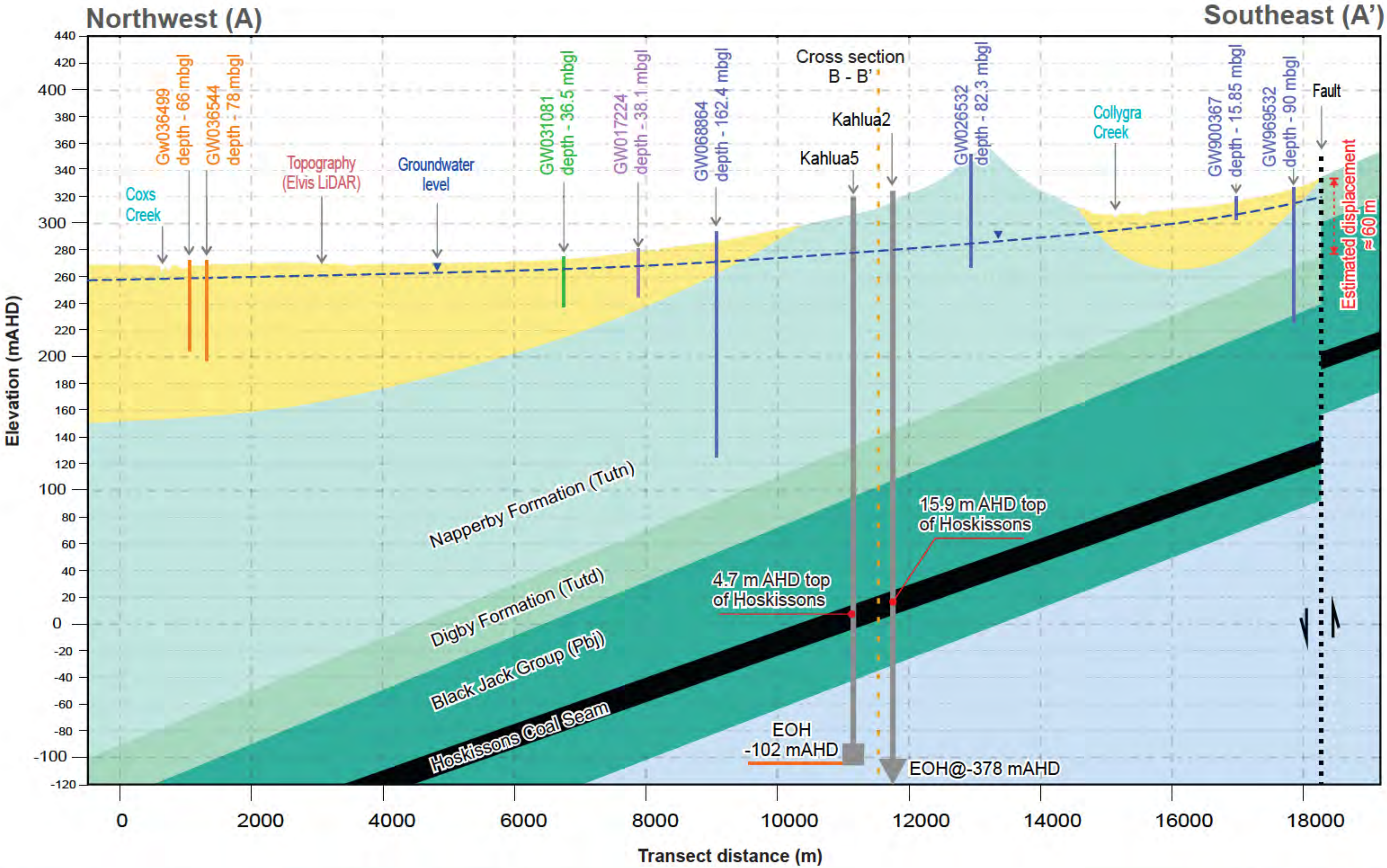

Conceptual geological/hydrogeological cross section (A-A')

Figure - 4.2

Kahlua Pilot Reactivation Groundwater Assessment (SAN5001.001)

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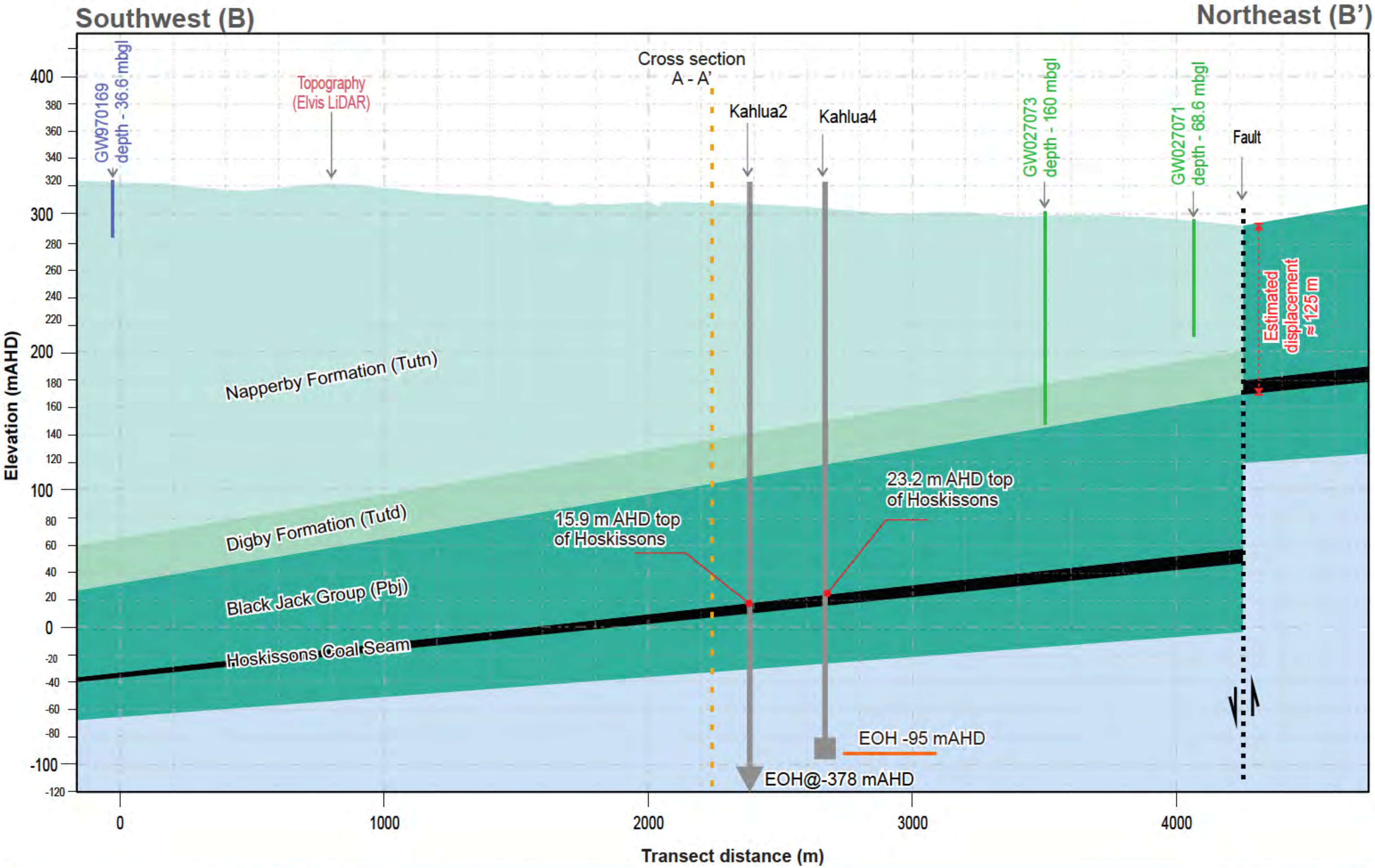

Conceptual geological_hydrogeological cross section (B-B')

Figure - 4.3

Kahlua Pilot Reactivation Groundwater Assessment (SAN5001.001)

AGE

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5 Conceptual groundwater model

5.1 Hydrostratigraphic units

The interpreted hydrogeological conditions of the subsurface stratigraphy are shown in Table 5.1, with the interpreted inter-relationships presented in Figure 4.2. Key characteristics are presented below.

Potential aquifer units in the stratigraphical sequence present in the Project area include:

- Quaternary alluvium (Narrabri and Gunnedah Formations) associated with Coxs Creek. These are not present at the Project site but are observed about 4 kilometres to the west. Where present, these sediments are more than 130 metres above the Hoskissons Coal Seam.
- Sandstone units within the Napperby Formation and the Digby Formation (i.e the Ulinda Sandstone). The Kahlua well completion reports (Appendix B) indicate that the Ulinda Sandstone lies approximately 110 metres to 120 metres above the top of the Hoskissons Coal Seam.
- The Clare Sandstone was observed at the location of Kahlua 1 but has not been identified in the well completion reports for the remaining Kahlua wells. Where present, it lies approximately 25 metres above the top of the Hoskissons Coal Seam. Due to its depth, and the presence of other permeable units closer to the ground surface, the Clare Sandstone is not significantly used as a producing aquifer.

As summarised in Table 5.1, however, significant extraction for irrigation and other intensive uses is typically only possible from the Quaternary Alluvium. Whilst groundwater can be extracted from higher permeability sections within the underlying consolidated units including the Napperby Formation and the Digby Formation bore yields are typically only sufficient to support extraction for stock and domestic uses. Both the Napperby and Digby formation also include significant proportions of fine material. As shown in the well completion reports provided in Appendix B the Napperby Formation is typically described as fine to medium sandstone interbedded with siltstones. Extensive drilling at the Narrabri Mine Project site around 30 kilometres north of the Project site suggests that the Napperby Sandstone comprises up to 60% fine material (i.e. siltstone, mudstone and claystone; AGE, 2020). Similarly, whilst the Ulinda Sandstone which forms the uppermost 10 metres of the Digby Formation at the site can be reasonably permeable the underlying Bomera Congolmerate which is around 26 metres at the Project site is considered to be an aquitard. All other stratigraphic units present within the area are also expected to act primarily as aquitards, which includes a ~100m thick stratigraphical sequence of the Black Jack Group above the Hoskissons Coal Seam. As discussed in Section 5.2, the Hoskissons coal seam and other coal rich units in the area including the Breeza coal seam can also be reasonably permeable but are not typically targeted for water supply purposes since they are relatively thin and characterised by relatively high salinity groundwater.

5.2 Aquifer parameters

Aquifer hydraulic parameters have been collated from a literature review that included Santos data from Kahlua Pilot Wells and Longlea 1, a single well located about 5.7 kilometres to the south west of the Project site. The parameters were used to develop input parameters for groundwater modelling purposes to assess impacts (Table 5.2)

The hydraulic properties of the Narrabri and Gunnedah Formations (the dominant alluvial aquifers in the area) are well documented, which was not the case for the underlying bedrock. Comparison of the hydraulic conductivities between stratigraphic units in Table 5.2 highlights the aquifer yield potential of the Narrabri and Gunnedah Formations relative to the underlying bedrock formations, and the Digby Formation (i.e. the Ulinda Sandstone) relative to other bedrock units.

Table 5.1 Hydrogeology of the project site (Golder Associates 2010)

Period	Litho - stratigraphy				Main Rock Types
Quaternary	Un-consolidated sediments	Narrabri Formation			Clays, minor sands and gravel beds
		Gunnedah Formation			Gravel and sand with minor clay beds
Triassic	Gunnedah Basin Sequence	Napperby Formation			Interbedded fine sandstone & siltstone
		Digby Formation	Ulinda Sandstone		Quartz sandstone
			Bomera Conglomerate		Conglomerate
Late Permian		Black Jack Group	Nea Subgroup	Trinkey Formation	Coal measures - siltstone, fine sandstone, tuffs, stony coal
				Wallala Formation	Conglomerate, sandstone, siltstone, minor coal bands
				Breeza Coal	Coal & claystone
				Clare Sandstone	Medium to coarse-grained quartzose sandstone; quartzose conglomerate
			Coogal Subgroup	Howes Hill Coal	Coal
				Benelabri Formation	Claystone, siltstone &sandstone; fining up cycles; more sandy towards top of unit
				Hoskissons Coal	Coal, minor claystone bands
				Brigalow Formation	Fining-up sequence of medium to coarse-grained quartzose sandstone and siltstone
			Brothers Subgroup	Arkarula Formation	Sandstone & siltstone; burrowed & bioturbated
				Melvilles Coal	Coal
				Pamboola Formation	Sandstone, siltstone, minor claystone &coal
Mid Permian		Millie Group	Watermark Formation		Marine - sandy siltstone, siltstone/claystone, silt/sand laminite, sandstone
			Porcupine Formation		Marine - diamictite, sandy-mudstone

Note: Aquitards are shaded light brown, potential or poor aquifers are shaded light blue. Significant aquifers are shaded darker blue.

Table 5.2 Hydraulic parameters used for groundwater modelling (Golder Associates 2010)

Formation	Hydraulic Conductivity (m/d)						Specific Storage (1/m)		Specific Yield (-)		
	Horizontal (Kh)			Vertical (Kv)			(Ss) [4, 9]		(Sy) [9]		
	max	base case	min	max	base case	min	max (best case)	min	max	best case	min
Narrabri Formation	6 [1]	6	0.008 [2]	0.00024 [3]	0.6	0.000024 [3]	-	-	0.2	0.10	0.01
Gunnedah Formation	31 [1]	15	8.6 [2]	7.2 [4]	1.5	3.5 [4]	-	-	0.46	0.15	0.13
Napperby / Digby Formations	1.5 [5]	0.1	0.08 [2]	0.71 [5]	0.01	0.62 [5]	1.0×10^{-5}	1.0×10^{-6}	0.20	0.10	0.05
Upper Black Jack Group	1.1 [5]	0.005	0.0003 [7]	0.59 [5]	0.0005	0.0001 [4]	1.0×10^{-5}	1.0×10^{-6}	-	-	-
Hoskissons Coal	3.3 [4]	0.5	0.13 [6]	0.002 [4]	0.005	0.00022 [4]	1.0×10^{-4}	1.0×10^{-5}	-	-	-
Lower Black Jack Group	0.047 [5]	0.004	0.0015 [7]		0.0004		1.0×10^{-5}	1.0×10^{-6}	-	-	-

Notes: Parameters assumed uniform across the model domain. Kz and Kh = Vertical and horizontal hydraulic conductivity. Ss and Sy = Specific storage and Specific yield. m/day = metres per day.

[1] Broughton A. 1994. Hydrogeological Map of the Liverpool Plains Catchment (1:250,000). NSW Department of Water Resources, Sydney, 1995.

[2] McLean W. 2003. Hydrogeochemical evolution and variability in a stressed alluvial aquifer system: Lower Namoi River Catchment, NSW. PhD Thesis, University of New South Wales, School of Biological, Earth and Environmental Science.

[3] Acworth R.I. and Timms W.A. 2003. Hydrogeological investigation of mud-mound springs developed over a weathered basalt aquifer on the Liverpool Plains, NSW, Australia. *Hydrogeology Journal*, 11, 659-672.

[4] Golder Associates 2008. Report on Groundwater Modelling for Sunnyside Open Pit Coal Mine, Gunnedah, NSW. Submitted to Geoterra Pty Ltd.(008-06636017-Rev3), 26 March 2008.

[5] Zhang Y., Person M. and Gable C.W. 2007. Representative hydraulic conductivity of hydrogeologic units: Insights from an experimental stratigraphy. *Journal of Hydrology*, 339, 65-78.

[6] Santos Pty Ltd. 2009. Kahlua Well Completion Report. DST.

[7] USGS. 2002. Documentation of Spreadsheets for the Analysis of Aquifer-Test and Slug -Test Data. Open-File Report 02-197.

[8] Fetter, C.W. 2001. Applied Hydrogeology. Prentice-Hall, 4th Edition.

[9] Anderson M.P. and Woessner W.W. 1992. Applied Groundwater Modelling: Simulation of Flow and Adjective Transport. Academic Press, Inc. San Diego, California.

An extended pumping test was conducted at Longlea 1 to enable quantification of the gas production potential of the Hoskissons and Breeza Coal Seams. The well was pumped at an average rate of 264 barrels of water per day (approximately 42 m^3/day), with hydraulic conductivity estimated to be in the range of 10 to 200 millidarcies. This is equivalent to a hydraulic conductivity range of between 0.0086 and 0.17 m/day.

Laboratory core testing results were available in the well completion reports for Kahlua 1 (available on the NSW DiGS website - https://search.geoscience.nsw.gov.au/). The results of the core testing are presented in Table 5.3 and include ten core tests from core samples located above the Hoskissons Coal Seam in the Upper Black Jack Group, the Digby Formation and the Napperby Formation. Noting the localised nature of core sample analysis, which may not account for macro hydraulic features such as fractures, the hydraulic conductivities range between 8×10^{-6} and 1×10^{-3} m/day. The porosities for the various units tested ranged between 0.095 and 0.163 %.

Table 5.3 Kahlua 1 core test results

Litho-stratigraphy		Depth (m bgl)	Porosity (percent)	Horizontal hydraulic conductivity (m/d)
Napperby Formation	Napperby Formation - Sandstone	118.7	14.9	0.0008
Digby Formation	Ulinda Sandstone	130.88	11.3	0.0003
Digby Formation	Ulinda Sandstone	140.89	12.5	0.0002
Digby Formation	Bomera Conglomerate Member	141.4	11.1	0.0002
Digby Formation	Bomera Conglomerate Member	154.59	9.5	0.0011
Digby Formation	Bomera Conglomerate Member	154.73	9.7	0.00003
Upper Black Jack Group	Wallala Formation - Conglomerate	212.7	12.4	0.00002
Upper Black Jack Group	Clare Sandstone	221.05	16.3	0.0004
Upper Black Jack Group	Clare Sandstone	222.75	11	0.00002
Upper Black Jack Group	Clare Sandstone - Conglomerate	230.75	10.1	0.000008

The results of packer testing completed by URS (2012) on the SAMBs within the Napperby Formation, Digby Formation and Upper Black Jack Group are presented in Table 5.4. The hydraulic conductivity results ranged between 0.0086 and 0.00086 m/day, and are therefore similar to, or slightly higher than the Kahlua core tests.

Table 5.4 Shallow aquifer monitoring bore packer test results

Well	Formation	Depth (m bgl)	Horizontal hydraulic conductivity (m/day)
SAMB1	Napperby	103 to 106	<0.0086
SAMB1	Digby	175 to 178	<0.00086
SAMB1	Trinkey Coals (Upper Black Jack Group)	195 to 198	<0.00086
SAMB2	Napperby	85 to 88	<0.0086
SAMB2	Digby	141 to 144	<0.0086
SAMB2	Trinkey Coals (Upper Black Jack Group)	158 to 161	<0.0086

5.3 Kahlua pilot test assessment

Figure 5.1 presents a summary of data collected during the 2011 Kahlua pilot test to assess the gas resource within the Hoskissons Coal Seam. Key features presented in Figure 5.1 include:

- The test was carried out over about 2.5 months between 1 September and 17 November 2011.
- The Kahlua 2 well was used as the abstraction well for the test. This well is screened in the Hoskissons Coal Seam. The pumping rate ranged from 0 to 14.7 m³/day during the pilot test with an average of 11.47 m³/day.
- Groundwater elevations were monitored in Kahlua 3 and Kahlua 5 from the commencement of the test on 1 September 2011 until 3 May 2012 (approximately 7 months after cessation of pumping).
- Groundwater elevations and electrical conductivity were also monitored in Kahlua 2 (the pumping well) from the day before pumping stopped, for 10 days.

Details of the wells used in the 2011 Kahlua pilot test are summarised in Table 5.5.

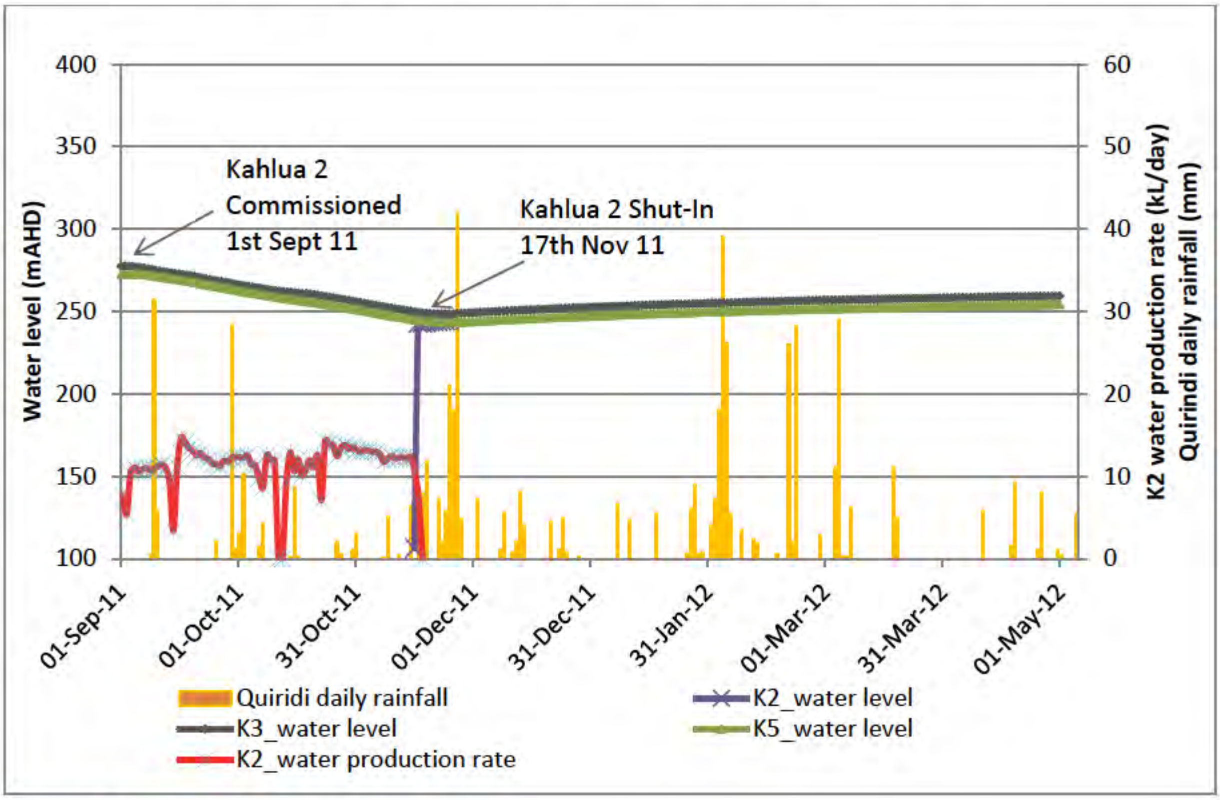


Figure 5.1 2011 Kahlua pilot test data

Table 5.5 Pilot testing well details

Well ID	Radial distance from Kahlua 2 (m)	Water level monitoring period	Ground surface (m AHD)	Screen location (m bgl)	Lithology of screen	Source
Kahlua 2	0.00	16/11/2011 to 25/11/2011	317.4	301.4 to 309.0	Hoskissons Coal	DiGS website and MinView website
Kahlua 3	426.89	01/09/2011 to 01/05/2012	318.50	306.7 to 316.2	Hoskissons Coal	DiGS website and MinView website
Kahlua 4	460.47	01/09/2011 to 01/05/2012	313.7	290 to 300	Hoskissons Coal	DiGS website and MinView website
Kahlua 5	540.94	01/09/2011 to 01/05/2012	307.6	302 to 310.6	Hoskissons Coal	DiGS website and MinView website

The 2011 pilot test data was analysed by GHD using version 4.51 of the AQTESOLV software. The Theis/Hantush solution and Theis recovery solution were used to analyse the groundwater drawdown data from Kahlua 3 and Kahlua 5. Data from these wells was analysed separately, and together, to constrain the results. Uncertainty in the results was assessed by analysing the late and early time data from the pilots.

Once the aquifer parameters had been established, a distance drawdown solution was established within AQTESOLV at a time of 76 days, which was equal to the total pumping time for the pilot test. This facilitated extrapolation of the zone of drawdown influence at the completion of pumping.

After 76 days of pumping and before pumping cessation, groundwater elevations were observed to have the following drawdown:

- Kahlua 2: Groundwater elevations fell from 275 metres AHD (estimate only) to 106.5 metres AHD, which represented a drawdown of 168.5 metres in the pumping well.
- Kahlua 3: Groundwater elevations fell from 277.6 metres AHD (estimate only) to 250 metres AHD, which represented a drawdown of 27.6 metres.
- Kahlua 5: Groundwater elevations fell from 272.8 metres AHD (estimate only) to 245.1 metres AHD, which represented a drawdown of 27.7 metres.

Figure 5.2 presents a distance drawdown plot of the pilot test and includes observed drawdowns at Kahlua 2, Kahlua 3 and Kahlua 5, as well as the interpolated drawdown distance from the aquifer test analysis using AQTESOLV.

Results showed that the distance from the wells to the one metre drawdown contour in the Hoskissons Coal Seam was about 1,550 metres. Drawdown reduced to about 0.2 metres at a distance of about 2,000 metres.

Interestingly despite being apparently located on the far side of the fault mapped just to south of the pumped bore (Kahlua 2) data for Kahlua 3 shows a similar level of drawdown and hence lateral connectivity as Kahlua 5. This suggests that this fault may not be a significant barrier to flow or that the location of this fault is not shown accurately on the regional mapping. Reference to the well completion report for Kahlua 3 (Appendix B) suggests that the Hoskissons coal seam and other strata are present at a similar depth as in the other nearby bores and there is also no mention of a fault being intersected suggesting either that there is minimal displacement at the fault or that it is actually located to the south, rather than the north of Kahlua 3.

The estimated aquifer parameters for the Hoskissons Coal Seam from the 2011 pilot test analysis are as follows:

- The hydraulic conductivity was estimated to range between $5x10^{-3}$ and $1x10^{-2}$ m/day.
- The storativity values were estimated to range between $9.4x10^{-6}$ and $5.8x10^{-5}$.

The analytical results from AQTESOLV are presented in Appendix D. Since these results relate to a large scale pumping test of the Hoskissons coal seam they have been used in preference to the parameter values for this unit presented in Table 5.2 (which were based on small scale DST test results and data for the Sunnyside mine in Gunnedah) for the assessment of impacts (Section 6). Interestingly the hydraulic conductivity values returned by the pumping test ($5x10^{-3}$ and $1x10^{-2}$ m/day) are lower than returned by the DST tests. This may be related to faulting and/or fracturing of the coals which can reduce the bulk hydraulic conductivity of coal seams by creating discontinuities within the coal which act to restrict to lateral flow. In particular the relatively low hydraulic conductivity values returned by the pump test analysis may be related to the nearby faults and compartmentalisation of the coal seam which was discussed above in Section 4.3.3.

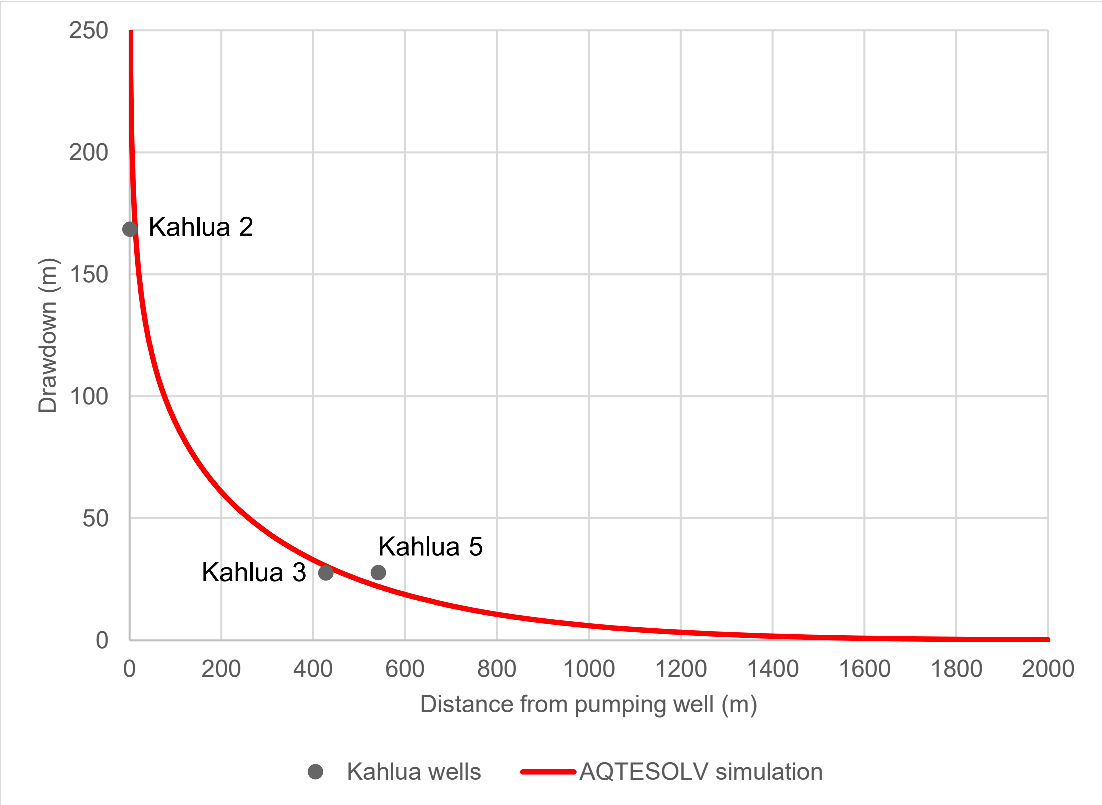


Figure 5.2 Distance drawdown plot for the 2011 Kahlua pilot data after 76 days of pumping

5.4 Groundwater levels and flow directions

Consistent with the topography shallow groundwater flow in the area is reported to be generally to the north within the Coxs Creek (Zone 2) and Mooki River (Zone 3) alluvium areas (DoI 2019b). There is insufficient groundwater level data to interpolate groundwater level contours for the underlying bedrock units, however, natural flow directions in these units are also likely to be towards the north. These strata, however, generally dip towards the west and hence westerly flow is possible in some deeper units.

Figure 5.3 shows groundwater elevations for selected monitoring points to highlight the characteristics of the main aquifers systems in this area and the differences between aquifer systems. Groundwater monitoring point locations are shown in Figure 5.4. The following key features are noted:

- Groundwater levels in the alluvial aquifer system associated with Cox's Creek suggest downward head gradients possibly related to increased groundwater abstraction from the deeper sections within the alluvium. The greater groundwater level fluctuation in the deeper wells supports this conclusion.
- Rest groundwater levels in the majority of the bedrock monitoring points including the nested monitoring point (GW093068) appear to be above those in the alluvium suggesting an general upward hydraulic gradient from the underlying bedrock aquifers towards the alluvial systems.
- The relative differences in bedrock groundwater elevations between the Kahlua pilot wells, the SAMBs and GW093068 tend to confirm a general westerly groundwater flow direction within some bedrock units, in line with the interpreted dip in geology (see Figure 4.2).

- At the Project site, while there is no time-based overlap between the groundwater elevation observations in the Kahlua wells and the SAMBs, given the observed differences in rest water levels of more than 10 m, the following inferences are noted:
  - Groundwater levels in the SAMBs (Digby, Napperby and Trinkey Formations) appear to be high relative to those in the surrounding aquifers/aquitards. In addition, Golder Associates (2010) reported elevations in Santos Bore ID 2120, screened in the Napperby Formation, to be 292.21 metres AHD in June 2010.
  - This suggests the presence of a significant hydraulic barrier (aquitard) between the Napperby Formation, Digby Formation, and the underlying Hoskissons Coal Seam.
- Observed groundwater levels in WaterNSW monitoring well GW093067 which is located around two kilometres to the north of the Kahlua pilot and close to the mapped fault in this area are around 50 metres lower than observed at the Project site. Reference to the logged depth and lithology of this hole suggests it is completed into the Hoskissons coal seam. This suggests that the bore may be located to the north of the fault and that this fault is causing a major discontinuity in levels in the coal seam at this location.

5.5 Groundwater surface water interaction

The following provides a summary of the groundwater – surface water interactions:

- In areas which are not heavily developed the Mooki River and Coxs Creek are considered likely to be connected to the underlying unconsolidated sediment (alluvium and colluvium) aquifer system, although groundwater levels are known to be significantly below these streams in reaches where groundwater is being used more intensively.
- Recharge to these alluvial systems is likely to comprise diffuse rainfall recharge with significant influx of additional recharge via leakage from the creeks during flood periods

A review of the surface water flow data for Coxs Creek from the WaterNSW real time data website for Tambar Springs (located about 44 kilometres south of the project site and upstream) and at Boggabri (located about 30 kilometres north of the project and downstream) suggests losing conditions in Coxs Creek between Tambar Springs and Boggabri. This tend to support the conclusions presented by Golder Associates (2010) that Coxs Creek is primarily losing water to the underlying alluvium rather than gaining groundwater flow within the Project area.

As shown in Figure 4.2 interpolated groundwater elevations in the alluvium are generally below creek bed levels (>10 m below ground surface), which is consistent with the WaterNSW monitoring bore water level data presented in Figure 5.3, which shows groundwater at a depths of approximately 14 m bgl in the alluvium west of the Kahlua pilot.

Shallow groundwater in other residual soils and minor alluvium associated with other creeks is less well characterised. The presence of ephemeral creeks (for example Collygra Creek) and farm dams along these creek systems suggests that groundwater discharge to these tributary creeks is also limited. The nearest shallow wells with groundwater table measurements include monitoring bores GW966645 (5 metres deep), GW966647 (5.4 metres deep), GW966648 (3.9 metres deep), GW966649 (7.7 metres deep) and GW966650 (6.3 metres deep); all located approximately 3.5 kilometres south east of the Kahlua pilot. These wells are located in the upper reaches of Collygra Creek in the vicinity of a large farm dam. Water levels in these wells were generally monitored intermittently (7 to 13 times in each well) between 1992 and 1997 with groundwater elevations ranging from between 1.5 and 7.2 m bgl. Within each well the range in groundwater observations varied between 0.7 metres and 3.11 metres. The groundwater elevations in GW966645 and GW966647 are most likely representative of baseline variability in shallow groundwater elevations (13 manual readings in each well between 1992 and 1997 with ranges of 2.42 m and 3.11 m respectively) as they have the longest data records relative to other wells and/or they are located upgradient and distant from farm dams. There is no lithological information available for the wells, however, logs for surrounding deeper bores suggest that the wells are likely to be screened in surficial clays or perched water on the top of shale bedrock.

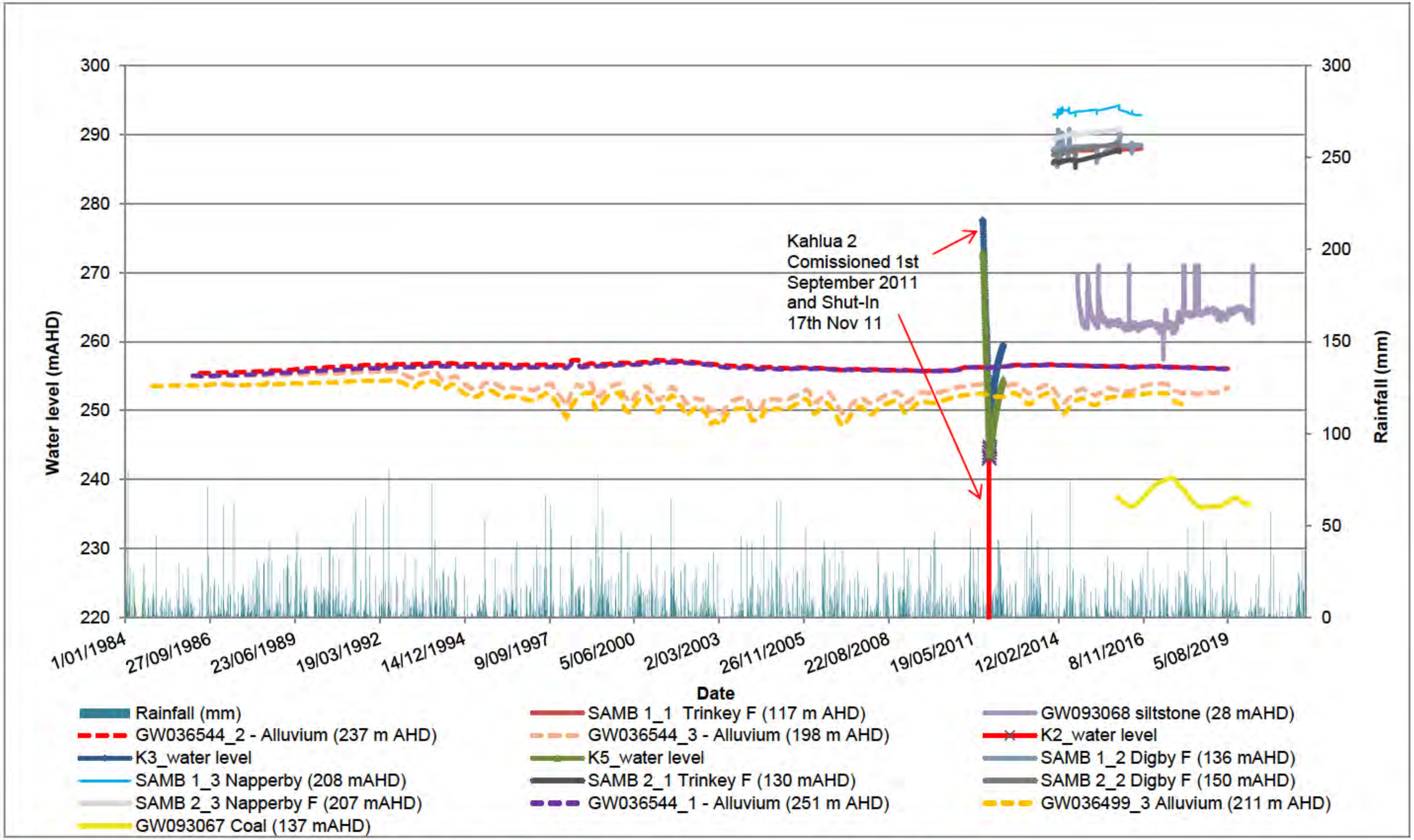
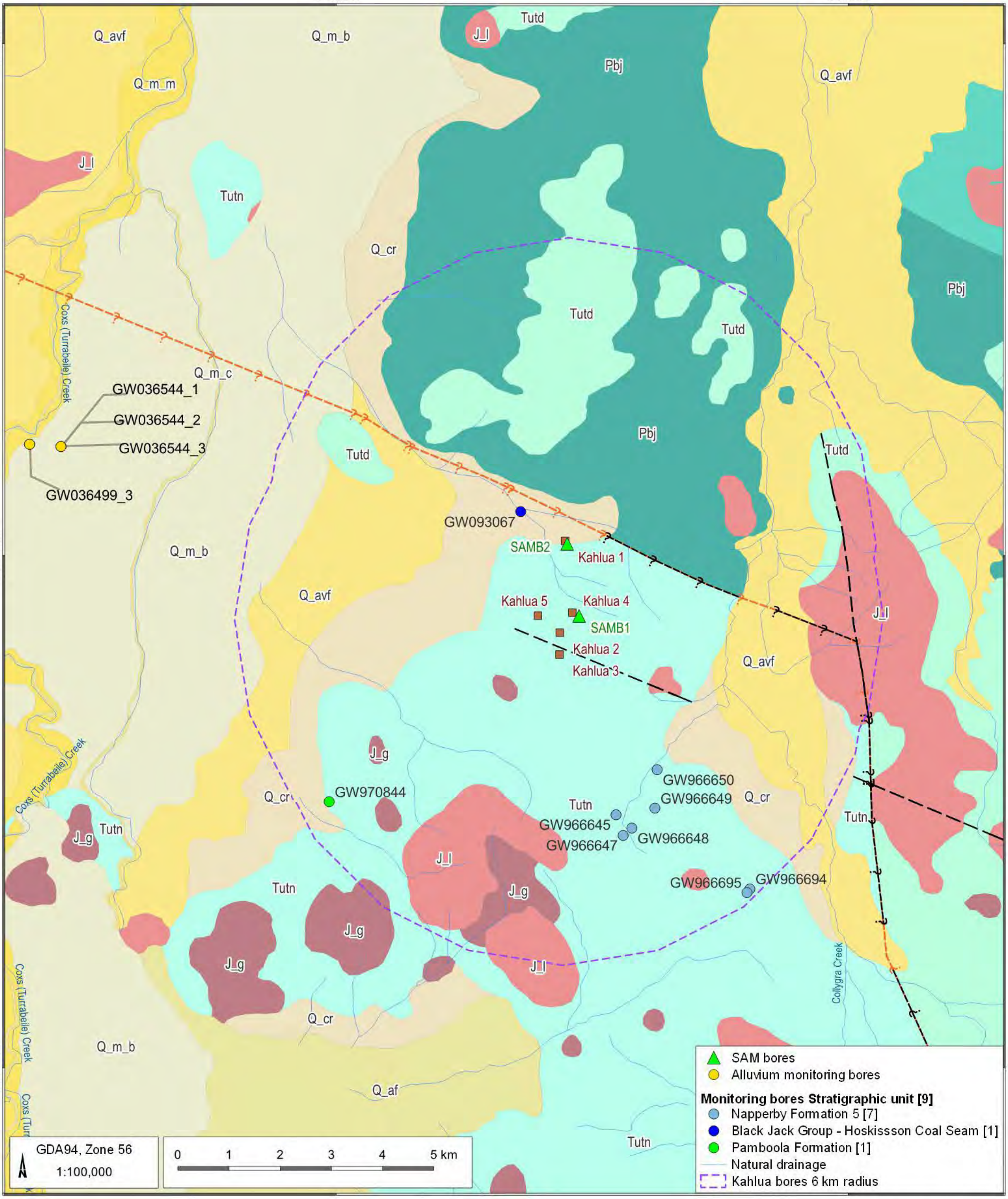


Figure 5.3 Selected groundwater level observation data at, and surrounding, the 2011 Kahlua Pilot test



LEGEND

Kahlua bores

Cenozoic Sedementary Province
- Q_af - Alluvial floodplain deposits
- Q_avf - Alluvial fan deposits
- Q_cr - Colluvial and residual deposits
- Q__m_b - Marra Creek Formation - back plain facies
- Q__m_c - Marra Creek Formation - channel facies
- Q__m_m - Marra Creek Formation - meander plain facies

Permian Mesozoic Igneous Province
- J__g - Garrawilla Volcanics
- J__l - Glenrowan Intrusives

Permo Triassic Basin
- Tutn - Napperby Formation
- Tutd - Digby Formation
- Pbj - Black Jack Group
- Pbb - Brothers Subgroup
- Pmiw - Watermark Formation

Structures
- Fault, position approximate
- Fault, inferred (geological mapping)
- Fault,inferred (AGE)

Kahlua Pilot Reactivation Groundwater Assessment (SAN5001.001)

Groundwater monitoring point locations

AGE

DATE 08/07/2022

FIGURE No: **5.4**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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5.6 Groundwater extraction

5.6.1 Registered groundwater bores

The location of 75 registered potential water supply groundwater bores within six kilometres of the Kahlua 2 well, as obtained from the National Groundwater Information System (NGIS) website in May 2022 is presented in Figure 5.5. The bores are also listed in Appendix E and identified as being used to extract groundwater for stock and domestic, water supply, irrigation, commercial industrial and unknown purposes, broken down as follows:

- 17 bores are identified as being for general water supply purposes;
- 27 are used for stock and domestic purposes;
- 13 are used for irrigation purposes; and
- 18 bores have unknown uses.

Unfortunately, information on the aquifer or even the stratigraphic unit intersected by each water supply bore is not recorded in either state or national databases. Nevertheless, this missing information is critical for understanding the potential for impact on other existing groundwater users and must therefore be added, as far as possible using the information which is available. As shown in Figure 5.6 each water supply bore has therefore been attributed to one of the hydrostratigraphic units present in the area using the following workflow:

- An interpolated base of Digby Formation surface was developed initially, using information on the logged elevation of this surface in the Kahlua boreholes and ground elevation at the mapped boundary between the Digby Formation and the underlying Black Jack Group (Figure 4.1)
- The elevation of the other key hydrostratigraphic surfaces were then calculated relative to the base of the Digby Formation based on their logged average thicknesses at the Kahlua bores.
- Each bore was then initially attributed to a hydrostratigraphic unit based on the total bore depth.
- These initial attributions were then reviewed to ensure consistency with the mapped outcrop geology at each location and based on bore construction and/or lithology information extracted from NGIS (where available).

Final bore attributions for each of the potential 75 water supply bore are shown in Figure 5.6 and listed in Appendix E and are broken down as follows:

- Nine water supply bores were attributed to Quaternary alluvium;
- 10 water supply bore were attributed to the Glenrowan intrusive or the Garrawilla Volcanics;
- 37 water supply bores to the Napperby Formation;
- Six bores to the Digby Formation (Ulinda Sandstone);
- Twelve bores, which are all located in the upthrown fault block to the north-east of the Project site, to the Black Jack Group (predominantly the Wallala Formation, Breeza coal measures, Benelabri Formation); and
- One bore could not be attributed since there was no depth or other relevant information in the NGIS database.

As shown in Figure 5.6 almost all of the bores in close proximity to the Project site are thought to be screened in either the Napperby Formation, which is also present at outcrop in the area, or the underlying Digby Sandstone. Hence, based on average strata thicknesses at the Project site these extractions are separated from the Hoskissons coal seam targeted by the Kahlua pilot by more than 120 m of intervening strata comprising the:

- Benelabri Formation, 26 metres of fine grained sandstone and carbonaceous mudstone;
- Breeza coal measures, three metres of tuff with coal fragments;
- Wallala Formation, 31 metres of medium grained sandstone and conglomerate;
- Trinkey Formation, 28 metres of tuff with coal bands; and the
- Digby Formation (26 metres of conglomerate overlain by 10 metres of sandstone).

As shown in Figure 5.6 no groundwater supply bores were identified within one kilometre of the Kahlua pilot. Further details relating to the five closest potential water supply bores to the pilot are as follows:

- GW026532 – Water supply bore of unknown status, installed in 1966 into the Napperby Formation to a depth of 82.3 metres. It is located about 1.74 kilometres south-east of Kahlua 2 and extracts water from around 230 metres above the estimated top of the Hoskissons coal seam at this location.
- GW027074 – Bore of unknown purpose and status, installed in 1965 into the Napperby Sandstone to a depth of 54.9 metres. It is located approximately 1.87 kilometres south-east of Kahlua 2 and extracts water from around 260 metres above the estimated top of the Hoskissons coal seam at this location.
- GW027071 – Irrigation bore of unknown status, installed in 1967 into the Napperby Sandstone to a depth of 68.6 metres. It is located approximately 1.75 kilometres north-east of Kahlua 2 and extracts water from around 220 metres above the estimated top of the Hoskissons coal seam at this location.
- GW027072 – Irrigation bore of unknown status, installed in 1965 into the Digby Sandstone to a depth of 109.7 metres. It is located approximately 1.94 kilometres north-east of Kahlua 2 and extracts water from around 118 metres above the estimated top of the Hoskissons coal seam at this location.
- GW027073 – Irrigation bore of unknown status, installed in 1965 into the Digby Sandstone to a depth of 160 metres. It is located approximately 1.46 kilometres northeast of Kahlua 2 and extracts water from around 90 metres above the estimated top of the Hoskissons coal seam at this location.

5.6.2 Groundwater entitlements

As discussed in Section 3.1.1, there are two primary water-sharing plans that overlap the Project area:

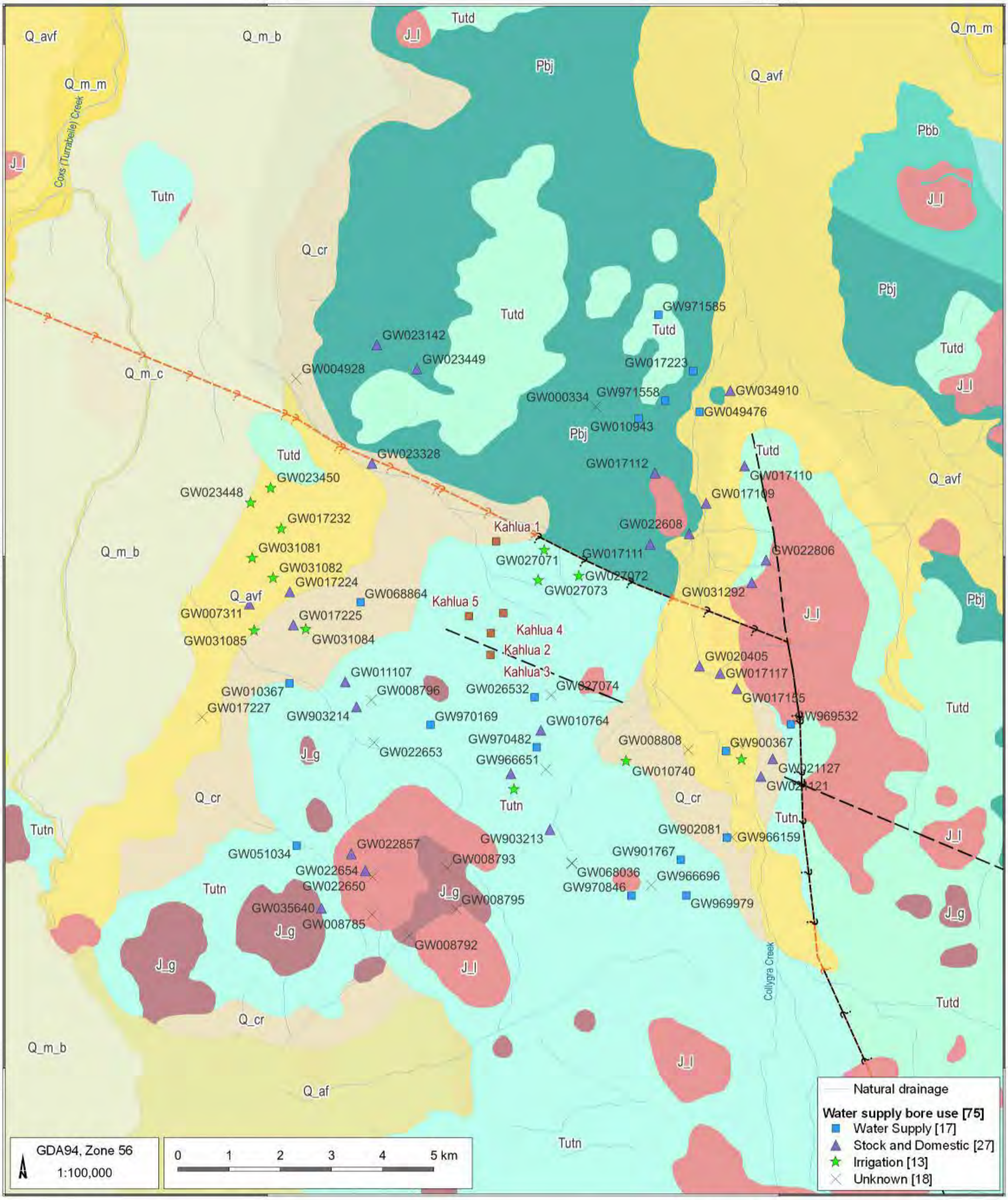
- The Murray-Darling Basin Porous Rock Groundwater Sources – Gunnedah Oxley Basin.
- Namoi Alluvial Groundwater Sources - Zone 2, Zone 3 and Zone 4. These are alluvial groundwater resources associated with Coxs Creek (Zone 2), Mooki River (Zone 3) and the Namoi River (Zone 4).

The groundwater source entitlements are discussed in detail in Section 3.1.1, with the following points noted in regard to the available water within each source:

- Thirty-four percent of the porous rock source is allocated, which suggests that there is available water that can be obtained for the Project.
- One hundred percent of the Namoi Alluvium Groundwater Sources are allocated. This suggest that this aquifer is highly sensitive and any reduced take impacts associated with the Project may be considered to be significant by regulators.

The BOM groundwater information insight webpage (BOM, 2020b) provides details of the distribution of the groundwater entitlements within the vicinity of the project site (refer Figure 5.7). The data presented is not available for detailed interrogation or download with the website indicating that the data presented is limited to the data collected and supplied by relevant state water agencies. Key features include:

- The entitlements are primarily located within alluvial aquifers along Coxs Creek, and the Mooki and Namoi Rivers.
- There are a number of entitlements within the Coxs Creek alluvium directly to the west of the project area. The nearest entitlement within the alluvium is expected to be about 9 kilometres east northeast of the Project site. The entitlements, with one exception, are all less than 500 ML/yr.
- There are four entitlements within Murray-Darling Basin Porous Rock Groundwater Sources – Gunnedah Oxley Basin. This includes:
  - One about 3 kilometres to the south.
  - Three about 8 kilometres to the east northeast and northeast.
  - The entitlements are all less than 500 ML/yr.



LEGEND

Kahlua bores

Cenozoic Sedementary Province

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- J__l - Glenrowan Intrusives

Permo Triassic Basin

- Tutn - Napperby Formation
- Tutd - Digby Formation
- Pbj - Black Jack Group
- Pbb - Brothers Subgroup
- Pmiw - Watermark Formation

Structures

- Fault, position approximate
- Fault, inferred (geological mapping)
- Fault,inferred (AGE)

Kahlua Pilot Reactivation Groundwater Assessment (SAN5001.001)

Registered water supply bore use

AGE

DATE 08/07/2022

FIGURE No: **5.5**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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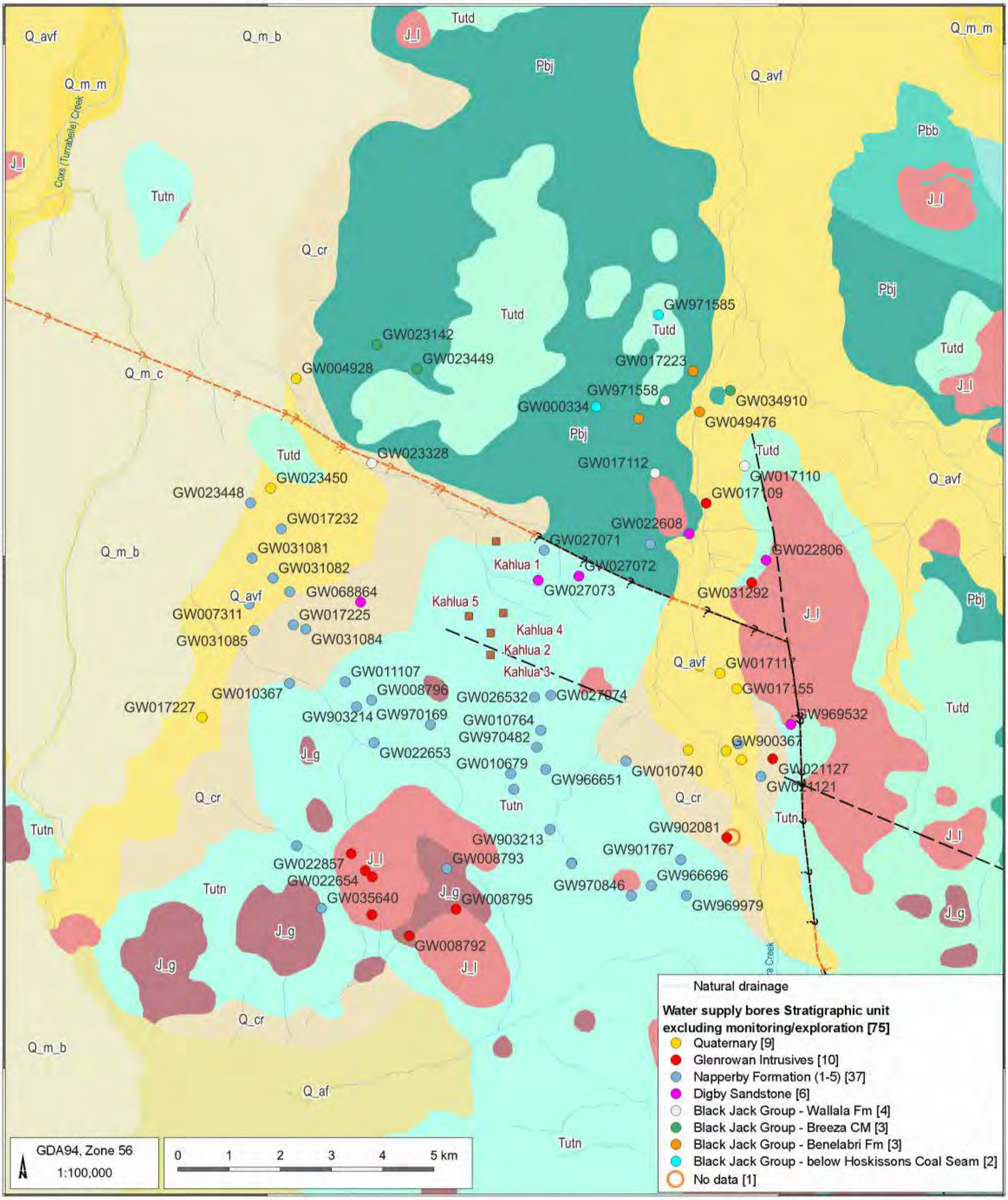

LEGEND

- Kahlua bores

Cenozoic Sedementary Province
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- Pmiw - Watermark Formation

Structures
- Fault, position approximate
- Fault, inferred (geological mapping)
- Fault, inferred (AGE)

Kahlua Pilot Reactivation Groundwater Assessment (SAN5001.001)

Registered water supply bore aquifer attributions

AGE

DATE 08/07/2022

FIGURE No: **5.6**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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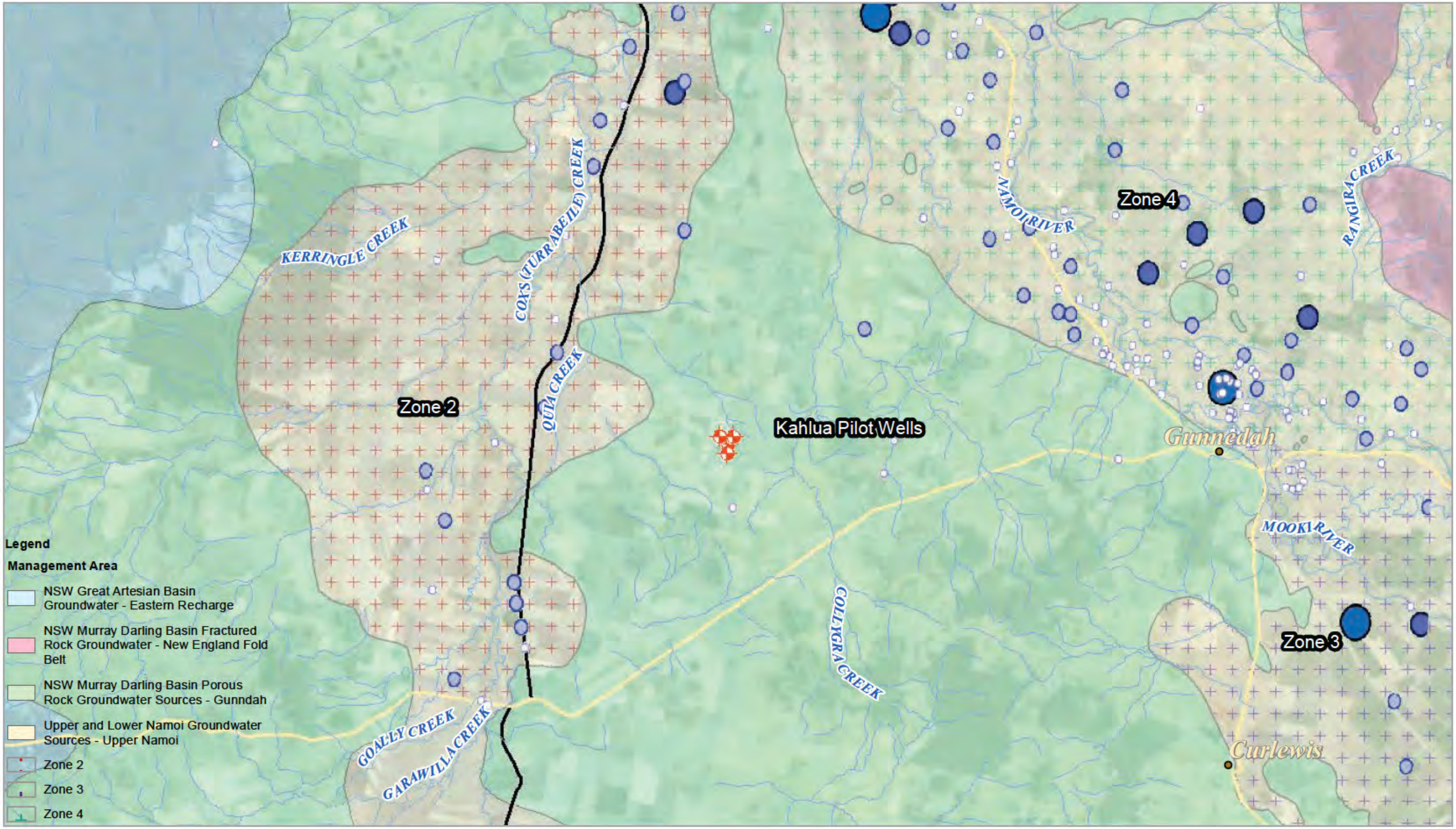


Legend

Kahlua Pilot Wells

Licenced Groundwater Entitlements

- 0 - 100
- 101 - 500
- 501 - 1000
- 1001 - 15000

Paper Size ISO A4

0 2.5 5 7.5 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Santos
Kahlua Pilot test

Project No. **2122463**
Revision No. **-**
Date **08/04/2021**

Licenced groundwater entitlements

FIGURE 5.7

G:\21\22463\GIS\Maps\Deliverables\21_22463_Z183_GroundwaterEntitlement.mxd
Print date: 08 Apr 2021 - 09:02

Data source: Groundwater Entitlment Data: BOM, 02/06/2020; Groundwater Management Data: BOM, 21/05/2020; Roads: NSW LPI; Waterways: NSW Gov. Geoscience Australia, 21/05/2020 © Department of Customer Service 2020. Created by: eibbertson

5.7 Environmentally sensitive areas

Figure 5.8 and Figure 5.9 present the location of groundwater dependent and inflow dependent aquatic and terrestrial ecosystems (GDEs and IDEs) respectively, as presented in the BOM GDE atlas (BOM, 2020b). It is noted that the information presented on these figures are different to the 'high priority' groundwater dependent ecosystems listed within the relevant NSW water sharing plan, which the water sharing plan rules apply to.

The information presented in Figure 5.8 and Figure 5.9 may be summarised as:

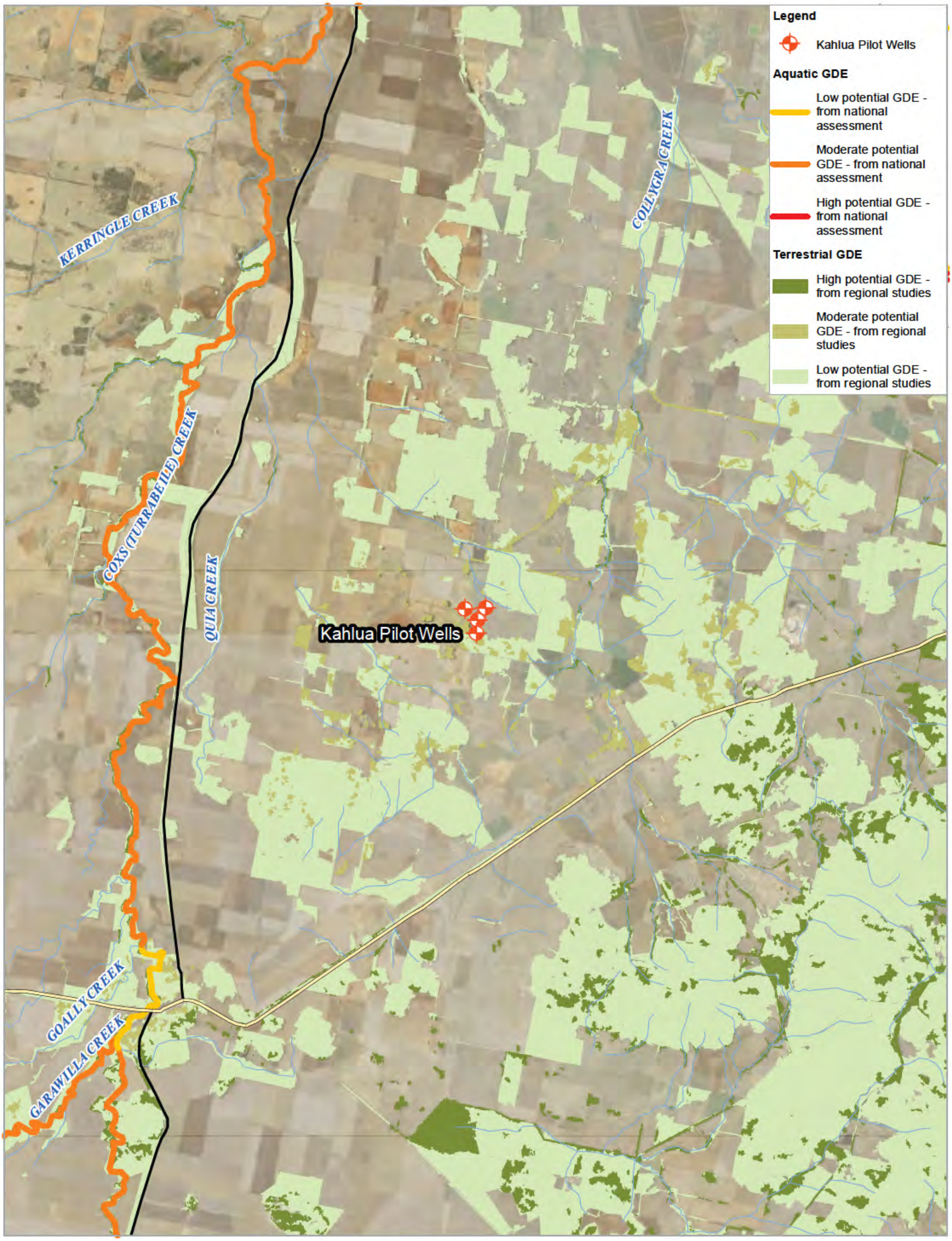
- A number of terrestrial GDEs have been identified in the vicinity of the Project site. The GDEs are primarily terrestrial (vegetation) based ecosystems. Within five kilometres of the project site, they are generally categorised as low to moderate potential GDEs. High potential terrestrial GDEs on the BOM GDE atlas and located within 10 kilometres of the project site include:
  - Shallow freshwater wetland sedgeland in depressions on inland alluvial plains and floodplains.
  - White Box grassy woodland to open woodland on basalt flats and rises in the Liverpool Plains sub-region.
  - White Box grass shrub hill woodland on clay to loam soils on volcanic and sedimentary hills in the southern Brigalow Belt South Bioregion.
  - Water Couch marsh grassland wetland of frequently flooded inland watercourses.
  - Black Tea-tree - River Oak - Wilga riparian low forest/shrubland wetland of rich soil depressions in Brigalow Belt South Bioregion.
  - Poplar Box - Yellow Box - Western Grey Box grassy woodland on cracking clay soils mainly in the Liverpool Plains.
- The nearest high probability GDEs appear to be associated with Collygra Creek located about four kilometres to the west and north west of the project site. The Namoi Alluvium WRP resource description (DoI, June 2019b) includes maps of high probability GDEs, which also identify these GDEs as being of high potential. The WRP indicates that these GDEs are of low to medium ecological value.
- A number of terrestrial IDEs have also been identified in the vicinity of the Project site. Terrestrial IDEs are vegetation that directly relate to the terrestrial GDEs listed above. The IDEs are ranked from one to ten based on their reliance on water sources other than rainfall (i.e., surface and groundwater), one having a low likelihood and 10 having a high likelihood of reliance. Within five kilometres of the project site, they are generally categorised as IDEs that are likely to highly likely to rely on groundwater inflow.
- No aquatic IDEs or GDEs are present within 10 kilometres of the project site. Those present are primarily associated with surface water features including Coxs Creek (11.8 kilometres to the west) and the Namoi River (23.3 kilometres to the east).

There are no high priority GDEs or karst environments listed in the relevant water sharing plans within 10 kilometres of the project site. The nearest high priority GDEs listed in a water sharing plan are:

- Tigheys Spring – 39.4 kilometres south-west (MDB Groundwater Sources Gunnedah–Oxley Basin).
- Porter's Camp Spring – 57 kilometres south-east (MDB Groundwater Source New England Fold Belt).

5.7.1 Groundwater dependent culturally significant sites

No specific groundwater dependent culturally significant sites are listed in the relevant water sharing plans for this area, however, protecting groundwater dependent ecosystems identified above will intrinsically provide protection to any groundwater dependent systems that are considered to be culturally significant.



Paper Size ISO A4

0 1.5 3 4.5 6

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Santos
Kahlua Pilot test
Groundwater Assessment

Project No. 2122463
Revision No. -
Date 08/04/2021

Groundwater dependent ecosystems

FIGURE 5.8

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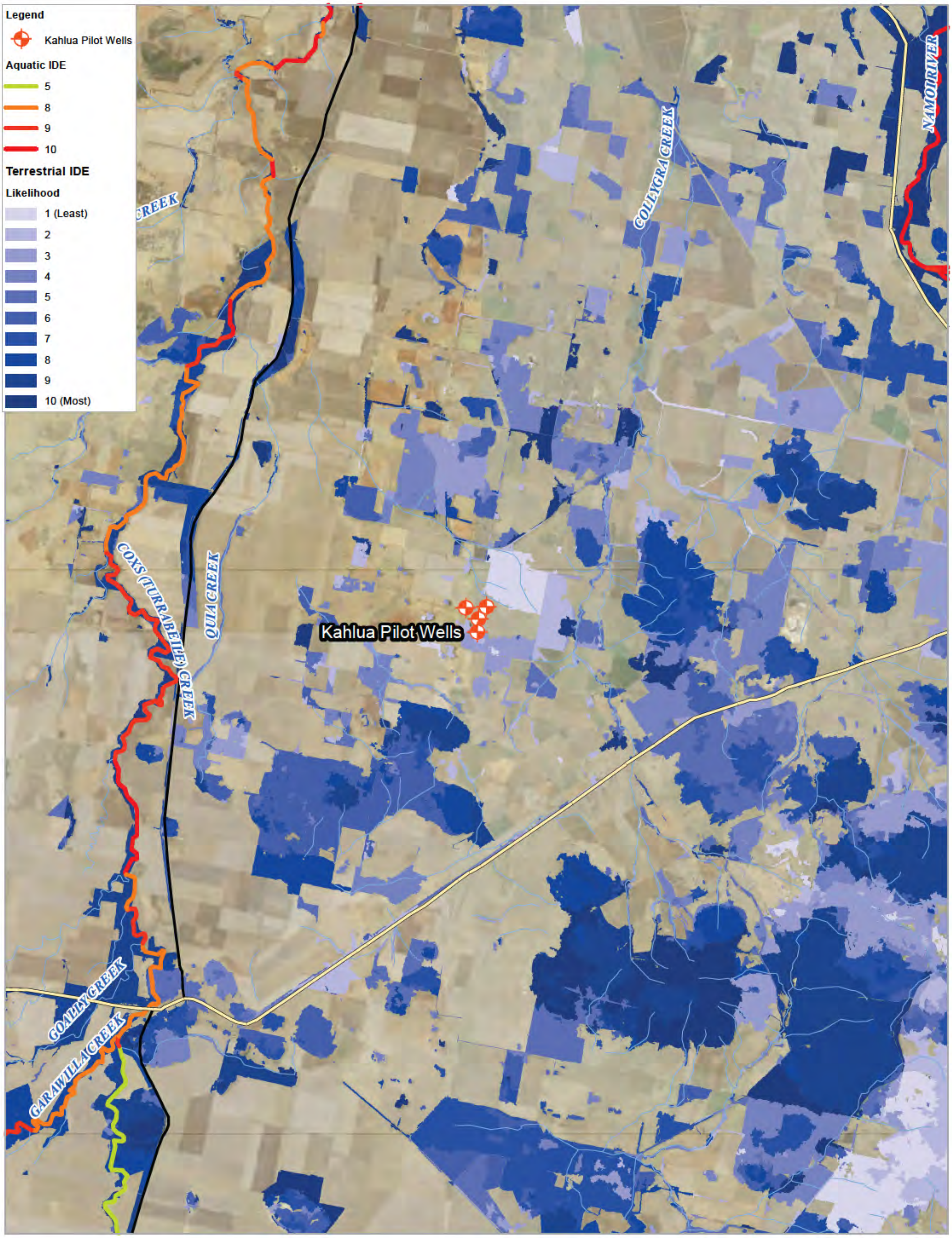
Print date: 08 Apr 2021 - 08:49

Data source: GDE Data: BOM, Australian Govt., 21/05/2020; Roads, Railways, Waterways, Populated PLaces, Built-up Areas Data: GeoScience NSW, NSW Govt, 14/05/2020; Bores: Santos, 08/05/2020 © Department of Customer Service 2020. Created by: eibbertson



Paper Size ISO A4

0 1.5 3 4.5 6

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Santos
Kahlua Pilot test
Groundwater Assessment

Inflow dependent ecosystems

Project No. **2122463**
Revision No. **-**
Date **08/04/2021**

FIGURE 5.9

G:\21\22463\GIS\Maps\Deliverables\21_22463_Z178_TerrestrialAquaticIDE.mxd
Print date: 08 Apr 2021 - 08:57

Data source: IDE Data: BOM, Australian Govt., 21/05/2020; Roads, Railways, Waterways, Populated PLaces, Built-up Areas Data: GeoScience NSW, NSW Govt, 14/05/2020; Bores: Santos, 08/05/2020 © Department of Customer Service 2020. Created by: elibbertson

5.8 Groundwater quality

5.8.1 Historical groundwater quality data

As part of this assessment GHD undertook a review of water quality data reported in Golder Associates (2010). Data included 157 groundwater samples collected in the vicinity of the Project site from the following sources:

- Pinneena database (21 samples).
- Selected data from the PhD thesis by Lavitt (1999), which included groundwater data collected by the author (78 samples) and a compilation of data from the Department of Land and Water Conservation (DLWC; currently NOW) database (26 samples), Bradd *et al*. (1994) (11 samples) and Acworth and Jankowski (1997) (six samples).
- Groundwater bores around the Project site, which were sampled as part of the Santos Bore Inventory program (six samples).
- Available chemical analyses from Longlea 1 (nine samples).

5.8.1.1 Water quality parameters assessed

The groundwater chemistry data assessed in the Golder Associates (2010) report included data collected over a period of 33 years, with the majority of data collected between 1992 and 1996. The groundwater quality assessment included analyses of pH, electrical conductivity (EC), total dissolved solids (TDS) and major ion chemistry.

5.8.1.2 Stratigraphic changes in water quality

Groundwater within the Quaternary alluvium (Narrabri/Gunnedah Formations) was found to contain slightly acidic to alkaline groundwater, with pH ranging between 6.0 and 8.7 and a mean pH of 7.54. The groundwater was generally found to be fresh (with mean TDS of 1,057 mg/L and mean EC of 1,557 µS/cm). A TDS of less than 1,000 mg/L was observed in 79% of the samples and a slightly brackish TDS (1,000 mg/L – 3,000 mg/L) in 18% of samples. Three samples reported brackish (TDS 3,000 mg/L – 10,000 mg/L) water and one sample reported saline water (TDS 10,000 mg/L – 100,000 mg/L).

Slightly brackish and saline groundwater was generally observed in the upper clay-rich aquifers (Narrabri Formation 53%) while mostly fresher water was observed in the Gunnedah Formation (93%). The dominant water type in this formation represents combinations of sodium, magnesium, calcium bicarbonates, chloride and to a lesser extent, sulphate.

Groundwater pH values in the Gunnedah Basin Sequence (excluding coal seams) fell within the range of pH 7 to 8 (with a mean pH of 7.27). The salinity data had a mean TDS of 1,712 mg/L (mean EC of 2,463 µS/cm) with a min and max of 502 mg/L and 3,198 mg/L respectively. The majority of samples (90%) were classified as fresh to slightly brackish. The dominant water type in these formations were combinations of sodium and magnesium, and bicarbonate and chloride.

The Hoskissons Coal Seam forms part of the Gunnedah Basin Sequence. Six groundwater samples were available for the Hoskissons Coal Seam from surrounding areas. Groundwater within the Hoskissons Coal Seam returned higher pH values (mean of 7.97, range between 7.4 to 8.5), higher EC (mean of 5,337 µS/cm) and higher TDS (mean of 3,240 mg/L) than groundwater observed within the Quaternary alluvium (Narrabri/Gunnedah Formations) and other Gunnedah Basin Sequence formations.

In general, groundwater was observed to be fresh to slightly brackish in non-coal seam formations, and more saline within coal seams. Generally, salinity was found to be lowest within the Quaternary alluvium, followed by the Napperby/Digby formations, with the highest salinity found in Hoskissons Coal Seam, suggesting that salinity generally increases with depth.

5.8.2 Kahlua 2011 pilot test data

Additional groundwater quality testing was carried out on samples taken from the Hoskissons coal seam in the Kahlua 2 well during pilot testing in 2011. The results were generally consistent with earlier groundwater quality data from Longlea 1 (Golder Associates, 2010), with relatively minor variations likely due to natural fluctuations, as shown below in Table 5.6.

Comparison of the results against irrigation criteria (ANZECC & ARMCANZ, 2000) and freshwater ecological criteria (ANZG, 2018) and drinking water criteria (NHMRC, 2011) indicates that the water is broadly of low beneficial use potential (for drinking water, irrigation and freshwater ecosystems) but could potentially be used as a water supply for some stock types (sheep, beef cattle, horses and pigs).

Table 5.6 Summary of key analytes

Analyte	Kahlua 2	Longlea 1
pH	8.11	7.97
EC	6,080 µS/cm	5,337 µS/cm
TDS	4,040 mg/L	3,240 mg/L
Ca	6 mg/L	6.78 mg/L
Na	1,600 mg/L	1,337 mg/L
K	35 mg/L	11 mg/L
Mg	1 mg/L	8.07 mg/L
Cl	209 mg/L	297 mg/L
SO_4	4 mg/L	2.56 mg/L
HCO_3	3,360 mg/L (as $CaCO_3$)	3,166 mg/L
CO_3	<1 mg/L (as $CaCO_3$)	102 mg/L

5.8.3 Key water quality findings

As would be expected, groundwater quality within the target Hoskissons Coal Seam was found to be significantly different from shallow aquifers — including a more elevated pH, electrical conductivity, and total dissolved solids.

The distinct difference in water quality between in the Hoskissons coal seam and the shallower groundwater units provides further evidence of their hydraulic separation. The downward hydraulic gradient induced during operation of the pilot would also tend to prevent any mixing of groundwater from the Hoskissons Coal Seam upward into the shallower groundwater units in any case.

Potential impacts on groundwater quality are discussed further in Section 6.4.4.

6 Impact assessment

6.1 Impact assessment approach

The approach used herein was to assess groundwater drawdown associated with the proposed activity including the operation of the Project against relevant Australian and NSW groundwater assessment criteria.

Impacts have been assessed using a relatively simple numerical modelling approach (Section 6.3) which is considered to be commensurate with the temporary nature, scale and hence environmental risks posed by the proposed extraction. Average extraction from the re-activated pilot is expected to be 24 m^3/d equivalent to less than 0.3 litres per second or 9 Megalitres per year (ML/year). As such this is a minor extraction equivalent to an additional temporary stock and domestic extraction. As show in Figure 5.7 many of the existing permanent groundwater entitlements in the area are licensed for over 100 ML/year, more than 10 times the expected extraction rate from the reactivated pilot.

Predicted drawdown impacts, as calculated using the numerical model were then compared against the applicable assessment guidelines to identify any potentially adverse impacts. The criteria adopted for the assessment of groundwater impacts are presented in Section 6.2 and discussed in more detail in Section 6.4.

Proposed mitigation and monitoring measures are outlined in Section 7.

6.2 Assessment criteria

The criteria/rules adopted for the assessment of impacts included the:

- Water sharing rules contained in the Water Sharing Plan for the Murray-Darling Basin Porous Rock Groundwater Resources 2020, including the LTAAEL.
- Water sharing rules contained in the Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020 (Zone 2), including the LTAAEL.
- NSW AIP minimal impact criteria for alluvial water sources.
- NSW AIP minimal impact criteria for porous rock water sources.
- Significant impact threshold for the water trigger under the EPBC Act.

Further detail on these criteria and the rationale for how these criteria intrinsically cover other relevant NSW policies and guidelines is provided in Section 3.

6.3 Numerical modelling

6.3.1 Model structure and initial parameterisation

Additional groundwater level drawdown as a result of the proposed development has been assessed using a simple multi-layer numerical model developed using MODFLOW-USG (Panday et al., 2013). The layering system and initial properties adopted for each layer used in the predictive model are summarised in Figure 6.1. This layering system was developed using the workflow described below. All layers were assumed to be of constant thickness and flat.

Initially, based their lithological descriptions, each hydrostratigraphic unit was defined as being either an aquifer or aquitard and represented using single layers, or defined as being a mixed aquifer/aquitard unit and represented using at least one pair of aquifer and aquitard layers. The following units were defined as aquifers:

- The Quaternary alluvium and intrusive Volcanics;
- The Ulinda Sandstone of the Digby Formation;
- The Breeza coal measures; and
- The Hoskissons coal seam.

The following units were defined as aquitards:

- The Bomera conglomerate of the Digby Formation; and
- The Trinkey Formation, since it typically comprises tuff with coal bands.

Since the Bomera conglomerate directly overlies the Trinkey Formation then a single model layer was used to represent the above two aquitard units.

The remaining units were defined as being mixed aquifer/aquitard units as follows:

- The Napperby Formation (interbedded fine to medium grained sandstone and siltstone);
- The Wallala Formation (medium grained sandstone and conglomerate);
- The Benelabri Formation (interbedded fine grained sandstone and carbonaceous mudstone)
- The Black Jack Group underlying the Hoskissons coal seam comprising the Arkarula Formation (sandstone and siltstone) and Pamboola Formation (sandstone, siltstone, coal and tuff; and
- The Watermark Formation (sandstone, siltstone with some intrusive material).

As shown in Figure 6.1 the Napperby Formation was then further subdivided equally into five pair of aquifers and aquitards since it is:

- substantially thicker than the other potentially affected formations overlying the Hoskissons coal seam at the Project site; and
- the target for the majority of the existing groundwater supplies in the Project area.

The use of multiple layers for the Napperby Formation also enabled the more accurate location of existing water users within the Napperby Formation. Given the interbedded nature of this unit impacts and hence low expected vertical hydraulic conductivity, on account of the multiple siltstone units present, then impacts will tend to be significantly different at the top of the Napperby Formation than at the bottom.

Formation	Layer ID	Layer Type	Thickness (m)	Horizontal hydraulic conductivity, Kh (m/d)	Vertical hydraulic conductivity, Kv (m/d)	Specific Storage, Ss (1/m)	Specific Yield, Sy	Transmissivity, T (m^2/d)	Storativity, S (-)	Hydraulic resistance, c (s)
Quaternary	1	Aquifer	20	6.0E+00	6.0E-01	NA	0.1	120	0.1	
Napperby	2	Aquitard	1	8.0E-02	8.0E-03	1.0E-05	NA		1.00E-05	1.08E+07
	3	Aquifer	28	1.5E+00	1.5E-01	1.0E-05	NA	42	2.80E-04	
	4	Aquitard	1	8.0E-02	8.0E-03	1.0E-05	NA		1.00E-05	1.08E+07
	5	Aquifer	28	1.5E+00	1.5E-01	1.0E-05	NA	42	2.80E-04	
	6	Aquitard	1	8.0E-02	8.0E-03	1.0E-05	NA		1.00E-05	1.08E+07
	7	Aquifer	28	1.5E+00	1.5E-01	1.0E-05	NA	42	2.80E-04	
	8	Aquitard	1	8.0E-02	8.0E-03	1.0E-05	NA		1.00E-05	1.08E+07
	9	Aquifer	28	1.5E+00	1.5E-01	1.0E-05	NA	42	2.80E-04	
	10	Aquitard	1	8.0E-02	8.0E-03	1.0E-05	NA		1.00E-05	1.08E+07
	11	Aquifer	28	1.5E+00	1.5E-01	1.0E-05	NA	42	2.80E-04	
	12	Aquitard	1	8.0E-02	8.0E-03	1.0E-05	NA		1.00E-05	1.08E+07
Digby Sandstone	13	Aquifer	10	1.5E+00	1.0E-02	1.0E-05	NA	15	1.00E-04	
Digby Conglomerate /Trinkey	14	Aquitard	54	3.0E-04	3.0E-05	1.0E-05	NA		5.40E-04	1.56E+11
Wallala	15	Aquifer	30	1.1E+00	1.1E-01	1.0E-05	NA	33	3.00E-04	
	16	Aquitard	1	3.0E-04	3.0E-05	1.0E-05	NA		1.00E-05	2.88E+09
Breeza / Benelabri	17	Aquifer	28	1.1E+00	1.1E-01	1.0E-05	NA	30.8	2.80E-04	
Benelabri	18	Aquitard	1	3.0E-04	3.0E-05	1.0E-05	NA		1.00E-05	2.88E+09
Hoskissons	19	Aquifer	8	8.0E-03	8.0E-04	1.0E-05	NA	0.064	8.00E-05	
Lower Black Jack	20	Aquitard	1	4.0E-03	4.0E-04	1.0E-05	NA		1.00E-05	2.16E+08
	21	Aquifer	50	1.1E+00	1.1E-01	1.0E-05	NA	55	5.00E-04	
Watermark	22	Aquitard	1	4.0E-03	4.0E-04	1.0E-05	NA		1.00E-05	2.16E+08
	23	Aquifer	163	1.1E+00	1.1E-01	1.0E-05	NA	179.3	1.63E-03	

Figure 6.1 Numerical model layers and initial properties

Initial hydraulic properties for the Hoskissons coal seam used for modelling purposes were based on the 2011 Kahlua pilot test analysis (Section 5.3). Parameters for other aquifer layers were predominantly based on the maximum values presented in Table 5.2 and those for aquitard layers based on the minimum values presented in the same table. Vertical hydraulic conductivity values were, however, assumed to be one tenth of the horizontal values in preference to the values shown in Table 5.2.

As shown in Figure 6.1 aquitard layers within mixed aquifer/aquitard layers were conservatively assumed to be only one metre thick. The Napperby Formation as modelled therefore comprises six metres of aquitard material and 140 metres of aquifer material. Lithological logs for the nearby Narrabri mine site (AGE, 2020), however, suggest that the Napperby Formation actually comprises up to 60% siltstone and mudstone suggesting up to around 90 m of aquitard material. Model results are not particularly sensitive to the thickness of the aquitard and a simple conservative approach was adopted and one metre thick aquitards assumed for mixed units, in part since quantitative information of the proportion of aquifer and aquitard material at the Project site is not available.

6.3.2 Model calibration

Prior to using the numerical model for impact prediction purposes some adjustment of the initial parameterisation of the coal seam (model layer 19) and adjacent layers (model layers 18 and 20) was required. As outlined above the initial parameters for these layers were based on an analytical pump test analysis undertaken assuming a leaky confined aquifer system (Hantush, 1961) i.e a single layer with an allowance for leakage from the overlying strata. Applying these parameters in the multi-layer MODFLOW-USG simulation and then running a simulation of the initial single well Kahlua 2 pilot test (Section 5.3) resulted in modelled drawdowns at the Kahlua 3 and Kahlua 5 wells which were significantly less than those observed. A better match to observations was achieved by reducing the hydraulic conductivity and specific storage of model layer 18, 19 and 20 (i.e. the Hoskissons coal seam and the two adjacent units). This allowed the numerical model to better simulate the 28 m of drawdown observed in Kahlua 3 and Kahlua 5 wells towards the end of the 2011 test by reducing the amount of leakage from adjacent units relative to the simpler analytical solution. Final modelled parameters used for impact prediction purposes following calibration are summarised in Table 6.1. As shown, other than layers 18, 19 and 20, all other parameters are the same as the initial parameters summarised in Figure 6.1.

Table 6.1 Final calibrated parameters

Unit	Model layer(s)	Modelled horizontal hydraulic conductivity (Kh, m/d)	Modelled vertical hydraulic conductivity (Kv, m/d)	Modelled Specific Yield (Sy)	Modelled Specific storage (Ss)
Quaternary / Intrusive Volcanics	1	6.0	0.6	0.1	NA
Napperby Formation – aquitard layers	2,4,6,8,10,12	8E-02	8E-03	NA	1E-05
Napperby Formation – aquifer layers	3,5,7,9,11	1.5	0.15	NA	1E-05
Digby Sandstone	13	1.5	0.15	NA	1E-05
Digby Conglomerate / Trinkey	14	3E-04	3E-05	NA	1E-05
Wallala – aquifer	15	1.1	0.11	NA	1E-05
Wallala – aquitard	16	3E-04	3E-05	NA	1E-05
Breeza / Benelabri aquifer	17	1.1	0.11	NA	1E-05
Benelabri -aquitard	18	3E-06	1E-08	NA	1E-06
Hoskissons coal seam	19	5E-03	5E-04	NA	8E-06
Lower Black Jack - aquitard	20	4E-06	1E-08	NA	1E-06
Lower Black Jack – aquifer	21	1.1	0.11	NA	1E-05
Watermark – aquitard	22	4E-03	4E-04	NA	1E-05
Watermark – aquifer	23	1.1	0.11	NA	1E-05

6.4 Predicted impacts

6.4.1 Drawdown

Forward predictions were undertaken assuming 24 m^3/d of extraction from the reactivated Kahlua pilot for a period of 730 days. Predicted drawdown at the end of the extraction period were then extracted for each modelled aquifer, plotted in GIS and used to predict drawdown at each of the registered water supply bores within six kilometres of the Project site. Drawdown predictions for the Hoskissons coal seam (i.e. the pumped aquifer, model layer 19) after 730 days pumping are presented in Figure 6.2. Predicted drawdowns in each of the under and overlying modelled aquifer units are less than 0.1 m and contours have not been produced for other units. Predicted impacts therefore do not extend beyond the Coogal sub-group of the Black Jack group, which the target Hoskissons coal seam forms part of (Table 5.1). As shown in Figure 6.2 whilst minor drawdown (0.1 to 0.5 metres) is predicted in the Hoskissions coal seam underneath the Cox's creek alluvial area, which forms part of the Namoi Alluvium Groundwater Source (Zone 2), the seam is present at around 500 metres below ground surface at this location (Figure 4.2). Accordingly, no impact (i.e zero drawdown) is predicted on groundwater levels in the surficial alluvium.

As shown in Figure 6.2 drawdowns in the Hoskissons coal seam predicted using the numerical model, which assumes constant layer thicknesses and elevations, have been truncated at the mapped locations of the faults to the north-east and east of the site. As discussed in Section 4.3.3 the strata on the far side of both of these faults appear to have been significantly upthrown such that the Project site sits within a downthrown block. Whilst the hydrogeological characteristics of these faults are not known it is considered highly unlikely that drawdown impacts in the Hoskissons coal seam could propagate across these faults, irrespective of whether they act as barriers or conduits to flow. It is considered most likely that they will act as flow barriers, since for flow to occur across the mapped fault planes then the Hoskissons coal seam would have to be juxtaposed against another strata with relatively high permeability and the fault itself would also have to characterised by relatively high permeability. However, the relatively high proportion of fine, low permeability material present in most of the strata present means that the probability of the Hoskissons being juxtaposed against unit with similar or higher permeability is low. Furthermore, the presence of clay rich siltstones and mudstones within the strata combined with the relatively large displacements (60 to 125 metres) means that clay smearing or shale gouge (Smith, 1966) along the fault plane is likely, such that the fault itself is also likely to restrict flow. Even where clay smearing has not occurred and the fault has lead to fracturing and permeability enhancement such that the fault acts as a conduit to flow then this would also result in little or no drawdown on the far side of the fault, since drawdown would instead to propagate along the fault. Accordingly, there are few if any fault settings which could result in any significant drawdown propagation across these two faults and the modelled drawdowns have been clipped accordingly. Conversely, however, the mapped fault immediately south of Kahlua 2 appears to be a relatively minor feature which was not picked up during drilling at the pilot site and its effects are also not evident in the geological mapping (Section 4.3.3). The 2011 pilot test results also suggested drawdown to the south of this fault (Section 5.3). Accordingly model predicted drawdowns to the south of the pilot site have not been clipped.

It should also be stressed that as shown in Figure 6.2 only two of the water supply bores (GW971585 and GW000334) on the far side of the fault to north east of Kahlua are thought to be deep enough to penetrate into the Hoskissons coal seam. In the unlikely event that the mapped fault in this area has no effect on lateral drawdown propagation within the coal seam then model predictions suggest that up to 1 m of drawdown could occur at GW000334 and 0.1 m at GW971585. The remaining bores on the far side of this fault all target shallower units and hence are not predicted to experience more than 0.1 m of drawdown irrespective of the hydraulic behaviour of the fault.

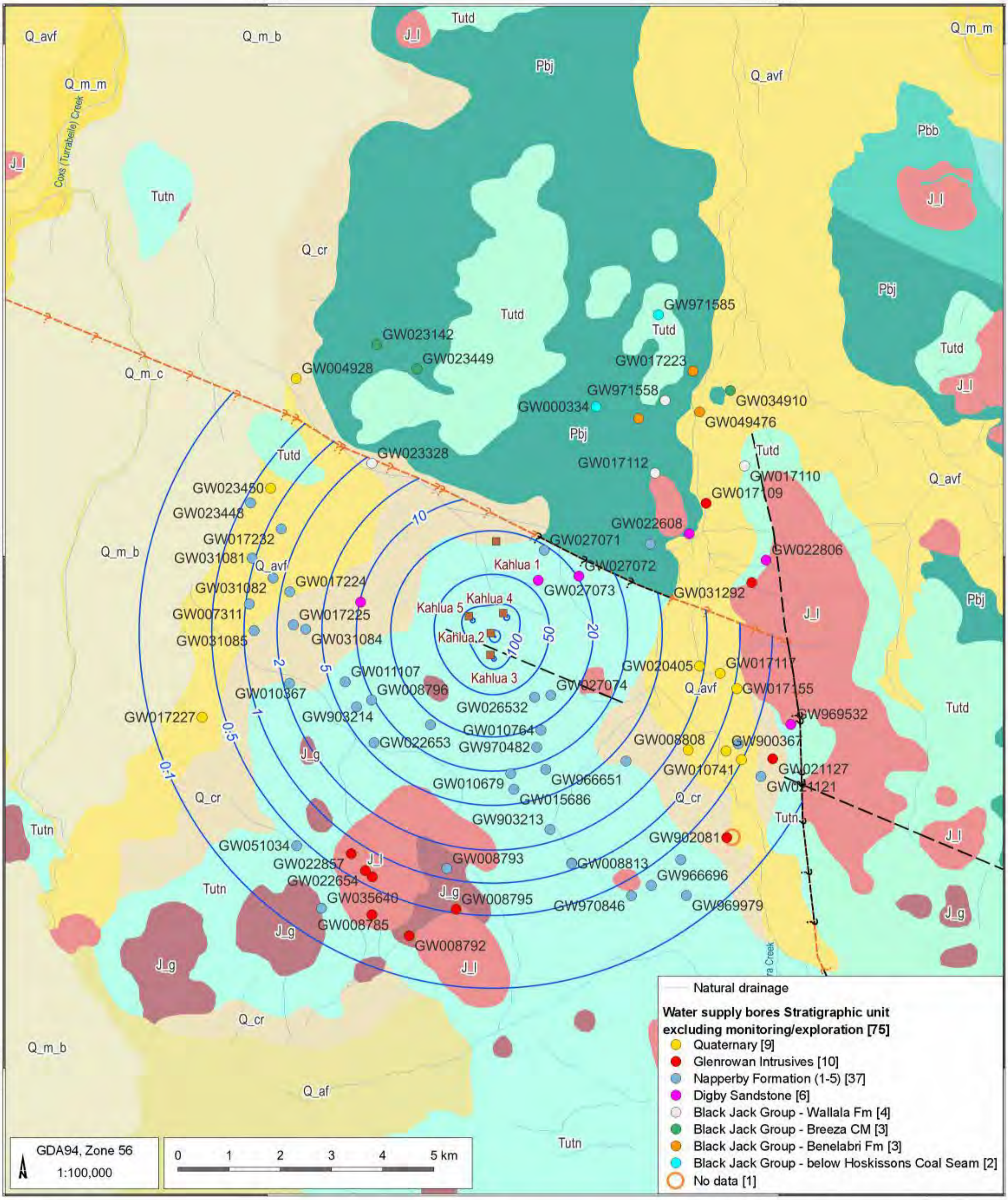
Predicted drawdown at known water supply bores are summarised in Table 6.2. As shown none of the existing privately owned water supply bores are predicted to experience more than the two metre minimal impact threshold identified in the AIP.

Table 6.2 Summary of predicted maximum drawdown impacts at nearby registered water supply bores

Hydrostratigraphic Unit	Number of existing water supply bores	Maximum predicted drawdown impact (m)	Number of water supply bores with predicted impacts exceeding the 2 metres AIP minimal impact threshold
Quaternary alluvium	9	<0.1	0
Glenrowan intrusives / Garrawilla Volcanics	10	<0.1	0
Napperby Formation	37	<0.1	0
Digby Formation (Ulinda Sandstone)	6	<0.1	0
Black Jack Group	12	208	0[1]

Predictions also suggest potential drawdowns of up to 10 m at monitoring point GW093067 which is located around 2.5 km to the north west of the Kahlua site and thought to be completed into the Hoskissons coal seam (Figure 5.4). The significantly lower observed groundwater levels at this site, however, suggest it might be located to the north of the nearby north west to south east trending fault (Section 5.4). If this is the case then, as discussed above in relation to drawdown at water supply bores, drawdown impacts are considered unlikely to occur. Nevertheless, groundwater level data for this site are likely to represent a key line of evidence for validation of the predicted drawdowns in the Hoskissons coal seam (Figure 6.2) and to confirm the behaviour of the fault.

[1] Model predictions suggest one bore (GW000334) could experience up to 1 m of drawdown in the unlikely event that the inferred fault to the northeast of Kahlua had no effect on lateral propagation of impacts within the Hoskissons coal seam. No other bores are predicted to experience more than 0.1 m of drawdown irrespective of the hydraulic behaviour of the fault.



LEGEND

Kahlua bores

Cenozoic Sedementary Province

- Q_af - Alluvial floodplain deposits
- Q_avf - Alluvial fan deposits
- Q_cr - Colluvial and residual deposits
- Q__m_b - Marra Creek Formation - back plain facies
- Q__m_c - Marra Creek Formation - channel facies
- Q__m_m - Marra Creek Formation - meander plain facies

Permian Mesozoic Igneous Province

- J__g - Garrawilla Volcanics
- J__l - Glenrowan Intrusives

Permo Triassic Basin

- Tutn - Napperby Formation
- Tutd - Digby Formation
- Pbj - Black Jack Group
- Pbb - Brothers Subgroup
- Pmiw - Watermark Formation

Structures

- Fault, position approximate
- Fault, inferred (geological mapping)
- Fault, inferred (AGE)

Drawdown (m)

- Drawdown contour

Kahlua Pilot Reactivation Groundwater Assessment (SAN5001.001)

Predicted drawdown after 730 days, Hoskissons coal seam (pumped aquifer, model layer 19)

AGE

DATE 06/07/2022

FIGURE No: **6.2**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\SAN5001.001 Kahlua Pilot Reactivation Groundwater Assessment\3_GIS\Workspaces\001_Deliverable1\06.02_SAN5001.001_Predicted drawdown after 730 days, Hoskissons coal seam (pumped aquifer, model layer 19).qgs

6.4.2 Impact on GDEs

With regard to water table impacts at GDEs since no impacts of greater than 0.1 m are predicted on any units which occur at outcrop then no impact on the water table at any GDEs are expected. Accordingly, the project can be considered to have "minimal harm" against the minimal impact considerations.

6.4.3 Additional take from water sharing plan areas

The NSW AIP requires that additional groundwater takes (both direct and indirect) from water sources which feature in WSPs be accounted for. Groundwater reporting to the Project pilot wells represents a direct take from Permian age units, primarily the Hoskissons coal seam, which forms part of the Gunnedah-Oxley Basin MDB Groundwater Source. Any impacts on Namoi Alluvium Groundwater Source would be indirect since they result from depressurisation of the underlying Permian strata and there is no direct extraction from these units. However, no drawdown impacts are predicted on any alluvial areas which form part of the Namoi Alluvium Groundwater Source (Section 6.4.1) and hence no additional indirect take is expected to occur from other WSP water sources.

Conversely, the expected direct take of 24 m^3/d (or around 9 ML/yr) on average from the Hoskissons coal seam exceeds the NSW water management (general) regulation (2018) of 3 ML/yr which also applies to exploration activities. Additional licences for extraction from the Gunnedah-Oxley Basin MDB Groundwater Source would therefore need to be acquired, despite the temporary nature of the extraction. However, this groundwater source is currently significantly under-allocated and has had several controlled allocation periods of interest between 2017 and 2020. Most recently, the Controlled Allocation Order (Various Groundwater Sources) 2020 offered 4,043 shares of the Gunnedah-Oxley Basin MDB Groundwater Source.

6.4.4 Water quality impacts

Since predicted impacts do not extend beyond the Hokissons coal seam and adjacent units which all form part of the Coogal sub-group of the Black Jack Group then no impacts on groundwater quality are anticipated. In particular drawdown in, and hence the volume of water drawn from overlying units, is expected to be negligible and hence the proposed extraction will primarily involve the removal of 17,520 m^3 (24m^3/d over a 730 day period) from storage within the Hoskissons coal seam and other immediately adjacent strata. Furthermore few, if any, existing water supply bores target the affected units on account of their depth and low beneficial use potential (Section 5.8.2).

7 Mitigation and monitoring measures

Consistent with the temporary nature and depth of the extraction and the relatively minor volumes to be extracted (9 ML/yr over two years or 18 ML total) minimal impacts are predicted on existing water users including local GDEs. Accordingly, no impact mitigation measures are considered necessary at this stage. Nevertheless, the following monitoring activities are proposed to confirm that actual impacts are negligible:

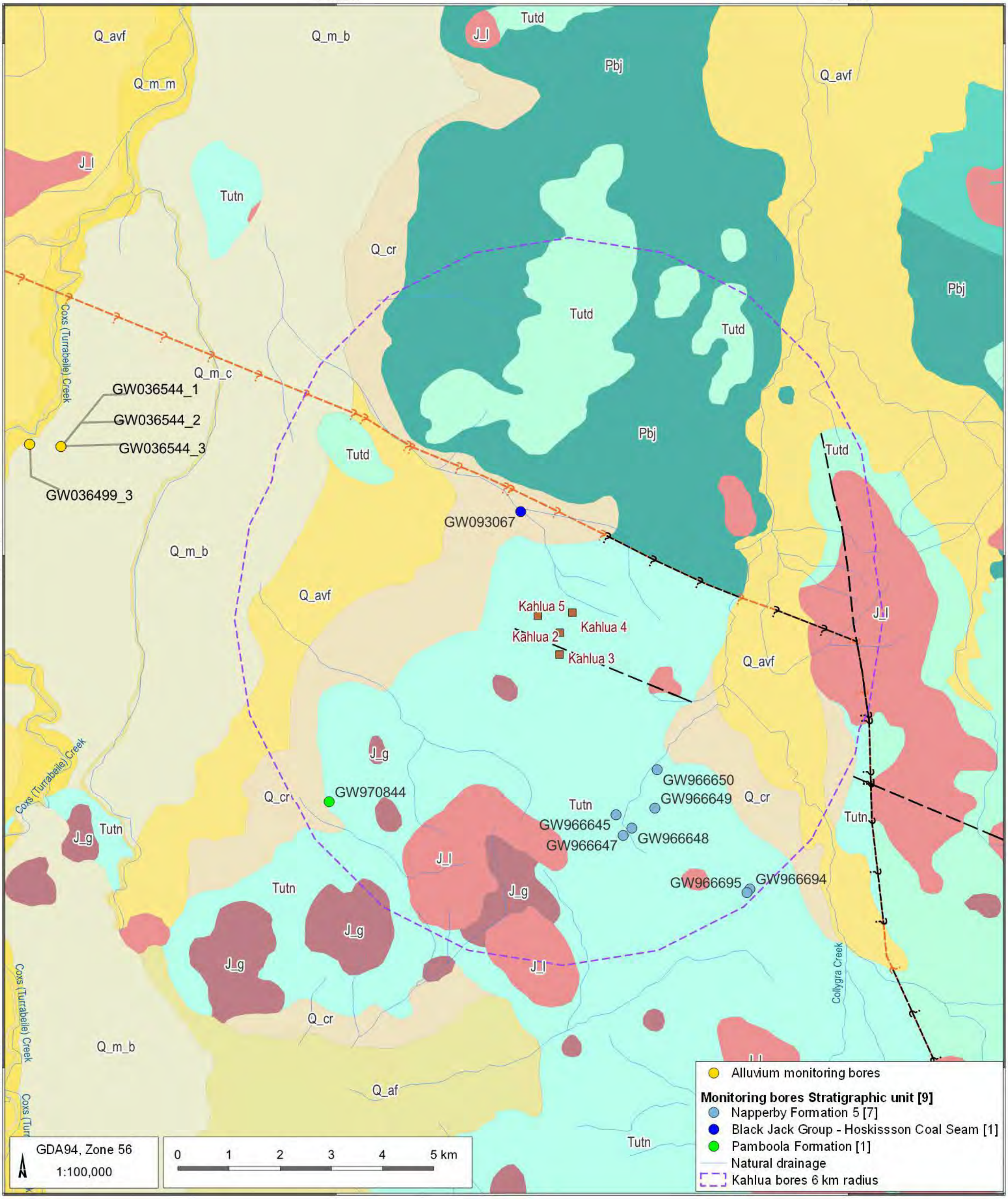
- Monitoring of daily extraction rates (in pumping wells) or groundwater levels (in non-pumping wells) in each of the Project pilot wells will be undertaken on a daily basis throughout the extraction period.
- Collation and review of groundwater level data from all available NSW state monitoring points within 10 km of the site (Figure 5.4, including in particular GW093067) for any evidence of impact twelve months after commencement of extraction and then again after completion of the pilot.
- Review results to be reported to the NSW Office of Water, highlighting any impacts in excess of those predicted, within eight weeks of the 12 month and 24 month anniversary of pilot commencement.

A summary of the proposed monitoring plan is provided below in Table 7.1, monitoring locations are shown in Figure 7.1.

Table 7.1 Proposed monitoring plan summary

Bore Owner	Bore ID	Latitude	Longitude	Easting[2]	Northing[2]	Formation Monitored	Predicted drawdown (m)	Monitored attribute
NSW State	GW093067	-30.9610	150.0019	213604	6570864	Hoskissons coal seam	<10	Level
NSW State	GW966649	-31.0138	150.0277	216226	6565069	Napperby Fm	<0.1	Level
NSW State	GW966650	-31.0071	150.0284	216270	6565821	Napperby Fm	<0.1	Level
NSW State	GW966694	-31.0285	150.0467	218081	6563489	Napperby Fm	<0.1	Level
NSW State	GW966648	-31.0173	150.0229	215776	6564679	Napperby Fm	<0.1	Level
NSW State	GW966647	-31.0185	150.0210	215606	6564535	Napperby Fm	<0.1	Level
NSW State	GW966695	-31.0291	150.0460	218025	6563419	Napperby Fm	<0.1	Level
NSW State	GW966645	-31.0148	150.0197	215467	6564939	Napperby Fm	<0.1	Level
NSW State	GW970844	-31.0112	149.9612	782716	6565395	Pamboola Fm	<0.1	Level
NSW State	GW036499_1	-30.9468	149.9020	777250	6572685	Alluvium	0	Level
NSW State	GW036499_2	-30.9468	149.9020	777250	6572685	Alluvium	0	Level
NSW State	GW036499_3	-30.9468	149.9020	777250	6572685	Alluvium	0	Level
NSW State	GW036544_1	-30.9473	149.9084	777859	6572608	Alluvium	0	Level
NSW State	GW036544_2	-30.9473	149.9084	777859	6572608	Alluvium	0	Level
NSW State	GW036544_3	-30.9473	149.9084	777859	6572608	Alluvium	0	Level
Santos	Kahlua 2	-30.9832	150.0100	214444	6568424	Hoskissons coal seam	>150	Flow/Level
Santos	Kahlua 3	-30.9870	150.0098	214436	6567997	Hoskissons coal seam	>150	Flow/Level
Santos	Kahlua 4	-30.9797	150.0126	214687	6568815	Hoskissons coal seam	>150	Flow/Level
Santos	Kahlua 5	-30.9801	150.0056	214016	6568755	Hoskissons coal seam	>150	Flow/Level

2 GDA 1994 Zone 56.



LEGEND

Kahlua bores

Cenozoic Sedementary Province
- Q_af - Alluvial floodplain deposits
- Q_avf - Alluvial fan deposits
- Q_cr - Colluvial and residual deposits
- Q__m_b - Marra Creek Formation - back plain facies
- Q__m_c - Marra Creek Formation - channel facies
- Q__m_m - Marra Creek Formation - meander plain facies

Permian Mesozoic Igneous Province
- J__g - Garrawilla Volcanics
- J__l - Glenrowan Intrusives

Permo Triassic Basin
- Tutn - Napperby Formation
- Tutd - Digby Formation
- Pbj - Black Jack Group
- Pbb - Brothers Subgroup
- Pmiw - Watermark Formation

Structures
- Fault, position approximate
- Fault, inferred (geological mapping)
- Fault,inferred (AGE)

Kahlua Pilot Reactivation Groundwater Assessment (SAN5001.001)

Proposed groundwater monitoring locations during pilot operation

AGE

DATE: 19/07/2022

FIGURE No: **7.1**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\SAN5001.001 Kahlua Pilot Reactivation Groundwater Assessment\3_GIS\Workspaces\001_Deliverable1\07.01_SAN5001.001_Proposed groundwater monitoring locations during pilot operation.qgs

8 Conclusions

The Kahlua pilot project has been assessed against the relevant NSW state and Australia federal groundwater impact assessment criteria. This has included relevant, and recently issued, water sharing plan rules for the MDB porous rock groundwater source (Gunnedah Oxley Basin) and the Namoi Alluvial groundwater source (Zone 2), the NSW AIP minimal impact considerations and the EPBC Act water trigger criteria.

A summary of the impact assessment results is provided below. Consistent with the temporary nature and depth of the extraction and the relatively minor volumes to be extracted impacts are expected to be negligible.

8.1 Interpreted impacts

8.1.1 Groundwater take

The proposed pilot reactivation will involve a direct take from Permian age units, primarily the Hoskissons coal seam, which forms part of the Gunnedah-Oxley Basin MDB Groundwater Source. As such the expected direct take of 24 m^3/d (or around 9 ML/yr) exceeds the NSW water management (general) regulation (2018) threshold of 3 ML/yr which also applies to exploration activities. Additional licences for extraction from the Gunnedah-Oxley Basin MDB Groundwater Source will therefore need to be acquired, despite the temporary nature of the extraction. However, this groundwater source is currently significantly under-allocated and has had several controlled allocation periods of interest between 2017 and 2020. Most recently, the Controlled Allocation Order (Various Groundwater Sources) 2020 offered 4,043 shares of the Gunnedah-Oxley Basin MDB Groundwater Source.

Indirect take from other overlying WSP units is expected be neglible since predicted drawdown impacts do not extend beyond the Coogal sub-group of the Black Jack Group, which the Hoskissons coal seam forms part of.

8.1.2 Aquifer interference policy

Predicted drawdown impacts do not extend beyond the Coogal sub-group of the Black Jack Group (i.e. around 300 m below ground at the Project site). As such no impacts on water levels and/or water quality at sensitive receptors including existing water supply bores which target shallower units and surficial GDEs and IDEs are predicted.

8.1.3 EPBC Act water trigger

As discussed above in relation to the NSW AIP, predicted impacts are expected to be minor or negligible and temporary and are therefore unlikely to result in reduction in the current and future utility of affected aquifers. As such, the impacts are not considered to represent a ‘significant impact’, and therefore, are interpreted not to require referral under the EPBC Act water trigger.

8.2 Monitoring

While impacts are expected to be negligible, a monitoring program is proposed in order to validate the assessment predictions and inform any future development assessments that may be required. In addition to monitoring of extraction volumes and/or groundwater levels in the Project pilot wells data from a number of existing nearby groundwater level monitoring points will be collated and reviewed after 12 and 24 months of commencement of operation. Review results would then be provided to the NSW Office of Water, highlighting any evidence of impacts in excess of those predicted, within eight weeks.

Due to the temporary nature of the proposed extraction and minor nature of the predicted impact no water level or water quality triggers have been identified at this stage.

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Appendix A

Other applicable guidance and policies

NSW State Groundwater Policy Framework Document

The objective of the NSW State Groundwater Policy Framework Document (Department of Land and Water Conservation (DLWC) (1997) is to manage the State's groundwater resources so that they can sustain environmental, social and economic uses for the people of NSW. The NSW groundwater policy has three component parts:

- NSW Groundwater Quantity Protection Policy (DLWC, 1997a)
- NSW Groundwater Quality Protection Policy (DLWC, 1998)
- NSW Groundwater Dependent Ecosystems Policy (DLWC, 2002)

NSW Groundwater Quantity Protection Policy

The principles of this policy include:

- Maintain total groundwater use within the sustainable yield of the aquifer from which it is withdrawn.
- Groundwater extraction shall be managed to prevent unacceptable local impacts.
- All groundwater extraction for water supply is to be licensed. Transfers of licensed entitlements may be allowed depending on the physical constraints of the groundwater system.

These principles are implemented under the NSW *Water Management Act 2000* and the AIP, which have been discussed above.

NSW Groundwater Quality Protection Policy

The objective of this policy is the ecologically sustainable management of the State's groundwater resources so as to:

- Slow and halt, or reverse any degradation in groundwater resources.
- Direct potentially polluting activities to the most appropriate local geological setting to minimise the risk to groundwater.
- Establish a methodology for reviewing new developments with respect to their potential impact on water resources that will provide protection to the resource commensurate with both the threat that the development poses and the value of the resource.
- Establish triggers for the use of more advanced groundwater protection tools such as groundwater vulnerability maps or groundwater protection zones.

These objectives are considered by assessing the project against the requirements outlined in the relevant WSP and the AIP. This includes incorporating the environmental values (beneficial use category) and trigger values outlined in National Water Quality Management Strategy (NWQMS), presented below, into the impact assessment criteria outlined into the AIP.

NSW Groundwater Dependent Ecosystems Policy

This policy was designed to protect ecosystems that rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations.

The objectives of this policy are considered by assessing the project against the requirements outlined in the WSP and the AIP. This includes criteria to be protective of groundwater dependent ecosystems.

Australian Drinking Water Guidelines

The Australian Drinking Water Guidelines (ADWG) (NHMRC, 2013) provide a framework for the appropriate management of drinking water supplies to achieve a safe and appropriate point of supply. The guidelines provide a base standard for aesthetic and health water quality levels.

Groundwater in the WSP for the alluvial groundwater sources has drinking water listed as a beneficial use and therefore these criteria need to be considered in the assessment of impacts.

National Water Quality Management Strategy

The NWQMS provides a national framework for improving water quality in Australia's waterways. The main policy objective of the NWQMS is to achieve sustainable use of the nation's water resources; protecting and enhancing their quality, while maintaining economic and social development. The NWQMS process involves community and government interaction, and implementation of a management plan for each catchment, aquifer, estuary, coastal water or other water body. This includes the use of national guidelines for local implementation.

The NWQMS policy and principles document (ARMCANZ/ANZECC, April 1994) provides an overview of the principles for water quality management in Australia. The primary objective of the guideline/policy is:

"to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development".

The policy and principles document states that:

"the generally accepted mechanism for establishing in-stream or aquifer water quality requirements is a two-step process which involves:

- establishing a set of environmental values, and
- establishing scientifically based water quality criteria corresponding to each environmental value".

Environmental values are often interchanged with the term beneficial use (which is referred to in regard to minimum impact criteria in the AIP) and are identified in the guidance to include:

- Ecosystem protection
- Recreation and aesthetics
- Drinking water
- Agricultural water (irrigation and stock water)
- Industrial water

Ecosystem protection, in this context, refers to ecosystems, which depend at least in part on groundwater to maintain ecosystem health (groundwater dependent ecosystems). Depending on the site setting, this may include surface water bodies such as wetlands, streams and rivers reliant on groundwater base flow, some estuarine and near-shore marine systems, as well as aquifer and cave ecosystems and terrestrial ecosystems with groundwater dependence.

Criteria have been developed to characterise water quality relative to these environmental criteria and are discussed further below.

The criteria presented below have been considered as the basis for assessing:

- The current environmental values (beneficial use category in the AIP) of groundwater and receiving water bodies on which impacts can be assessed.
- Management requirements for discharge to receiving water environments, which could include:
  - Discharge to surface water along current pathways or by direct discharge
  - Discharge to groundwater
  - Discharge to land

Australian and New Zealand Guidelines for Fresh and Marine Water Quality

For this project, the national guidelines on water quality benchmarks within the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) (previously ANZECC (2000)) are applicable and provide default trigger values of various analytes for comparison with sampled values.

Water criteria are presented in the guidelines for:

- Aquatic Ecosystems
- Primary Industries (which includes agricultural and industrial water criteria).

The ANZG (2018) guidelines for protection of 95% of species in freshwater ecosystems have been used as trigger values for assessing current groundwater quality as the catchments are moderately disturbed by agricultural activities.

Appendix B

Kahlua Well Completion Reports

SANTOS QNT PTY LTD
(As Operator for and on behalf of the title holder ACM)

Kahlua 1

WELL COMPLETION REPORT

PEL 1

Prepared by:

Earth Data Pty. Ltd. (P. Skeet, M. Harkins, J. Howard)
For
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF DIGITAL DATA

Table 1: Well Data Card

Well Name:	Kahlua 1	Well Type:	CSG Corehole

Final post-drill survey data

Licence:	Petroleum Exploration Licence 1 ("PEL 1")	Joint Venture:	ACM	Latitude: (GDA94, z55)	30° 58' 01.4" S / 6570215mE
Equity:	100%	Budget Status:	Budget Item	Longitude: (GDA94, z55)	150° 00' 41.6" E /214547mN
				Seismic Reference:	N/A
Voting (%)					
Santos QNT Pty Ltd				Ground Level:	294.4 m.a.s.l.
				Rotary Table:	0.9m
				Rig:	McDermott Rig 29 KWL1600
				Nearby Facilities:	

Drilling Timing		Drilling Details:	
Spud Date:	26th July 2008 at 14:00hrs	TD (driller):	660.65mGL (-365.61mSS)
TD Reached Date:	1st September 2008 at 17:30hrs	TD (logger):	661.4mGL (-367.0mSS)
Rig Release Date:	16th September 2008 at 12:00hrs	Well Status:	ABGS

Net Pay

Coal Seam	Top (mRT)	Base (mRT)	Net Coal (m)
Black Jack Fm			
Hoskissons Coal A	251.3	252.7	1.4
Hoskissons Coal B	255.9	262.9	7.0
Melvilles Coal Seam	303.1	307.0	3.9
Maules Creek Fm			
Maules Creek Coal A	555.8	557.7	1.9
Maules Creek Coal B	609.4	612.1	2.8
Maules Creek Coal C	625.0	627.3	2.3

Stratigraphy

Formation top picks below are based on wireline logs.

Formation	GL Depth (m)	Subsea Depth (m)	Thickness (m)
Surface (Alluvium)	0.0	-294.4	32.1
Napperby Fm	32.1	-262.3	96.2
Digby Fm (Ulinda Sst)	128.3	-166.1	13.1
Bomera Conglomerate	141.4	-153.0	17.2
Black Jack Group	158.6	-135.8	
Trinkey Fm	158.6	-135.8	36.7
Wallala Fm	195.3	-99.1	21.5
Clare Sandstone	216.8	-77.6	18.6
Benelabri Fm	235.4	-59.0	15.9
Hoskissons Coal Seam	251.3	-43.1	11.6
Arkarula Fm	262.9	-31.5	27.1
Pamboola Fm	289.9	-4.5	62.5
Melvilles Coal Seam	303.1	8.7	3.9
Watermark Fm	356.3	61.9	142.2
Porcupine Fm	498.5	204.1	57.3
Maules Creek Fm	555.8	261.4	71.5
Leard Fm	627.3	332.9	24.4
Boggabri Volcanics	651.7	357.3	9.7
Total Depth	661.4	367.0	

Formation Evaluation

Wireline Logging:

Run	Log	From (mRT)	To (mRT)
1	Gamma Ray-Density	661.4	Surface
1	Neutron-Sonic-Caliper-Resistivity	661.4	110.0
2	Acoustic Scanner	641.6	548.4
2	Acoustic Scanner	321.8	158.7

SWC's:	Nil
MDT's:	Nil
Velocity Survey:	Sonic log

Formation Testing:
DST #1 – 248.0 – 264.6m
DST #2 – 299.4 – 330.6m
DST #3 – 605.0 – 635.0m
DST#4 – 248.0 – 264.6m

Coring:	Coring was conducted between 116m to TD.
Desorption Samples:	35 Desorption Samples. See document for further details.

Hole Design / Drilling

Well Class:	CSG Corehole	
Hole Type:		
Hole Size	Depth	Casing Size
8½ " (216 mm)	6.0 m	6 ½ " (165 mm)
6 1/8" (156 mm)	115 m	4 ½" (114 mm)
96 mm (HQ) Core	660.65 m (TD)	N/A
Drill Fluid:	Town Supply/KCl/Polymer	

Dev:	MD (mRT)	TVD (mRT)	Incl (°)	Azim (°)

Mud Logging	One set of ditch cuttings were collected and bagged at 6m intervals from surface to core point.
Nearby Wells	DM Benelabri 1 (1.2km along strike to north-west)

General Comments :

Personnel:

Project Leader	Final Wellcard Compiled By	Operations Geology	Drilling Engineer
Carl D'Silva	Carl D'Silva	Andy Pietsch	Jordan Bunning

1 INTRODUCTION

Kahlua 1 is the first dedicated Coal Seam Gas "CSG" corehole to be drilled in PEL 1 as part of the Santos (QNT) Pty Ltd. farm-in commitment and work programme with Australian Coalbed Methane (ACM) Pty Ltd. The drilling objective of Kahlua 1 was to provide additional data on the stratigraphy and coal development of the Late Permian Black Jack Group and Early Permian Maules Creek Coal seams. The Hoskissons Coal Seam and Melvilles Coal Seams of the Black Jack Group were the primary targets of the corehole.

Kahlua 1 spudded at 14:00 hours on 26th July 2008. The well penetrated a sequence containing the early to mid Triassic Napperby Formation, the early Triassic Digby Formation, the late Permian Black Jack Group, the late Permian Watermark and Porcupine Formations, and the early Permian Maules Creek Formation comprising several laterally extensive coal seams which were the secondary target of the hole. The hole reached Total Depth (TD) within the early Permian Boggabri Volcanics which comprised weathered and altered Rhyolites and Basalt.

The 8½" (216 mm) conductor hole was drilled to 6m and 6½" (165 mm) conductor pipe cemented in place. The surface hole 6 1/8" (156 mm) was drilled to 114.88m and 4½" (114mm) casing cemented to surface within the Napperby Formation. HQ coring commenced from this point and continued until Total Depth "TD" was reached at 17:30 hours on 1st September 2008 with a final depth of 660.65m (driller). Throughout the cored interval, gas monitoring and gas desorption sampling were carried out on-site, with a total of thirty five gas desorption samples collected. Earth Data Pty Ltd. provided the well-site geological supervision and desorption sample monitoring at Kahlua 1.

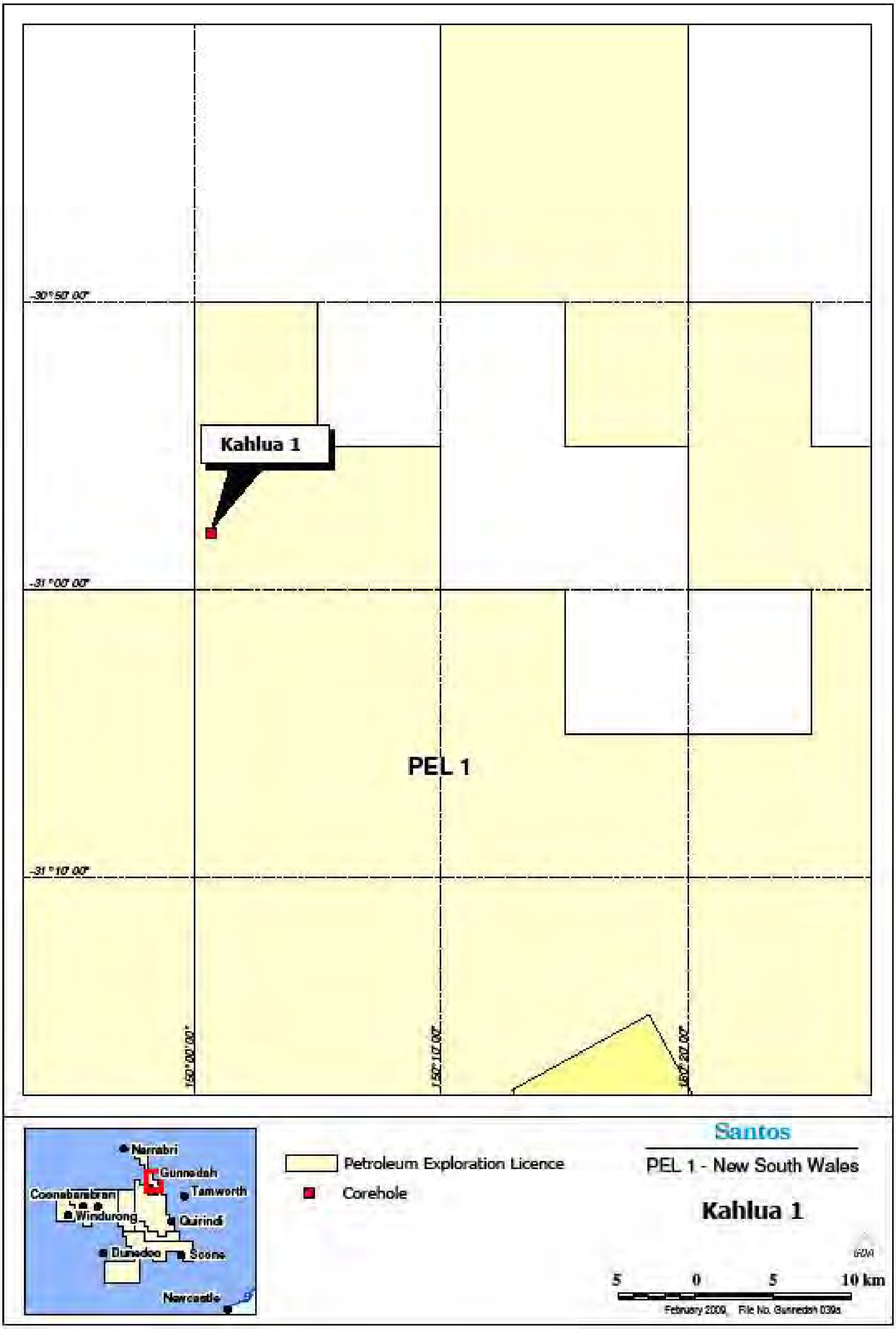
A complete set of wireline logs was run at TD. In addition, a total of four drill stem tests (DSTs) was carried out both on-penetration testing as well as at the completion of drilling. Kahlua 1 was plugged and abandoned at the completion of the testing program and the rig was released at 12:00 hours on the 16th September 2008.

2 WELL HISTORY

2.1 General Data

Well Name and Number:		KAHLUA 1
Location:	Latitude:	30º 58’ 01.4" S
	Longitude:	150º 00' 41.6 " E
MGA (Zone 56) Easting:		657 0215 m
MGA (Zone 56) Northing:		214547 m
Elevations:	G.L.:	294.4m A.S.L.
	K.B.:	295.3m A.S.L. (all depths referenced to GL)
Petroleum Tenement:		Petroleum Exploration Licence No. 1
Permit Holder:		AUSTRALIAN COALBED METHANE PTY LTD (“ACM”)
Farm-in Partner		SANTOS QNT PTY LTD A.B.N. 33 083 077 196 Level 14 Santos House 60 Edward Street Brisbane Qld 4000 Ph: (07) 3838 3666
Drilling Contractor:		McDermott Drilling Pty Ltd 24-26 Airds Road Minto, NSW 2566
Drilling Rig:		Rig #29
Date Drilling Commenced:		14:00hrs on 26th July 2008
Date Drilling Completed:		17:30hrs on 1st September 2008
Date Rig Released:		12:00hrs on 16th September 2008
Drilling time to T.D.:		51.92 days
Total Depth: Driller		660.65m
Logger		661.40m
Status:		Plugged and Abandoned

Figure 1: Location Map



2.2 Drilling Data

2.2.1 Drilling Data Summary

Below is a summary of drilling operations at Kahlua 1, compiled from the daily drilling reports (**Appendix 1)**. A Santos Drilling Supervisor was present on-site at all times to supervise drilling operations, manage third party contractors as well as monitor safety and environmental concerns at the rig-site. Further details are provided in the time/depth curve (Figure 2) and in the Well Schematic (Figure 3).

2.2.1.1 Conductor Hole

Size: 10.0” (254 mm)
Interval: 0 – 6 m
Drilling Fluid: Air

Kahlua 1 spudded at 14:00 hours on 26th July 2008. The 10” (254 mm) hole section was auger-drilled to 6 m with 6½” (165 mm) conductor casing set and cemented to 6 m.

2.2.1.2 Surface Hole

Size: 6 1/8” (156 mm)
Interval: 6 – 116 m (shoe at 114.9 m)
Drilling Fluid: Water and KCl

The 6.125” hole section was drilled to 116m. A total of 21 joints of 4 ½” (114mm) K-55, BTC/SFJ casing were run in and set at 114.9m. A total of 261 sacks of cement at 14.00ppg with 9.30gal/sx of mix-water used to cement to surface. Cement returns were good while pumping and displacing cement. The casing was then pressure tested to 500psi using the HQ core barrel.

2.2.1.3 Cored (HQ) Hole Section

Size: 3 7/9” (96 mm) (HQ)
Interval: 116 – 660.7 m
Drilling Fluid: KCl/Polymer

After drilling out the shoe, the 3 7/9” (96 mm) HQ core hole was drilled to a TD of 660.65 m. Three potential target coal seams were intersected within the Black Jack Group and three in the Maules Creek Formation, with thirty five desorption samples taken from within these formations. On completion of wire line logs and DST’s, the hole was plugged and abandoned (refer to section 2.2.6 for details of plugs).

McDermott Rig 29 was released at 12:00 hours on 16th September 2009. The rig then moved to the next location at Pibbon North 1. The final well surveying report is attached in **Appendix 2**.

2.2.2 *Casing and Cementing*

Refer to the Well Schematic and Casing and Cementing Summary below (Table 2).

Table 2 – Casing and Cementing Summary

Conductor		
Hole/Casing Size	-	10" / 6½" (254mm / 165 mm)
Shoe Setting Depth	-	6.0 m
Quantity of Cement	-	5 sacks of cement at 14.00 PPG
Interval Cemented	-	6m – to surface
Surface		
Hole/Casing Size	-	6⅛" / 4½" (156 mm / 114 mm)
Weight	-	11.6lbs/ft
Grade	-	K-55
Shoe Setting Depth	-	114.88 m
Quantity of Cement	-	72 sacks of cement at 14.00 PPG
Interval Cemented	-	116 – Surface

2.2.3 *Deviation Surveys*

No deviation survey tools were recorded whilst drilling. However, deviation of the well was recorded as part of the acoustic scanner tool.

2.2.4 *Drilling Fluid Data*

Materials used in the mud system whilst drilling this hole include a small amount of liquid polymer to assist in cuttings recovery and KCl (2-5%) to assist in maintaining mud weight and minimise clay swelling.

(a) 0 – 6 m Air
(b) 6 – 116 m Air and water
(c) 116 – 660.65 m KCl/ Polymer Mud

2.2.5 *Water Supply*

Water was obtained from local council water supply in Gunnedah and brought to site in a water tanker.

2.2.6 *Plugs*

The well was cemented on the 15th September 2008 using 261 bags cement/water mix at 14.00 PPG. The top of the plug was tagged at 110m (Figure 3). The cemented section was tested at 500 psi for 10 minutes before the well was capped. McDermott Rig 29 was released at 12:00hrs on 16th September 2008.

Figure 2: Drilling Time-Depth Curve

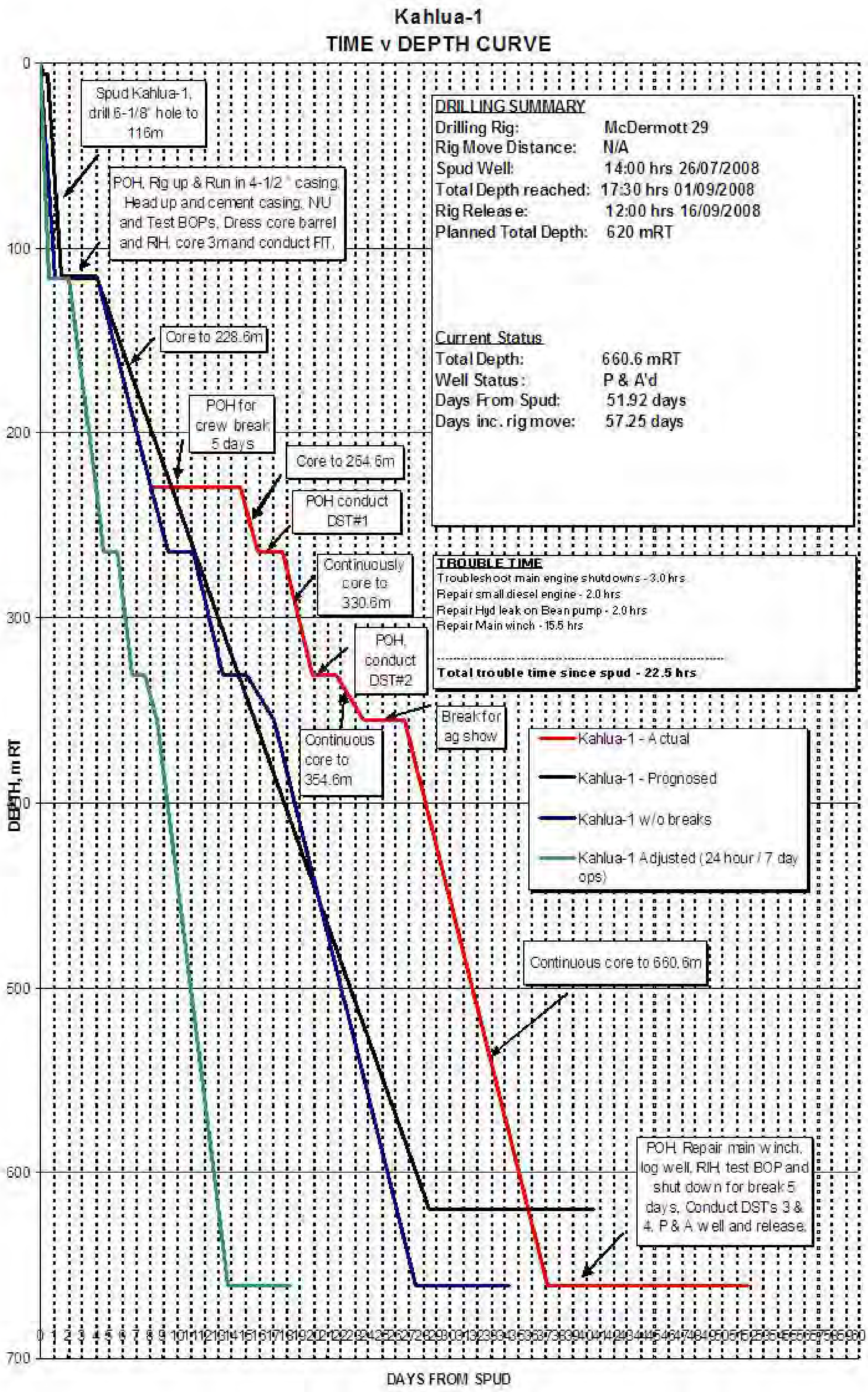
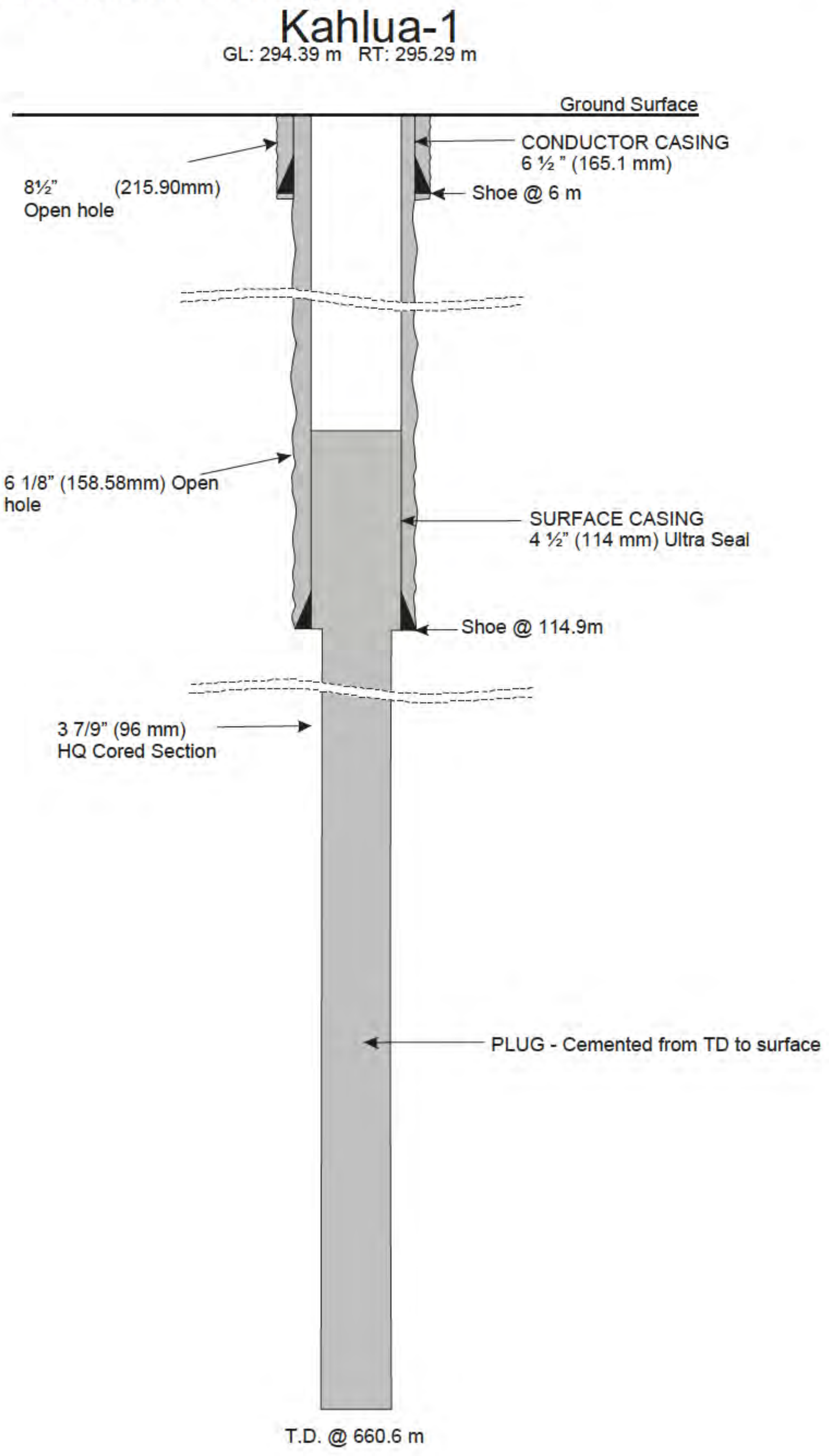


Figure 3: Well Abandonment Summary



2.3 Logging and Testing

2.3.1 Well site Geologist

Earth Data provided geological supervision and desorption testing at Kahlua 1.

2.3.2 Mud logging

Mud logging services were not used on this well. Gas was monitored from surface by Earth Data, with a gas monitor fitted to the end of the flow line. The rig compressor did break down during the course of the hole so only an incomplete set of gas data is available. No visible gas was noted whilst drilling Kahlua 1.

2.3.3 Ditch Cutting Samples

Cuttings were collected at 6 m intervals from the surface to core depth (116 m). Both cuttings samples and the core recovered at Kahlua 1 were sent to the Department of Primary Industries core storage facility in Londonderry, NSW.

The cutting samples and sets were:

Sample Type	No. Sets
Washed	1

2.3.4 Core Logging

HQ coring commenced from 116m to TD (660.65m). Core logging on-site was undertaken by the well site geologist. The geologist's logs are attached in **Appendix 3**. Photographs of the core were taken in the field and the photos are recorded in **Appendix 4**.

Desorption samples were collected across coal intervals greater than 50cm taken. The intervals and formations are outlined in Table 3. The results of these tests will be forwarded when they come to hand.

Table 3: Desorption Samples Canisters for Kahlua 1

Sample Number	Sample ID	Interval From (m)	Interval To (m)	Thickness (m)	Formation	Type
1	KAH1ED754	158.64	159.45	0.81	Trinkey	Desorption
2	KAH1ED841	159.57	160.39	0.82	Trinkey	Desorption
3	KAH1ED837	160.60	161.40	0.80	Trinkey	Desorption
4	KAH1ED750	171.47	172.27	0.80	Trinkey	Desorption
5	KAH1ED838	173.27	174.07	0.80	Trinkey	Desorption
6	KAH1ED840	174.73	175.53	0.80	Trinkey	Desorption
7	KAH1ED839	183.59	184.42	0.83	Trinkey	Desorption
8	KAH1ED747	191.09	191.90	0.81	Trinkey	Desorption
9	KAH1ED842	208.14	208.93	0.79	Wallala	Desorption
10	KAH1ED843	216.79	217.60	0.81	Breeza Coal Member	Desorption
11	KAH1ED669	250.93	251.71	0.78	Hoskissons	Desorption
12	KAH1ED306	251.71	252.51	0.80	Hoskissons	Desorption
13	KAH1ED632	255.85	256.65	0.80	Hoskissons	Desorption
14	KAH1ED905	256.65	257.45	0.80	Hoskissons	Desorption
15	KAH1ED312	257.45	258.25	0.80	Hoskissons	Desorption
16	KAH1ED245	258.25	258.85	0.60	Hoskissons	Desorption
17	KAH1ED291	258.85	259.65	0.80	Hoskissons	Desorption
18	KAH1ED516	259.65	260.45	0.80	Hoskissons	Desorption
19	KAH1ED114	260.45	261.25	0.80	Hoskissons	Desorption
20	KAH1ED063	261.25	262.05	0.80	Hoskissons	Desorption
21	KAH1ED165	262.05	262.84	0.79	Hoskissons	Desorption
22	KAH1ED071	289.80	290.53	0.73	Pamboola	Desorption
23	KAH1ED240	303.03	303.77	0.74	Melvilles Coal Member	Desorption
24	KAH1ED155	303.77	304.55	0.78	Melvilles Coal Member	Desorption
25	KAH1ED117	304.55	305.36	0.81	Melvilles Coal Member	Desorption
26	KAH1ED023	305.36	306.14	0.78	Melvilles Coal Member	Desorption
27	KAH1ED563	306.14	306.94	0.80	Melvilles Coal Member	Desorption
28	KAH1ED041	555.71	556.45	0.74	Maules Creek A	Desorption
29	KAH1ED109	557.14	557.69	0.55	Maules Creek A	Desorption
30	KAH1ED064	609.33	610.13	0.80	Maules Creek B	Desorption
31	KAH1ED518	610.13	610.93	0.80	Maules Creek B	Desorption
32	KAH1ED502	610.93	611.49	0.56	Maules Creek B	Desorption
33	KAH1ED173	624.93	625.76	0.83	Maules Creek C	Desorption
34	KAH1ED577	625.90	626.69	0.79	Maules Creek C	Desorption
35	KAH1ED029	626.69	627.48	0.79	Maules Creek C	Desorption

On completion of the desorption program, the coal from each canister was logged in detail before the core was slabbed in half with one half returned back to the core boxes. Table 4 summarises the testing requested with the results of the tests will be forwarded to the DPI once they come to hand. Sub-samples of each sample canister were removed for residual gas, adsorption isotherm, vitrinite reflectance, rank determination and proximate analyses.

Table 4 – Additional Sampling Submitted for Coal Analysis

Sample ID	Formation	True SG	Proximate Analysis	Adsorption Isotherm	Ultimate Analysis	Maceral Analysis	Vitrinite Reflectance
KAH1ED754	Trinkey	Yes	Yes	No	No	Yes	No
KAH1ED841	Trinkey	Yes	Yes	No	No	Yes	No
KAH1ED837	Trinkey	Yes	Yes	No	No	Yes	No
KAH1ED750	Trinkey	Yes	Yes	No	No	Yes	No
KAH1ED838	Trinkey	Yes	Yes	No	No	Yes	No
KAH1ED840	Trinkey	Yes	Yes	No	No	Yes	No
KAH1ED839	Trinkey	Yes	Yes	No	No	Yes	No
KAH1ED747	Trinkey	Yes	Yes	No	No	Yes	No
KAH1ED842	Wallala	Yes	Yes	No	No	Yes	No
KAH1ED843	Breeza Coal	Yes	Yes	No	No	Yes	No
KAH1ED669	Hoskissons	Yes	Yes	No	No	No	No
KAH1ED306	Hoskissons	Yes	Yes	No	No	No	No
KAH1ED632	Hoskissons	Yes	Yes	No	No	No	No
KAH1ED905	Hoskissons	Yes	Yes	No	No	No	No
KAH1ED245	Hoskissons	Yes	Yes	No	No	No	No
KAH1ED312	Hoskissons	Yes	Yes	No	No	No	No
KAH1ED291	Hoskissons	Yes	Yes	No	No	No	No
KAH1ED516	Hoskissons	Yes	Yes	No	Yes	Yes	Yes
KAH1ED114	Hoskissons	Yes	Yes	No	No	No	No
KAH1ED063	Hoskissons	Yes	Yes	No	No	No	No
KAH1ED165	Hoskissons	Yes	Yes	No	No	No	No
KAH1ED071	Pamboola	Yes	Yes	No	No	No	No
KAH1ED240	Melvilles Coal	Yes	Yes	No	No	No	No
KAH1ED155	Melvilles Coal	Yes	Yes	No	No	No	No
KAH1ED117	Melvilles Coal	Yes	Yes	No	No	No	No
KAH1ED023	Melvilles Coal	Yes	Yes	No	No	No	No
KAH1ED563	Melvilles Coal	Yes	Yes	Yes	No	No	No
KAH1ED041	Maules Creek A	Yes	Yes	No	No	No	No
KAH1ED109	Maules Creek A	Yes	Yes	No	No	No	No
KAH1ED064	Maules Creek B	Yes	Yes	Yes	No	Yes	Yes
KAH1ED518	Maules Creek B	Yes	Yes	No	No	Yes	Yes
KAH1ED502	Maules Creek B	Yes	Yes	No	No	No	No
KAH1ED173	Maules Creek C	Yes	Yes	No	No	No	No
KAH1ED577	Maules Creek C	Yes	Yes	No	No	Yes	Yes
KAH1ED029	Maules Creek C	Yes	Yes	No	No	No	No

2.3.5 Wireline Logs

Weatherford Australia Pty Ltd provided slim-hole wireline services at Kahlua 1. A complete suite of wireline logs was run in multiple runs at Kahlua 1 (See Table 5). In addition, an Acoustic Scanner tool was run across the coal intervals to determine borehole break-out and coal fracture orientations. Wireline logs are attached in **Enclosure 1**.

Table 5 – Wireline Logs Summary

Log Type	**Interval Run**
SP	115 – 656m
RR5 (resistivity or laterolog)	662 – 115m
DD6 (Gamma, Calliper, Dual density)	661 – 2m
MS2 (multichannel sonic)	660 – 115m
NN2 (Gamma, neutron Porosity)	661 – 115m
TT2 (Temperature)	660 – 115m
ALT Fac 40 (Acoustic Scanner)	640 – 550m and 312 – 155m

2.3.6 Temperature Survey

The maximum temperature recorded was 43°C at the bottom of the hole.

2.3.7 Drill Stem Tests (DST)

DST Australia Pty Ltd. completed four drill stem tests at Kahlua 1. The results from the tests are contained in **Enclosure 2**. Permeability of the coals was determined through two on-penetration drill stem tests and two drill stem test at Kahlua 1 reaching TD. Intervals tested included:

DST #1 – 248.0 – 264.6 m (Hoskissons Coal)
DST #2 – 299.4 – 330.6 m (Melvilles Coal)
DST #3 – 605.0 – 635.0 m (Maules Creek Coal Measues)
DST#4 – 248.0 – 264.6 m (Re-test of Hoskissons Coal)

3 GEOLOGY

3.1 Reasons for Drilling

Kahlua 1 was drilled as a dedicated coal seam gas well to provide knowledge on the stratigraphy of the Gunnedah Basin as well as to determine the coal development and gas content in the Permian Black Jack Group and Maules Creek Formation at this location. The primary target was the Hoskissons Coal with the Melvilles Coal Member and Maules Creek Coals providing secondary target.

3.2 Reservoir

The coal seams intersected at Kahlua 1 comprised the Late Permian Black Jack Group including the Breeza Coal Member, the Hoskissons Coal and the Melvilles Coal Member along with the Early Permian coals of the Maules Creek Formation.

The seams and members differ in thickness with the Breeza CM being roughly 1m, the Hoskissons Seam being roughly 12m thick with a 3m intrusion towards the top of the unit, and the Melville's CM being 4m thick. In the Early Permian Maules Creek Formation three seams were intersected ranging in thickness from 2-3m. These coals are generally vitrinite-poor (dull) with minor bright bands.

Several of these coal units are very distinctive, laterally extensive and prominent stratigraphic marker units, namely the Hoskissons Coal and the Melville's Coal Member. Several igneous intrusions are also present within the area giving rise to some gaseous and partially cindered coals.

Refer to the geologists logs for more details (Appendix 3).

3.3 Stratigraphic Prognosis

The stratigraphy of the Gunnedah Basin including the Permian Black Jack Group and earlier Maules Creek Formation can be seen in Figure 4. Kahlua 1 spudded into the Mid Triassic sediments of the Napperby Formation. Depth prognoses were based on nearby wells and some seismic data.

The Black Jack Group lies unconformably under the Bomera (Digby) Conglomerate. The uppermost formation of this group is the Trinkey Formation (36.68m thick), comprising coals, carbonaceous mudstones, tuffs with interbedded sandstone and siltstone. A total of eight desorption samples were taken from this formation with coal quality ranging from dull banded to mainly dull and stony coal.

The Breeza Coal Member is a thin (0.87m) seam of low quality (dull) coal with a tuff band at the centre and carbonaceous mudstone at the top of the unit. It is within the Clare Sandstone at the base of a conglomeratic section of the Wallala Formation.

The Hoskissons Coal (~12m) is overlain by the Benelabri Formation containing interbedded sandstone and siltstone with carbonaceous mudstone. The Hoskissons Seam is uniformly dull coal however where it is in proximity to the intrusion it has been heat altered and cleats have been heavily in-filled with calcium carbonate.

The Melvilles Coal Member is a thick (~4m) seam within the Pamboola Fm, mainly comprising sandstone and siltstone with some bands of coal. The coal quality ranges from dull-dull and bright and is generally upward brightening.

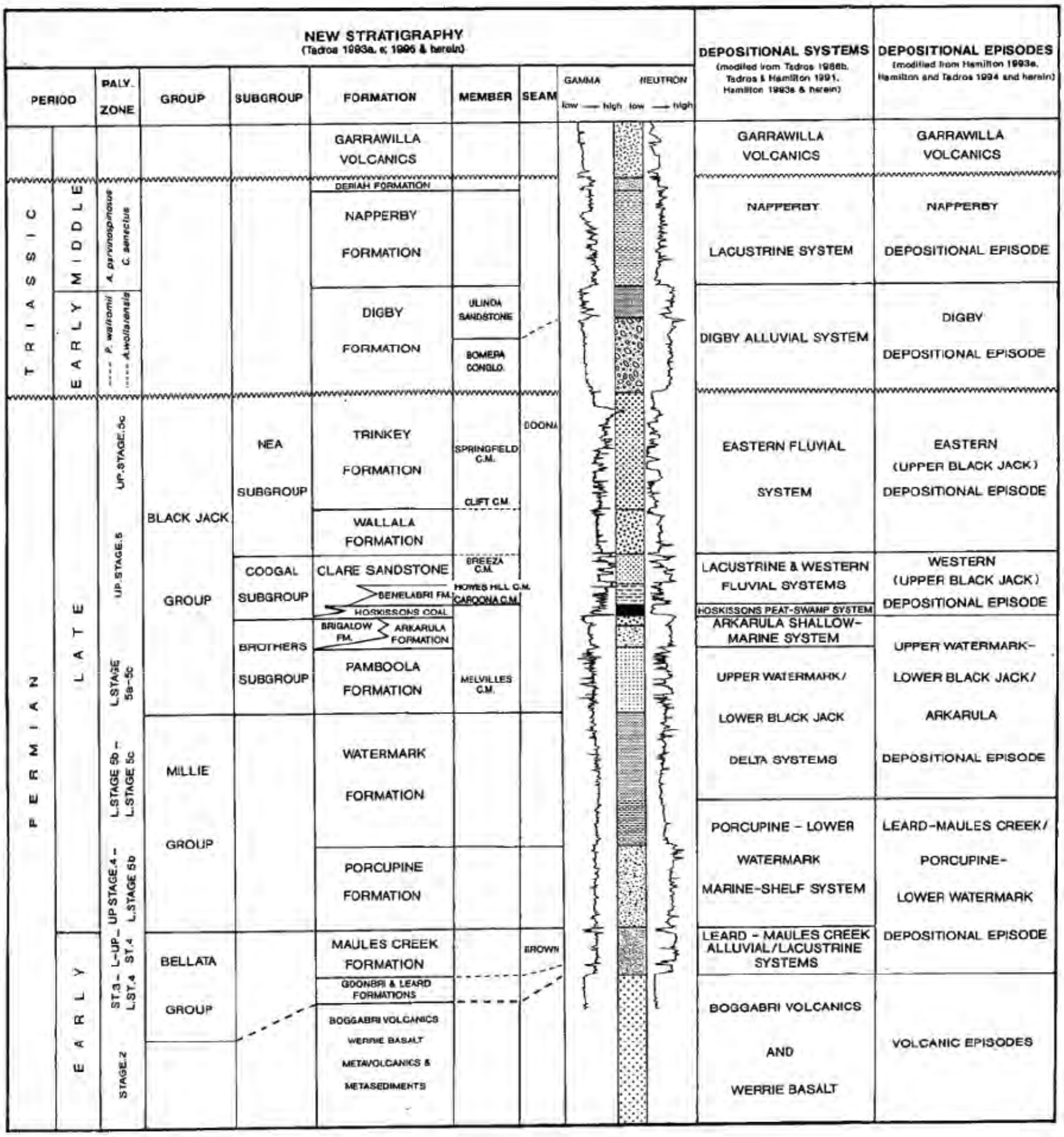
The Maules Creek Formation is composed of conglomerates, sandstone and siltstone with carbonaceous mudstone and coal seams. The coal quality is dull with bright bands. Only the lower seams, Maules Creek Coal B & C exhibit the bright banded coals, overall the coal is dull-dull minor bright. The Maules Creek Formation overlies and has a gradational contact with the underlying Leard Formation as the pelletal claystone of the Leard Fm is interbedded with the basal coals of the Maules Creek Fm. The intersected stratigraphy (as interpreted from wireline logs) at Kahlua 1 is outlined below in Table 6.

There were no aquifers intersected within cored section at Kahlua 1.

Table 6: Stratigraphy Summary

Formation	**Actual Top (m GL)**	**Predicted Top (m GL)**	**Difference (m)**
Napperby Formation	32.1	0.0	Low 32.1
Digby Formation	128.3	75.0	Low 53.3
Ulinda Sandstone Member	128.3	75.0	Low 53.3
Bomera Conglomerate Member	141.4	80.0	Low 61.4
Black Jack Group	158.6	95.0	Low 63.6
Trinkey Formation	158.6	95.0	Low 63.6
Wallala Formation	195.3	130.0	Low 65.3
Clare Sandstone	216.8	150.0	Low 66.8
Benelabri Formation	235.4	155.0	Low 80.4
Hoskissons Coal	251.3	180.0	Low 71.3
Arkarula Formation	262.9	-	Not Prognosed
Pamboola Formation	289.9	188.0	Low 101.9
Watermark Formation	356.3	275.0	Low 81.3
Porcupine Formation	498.5	450.0	Low 48.5
Maules Creek Formation	555.8	520.0	Low 35.8
Leard Formation	627.3	-	Not Prognosed
Boggabri Volcanics	651.7	600.0	Low 51.7
Total Depth	**661.4**	**620.0**	

Figure 4: Generalised Stratigraphy of the Gunnedah Basin, NSW (Tadros, 1999)



3.4 Stratigraphy

Refer to the well site geologists logs in Appendix 3. Below is a summary of the stratigraphy as described from the well site geologist.

3.4.1 Napperby Formation (32.1 - 128.3 m)

Sandstone with interbedded Siltstone
Sandstone – light grey, fine to medium grained, occasional silty laminae.
Siltstone – Dark grey, occasional sandy laminae, carbonaceous traces in part.

3.4.2 Digby Formation – Ulinda Sandstone (128.3 – 141.4 m)

Sandstone – light grey, medium to coarse grained quartzose sand, occasional silty laminae, carbonaceous traces.

3.4.3 Digby Formation – Bomera Conglomerate (141.4 – 158.6 m)

Conglomerate – multicoloured, clast supported, pebble to cobble sized clasts, tuffaceous matrix.

3.4.4 Black Jack Group – Trinkey Formation (158.6 – 195.3 m)

Coal – Dull to Dull Banded coal, 8 canisters taken for desorption sampling
Tuff – buff, fine grained, common carbonaceous laminae
Carbonaceous Mudstone – dark grey, tuffaceous laminae and bands throughout, tending to stony coal in part.
Sandstone – light grey, medium to coarse grained, quartz lithic, tuffaceous, massively bedded
Siltstone – grey to dark grey with occasional carbonaceous laminae

3.4.5 Wallala Formation (195.3 – 216.8 m)

Sandstone – light grey, medium to coarse, silty laminae in part, tuffaceous in part, occasional lithic clasts.
Conglomerate – multicoloured, clast supported, granule to cobble sized clasts, light brown sandy matrix.
Tuff – grey/green, very fine grained, silty in part
Carbonaceous Mudstone - dark grey to black, common coaly wisps, tending to occasional dull coal.

3.4.6 Clare Sandstone (216.8 – 235.4 m)

Siltstone – grey to dark grey, carbonaceous laminae and occasional wisps.
Sandstone – light grey, medium to very coarse grained, quartz lithic with occasional lithic pebbles, conglomeratic in part.
Carbonaceous Mudstone – dark grey, common sandy laminae.
Conglomerate – light brown/grey, matrix supported, coarse grained matrix, and pebble sized lithic clasts, occasional fining upwards cycles.
Breeza Coal Member (216.8 – 217.7 m): Dull minor bright coal, one sample taken for desorption sampling.

3.4.7 Benelabri Formation (235.4 – 251.3m)

Siltstone – dark grey common carbonaceous laminae throughout
Sandstone – light grey, fine to medium grained, common carbonaceous laminae and bands throughout.
Carbonaceous Mudstone – black brown, common mudstone laminae, tending to silt in part.

3.4.8 Hoskissons Coal (251.3 – 262.9m)

Coal – Dull, eleven samples taken for desorption sampling, KAH1ED669, KAH1ED306, KAH1ED632, KAH1ED905, KAH1ED245, KAH1ED312, KAH1ED291, KAH1ED516, KAH1ED114, KAH1ED063 and KAH1ED165.
Intrusion – buff, very fine grained, hard, crystalline, little to no quartz, high in feldspar.

3.4.9 Arkarula Formation (262.9 – 289.9m)

Sandstone – grey, medium grained, lithic sand, abundant bioturbation sub vertical mud lined worm burrows, coarsening upwards cycles, may show local fining upwards cycles, occasional quartz drop pebbles.
Siltstone – dark grey, carbonaceous in part, rootlets, abundant bioturbation.

3.4.10 Pamboola Formation (289.9 – 356.3m)

Sandstone – light grey fine to coarse grained lithic sand, common carbonaceous wisps and laminae, fining upwards cycles, occasional cross bedding.
Siltstone – dark grey, common carbonaceous wisps and laminae throughout.
Melvilles Coal Seam (303.1– 307.0m) dull coal, tending to carbonaceous mud.
Tuff – buff, common coaly specks, relatively uncommon.

3.4.11 Watermark Formation (356.3 – 498.5m)

Sandstone – off white fine grained, quart lithic, occasional silty blebs, carbonaceous wisps and traces.
Siltstone – grey, occasional sandy bands, massive, occasional siderite bands,
Intrusion – off white to blue, crystalline, occasional silty blebs, heavy veining with high strength.

3.4.12 Porcupine Formation (498.5 – 555.8m)

Siltstone – grey, sandy throughout, drop clasts, occasional zoophycus (burrows), occasional carbonaceous wisps, occasional mineralised brachiopod fossils, conglomeratic in part.
Conglomerate – para-conglomerate, dark grey matrix of fine to medium grained sands and silts, well cemented, pebble to cobble sized clasts of white and green clastic, occasional carbonate clasts, occasional igneous clasts.

3.4.13 Maules Creek Formation (555.8 – 627.3m)

Sandstone – grey, medium to coarse grained, quartz lithic sand, sub rounded to sub angular, well cemented, poorly sorted, common carbonaceous and coaly traces and lenses.
Siltstone – grey to dark grey, occasional carbonaceous specks and laminae.

Conglomerate – off white to grey, ortho-conglomerate tending to para-conglomerate in part, pebble sized sub rounded clasts of volcanics and lithics, dark grey and green in colour, medium to coarse sandy matrix.
Coal – dull coal, tending to carbonaceous mudstone in part, several small seams within the Maules Creek Formation, named Maules Creek A, B, C.
Carbonaceous Mudstone – black brown, tending to stony coal in part.
Claystone – brown to buff coloured claystone, comprising many rounded clay pellets with gradational boundary.

3.4.14 Leard Formation (627.3 – 651.7m)

Pelletal claystone – brown to buff coloured claystone, comprising many tuffaceous rounded kaolin clay pellets, common carbonaceous laminae.
Coal – common thin bands of dull coal, little visible free gas.

3.4.15 Boggabri Volcanics (651.7 – 661.40m)

Weathered and altered intermediate to basic volcanics – red, purple and blue coloured clasts, iron staining, mottled appearance, very hard, igneous inclusions, quartz veining throughout.

3.4.16 Total Depth

Driller: 660.65 m
Logger: 661.40 m

3.5 Hydrocarbon Shows

Due to an incomplete set of data from the gas detector as a result of the compressor failure on the rig, there is no CH_4 vs. time graph available.

4 DISCUSSION AND CONCLUSIONS

Kahlua 1 was the first corehole drilled as part of the 2008 Santos Gunnedah Coring Programme. The hole reached Total Depth (TD) within the early Permian Boggabri Volcanics which comprised weathered intermediate to basic volcanics.

There was good well control at Kahlua 1 with the nearby DM Benelabri coreholes providing geological control. However, formation tops intersected at Kahlua 1 were approximately 60m lower than prognosed due to Kahlua 1 being present on the down-thrown side of a fault with DM Benelabri 1 on the up-thrown block. This fault is confirmed on surface geological mapping.

The primary target of the Hoskissons Coal of the Black Jack Group was found to be ~12m thick. However, the coal seam was intruded by a 3.3m sill and found to be cindered close to the intrusion. In addition, the Melvilles Coal Member was well developed with a thickness of 3.9m.

The secondary target coals of the Early Permian Maules Creek Formation were intersected as three seams, identified as Maules Creek Coal A, B and C. A total of ~7m of gross coal was intersected from the Early Permian sequence.

Permeability of the coals was determined through two on-penetration drill stem tests and two drill stem test upon Kahlua 1 reaching TD. The well was plugged and abandoned and the rig released on 16th September 2008. The well site at Kahlua 1 has been fully rehabilitated.

5 REFERENCES

Santos (QNT) Pty Ltd	Authorisation for Expenditure, Project No: 5638013, Project Name: Kahlua 1 Corehole, NSW, Australia (Internal Document)
Tadros N.Z. 1999.	Permian stratigraphy of the Gunnedah Basin, pp120-152. In Coalfield Geology Council of New South Wales, Bulletin 1.

SANTOS QNT PTY LTD

Kahlua 2

WELL COMPLETION REPORT

PEL 1 - NSW

SANTOS QNT PTY LTD
A.B.N. 33 083 077 196
Level 22 Santos Place
32 Turbot Street
Brisbane Qld 4000

March 2011

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ENCLOSURES

Table 1: Well Data Card

Well Name:	Kahlua 2	Well Type:	CSG Pilot

POST WELL CARD

Licence: PEL 1	Joint Venture: ACM / Santos	Latitude: (GDA94, MGA55)	30° 58'59.467" S / 214443.70m
Equity:	Budget Status: Budget Item	Longitude: (GDA94, MGA55)	150°00'35.949" E / 6568423.73m
		Seismic Reference:	N/A

	Voting (%)
Santos QNT Pty Ltd	25
ACM	75

Ground Level:	317.4m A.S.L
Rotary Table:	321.4m A.S.L
Rig:	EWG 103
Nearby Facilities:	N/A

Drilling Timing

Spud Date:	07:00hrs on 30 November 2010
TD Reached Date:	16:45hrs on 5 December 2010
Rig Release Date:	18:00hrs on 13 December 2010

Drilling Details

TD (driller):	695.0mGL (-373.6m ASL)
TD (logger):	695.0mGL (-373.6m ASL)
Well Status:	Suspended Gas Well (SUG)

Net Pay

Coal Seam	Top (mGL)	Base (mGL)	Net Coal (m)
Hoskissons Coal	301.5	308.9	7.2
Melvilles Coal	346.6	350.2	3.4
Maules Creek Coal	593.7	594.9	1.3
Maules Creek Coal	643.0	645.3	2.4
Maules Creek Coal	672.4	676.4	3.8
Maules Creek Coal	679.2	680.2	1.1

Stratigraphy (from wireline logs)

Formation	Depth (m GL)	mSS (m)	Thickness (m)
Quaternary Alluvium (Surface)	4.0	317.4	20.0
Napperby Formation	24.0	297.4	149.1
Digby Formation	173.1	148.3	
Ulinda Sandstone	173.1	148.3	9.0
Bomera Conglomerate	182.1	139.3	26.0
Black Jack Group	208.1	113.3	
Trinkey Formation	208.1	113.3	23.3
Wallala Formation	231.4	90.0	39.7
Breeza Coal Measures	271.1	50.3	20.1
Benelabri Formation	291.2	30.2	10.3
Hoskissons Coal Measures	**301.5**	**19.9**	7.4
Arkarula Formation	308.9	12.5	26.6
Pamboola Formation	335.5	-14.1	68.6
Melvilles Coal Measures	**346.6**	**-25.2**	
Millie Group	404.1	-82.7	
Watermark Formation	404.1	-82.7	129.2
Porcupine Fm	533.3	-211.9	60.4
Bellata Group	593.7	-272.3	
Maules Creek Fm	**593.7**	**-272.3**	82.7
Leard Fm	676.4	-355.0	18.6
Total Depth	695.0	-373.6	

Formation Evaluation

Wireline Logging:

Run	Log	From	To	Run	Log	From	To (mGL)
1	Super Combo	695.0	5.0				
2	CMI	695.0	244.0				

SWC's:	Nil
MDT's:	Nil
Velocity Survey:	Nil

Formation Testing:

DST No.	Interval (mRT)	ISIP Out	FSIP Out (psi)	Max surf pres	Recovery
1	290.07-312.40	355.9	354.1	N/A	161m
2	342.85-354.00	431.3	431.8	N/A	163m
3	669.00-683.01	N/A	N/A	N/A	Miss Run
4	669.00-683.01	N/A	N/A	N/A	Miss Run
5	668.85-683.08	394.0	449.5	N/A	1.3m

Coring:	No coring
Desorption Samples (mGL):	Nil

Hole Design / Drilling

Well Class:	Appraisal Pilot
Hole Type:	Suspended Pilot

Hole Size	Depth (m)	Casing Size
12.25"	242.5	9.625"
8.5"	695.0	7.0"

Drill Fluid:	Formation Water and KCL

Deviation Data:

MD (mRT)	TVD (mRT)	Incl (°)	Azim (°)
100.00	100.00	0.3	261.80
200.00	200.00	0.2	324.90
300.00	300.00	0.6	309.50
400.00	399.99	0.6	326.30
500.00	499.99	0.4	311.10
600.00	599.98	0.4	322.30
690.00	689.98	1.1	309.70

Mud Logging:	One set of ditch cuttings was collected and bagged at 6m intervals from surface to TD.
Nearby Wells:	STO Kahlua 1 (1.6 km to the N) DM Benelabri DDH 1 (2.7 km to the N) ACM Longlea 1 (5.6 km to SW)

General Comments :

Personnel:

Project Leader	Final Wellcard Compiled By	Operations Geology	Drilling Engineer
Parisa Rhabraian	David Adderley	Andy Pietsch / Jim Day	Bob Goosem

1 INTRODUCTION

Kahlua 2 was the last well to be drilled as part of the Santos (QNT) Pty Ltd, Gunnedah Gas Pilot Project. The role of the Kahlua 2 borehole within this program is to act as the central pumping well with Kahlua 3-5 acting as observation wells. Broadly the project seeks to follow previous exploration within PEL 1 to determine the hydrocarbon potential of the license and assess the deliverability of the Hoskissons and Melvilles Coal Members. The project is also an extension of the farm-in commitment that Santos has in PEL 1 with Australia Coalbed Methane (ACM) Pty Ltd.

Kahlua 2 spudded at 7:00 hours on 30th November 2010. The well penetrated a sequence containing the early to mid Triassic Napperby Formation, the early Triassic Digby Formation, the late Permian Black Jack Group, the late Permian Watermark and Porcupine Formations, and the early Permian Maules Creek Formation. The hole reached Total Depth (TD) within the early Permian Leard Formation.

The 17.5" (445mm) conductor hole was drilled to ~11m and 14" (356mm) conductor pipe cemented in place. The surface hole 12.25" (311mm) was drilled to 242.50m and 9.625" (245mm) casing cemented to surface within the Wallala Formation. Drilling continued utilising an 8.5" (216mm) PCD bit until Total Depth "TD" was reached at 16:45 hours on 5th December 2010 with a final depth of 695.00mRT (driller). Earth Data Pty Ltd. provided the well-site geological supervision at Kahlua 2.

A complete set of wireline logs was run at TD. In addition, a total of five drill stem tests (DSTs) were conducted at the completion of drilling. Kahlua 2 was suspended at the completion of the testing program and the rig was released at 18:00 hours on the 13th December 2010.

Figure 1: Location Map of Kahlua 2-5

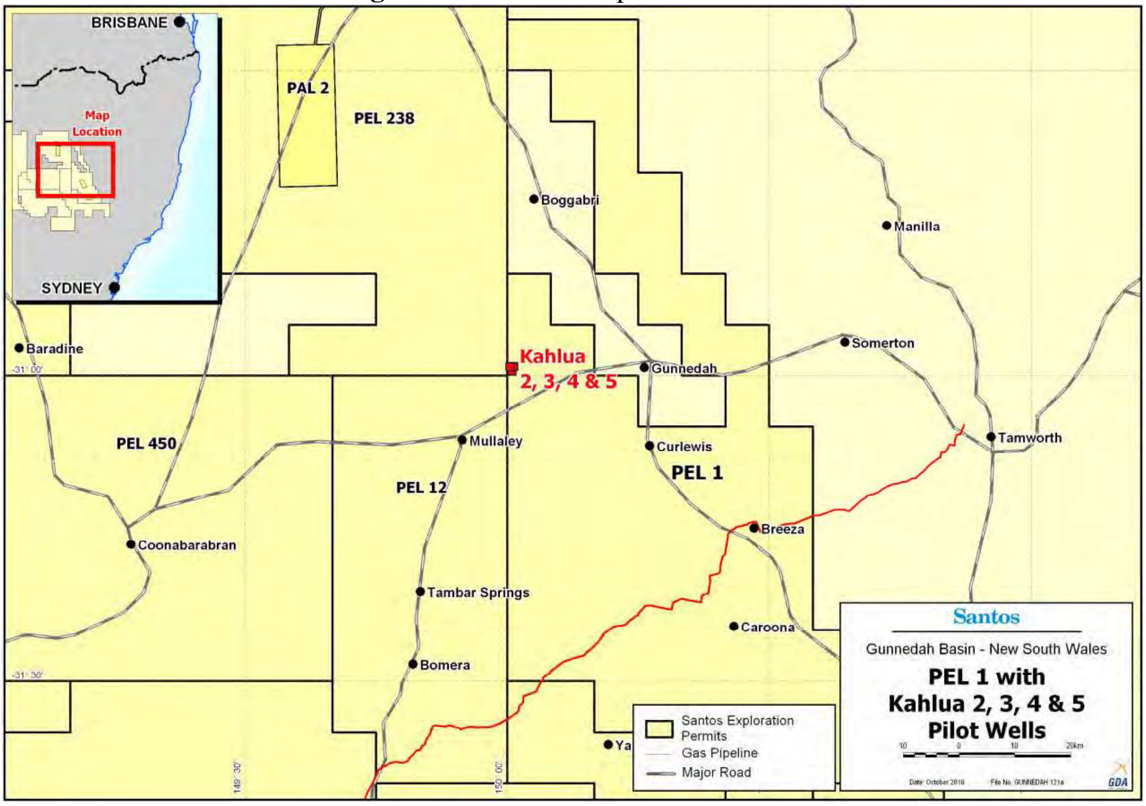
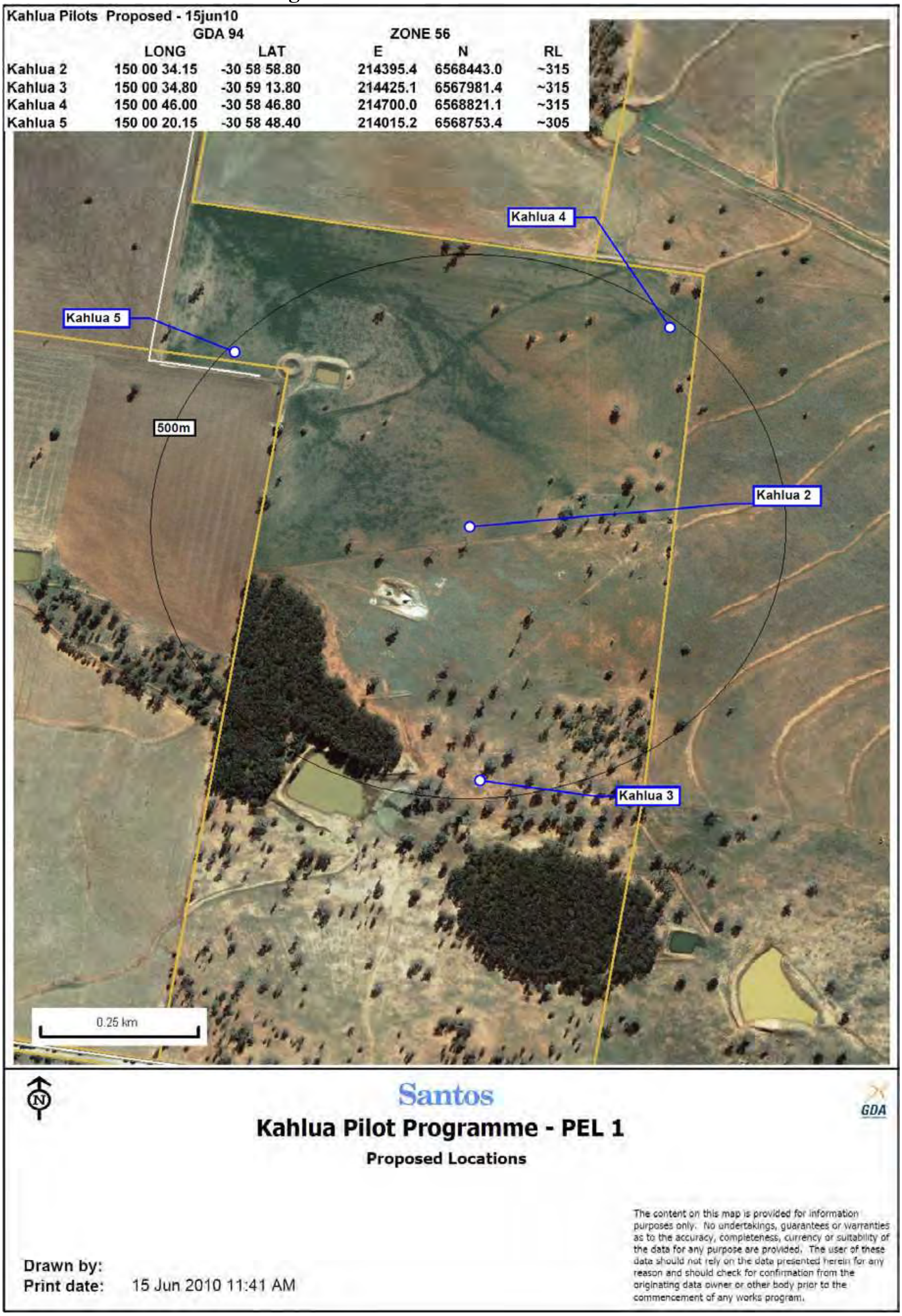


Figure 2: Aerial Photo of Site Location



2 WELL HISTORY

2.1 General Data

Well Name and Number:		Kahlua 2
Location:	Latitude:	30° 58'59.467" S (GDA 94)
	Longitude:	150°00'35.949" E (GDA 94)
MGA Easting (m E):		214443.70
MGA Northing (m N):		6568423.73
Zone		56
Elevations:	G.L.(m):	317.40m A.S.L.
	K.B.(m):	321.40m A.S.L.
Petroleum Tenement:		PEL 1
Permit Operator:		SANTOS QNT PTY LTD Level 22 Santos Place 32 Turbot Street Brisbane Qld 4000
Drilling Contractor:		Eastern Well Drilling Pty Ltd 371 Taylor Street TOOWOOMBA QLD 4350
Drilling Rig:		EWG 103
Date Drilling Commenced:		07:00hrs on 30 November 2010
Date Drilling Completed:		16:45hrs on 5 December 2010
Date Rig Released:		18:00hrs on 13 December 2010
Drilling time (Spud to Rig Release):		14.99 days
Total Depth: Driller		695.00mRT
Logger		695.00mRT
Status:		Suspended Gas Well

2.2 Drilling Data

2.2.1 Introduction

Below is the operations summary for Kahlua 2. It has been compiled from the daily drilling reports (**Appendix 1**) as sent in from the rig-site. A Santos Drilling Supervisor was present on-site at all times to supervise drilling operations, manage third party contractors as well as monitor safety and environmental concerns at the rig-site.

The well lease was prepared by Daracon Pty Ltd and a final well location was surveyed by Stewart Surveys Pty Ltd with the details included in **Appendix 2**.

2.2.2 Kahlua 2 Drilling Summary

2.2.2.1 Conductor Casing

Size: 17.5” (445mm)
Interval: 0.00m – ~11.00 m
Drilling Fluid: Air

The conductor hole 17.5” (445mm) was drilled by Daracon prior to well spud. The 14” (356mm) conductor casing was installed and cemented from surface down to a depth of ~11.00mRT on the same day.

2.2.2.2 Surface Hole

Size: 12.25” (311mm)
Interval: ~11.00m – 242.50m (shoe at 241.62m)
Drilling Fluid: Water and KCl

Kahlua 2 spudded at 07:00 hrs on 30th November 2010. The surface hole section 12.25” (311mm) was drilled using an 12.25” PDC bit to a depth of 242.5mRT. No problems were encountered while drilling out this section of the borehole. A total of 20 joints of 9.625” (245mm) K-55, BTC casing were run in to a shoe depth of 241.62mRT and fully cemented to surface. A total of 596 sacks of cement were used to produce a lead slurry at 12.50ppg to cement from 200.00m to surface, a further 159 sacks were used to produce a tail slurry at 14.80ppg to cement from casing shoe to 200.00m. Cement returns were good, circulating, pumping and displacing returned 27 barrels of cement to surface. The casing was then pressure tested to 1000psi for 5 minutes.

2.2.2.3 Production Hole

Size: 8.5” (216mm)
Interval: 242.50m – 695.00m
Drilling Fluid: Water and KCl

The 8.5” hole section was drilled from 242.50 to 695.00mRT using two 8.5” PCD bits, drilling was continued beyond predicted TD. DST’s were performed upon penetration of the target Melvilles and Hoskissons Coal Members. Upon reaching TD the borehole was plugged to 385.00m below the target seams. Following the well being plugged production casing was run with a shoe depth of 383.84 and fully cemented to surface. A total of 34 joints of 7" (178mm) steel and fibreglass casing was used with 28 joints of steel K-55, 23lbs/ft, BTC casing and 6 joints of fibreglass DHC350, 7.6lbs/ft, 4rd casing set over the target seams. A total of 262 sacks of cement were used to produce a lead slurry at 12.00ppg to cement from 233.90m to surface, a further 96 sacks were used to produce a tail slurry at 14.00ppg to cement from casing shoe to 233.90m. Cement returns were good, circulating, pumping and displacing returned 7.3 barrels of cement to surface. The casing was then pressure tested to 1500psi for 5 minutes losing 30psi per minute. Once the casing was set the borehole was then underreamed from 301.40 to 309.00m over the Hoskissons Coal Measures.

The rig was released at 18:00 hrs on the 13th December 2010.

2.2.3 Casing and Cementing

Refer to the Well Schematic (**Figure 4** and **Table 2**) for the Casing and Cementing Summary details at Kahlua 2.

Table 2: Casing and Cementing Summary

Conductor		
Hole/Casing Size	-	17.5" / 14" (445mm / 356mm)
Weight	-	54.5lbs/ft
Grade	-	
Shoe Setting Depth	-	~11.0 m
Interval Cemented	-	~11.0 m – to surface
Surface		
Hole/Casing Size	-	12.25" / 9.625" (311mm / 245mm)
Weight	-	36.0lbs/ft
Grade	-	K-55
Shoe Setting Depth	-	241.62 m
Interval Cemented	-	241.62m – to surface
Production		
Hole/Casing Size	-	8.5" / 7" (216mm / 178mm)
Weight	-	23lbs/ft / 7.6lbs/ft
Grade	-	K-55 / DHC350
Shoe Setting Depth	-	383.84m
Quantity of Cement	-	262 sacks at 12.00ppg / 96 sacks at 14.00ppg
Interval Cemented	-	383.84m – to surface

2.2.4 Deviation Surveys

The largest deviation recorded at Kahlua 2 was 0.6° and was recorded at 300.00 and 400.00mRT.

2.2.5 Drilling Fluid Data

Materials used in the mud system whilst drilling included salt (KCl) and fresh water sourced locally. KCl (3-6%) was used to assist in maintaining mud weight and minimise clay swelling.

a) 0.00 – ~11.00 m Air
b) ~11.00 – 242.50m Water and KCl

c) 242.50 – 695.00m Water and KCl

2.2.6 Water Supply

Drilling water supply was obtained from dams near location and trucked to site.

2.3 Drilling Contractors and Personnel

Project Leader	:	P Rhabraian
Drilling Engineer/Supervisor	:	B Goosem
Drilling Rig Representative	:	K Parker/S Hobday/E Bennett
Drilling	:	Eastern Well Drilling Pty Ltd
Wellsite Geologist	:	M Vippond
Field Testing	:	Earth Data Pty Ltd
Cementing	:	Halliburton Pty Ltd
Mud Engineering	:	Eastern Well Drilling Pty Ltd
Wireline Logging	:	Weatherford Australia Wireline Pty Ltd
Well Testing	**:**	DST Australia
Casing Perforation	**:**	Not Conducted

Figure 3: Kahlua 2 Time-Depth Curve

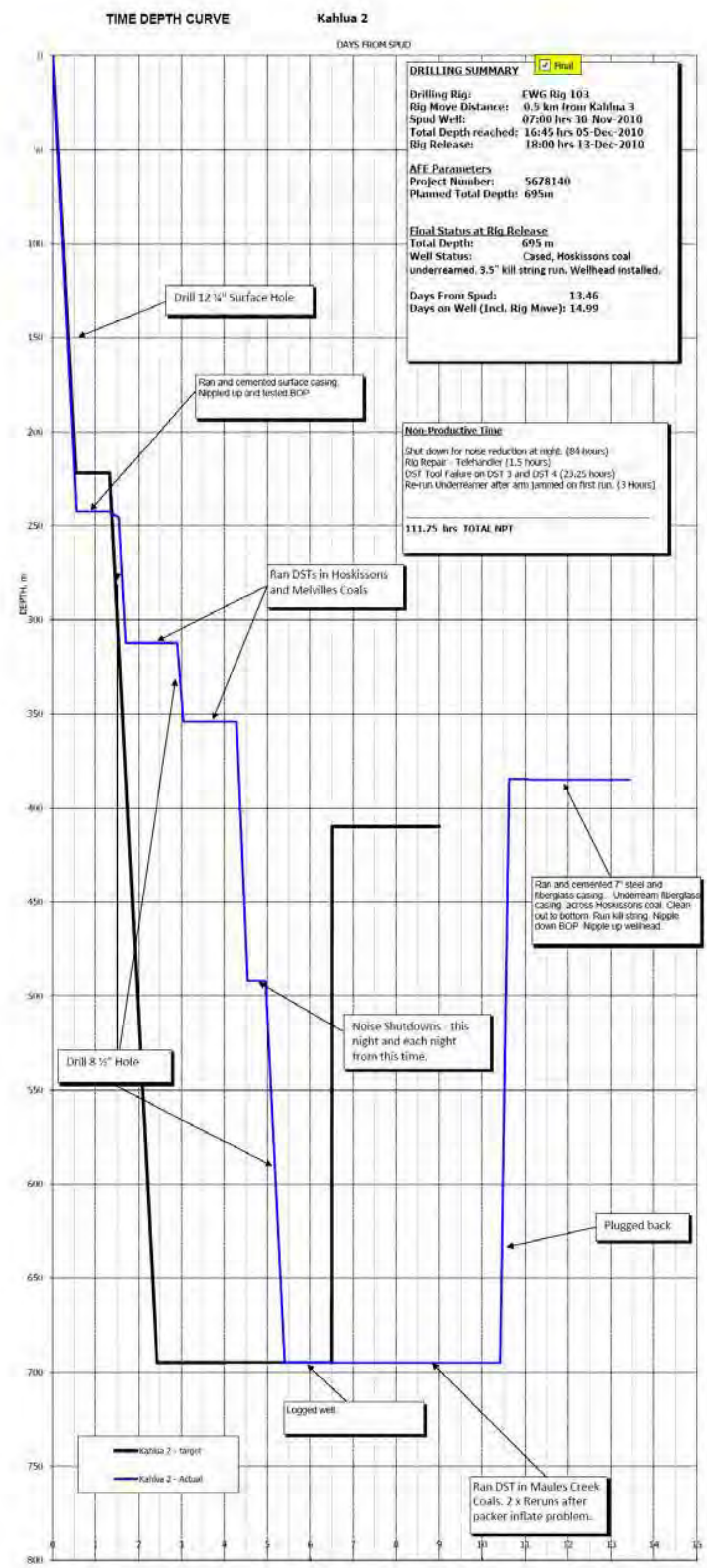
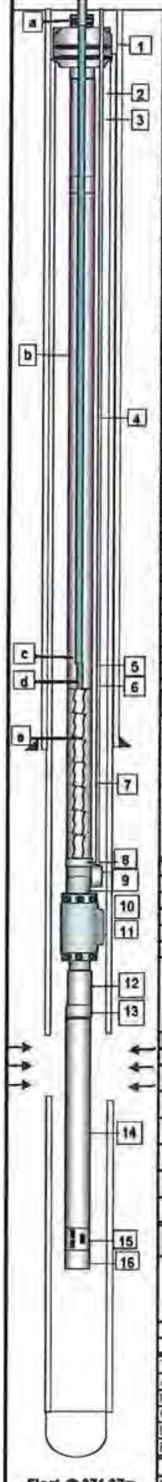


Figure 4: Kahlua 2 Well Schematic

Santos
Santos Ltd A.C.N 007 550 923

KAHLUA 2

Latitude: 30° 68' 69.467" S	**Well spudded 30-11-2010**	**Ground Level:**	**317.43 m**
Longitude: 150° 0.00 35.949" E	**Last activity: 29-01-2011**	**RT elevation:**	**321.44 m**



ITEM No	DESCRIPTION	LTH (m)	DTH KB (m)	MIN I.D.	MAX O.D.
	RT to top of tubing spool flange	4.30			
1	Tubing Hanger, Nested /O-Ring external seal, WG 7-1/16" X 3-1/2" EUE box bot, 3-3/4" Acme top	0.36	4.30	2.95"	7.0625"
2	Tubing, 1 joint, 3-1/2" 9.3 lb/ft J55 EUE	9.57	4.66	2.992"	4.5"
3	Pup joint, 3-1/2" 9.3 lb/ft J55 EUE, (for space out)	2.47	14.23	2.992"	4.5"
4	Tubing, 28 joints, 3-1/2" 9.3 lb/ft J55 EUE	267.14	16.70	2.992"	4.5"
5	Pup Joint, 3-1/2" 9.3 lb/ft J55 EUE (for handling)	1.89	283.84	2.992"	4.5"
6	XO, 3-1/2" EUE box x 2-7/8" EUE pin	0.20	285.73	Drift	
7	PCP, Weatherford 60-600, 2-7/8" EUE, SN 60-600-E57513.105585 MN	7.05	285.93	N/A	4.5"
8	PCP Tag Bar Sub, Tag bar to elastomer .41M, stator to tag bar .16	0.50	292.98	N/A	3.50
9	XO, 2-7/8" EUE box x 3-1/2" EUE pin	0.28	293.48	Drift	4-1/2"
10	Pup Joint, 3-1/2" J55 EUE, c/w sensor/ protection assembly	1.25	293.76	2.992"	4.9"
11	Torque Anchor, 3-1/2" x 7" EUE box x pin, single blade. Tx-7-3-9617	0.35	295.01	Drift	
12	Tubing, 1 joints, 3-1/2" 9.3 lb/ft J55 EUE	9.56	295.36	2.992"	4.5"
13	XO, 3-1/2" EUE box x 3-1/2" SFJ pin	0.16	304.92	Drift	
14	Tubing, 2 joints, 3-1/2" 9.3 lb/ft J55 SFJ	18.17	305.08	2.992"	3.5"
15	Perforated Pup Joint, 3-1/2" 9.3 lb/ft J55 SFJ, length 2 ft	0.50	323.25	2.992"	3.5"
16	Tubing, 1 joint, 3-1/2" 9.3 lb/ft J55 SFJ	9.26	323.75	2.992"	3.5"
	End of Pipe		**333.01**		
A	**DH Gauge & Cable**				
	CSGas supplied "Universal" 0 - 1500 psi Down hole Sensor & 10 mm Blue PVC armored.				
	Sensor SN # 3062050. Cable strapped to tubing centre of each jt.	Landed	295.01		
	6-5/8" x 3 1/2" Basket Type Tubing Centralisers				
	6 total installed on joints 2, 7, 12, 17, 22 and 27 above the Tubing Anchor				
	Cable Protectors - "Boss				
	1 clamp per joint centre of each joint and 1 clamp above and below each centraliser				
	Rod String				
	KB Difference to top of polish rod	3.44	0.00		
a	Polished Rod, 1-1/4" 7.92 m (26 ft) long (with 8" stick-up above drive head)	7.92	3.44		
b	Sucker Rod, 35 rods, 1" Grade H c/w 2 snap on Endurance guides	265.65	11.36		
c	Sucker Rod, 1 rod, 1" Grade H Plain (no guides)	7.64	277.01		
d	x/o 7/8" SR x 1" SR	0.12	284.65		
e	PCP rotor, Weatherford 60-600 SN XL 105585	7.03	284.77		
	End of Rod		291.80		

BRIEF HISTORY ON WELL

Kahlua 2 was spudded by EWG Rig # 103 on the 30th November 2010 @ 07:00hrs, 12-1/4" surface hole was drilled to 242.5m and 9-5/8" casing was RIH and cemented @ 241.62m. a 9 5/8" x 7" 3K BTC compact wellhead installed. The shoe was drilled out and an LOT was performed to an EMW of 20.9ppg. The 8.5" production hole section was drilled from 242.5m to 312.4m to the Hoskissons coals. DST #1 was run to Test interval 290 to 312.4m. The 8.5" production hole section was drilled from 312.4m to 354m to second DST point. DST # 2 was run Test interval 342.85m to 354m. The 8.5" production hole section was drilled from 354m to TD of 695m. A 3rd Straddle DST was done at the Maules creek coal at 668.85m to 683.08m. Well was plugged back from 695m to 385m. 7" steel casing and fibre glass casing was run to 383.76m. Well was 12-1/4" under reamed from 301.4m to308.9m. 3 1/2" EUE kill string was run and landed @ 61.9m with a 11" x 3 1/2" EUE nested hanger. 11" x 3m x 7-1/16" x 3M DSA, 7-1/16" x 3-1/8" 3M BSA and a 3-1/8" x 3M universal C-section Valve was installed and tested by Wood Group. Rig released at 1800 hrs on 13th December 2010. EWG 103 POH Suspension string. RIH PC Pump completion string. Rig released @ 10:00 Hrs 30-Jan-2011

CASING DETAILS		CEMENTING DETAILS:
Size:	9-5/8"	Cement 9 5/8" casing as per program
Weight:	36 lb/ft	Pump 5 bbls of Preflush, Pressure test surface lines to 2000 psi/5 minutes.
Grade:	K-55	Pump 5 bbls of Preflush.
Depth Set:	241.62	Mix & pump 205sxs (75bbls) of 12.5ppg Lead cement
		Mix & pump 82sxs (20bbls) of 14.8ppg Tail cement.
		Drop top plug & Displace with 67.3 bbls of water (Cement returns at surface after 40bbls of displacement pumped) 27 bbls of cement to surface.
		Bump plug with 320 psi @ 2.5bpm, Pressure test 9 5/8" casing to 1000psi/5minutes
		Bleed back 0.25bbl - Float holding
		**Note- Full returns during the cement job **

PRODUCTION

CASING DETAILS		CEMENTING DETAILS:
		Hold PJSM with Halliburton.
Size:	7"	Pumped 10 bbls weighted spacer (9.2 ppg) Pressure tested lines to 3000 psi. Pumped 10 bbls weighted spacer
Weight:	23ppf	Mixed and pumped 33 bbls (82sx)12 ppg Lead cement. 19 bbls (62sx) 14 ppg Tail cement.
Grade:	K-55	Flushed surface lines, Dropped top plug and displaced with 49.3 bbls of fresh water. Cement returns to surface after 42 bbls displacement pumped.
Depth Set:	409.32	Bumped plug with 480 psi @ 1.3 bpm. Pressure tested 7" casing to 1500 psi for 5 min. 30 psi pressure loss per minute. Bleed back 0.25 bbls, float not holding, small leak. Locked in cement at zero pressure.
I.D:	6.368	Constant returns throughout cement job
Capacity:	.0394lb/ft	

FORMATION	(mKB)	GUN: SIZE	GUN: TYPE	CHARGES: SPF	CHARGES: TYPE	CHARGES: WT(g)
Hoskissons Coal	Hoskissons = 301.4m to 308.9m					
PRESSURE						
TEMPERATURE						

TAGGED DEPTHS:			
ANNULUS FLUID:	3% KCl brine		
INDICATED STRING WEIGHT:	21,000 lbs		
CALCULATED STRING WEIGHT:	21,000 lbs including 12,000 lbs travelling assembly		
LANDED WEIGHT:	Hanging		
REMARKS:	**WELLHEAD DERATED TO 1500 psi**		
NOT TO SCALE	WELLSITE SUPERVISOR:	Dean Malone / Scott Hobday / Steve Hall	
PROPOSED:	TUBING INSTALLATION / LAST WORKOVER	29/01/2011	
COMPLETION:	DRAFTED BY: Mike O'Connell	DATE:	5/01/2011
RE-COMPLETION:	REVISED BY:	DATE:	
OTHER:	CHECKED BY:	DATE:	

Float @ 371.37m
Shoe @ 383.76m
TD @ 695m

2.4 Formation Sampling and Evaluation

2.4.1 Well site Geologist

Earth Data Pty Ltd ("Earth Data") provided onsite geological supervision and desorption testing at Kahlua 2. A composite log summarising geological activities is included in **Appendix 5**.

2.4.2 Mud logging

Mud logging unit services were not used whilst drilling this well and no record of conventional hydrocarbon shows were made. No drilling breaks or gains/losses in drilling fluid were noted whilst drilling through the potential gas-bearing sandstones.

2.4.3 Ditch Cutting Samples

Cuttings were collected from the surface to TD. The sampling intervals for Kahlua 2 are outlined in **Table 3** below.

Interval/Formation	Sample Type (and recipient)	Sample Volume and Frequency
Surface – 695.0mRT	Cuttings Samples	Cuttings collected every 6m

Table 3: Sampling Intervals at Kahlua 2

2.4.4 Wireline Logs

Weatherford Australia Pty Ltd provided slimhole mineral logging services at Kahlua 2. A complete suite of wireline logs was run in multiple runs at Kahlua 2 (**Table 4**). Wireline logging was carried on the 6th December 2010.

Table 4: Wireline Logging Summary

SUITE	RUN	TOOL STRING	INTERVAL (m RT)	TIME SINCE CIRC.
1	1	SuperCombo	0 – 695.00	18hrs
1	2	Verticality	244.00 – 693.00	23hrs

2.4.5 Temperature Surveys

The highest recorded temperature at Kahlua 2 was 40 degrees Celsius at the bottom of the hole.

2.4.6 Drill Stem Tests ("DST")

Five DST tests were conducted at Kahlua 2, with two failed tests. The full reports from DST Australia can be found within **Enclosure 1**.

- DST 1: 290.07 – 312.40m; Over Hoskissons Coal Member
- DST 2: 342.85 – 354.00m; Over Melvilles Coal Member
- DST 3: 669.00 – 683.01m; Failed, over Maules Creek Coal Member

- DST 4: 669.00 – 683.01m; Failed , over Maules Creek Coal Member
- DST 5: 668.85 – 683.08m; Over Maules Creek Coal Member

3 GEOLOGY

3.1 Reasons for Drilling

The Kahlua 2 borehole is part of the Santos Gunnedah Gas Pilot drilling program which is designed to provide information on the hydrocarbon potential of PEL 1. In conjunction with the Kahlua 3, 4 and 5 boreholes, Kahlua 2 will be the central pumping well used to appraise the deliverability of the Hoskissons and Melvilles coal seams. Results from the previously drilled Kahlua 1 corehole were encouraging and suggested potential hydrocarbon resources in the region.

3.2 Regional Geology of the Gunnedah Basin (taken from Tadros, 1993)

The effective Basement of the Gunnedah Basin sequence consists of the Boggabri Volcanics and Werrie Basalts (Late Carboniferous to Early Permian age) that make up the economic floor of the basin. These units contain un-deformed lavas, tuffs and intercalated sediments. The top of these basal volcanics is deeply weathered, indicating an unconformity with the overlying units.

The Leard and Goonbri Formations unconformably overlie Basement (**Figure 5**). The Leard Formation comprises Early Permian pelletal flint claystone, conglomerate, sandstone and siltstone, commonly interbedded with coal. It forms a discontinuous thin veneer deposited in the more deeply eroded and weathered basement structure. The Goonbri Formation unconformably overlies the Boggabri Volcanics and the Leard Formation. It is a regressive lacustrine sequence comprising predominantly bioturbated organic-rich siltstone and thin coal, coarsening upwards to laminated siltstone and fine grained sandstone and then moderately well sorted medium grained sandstone.

The Maules Creek Formation is an Early Permian alluvial to fluvial system which overlies and onlaps both the Leard and Goonbri Formations. In the Mullaley Sub-basin, the Maules Creek Formation is subdivided into a northern zone containing quartz rich sandstone; a central zone of volcanogenic sediments; and a south eastern zone consisting of fine grained sediments rich in coal. The boundary with the overlying Porcupine Formation is disconformable and the two formations inter-finger each other.

The Porcupine Formation is a late Permian fan delta marine incursion into the Gunnedah Basin. The unit is a fining up sequence from a para-conglomerate with a poorly sorted sandstone and siltstone matrix at the base through an ortho-conglomerate with moderately sorted sandstone and siltstone matrix to a homogeneous bioturbated sandstone and mudstone. The conglomerate clasts are dominantly siliceous volcanics. The upper boundary with the overlying Watermark Formation is gradational. In the western margin of the Basin, the Porcupine Formation is approximately 10m thick.

The lower part of the Watermark Formation represents the maximum extent of the Late Permian transgression. The upper part is a marine regression associated with the overlying Black Jack delta system. The lower part is characterized by a fining up sequence from sandy siltstone at the base to siltstone / claystone laminate at the top. The upper part consists of a major coarsening up succession consisting of two distinctive units; the lower unit which is finely laminated siltstone and claystone with sporadic “dropped pebbles”; and the upper unit which consists of well

developed coarsening up sequences of siltstone, sandy siltstone to interbedded siltstone and sandstone, the percentage of sandstone increases up the sequence.

The Late Permian Black Jack Group is divided into a deltaic lower unit containing the target coals and an upper fluvial-lacustrine unit.

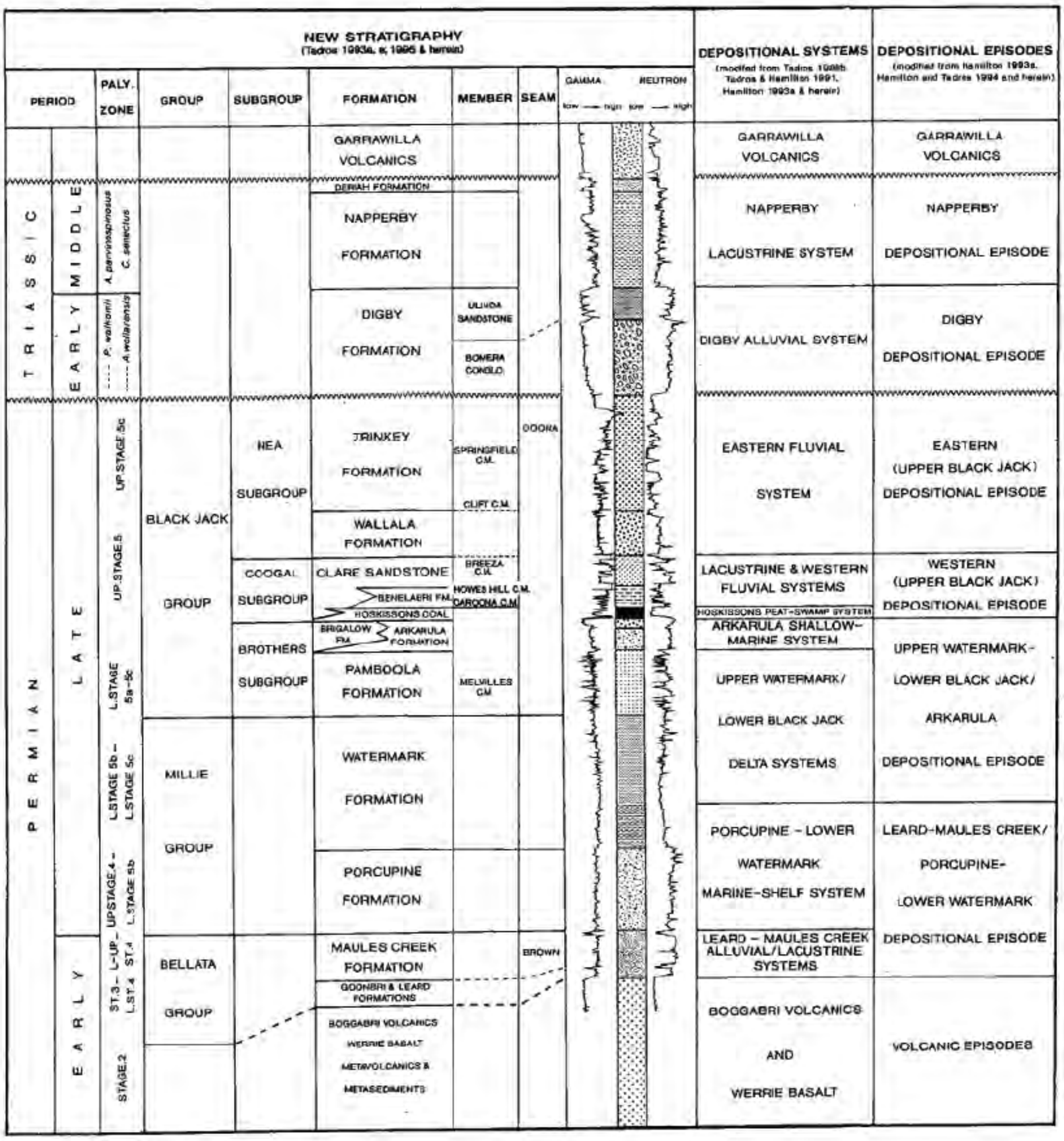
- A basal lithic unit consisting of sandstone, siltstone, claystone, conglomerate and intercalated coals thins towards, and onlaps, the western margin of the basin. The Melvilles Coal Member within this unit is not thought to be present within PEL450. The lithic unit is followed by the Arkarula Sandstone, a fine – medium grained lithic unit which is in turn overlain, in the Mullaley Sub-basin, by medium – coarse – pebbly quartz rich sandstone with a sharp erosive contact.
- The upper part of the Black Jack Group includes the Hoskissons Coal (primary target). The coal consists of predominantly vitrinite poor/inertinite rich coal with subordinate layers of fine sandstone, carbonaceous siltstone/claystone and tuff. The peat swamps developed as a result of marine regression and are fluvial influenced with westerly sourced quartzose channel fills seen along the western margin. The coal is overlain by the coarse grained to conglomeratic, quartz rich Clare Sandstone Member, followed by a lithic conglomerate and finally a fine grained tuffaceous coaly unit.

The Early Triassic Digby Formation unconformably overlies the Permian sequence. The Formation consists of a lower lithic conglomerate unit, quartz–lithic sandstone unit and an upper quartzose unit. The lithic conglomerate unit formed as a result of an alluvial fan system and consists of clast supported conglomerate with subordinate lithic sandstone. The clasts comprise green and red jasper, chert and siliceous and mafic volcanics. The middle quartz –lithic sandstone comprises approximately equal parts of quartz and lithics, locally conglomeratic towards the base. The upper quartzose unit comprises predominantly quartzose sandstone with subordinate conglomerate and claystone. Lithics are generally less than 25% of the composition.

The Early–Mid Triassic Napperby Formation is an overall upward coarsening sequence. The lower part consists of dark grey claystone and finely interlaminated sandstone and mudstone. The middle becomes increasingly silty and the upper unit comprises mainly off-white, medium grained lithic sandstone. The Napperby Formation is unconformably overlain by the Late Triassic–Early Jurassic Garrawilla Volcanics. These comprise alkali basalt flows, tuffs and intrusives with weathered surfaces occurring sporadically. Flows are commonly vesicular and contain common secondary zeolite mineralization.

The Garrawilla Volcanics are unconformably overlain by the Jurassic Purlawaugh Formation and Pilliga Sandstone of the Surat Basin sequence. These are respectively flood plain and braided stream deposits equivalent to the Hutton Sandstone sequence to the north.

Figure 5: Generalised Stratigraphy of the Gunnedah Basin, NSW (Tadros, 1999)



3.3 Stratigraphic Prognosis

Well control for Kahlua 2 was provided by surrounding wells STO Kahlua 1, DM Benelabri DDH 1 and ACM Longlea 1. STO Kahlua 1 was the closest corehole (1.6km to the N) and acted as the primary offset for the Kahlua portion of the Gunnedah gas pilot program. Previous drilling in the gas pilot program was used to refine local models and predictions.

Table 5 Summarises the actual formation top depths, thickness and difference to prognosis. Formation tops are interpreted from electric logs data, ditch cuttings descriptions along with the core data and adjacent well control.

FORMATION	FORMATION TOPS				
	ACTUAL TOP		High / Low	PROGNOSED TOP	
	(MDmRT)	(TVDmSS)	Prognosis (m)	(MDmRT)	(TVDmSS)
Alluvium	4	317.4	0	4	317.4
Napperby Fm	12	309.4	11.5	23.5	298
Digby Fm	174	147.4	1.5	175.5	145.9
Ulinda Sandstone	*174*	*147.4*	*1.5*	*175.5*	*145.9*
Bomera Conglomerate	*180*	*141.4*	*8.2*	*188.2*	*133.2*
Black Jack Group	**210**	**111.4**	**5.9**	**215.9**	**105.5**
Trinkey Fm	210	111.4	5.9	215.9	105.5
Wallala Fm	234	87.4	11.4	245.4	76.1
Breeza CM	268	53.4	8.8	276.8	44.6
Benelabri Fm	273	48.4	17.7	290.7	30.7
Hoskissons CM	301.35	20.05	3.25	304.6	16.8
Arkarula Fm	308.95	12.45	3.05	312	9.4
Pamboola Fm	338	-16.6	1	339	-17.6
Melvilles CM	347	-25.6	5.3	352.3	-30.9
Millies Group	**384**	**-62.6**	**12.7**	**396.7**	**-75.3**
Watermark Fm	384	-62.6	12.7	396.7	-75.3
Porcupine Fm	534	-212.6	14.5	548.5	-227.1
Bellata Group	**600**	**-278.6**	**5.8**	**605.8**	**-284.4**
Maules Creek Fm	600	-278.6	5.8	605.8	-284.4
Maules Creek CM	600	-278.6	5.8	605.8	-284.4
Leard Fm	678	-356.6	-0.7	677.3	-355.9
Total Depth	**695**	**-373.6**	**0**	**695**	**-373.6**

Table 5: Kahlua 2 Stratigraphy Summary

3.4 Stratigraphy Penetrated

Kahlua 2 spudded into the Napperby Formation below a thin layer of alluvium. Following this the well penetrated Jurassic & Triassic sediments before drilling into the Late Permian sediments of the Black Jack Group at 210.0mRT. The well was open holed or "chipped" down to TD of 695.0mRT (driller) within the Leard Formation. Below is a summary of the stratigraphy penetrated at Kahlua 2 utilising field geology logs and is described in more detail in the well site geologist field logs (**Appendix 6**).

3.4.1 Napperby Formation (12.0 –174.0m)

The Napperby Formation consists of an upper band of siltstone and mudstone while the majority of the remainder of the formation consists of medium grained sandstone interbedded with siltstone. This gradational change from a fine siltstone to increasingly coarse sandstones through the formation correlates with the interpretation of the unit being deposited in a lacustrine delta environment.

3.4.2 Digby Formation (174.0 – 210.0m)

The Digby formation is typically comprised of two main units, an upper sandstone dominated unit and a lower conglomerate dominated unit, at Kahlua 2 both the Ulinda Sandstone and the Digby or Bomera Conglomerate were visible. The Ulinda Sandstone consisted of a band of primarily medium grained sandstone. The Bomera Conglomerate was comprised of thick units of multicoloured lithics and volcanic pebbles within a sandy matrix. The Digby formation has been interpreted as being derived from massive alluvial systems flowing from the New England Fold Belt.

3.4.3 Trinkey Formation (210.0 – 234.0m)

The Trinkey Formation at Kahlua 2 was dominated by white to grey tuffs and coal bands. Occasional sandy traces were noted in chip samples however these were not predominant throughout the unit. The high tuffaceous content of the unit can be attributed to the tephra ejected from the volcanoes of the New England region.

3.4.4 Wallala Formation (234.0 – 268.0m)

The Wallala Formation at Kahlua 2 is a conglomerate dominated unit with a medium to coarse grained sandstone band at the top of the unit and occasional sandstone bands throughout the remainder. The conglomerates comprising the majority of the unit contained granule to pebble sized clasts similar in appearance to those of the Digby Formation with within a coarse grained sandy matrix. The intermediate casing was set at 241.62mGL within this unit. The Wallala Formation is interpreted as being formed from an eastern fluvial system.

3.4.5 Breeza Coal Measures (268.0 – 273.0m)

No coal profiling was performed at Kahlua 2 however occasional tuffaceous fragments were noted in the Breeza Coal Member.

3.4.6 Benelabri Formation (273.00 – 301.35m)

The Benelabri Formation at Kahlua consisted of interbedded medium grained sandstone and siltstone layers. One coal seam was noted towards the base of the unit. The contact with the underlying Hoskissons Coal Member was a fine to medium grained sandstone with common silty laminae. The Benelabri Formation is believed to be the result of a large lake system.

3.4.7 Hoskissons Coal Member (301.35 – 308.95m)

The Hoskissons Coal at Kahlua 2 was intersected below the Benelabri Formation. No coal profiling was performed.

3.4.8 Arkarula Formation (308.95 – 338.0m)

The Arkarula Formation is present immediately following the Hoskissons coal and consists of a brief band of fine sandstone and siltstone followed by a thick medium to very coarse grained sandstone. The formation is interpreted as having originated in a wave-dominated delta system as a part of the Arkarula shallow marine system.

3.4.9 Pamboola Formation (338.0 – 384.0m)

The Pamboola Formation at Kahlua 2 is an interbedded siltstone and fine to medium grained sandstone unit. The unit contains occasional carbonaceous traces and the Mellviles Coal Member was intersected near the top of the unit. The Pamboola Formation is interpreted as being the product of deposition within a major delta system.

3.4.10 Melvilles Coal Member (347.0 – 350.0m)

The Melvilles Coal Member at Kahlua 2 are located within the Pamboola Formation. The underlying contact with the coal is an interbedded fine grained siltstone unit while the overlying unit is a medium to coarse grained sandstone unit. No coal profiling was performed.

3.4.11 Watermark Formation (384.0 – 534.0m)

The Watermark Formation at Kahlua 2 transitions from a medium grained sandstone unit with occasional silty bands to an interbedded very fine to fine grained sandstone and siltstone unit fining towards the base. The upper Watermark is interpreted as having formed in a marine delta system while the lower Watermark is interpreted as forming in the same marine-shelf as the Porcupine Formation.

3.4.12 Porcupine Formation (534.0 – 600.0m)

The Porcupine Formation at Kahlua 2 is comprised of conglomerate dominated by siliceous volcanic clasts with an organic-rich fine grained sandstone-siltstone matrix in the upper half whilst the lower half contains a matrix of medium to coarse grained sandstone. The Porcupine Formation is interpreted as a Late Permian marine incursion into the Gunnedah Basin.

3.4.13 Maules Creek Formation (600.0 – 678.0m)

The Maules Creek Formation at Kahlua 2 is dominated by conglomerate throughout, with siltstone and mudstone bands associated as overlying or underlying units with the numerous coal seams throughout.

3.4.14 Leard Formation (678.0 – 695.0m)

The Leard Formation at Kahlua 2 is a brown pelletal claystone with a high organic content. The formation was deposited through colluvial and alluvial processes with material derived from the underlying basal rocks.

3.4.15 Total Depth

Driller:	695.00mRT
Logger:	695.00mRT

3.5 Coal Results

Approximately 34.18m of gross coal was recorded during drilling operations at Kahlua 2. No coal profiling was conducted and no samples were sent for analysis.

Due to previous drilling and correlation work in the area coals intersected can be assigned to a known coal member. The major coal members penetrated and their approximate thicknesses after reconciliation with wireline logs are detailed below:

- Breeza Coal Member: ~1.46m
- Hoskissons Coal Member (Target): ~7.50m
- Melvilles Coal Member (Target): ~4.16m
- Maules Creek Coal Member: ~11.80m

3.6 Hydrocarbon Shows

No gas detector was used onsite to record hydrocarbon shows.

4 DISCUSSION AND CONCLUSIONS

Kahlua 2 concluded drilling for Gunnedah Gas Pilot Project for the four wells to be drilled in the area, further drilling will be undertaken in the southern part of PEL1 at a later date. As the well has been suspended, the success of the program in assessing the hydrocarbon potential of PEL 1 and the deliverability of the Hoskissons and Melvilles Coal Members is yet to be determined.

An approximate total of 34.18 metres of coal from the Black Jack Group and Maules Creek Formation was intersected throughout the borehole. The target Hoskissons Coal Member presented with a thickness of ~7.50m and the Melvilles Coal Member presented with a thickness of ~4.16m. No coal profiling was performed by the wellsite geologist as no core was collected.

Upon conclusion of drilling activities the borehole was suspended and the drill rig was released on 13th December 2010.

5 REFERENCES

Tadros, N.Z. (1999)	Permian stratigraphy of the Gunnedah Basin, pp120-152. In Coalfield Geology Council of New South Wales, Bulletin 1.
Tadros, N.Z. (Ed.) 1993	The Gunnedah Basin, New South Wales. Geological Survey of New South Wales, Memoir Geology 12, 649 pp.

SANTOS QNT PTY LTD

Kahlua 3

WELL COMPLETION REPORT

PEL 1 - NSW

SANTOS QNT PTY LTD
A.B.N. 33 083 077 196
Level 22 Santos Place
32 Turbot Street
Brisbane Qld 4000

March 2011

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ENCLOSURES

Table 1: Well Data Card

Well Name: Kahlua 3 — **Well Type:** CSG Pilot

POST WELL CARD

Licence:	PEL 1	Joint Venture:	ACM / Santos
Equity:		Budget Status:	Budget Item

Latitude: (GDA94, MGA55)	30° 59'13.307" S / 214436.48m
Longitude: (GDA94, MGA55)	150°00'35.245" E / 6567996.90m
Seismic Reference:	N/A
Ground Level:	318.5m A.S.L
Rotary Table:	322.5m A.S.L
Rig:	EWG 103
Nearby Facilities:	N/A

	Voting (%)
Santos QNT Pty Ltd	25
ACM	75

Drilling Timing

Spud Date:	02:00hrs on 21 November 2010
TD Reached Date:	15:15hrs on 26 November 2010
Rig Release Date:	18:15hrs on 28 November 2010

Drilling Details

TD (driller):	402.5mGL (-80.0m ASL)
TD (logger):	402.1mGL (-79.6m ASL)
Well Status:	Suspended Gas Well (SUG)

Net Pay

Coal Seam	Top (mGL)	Base (mGL)	Net Coal (m)
Hoskissons Coal	307.8	309.2	1.4
Hoskissons Coal	309.4	315.5	6.1
Melvilles Coal	353.8	357.7	3.7

Stratigraphy (from wireline logs)

Formation	Depth (m GL)	mSS (m)	Thickness (m)
Quaternary Alluvium (Surface)	4.0	318.5	8.0
Napperby Formation	12.0	310.5	161.5
Digby Formation	173.5	149.0	
Ulinda Sandstone	173.5	149.0	18.3
Bomera Conglomerate	191.8	130.7	16.2
Intrusion	208.0	114.5	
Black Jack Group	225.6	96.9	
Trinkey Formation	225.6	96.9	26.9
Wallala Formation	252.5	70.0	38.9
Breeza Coal Measures	291.4	31.1	9.5
Benelabri Formation	300.9	21.6	6.9
Hoskissons Coal Measures	**307.8**	**14.7**	7.6
Arkarula Formation	315.4	7.1	38.4
Pamboola Formation	342.4	-19.9	
Melvilles Coal Measures	**353.8**	**-31.3**	
Total Depth	402.5	-80.0	

Formation Evaluation

Wireline Logging:

Run	Log	From	To	Run	Log	From	To (mGL)
1	Super Combo	402.0	5.0				
2	CMI	402.0	259.0				

SWC's:	Nil
MDT's:	Nil
Velocity Survey:	Nil

Formation Testing:

DST No.	Interval (mRT)	ISIP Out	FSIP Out (psi)	Max surf pres	Recovery
1	306.97-330.77	377.2	377.4	N/A	106m
2	350.54-365.10	438.4	437.5	N/A	249m

Coring: Conventionally Cored: 312.5m - 330.8m & 351.5m - 365.1m

Desorption Samples (mGL): Nil

Hole Design / Drilling

Well Class:	Appraisal Pilot
Hole Type:	Suspended Pilot

Hole Size	Depth (m)	Casing Size
12.25"	261.0	9.625"
8.5"	402.5	7.0"

Drill Fluid: Formation Water and KCL

Deviation Data:

MD (mRT)	TVD (mRT)	Incl (°)	Azim (°)
50.00	50.00	0.3	162.00
100.00	100.00	0.2	214.70
150.00	150.00	0.4	149.10
200.00	200.00	0.9	78.90
250.00	249.99	1.1	197.50
300.00	299.98	1.9	95.60
350.00	349.95	2.1	87.00
400.00	399.92	2.0	87.80

Mud Logging: One set of ditch cuttings was collected and bagged at 6m intervals from surface to TD.

Nearby Wells:
STO Kahlua 1 (2.2 km to the N)
DM Benelabri DDH 1 (3.1 km to the N)
ACM Longlea 1 (5.3 km to SW)

General Comments :

Personnel:

Project Leader	Final Wellcard Compiled By	Operations Geology	Drilling Engineer
Parisa Rhabraian	David Adderley	Andy Pietsch / Jim Day	Bob Goosem

1 INTRODUCTION

Kahlua 3 was the third well to be drilled as part of the Santos (QNT) Pty Ltd, Gunnedah Gas Pilot Project. Kahlua 3 along with Kahlua 4 and 5 will act as observations wells whilst Kahlua 2 is to act as the central pumping well. Broadly the project seeks to follow previous exploration within PEL 1 to determine the hydrocarbon potential of the license and assess the deliverability of the Hoskissons and Melvilles Coal Members. The project is also an extension of the farm-in commitment that Santos has in PEL 1 with Australia Coalbed Methane (ACM) Pty Ltd.

Kahlua 3 spudded at 2:00 hours on 21st November 2010. The well penetrated a sequence containing the early to mid Triassic Napperby Formation, the early Triassic Digby Formation and the late Permian Black Jack Group. The hole reached Total Depth (TD) within the Late Permian Watermark Formation.

The 17.5” (445mm) conductor hole was drilled to ~11m and 14” (356mm) conductor pipe cemented in place. The surface hole 12.25” (311mm) was drilled to 259.50m and 9.625” (245mm) casing cemented to surface within the Wallala Formation. Drilling continued utilising an 8.5” (216mm) PCD bit and an 8.5” core bit until Total Depth “TD” was reached at 15:55 hours on 26th November 2010 with a final depth of 402.50mRT (driller). 4.0” core was retrieved conventionally from the Hoskissons and Melvilles Coal Members for the collection of geomechanical samples. Earth Data Pty Ltd. provided the well-site geological supervision at Kahlua 3.

A complete set of wireline logs was run at TD. In addition, a total of two drill stem tests (DSTs) were performed upon penetration of the target Melvilles and Hoskissons Coal Members. Kahlua 3 was suspended at the completion of the testing program and the rig was released at 18:15 hours on the 28th November 2010.

Figure 1: Location Map of Kahlua 2-5

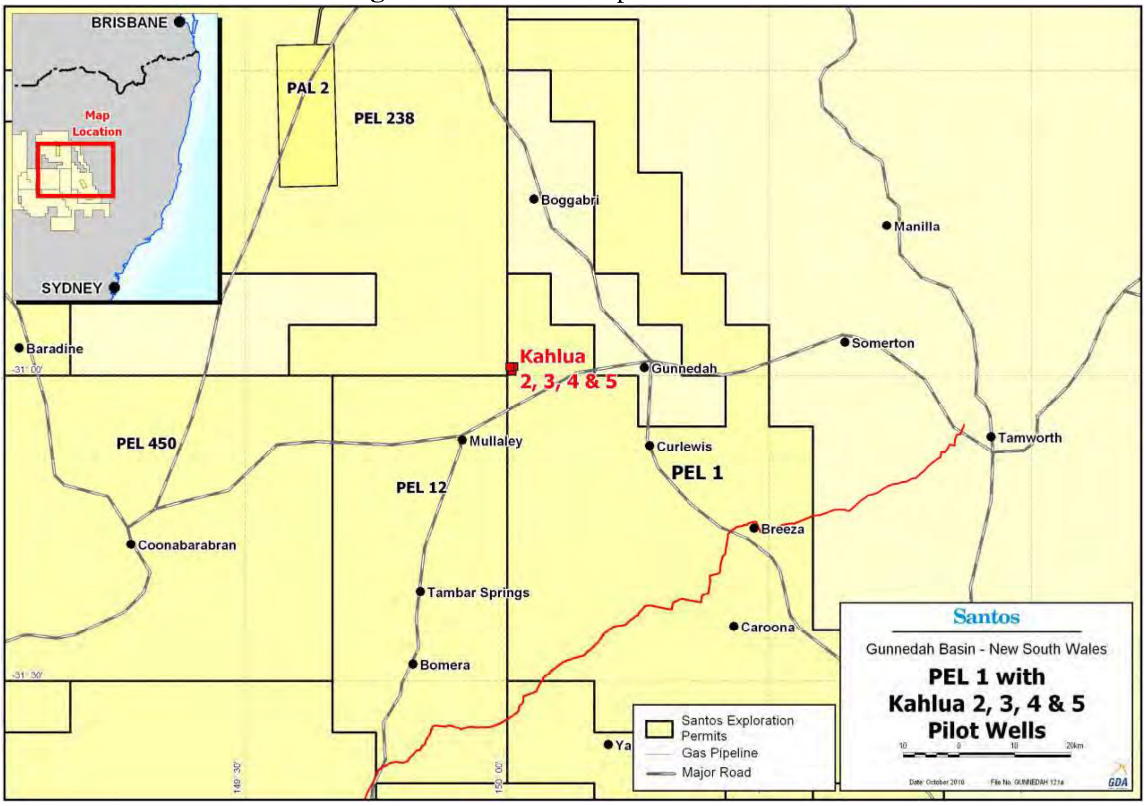
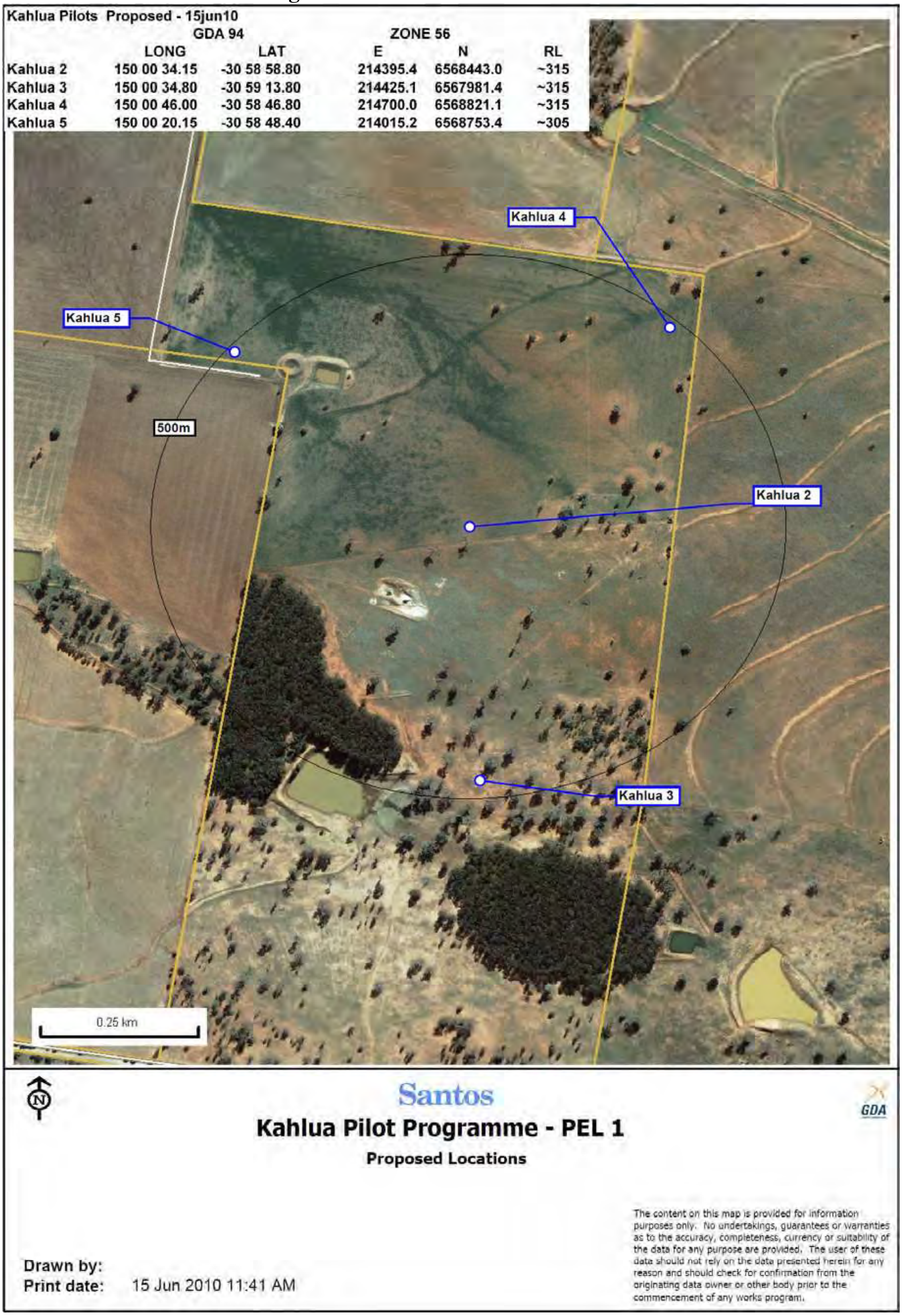


Figure 2: Aerial Photo of Site Location



2 WELL HISTORY

2.1 General Data

Well Name and Number:		Kahlua 3
Location:	Latitude:	30° 59'13.307" S (GDA 94)
	Longitude:	150°00'35.245" E (GDA 94)
MGA Easting (m E):		214436.48
MGA Northing (m N):		6567996.90
Zone		56
Elevations:	G.L.(m):	318.50m A.S.L.
	K.B.(m):	322.50m A.S.L.
Petroleum Tenement:		PEL 1
Permit Operator:		SANTOS QNT PTY LTD Level 22 Santos Place 32 Turbot Street Brisbane Qld 4000
Drilling Contractor:		Eastern Well Drilling Pty Ltd 371 Taylor Street TOOWOOMBA QLD 4350
Drilling Rig:		EWG 103
Date Drilling Commenced:		02:00hrs on 21 November 2010
Date Drilling Completed:		15:15hrs on 26 November 2010
Date Rig Released:		18:15hrs on 28 November 2010
Drilling time (Spud to Rig Release):		7.68 days
Total Depth: Driller		402.50mRT
Logger		402.10mRT
Status:		Suspended Gas Well

2.2 Drilling Data

2.2.1 Introduction

Below is the operations summary for Kahlua 3. It has been compiled from the daily drilling reports (**Appendix 1**) as sent in from the rig-site. A Santos Drilling Supervisor was present on-site at all times to supervise drilling operations, manage third party contractors as well as monitor safety and environmental concerns at the rig-site.

The well lease was prepared by Daracon Pty Ltd and a final well location was surveyed by Stewart Surveys Pty Ltd with the details included in **Appendix 2**.

2.2.2 Kahlua 3 Drilling Summary

2.2.2.1 Conductor Casing

Size: 17.5” (445mm)
Interval: 0.00m – ~11.00 m
Drilling Fluid: Air

The conductor hole 17.5” (445mm) was drilled by Daracon prior to well spud. The 14” (356mm) conductor casing was installed and cemented from surface down to a depth of ~11.00mRT on the same day.

2.2.2.2 Surface Hole

Size: 12.25” (311mm)
Interval: ~11.00m – 261.00m (shoe at 259.50m)
Drilling Fluid: Water and KCl

Kahlua 3 spudded at 02:00 hrs on 21st November 2010. The surface hole section 12.25” (311mm) was drilled using an 12.25” PDC bit to a depth of 261.00mRT. The drill bit was damaged during drilling which dramatically reduced the rate of penetration. A total of 21 joints of 9.625” (245mm) K-55, BTC casing were run in to a shoe depth of 259.50mRT and fully cemented to surface. A total of 605 sacks of cement were used to produce a lead slurry at 12.50ppg to cement from 210.00m to surface, a further 144 sacks were used to produce a tail slurry at 14.80ppg to cement from casing shoe to 210.00m. Cement returns were good, circulating, pumping and displacing returned 27.3 barrels of cement to surface. The casing was then pressure tested to 1000psi for 5 minutes.

2.2.2.3 Production Hole

Size: 8.5” (216mm)
Interval: 261.00m – 402.50m
Drilling Fluid: Water and KCl

The 8.5” production hole section was drilled from 261.00 to 402.50mRT alternating between an 8.5” PCD bit and an 8.5” core bit, TD was reached 10.00m into the Watermark Formation. 4.0” core was retrieved conventionally from the Hoskissons and Melvilles Coal Members for the collection of geomechanical samples. DST’s were performed upon penetration of the target

Melvilles and Hoskissons Coal Members. Upon completion of drilling and DST testing, wireline logs were run. Following all testing production casing was run with a shoe depth of 400.34 and fully cemented to surface. A total of 35 joints of 7" (178mm) steel and fibreglass casing was used with 27 joints of steel K-55, 23lbs/ft, BTC casing and 8 joints of fibreglass DHC350, 7.6lbs/ft, 4rd casing set over the target seams. A total of 366 sacks of cement were used to produce a lead slurry at 12.00ppg to cement from 273.00m to surface, a further 96 sacks were used to produce a tail slurry at 14.00ppg to cement from casing shoe to 237.00m. Cement returns were good, circulating, pumping and displacing returned 22 barrels of cement to surface. The casing was then pressure tested to 1500psi for 5 minutes. Once the casing was set the borehole was then under reamed from 306.70 to 316.12m over the Hoskissons Coal Members.

The rig was released at 18:15 hrs on the 28th November 2010.

2.2.3 Casing and Cementing

Refer to the Well Schematic (**Figure 4** and **Table 2**) for the Casing and Cementing Summary details at Kahlua 3.

Table 2: Casing and Cementing Summary

Conductor		
Hole/Casing Size	-	17.5" / 14" (445mm / 356mm)
Weight	-	54.5lbs/ft
Grade	-	
Shoe Setting Depth	-	~11.0 m
Interval Cemented	-	~11.0 m – to surface
Surface		
Hole/Casing Size	-	12.25" / 9.625" (311mm / 245mm)
Weight	-	36.0lbs/ft
Grade	-	K-55
Shoe Setting Depth	-	259.50 m
Interval Cemented	-	259.50m – to surface
Production		
Hole/Casing Size	-	8.5" / 7" (216mm / 178mm)
Weight	-	23lbs/ft / 7.6lbs/ft
Grade	-	K-55 / DHC350
Shoe Setting Depth	-	400.34m
Quantity of Cement	-	366 sacks at 12.00ppg / 96 sacks at 14.00ppg
Interval Cemented	-	400.34m – to surface

2.2.4 Deviation Surveys

The largest deviation recorded at Kahlua 3 was 2.1° and was recorded at 350.00mRT.

2.2.5 Drilling Fluid Data

Materials used in the mud system whilst drilling included salt (KCl) and fresh water sourced locally. KCl (3-6%) was used to assist in maintaining mud weight and minimise clay swelling.

a) 0.00 – ~11.00 m Air
b) ~11.00 – 261.00m Water and KCl
c) 261.00 – 402.50m Water and KCl

2.2.6 Water Supply

Drilling water supply was obtained from dams near location and trucked to site.

2.3 Drilling Contractors and Personnel

Project Leader	:	P Rhabraian
Drilling Engineer/Supervisor	:	B Goosem
Drilling Rig Representative	:	K Parker/S Hobday/E Bennett/D Malone
Drilling	:	Eastern Well Drilling Pty Ltd
Wellsite Geologist	:	A Price
Field Testing	:	Earth Data Pty Ltd
Cementing	:	Halliburton Pty Ltd
Mud Engineering	:	Eastern Well Drilling Pty Ltd
Wireline Logging	:	Weatherford Australia Wireline Pty Ltd
Well Testing	**:**	DST Australia
Casing Perforation	**:**	Not Conducted

Figure 3: Kahlua 3 Time-Depth Curve

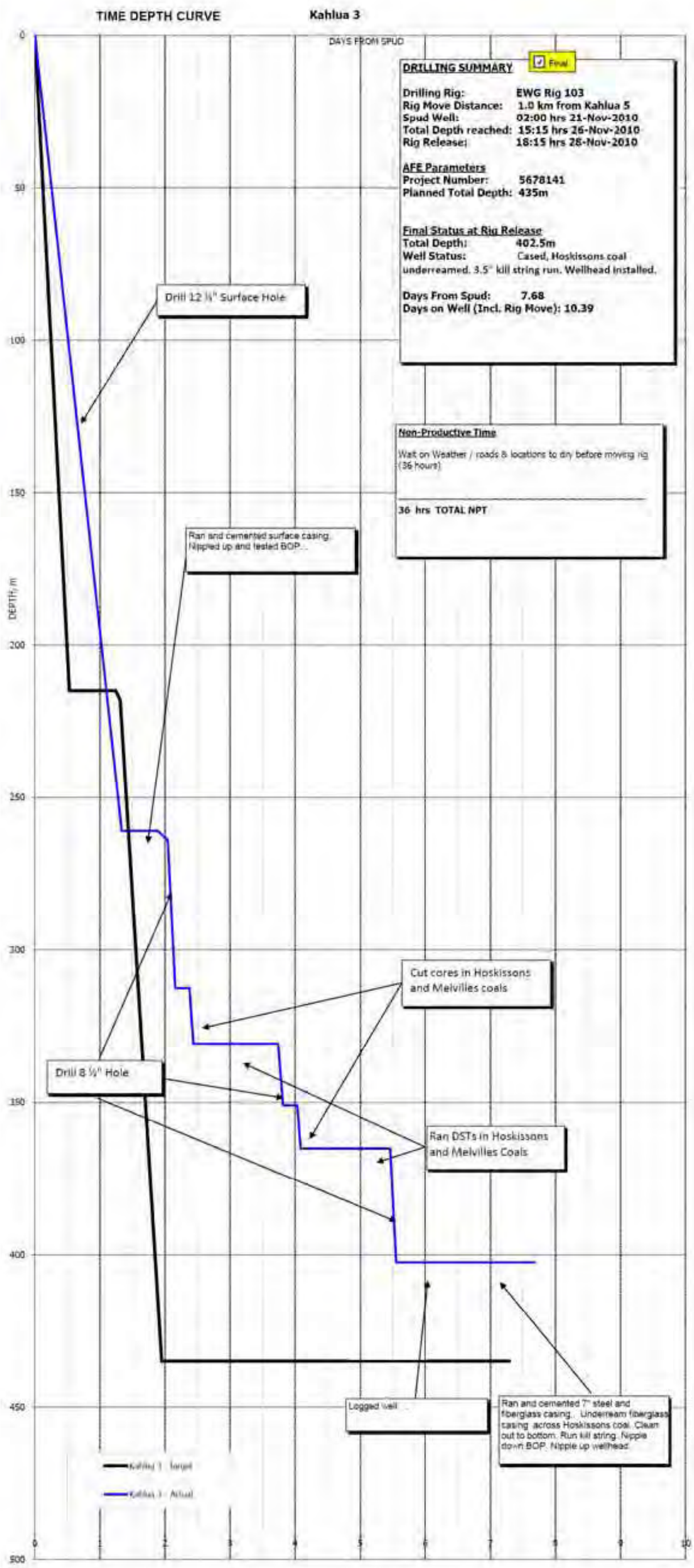


Figure 4: Kahlua 3 Well Schematic

Santos
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KAHLUA 3

Latitude:	30° 58' 13.307" S	Well spudded 21-11-2010	Ground Level:	318.54	m
Longitude:	150° 00 35.245" E	Last activity: 28-11-2010	RT elevation:	322.54	m

ITEM No	DESCRIPTION	LTH (m)	DTH KB (m)	MIN I.D.	MAX O.D.
	KB to top of tubing spool flange	4.04	4.04		
1	3 1/2 Back pressure profile tubing hanger (Nested Hanger)		4.04		
2	6 jnts 3 1/2" eue tubing plus hanger and nipple **3 1/2" tubing set @ 61.92m**	57.43	61.90		
	Wood Group single stage conventional well head option 7A (Compact well head)				
	A Section - Top of 11"3M x 9 5/8" BTC wellhead at 0.03m below ground level				
	11" x 3m x 7-1/16" x 3M DSA				
	7-1/16" x 3-1/8" 3M SSA				
	3-1/8" x 3M universal C-section Valve				
	NOTE- 3" BPV not installed				

BRIEF HISTORY ON WELL

Kahlua 3 was spudded by EWG Rig #103 on the 21st November 2010 @ 02:00hrs, 12-1/4" surface hole was drilled to 261m and 9-5/8" casing was RIH and cemented @ 259.53m. An 9 5/8" x 7" 3K BTC wellhead installed. The shoe was drilled out and an LOT was performed to an EMW of 20.5ppg. The 8.5" production hole section was drilled from 261m to 312.5m to first core point. Cored from 312.5m to 330.77m 97% recovery DST 1 was run Test interval 306.97 to 330.77m. The 8.5" production hole section was drilled from 330.77m to 351m to second core point. Cored from 351m to 365m 97% recovery DST 2 was run Test interval 350.54 to 365.10 The 8.5" production hole section was drilled from 365m to TD of 402.5m. 7" steel casing and fibre glass casing was run to 400.38m. Well was 12-1/4" underreamed from 308.7m to 316.12m. A 3 1/2" EUE kill string was run and landed @ 61.9m with a 11" x 3 1/2" EUE nested hanger. 11" x 3m x 7-1/16" x 3M DSA, 7-1/16" x 3-1/8" 3M SSA and a 3-1/8" x 3M universal C-section Valve was installed and tested by Wood Group Rig released at 18:15 hrs on 28 November 2010.

CASING DETAILS		CEMENTING DETAILS:
Size	9-5/8"	Cement 9 5/8" casing as per program.
Weight	36 lb/ft	Pump 5 bbls of Preflush, Pressure test surface lines to 2000 psi/5 minutes
Grade	K-55	Pump 5 bbls of Preflush.
Depth Set	259.53	Mix & pump 206sxs (76bbls) of 12.5ppg Lead cement
		Mix & pump 82sxs (18bbls) of 14.8ppg Tail cement.
		Drop top plug & Displace with 87.3 bbls of water (Cement returns at surface after 40bbls of displacement pumped) 27.3 bbls of cement to surface.
		Bump plug with 274 psi @ 2.8bpm. Pressure test 9 5/8" casing to 1000psi/5minutes
		Bleed back 0.3bbl - Float holding
		Note- Full returns during the cement job.

PRODUCTION

CASING DETAILS		CEMENTING DETAILS:
Size	7"	Pump 10 bbls weighted spacer (8.6ppg) Pressure test lines to 2400 psi. Pump 10 bbls weighted spacer
Weight	23ppf	Mix and pump 40bbls (118sx) EconoCem 12ppg Lead cement.
Grade	K-55	12bbls (45sx) CBMCem 14 ppg Tail cement.
Depth Set	409.32	Flush surface lines Drop top plug and displace with 51.5 bbls of fresh water.
ID	6.366	Cement returns to surface after 22 bbls of displacement pumped. 12 bbls of cement to surface.
Capacity	.0394lb/ft	Bump plug with 650 psi @ 1.3 bpm. Pressure test 7" casing to 1500 psi for 5 min
		Bleed back 0.25 bbls floats holding
		Full returns throughout job

FORMATION	(mKB)	GUN: SIZE	GUN: TYPE	CHARGES: SPF	CHARGES: TYPE	CHARGES: WT(g)
Hoskissons Coal and Melvilles Coal	Hoskissons = 307.7m to 315.4m					
	Melvilles = 353.8m to 357.8m					
PRESSURE						
TEMPERATURE						

TAGGED DEPTHS:	
ANNULUS FLUID:	
INDICATED STRING WEIGHT:	
CALCULATED STRING WEIGHT:	
LANDED WEIGHT:	
REMARKS:	

Float @ 387.6m
Shoe @ 400.31m
TD @ 402.5m

NOT TO SCALE			
PROPOSED	TUBING INSTALLATION / LAST WORKOVER	None	
COMPLETION	DRAFTED BY:	DATE	
RE-COMPLETION:	REVISED BY:	DATE	
OTHER:	CHECKED BY:	DATE	

WELLSITE SUPERVISOR: Dean Malone

2.4 Formation Sampling and Evaluation

2.4.1 Well site Geologist

Earth Data Pty Ltd ("Earth Data") provided onsite geological supervision at Kahlua 3. A composite log summarising geological activities is included in **Appendix 4**.

2.4.2 Mud logging

A mud logging unit services were not used whilst drilling this well and no record of conventional hydrocarbon shows were made. No drilling breaks or gains/losses in drilling fluid were noted whilst drilling through the potential gas-bearing sandstones.

2.4.3 Ditch Cutting Samples

Cuttings were collected throughout the open hole sections, core and geomechanical samples were collected across the target coal measures. The sampling intervals for Kahlua 3 are outlined in **Table 3** below.

Interval/Formation	Sample Type (and recipient)	Sample Volume and Frequency
Surface – 312.00mRT	Cuttings Samples	Cuttings collected every 6m
312.00 – 330.77mRT	4" Core (NSW DII)	Continuous Core
330.77 – 351.00mRT	Cuttings Samples	Cuttings collected every 6m
351.00 – 365.12mRT	4" Core (NSW DII)	Continuous Core
365.12 – 402.5mRT	Cuttings Samples	Cuttings collected every 6m
	Geomechanical Samples (Strata Testing Services)	10 samples (~30cm)

Table 3: Sampling Intervals at Kahlua 3

2.4.4 Wireline Logs

Weatherford Australia Pty Ltd provided slimhole mineral logging services at Kahlua 3. A complete suite of wireline logs was run in multiple runs at Kahlua 3 (**Table 4**). Wireline logging was carried on the 26th November 2010.

Table 4: Wireline Logging Summary

SUITE	RUN	TOOL STRING	INTERVAL (m RT)	TIME SINCE CIRC.
1	1	SuperCombo	0 – 402.10	6.25hrs
2	2	Verticality	0 – 400.00	10.25hrs

2.4.5 Temperature Surveys

The highest recorded temperature at Kahlua 3 was 32 degrees Celsius at the bottom of the hole.

2.4.6 Drill Stem Tests ("DST")

Two DST tests were conducted at Kahlua 3**.**

- DST 1: 306.97 – 330.77m; Over Hoskissons Coal Member
- DST 2: 350.54 – 365.10m; Over Melvilles Coal Member

3 GEOLOGY

3.1 Reasons for Drilling

The Kahlua 3 borehole is part of the Santos Gunnedah Gas Pilot drilling program which is designed to provide information on the hydrocarbon potential of PEL 1. In conjunction with the Kahlua 3, 4 and 5 boreholes, Kahlua 2 will be the central pumping well used to appraise the deliverability of the Hoskissons and Melvilles Coal Members. Results from the previously drilled Kahlua 1 corehole were encouraging and suggested potential hydrocarbon resources in the region.

3.2 Regional Geology of the Gunnedah Basin (taken from Tadros, 1993)

The effective Basement of the Gunnedah Basin sequence consists of the Boggabri Volcanics and Werrie Basalts (Late Carboniferous to Early Permian age) that make up the economic floor of the basin. These units contain un-deformed lavas, tuffs and intercalated sediments. The top of these basal volcanics is deeply weathered, indicating an unconformity with the overlying units.

The Leard and Goonbri Formations unconformably overlie Basement (**Figure 5**). The Leard Formation comprises Early Permian pelletal flint claystone, conglomerate, sandstone and siltstone, commonly interbedded with coal. It forms a discontinuous thin veneer deposited in the more deeply eroded and weathered basement structure. The Goonbri Formation unconformably overlies the Boggabri Volcanics and the Leard Formation. It is a regressive lacustrine sequence comprising predominantly bioturbated organic-rich siltstone and thin coal, coarsening upwards to laminated siltstone and fine grained sandstone and then moderately well sorted medium grained sandstone.

The Maules Creek Formation is an Early Permian alluvial to fluvial system which overlies and onlaps both the Leard and Goonbri Formations. In the Mullaley Sub-basin, the Maules Creek Formation is subdivided into a northern zone containing quartz rich sandstone; a central zone of volcanogenic sediments; and a south eastern zone consisting of fine grained sediments rich in coal. The boundary with the overlying Porcupine Formation is disconformable and the two formations inter-finger each other.

The Porcupine Formation is a late Permian fan delta marine incursion into the Gunnedah Basin. The unit is a fining up sequence from a para-conglomerate with a poorly sorted sandstone and siltstone matrix at the base through an ortho-conglomerate with moderately sorted sandstone and siltstone matrix to a homogeneous bioturbated sandstone and mudstone. The conglomerate clasts are dominantly siliceous volcanics. The upper boundary with the overlying Watermark Formation is gradational. In the western margin of the Basin, the Porcupine Formation is approximately 10m thick.

The lower part of the Watermark Formation represents the maximum extent of the Late Permian transgression. The upper part is a marine regression associated with the overlying Black Jack delta system. The lower part is characterized by a fining up sequence from sandy siltstone at the base to siltstone / claystone laminate at the top. The upper part consists of a major coarsening up succession consisting of two distinctive units; the lower unit which is finely laminated siltstone and claystone with sporadic “dropped pebbles”; and the upper unit which consists of well

developed coarsening up sequences of siltstone, sandy siltstone to interbedded siltstone and sandstone, the percentage of sandstone increases up the sequence.

The Late Permian Black Jack Group is divided into a deltaic lower unit containing the target coals and an upper fluvial-lacustrine unit.

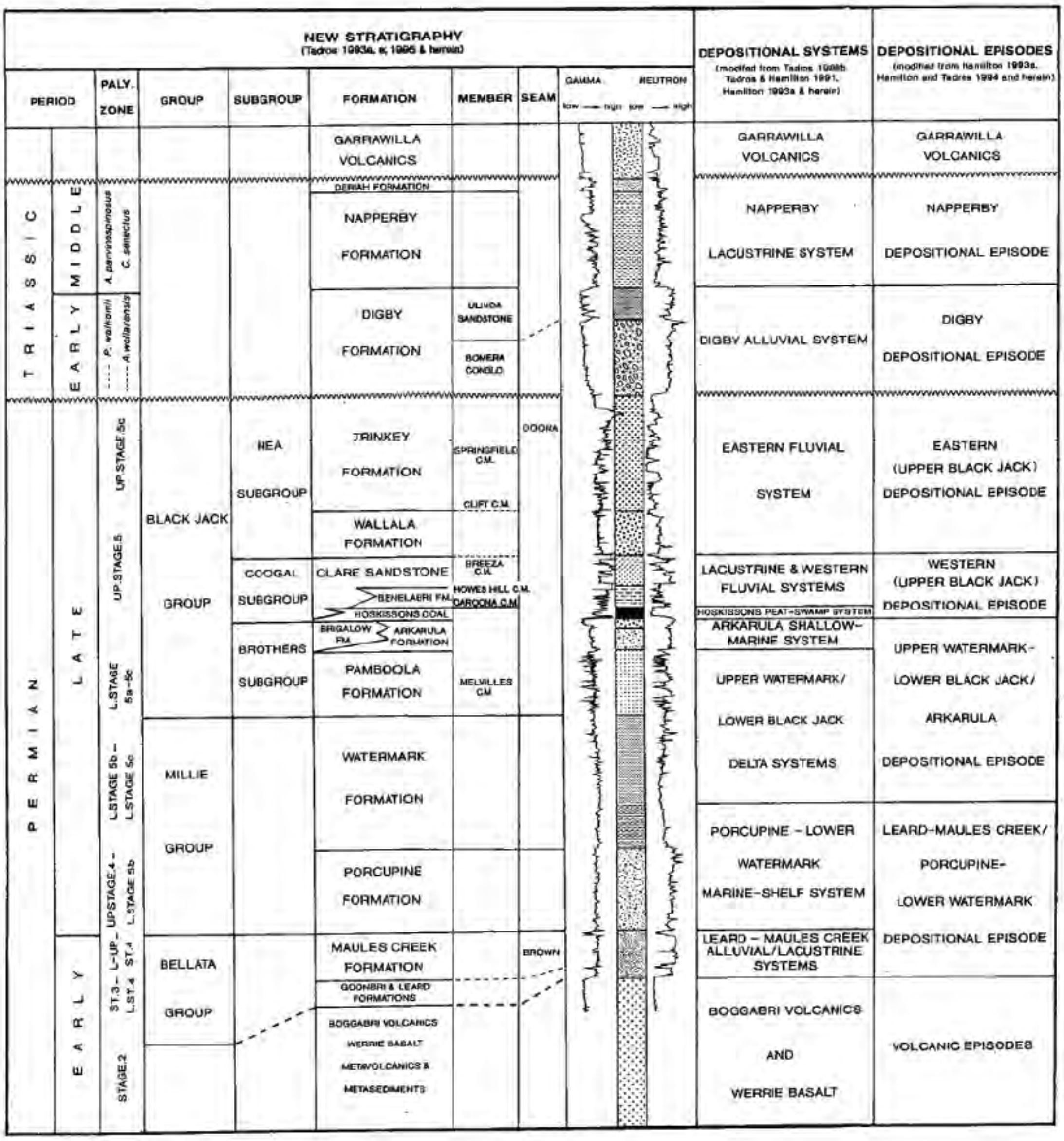
- A basal lithic unit consisting of sandstone, siltstone, claystone, conglomerate and intercalated coals thins towards, and onlaps, the western margin of the basin. The Melvilles Coal Member within this unit is not thought to be present within PEL450. The lithic unit is followed by the Arkarula Sandstone, a fine – medium grained lithic unit which is in turn overlain, in the Mullaley Sub-basin, by medium – coarse – pebbly quartz rich sandstone with a sharp erosive contact.
- The upper part of the Black Jack Group includes the Hoskissons Coal (primary target). The coal consists of predominantly vitrinite poor/inertinite rich coal with subordinate layers of fine sandstone, carbonaceous siltstone/claystone and tuff. The peat swamps developed as a result of marine regression and are fluvial influenced with westerly sourced quartzose channel fills seen along the western margin. The coal is overlain by the coarse grained to conglomeratic, quartz rich Clare Sandstone Member, followed by a lithic conglomerate and finally a fine grained tuffaceous coaly unit

The Early Triassic Digby Formation unconformably overlies the Permian sequence. The Formation consists of a lower lithic conglomerate unit, quartz–lithic sandstone unit and an upper quartzose unit. The lithic conglomerate unit formed as a result of an alluvial fan system and consists of clast supported conglomerate with subordinate lithic sandstone. The clasts comprise green and red jasper, chert and siliceous and mafic volcanics. The middle quartz –lithic sandstone comprises approximately equal parts of quartz and lithics, locally conglomeratic towards the base. The upper quartzose unit comprises predominantly quartzose sandstone with subordinate conglomerate and claystone. Lithics are generally less than 25% of the composition.

The Early–Mid Triassic Napperby Formation is an overall upward coarsening sequence. The lower part consists of dark grey claystone and finely interlaminated sandstone and mudstone. The middle becomes increasingly silty and the upper unit comprises mainly off-white, medium grained lithic sandstone. The Napperby Formation is unconformably overlain by the Late Triassic–Early Jurassic Garrawilla Volcanics. These comprise alkali basalt flows, tuffs and intrusives with weathered surfaces occurring sporadically. Flows are commonly vesicular and contain common secondary zeolite mineralization.

The Garrawilla Volcanics are unconformably overlain by the Jurassic Purlawaugh Formation and Pilliga Sandstone of the Surat Basin sequence. These are respectively flood plain and braided stream deposits equivalent to the Hutton Sandstone sequence to the north.

Figure 5: Generalised Stratigraphy of the Gunnedah Basin, NSW (Tadros, 1999)



3.3 Stratigraphic Prognosis

Well control for Kahlua 3 was provided by surrounding wells STO Kahlua 1, DM Benelabri DDH 1 and ACM Longlea 1. STO Kahlua 1 was the closest corehole (1.6km to the N) and acted as the primary offset for the Kahlua portion of the Gunnedah gas pilot program. Previous drilling in the gas pilot program was used to refine local models and predictions.

Table 5 summarises the actual formation top depths, thickness and difference to prognosis. Formation tops are interpreted from electric logs data, ditch cuttings descriptions along with the core data and adjacent well control.

FORMATION	FORMATION TOPS				
	ACTUAL TOP		High / Low	PROGNOSED TOP	
	(MDmRT)	(TVDmSS)	Prognosis (m)	(MDmRT)	(TVDmSS)
Alluvium	-	-	-	4	318.54
Napperby Fm	12.00	310.54	16.4m High	28.4	294.14
Digby Fm	177.00	145.54	9.8m High	186.8	135.74
Ulinda Sandstone	177.00	145.54	9.8m High	186.8	135.74
Bomera Conglomerate	196.00	126.54	0.6m Low	195.4	127.14
Intrusion	208.00	114.54			
Black Jack Group	**226.00**	**96.54**	**0.5m Low**	**225.5**	**97.04**
Trinkey Formation	226.00	96.54	0.5m Low	225.5	97.04
Wallala Fm	253.00	69.54	2.9m High	255.9	66.64
Breeza CM	290.00	32.54	11.2m Low	278.8	43.74
Benelabri Fm	292.00	30.54	4.8m High	296.8	25.74
Hoskissons CM	310.00	12.54	4.1m High	314.1	8.44
Arkarula Fm	316.36	6.18	4.74m High	321.1	2.56
Pamboola Fm	341.00	-18.46	5.7m High	346.7	-24.16
Melvilles CM	354.15	-31.61	6.55m High	360.7	-38.16
Millie Group	**392.00**	**-69.46**	**21m High**	**413.0**	**-90.46**
Watermark Fm	392.00	-69.46	21m High	413.0	-90.46
Total Depth	**402.50**	**-79.96**	**20.5m High**	**423.0**	**-100.46**

Table 5: Kahlua 3 Stratigraphy Summary

3.4 Stratigraphy Penetrated

Kahlua 3 spudded into the Napperby Formation below a thin layer of alluvium. Following this the well penetrated Jurassic & Triassic sediments before drilling into the Late Permian sediments of the Black Jack Group at 226.0mRT. The well was open holed or "chipped" down to TD of 402.5mRT (driller) within the Watermark Formation, except at the Hoskissons and Melvilles Coal Members where the well was cored. Below is a summary of the stratigraphy penetrated at Kahlua 3 utilising field geology logs and is described in more detail in the well site geologist field logs (**Appendix 4**).

3.4.1 Napperby Formation (12.0 –177.0m)

The Napperby Formation consists of an upper band of siltstone and mudstone while the majority of the remainder of the formation consists of fine to coarse grained sandstone interbedded with siltstone. This gradational change from a fine siltstone to increasingly coarse sandstones through the formation correlates with the interpretation of the unit being deposited in a lacustrine delta environment.

3.4.2 Digby Formation (177.0 – 226.0m)

The Digby formation is typically comprised of two main units, an upper sandstone dominated unit and a lower conglomerate dominated unit, at Kahlua 3 both the Ulinda Sandstone and the Digby or Bomera Conglomerate were visible. The Ulinda Sandstone consisted of a band of primarily medium grained sandstone. The Bomera Conglomerate was comprised of thick units of multicoloured lithics and volcanic pebbles within a sandy matrix, the conglomerate was heat affected in part and intruded by microcrystalline igneous rock towards the middle of the formation. The Digby formation has been interpreted as being derived from massive alluvial systems flowing from the New England Fold Belt.

3.4.3 Trinkey Formation (226.0 – 253.0m)

The Trinkey Formation at Kahlua 3 was dominated by white to grey tuffs and coal bands. The high tuffaceous content of the unit can be attributed to the tephra ejected from the volcanoes of the New England region.

3.4.4 Wallala Formation (253.0 – 290.0m)

The Wallala Formation at Kahlua 3 is a conglomerate dominated unit with a medium to coarse grained sandstone band at the top of the unit. The conglomerates comprising the majority of the unit contained granule to pebble sized clasts similar in appearance to those of the Digby Formation within a coarse grained sandy matrix. The intermediate casing was set at 259.5mGL within this unit. The Wallala Formation is interpreted as being formed from an eastern fluvial system.

3.4.5 Breeza Coal Member (290.0 – 292.0m)

No coal profiling was performed in the Breeza Coal at Kahlua 3 however occasional tuffaceous fragments were noted in the Breeza Coal Member.

3.4.6 Benelabri Formation (292.00 – 310.0m)

The Benelabri Formation at Kahlua 3 consisted of interbedded medium grained sandstone and siltstone layers with occasional coal bands. The Benelabri Formation is believed to be the result of a large lake system.

3.4.7 Hoskissons Coal Measures (310.0 – 316.36m)

The Hoskissons Coal at Kahlua 3 was intersected below the Benelabri Formation. The coal is predominately dull near the top of the Hoskissons and generally increasing in brightness towards the base.

3.4.8 Arkarula Formation (316.36 – 341.0m)

The Arkarula Formation is present immediately following the Hoskissons coal and consists of a band of fine sandstone and siltstone followed by a medium to very coarse grained sandstone. The formation is interpreted as having originated in a wave-dominated delta system as a part of the Arkarula shallow marine system.

3.4.9 Pamboola Formation (341.0 – 392.0m)

The Pamboola Formation at Kahlua 3 is an interbedded siltstone and fine to medium grained sandstone unit. The unit contains occasional carbonaceous traces and the Melvilles Coal Member were intersected near the top of the unit. The Pamboola Formation is interpreted as being the product of deposition within a major delta system.

3.4.10 Melvilles Coal Member (354.15 – 358.63m)

The Melvilles Coal Member at Kahlua 3 are located within the Pamboola Formation. The underlying contact with the coal is an interbedded fine grained siltstone unit while the overlying unit is a medium grained sandstone unit. The coal is predominantly dull with minor bright bands and moderately fractured.

3.4.11 Watermark Formation (392.0 – 402.5m)

The Watermark Formation at Kahlua 3 is a fine to medium grained sandstone unit with occasional silty bands. The upper Watermark is interpreted as having formed in a marine delta system.

3.4.12 Total Depth

Driller:	402.50mRT
Logger:	402.10mRT

3.5 Coal Results

Approximately 25.7m of gross coal was recorded at Kahlua 3, 19.24m of this is inferred from chip samples and wireline logging, while the remaining 6.46m was directly measured from core. Coal profiling was conducted only on the cored coal; geomechanical samples were collected and sent for analysis.

Due to previous drilling and correlation work in the area coals intersected can be assigned to a known coal member. The major coals penetrated and their approximate thicknesses after reconciliation with wireline logs are detailed below:

- Breeza Coal Member: ~0.70m
- Hoskissons Coal Member (Target): 7.34m
- Melvilles Coal Member (Target): 4.36m

3.6 Hydrocarbon Shows

No gas detector was used onsite to record hydrocarbon shows.

4 DISCUSSION AND CONCLUSIONS

Kahlua 3 was the third well drilled for Gunnedah Gas Pilot Project of the Kahlua portion of the investigation into PEL 1. As the well has been suspended the success of the program in assessing the hydrocarbon potential of PEL 1 and the deliverability of the Hoskissons and Melvilles Coal Members is yet to be determined.

An approximate total of 25.7 metres of coal from the Black Jack Group was intersected throughout the borehole. The target Hoskissons Coal Member presented with a thickness of 7.34m and the Melvilles Coal Member presented with a thickness of 4.36m.

Upon conclusion of drilling activities the borehole was suspended and the drill rig was released on 28th November 2010.

5 REFERENCES

Tadros N.Z. (1999) Permian stratigraphy of the Gunnedah Basin, pp120-152. In Coalfield Geology Council of New South Wales, Bulletin 1.

Tadros, N.Z. (Ed.) 1993 The Gunnedah Basin, New South Wales. Geological Survey of New South Wales, Memoir Geology 12, 649 pp.

SANTOS QNT PTY LTD

Kahlua 4

WELL COMPLETION REPORT

PEL 1 - NSW

SANTOS QNT PTY LTD
A.B.N. 33 083 077 196
Level 22 Santos Place
32 Turbot Street
Brisbane Qld 4000

March 2011

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ENCLOSURES

Table 1: Well Data Card

Well Name:	Kahlua 4	Well Type:	CSG Pilot

POST WELL CARD

Licence: PEL 1	Joint Venture: ACM / Santos	Latitude: (GDA94, MGA55)	30° 58'46.994" S / 214686.85m
Equity:	Budget Status: Budget Item	Longitude: (GDA94, MGA55)	150°00'45.500" E / 6568814.77m
		Seismic Reference:	N/A
	Voting (%)	Ground Level:	313.7m A.S.L
Santos QNT Pty Ltd	25	Rotary Table:	317.7m A.S.L
ACM	75	Rig:	EWG 103
		Nearby Facilities:	N/A

Drilling Timing		Drilling Details	
Spud Date:	21:30hrs on 04 November 2010	TD (driller):	409.0mGL (-91.3m ASL)
TD Reached Date:	10:00hrs on 07 November 2010	TD (logger):	409.2mGL (-91.5m ASL)
Rig Release Date:	22:00hrs on 10 November 2010	Well Status:	Suspended Gas Well (SUG)

Net Pay

Coal Seam	Top (mGL)	Base (mGL)	Net Coal (m)
Hoskissons Coal	290.5	298.1	7.3
Melvilles Coal	341.0	344.3	3.0

Stratigraphy (from wireline logs)

Formation	Depth (m GL)	mSS (m)	Thickness (m)
Quaternary Alluvium (Surface)	4.0	313.7	24.5
Napperby Formation	28.5	289.2	136.3
Digby Formation	164.8	152.9	
Ulinda Sandstone	164.8	152.9	11.2
Bomera Conglomerate	176.0	141.7	19.2
Black Jack Group	195.2	122.5	
Trinkey Formation	195.2	122.5	31.0
Wallala Formation	226.2	91.5	32.6
Breeza Coal Measures	258.8	58.9	14.2
Benelabri Formation	273.0	44.7	17.5
Hoskissons Coal Measures	**290.5**	**27.2**	7.6
Arkarula Formation	298.1	19.6	28.3
Pamboola Formation	326.4	-8.7	68.4
Melvilles Coal Measures	**341.0**	**-23.3**	
Millie Group	394.8	-77.1	
Watermark Formation	394.8	-77.1	
Total Depth	409.0	-91.3	

Formation Evaluation

Wireline Logging:

Run	Log	From	To	Run	Log	From	To (mGL)
1	Super Combo	409.0	5.0				
2	CMI	409.0	231.0				

SWC's:	Nil
MDT's:	Nil
Velocity Survey:	Nil

Formation Testing:

DST No.	Interval (mRT)	ISIP Out	FSIP Out (psi)	Max surf pres	Recovery
None					

Coring: No coring

Desorption Samples (mGL): Nil

Hole Design / Drilling

Well Class:	Appraisal Pilot
Hole Type:	Suspended Pilot

Hole Size	Depth (m)	Casing Size
12.25"	232.0	9.625"
8.5"	409.0	7.0"

Drill Fluid: Formation Water and KCL

Deviation Data:

MD (mRT)	TVD (mRT)	Incl (°)	Azim (°)
50.00	50.00	0.2	132.70
100.00	100.00	0.9	223.30
150.00	149.99	1.0	269.20
200.00	199.99	0.5	164.80
250.00	249.99	1.4	54.60
300.00	299.98	1.4	54.70
350.00	349.95	1.4	52.80
405.00	404.94	1.4	49.40

Mud Logging: One set of ditch cuttings was collected and bagged at 6m intervals from surface to TD.

Nearby Wells:
STO Kahlua 1 (1.5 km to the N)
DM Benelabri DDH 1 (2.5 km to the N)
ACM Longlea 1 (6.1 km to SW)

General Comments :

Personnel:

Project Leader	Final Wellcard Compiled By	Operations Geology	Drilling Engineer
Parisa Rhabraian	David Adderley	Andy Pietsch / Jim Day	Bob Goosem

1 INTRODUCTION

Kahlua 4 was the first well to be drilled as part of the Santos (QNT) Pty Ltd, Gunnedah Gas Pilot Project. Kahlua 4 along with Kahlua 3 and 5 will act as observations wells whilst Kahlua 2 is to act as the central pumping well. The project seeks to follow previous exploration within PEL 1 to determine the hydrocarbon potential of the license and assess the deliverability of the Hoskissons and Melvilles Coal Members. The project is also an extension of the farm-in commitment that Santos has in PEL 1 with Australia Coalbed Methane (ACM) Pty Ltd.

Kahlua 4 spudded at 21:30 hours on 4th November 2010. The well penetrated a sequence containing the early to mid Triassic Napperby Formation, the early Triassic Digby Formation, and the late Permian Black Jack Group. The hole reached Total Depth (TD) within the Late Permian Watermark Formation.

The 17.5” (445mm) conductor hole was drilled to ~11m and 14” (356mm) conductor pipe cemented in place. The surface hole 12.25” (311mm) was drilled to 232.00m and 9.625” (245mm) casing cemented to surface within the Wallala Formation. Drilling continued utilising an 8.5” (216mm) PDC bit until Total Depth “TD” was reached at 16:45 hours on 5th December 2010 with a final depth of 409.00mRT (driller). Earth Data Pty Ltd. provided the well-site geological supervision and desorption sample monitoring at Kahlua 4.

A complete set of wireline logs was run at TD and the rig was released at 22:00 hours on the 10th November 2010.

Figure 1: Location Map of Kahlua 2-5

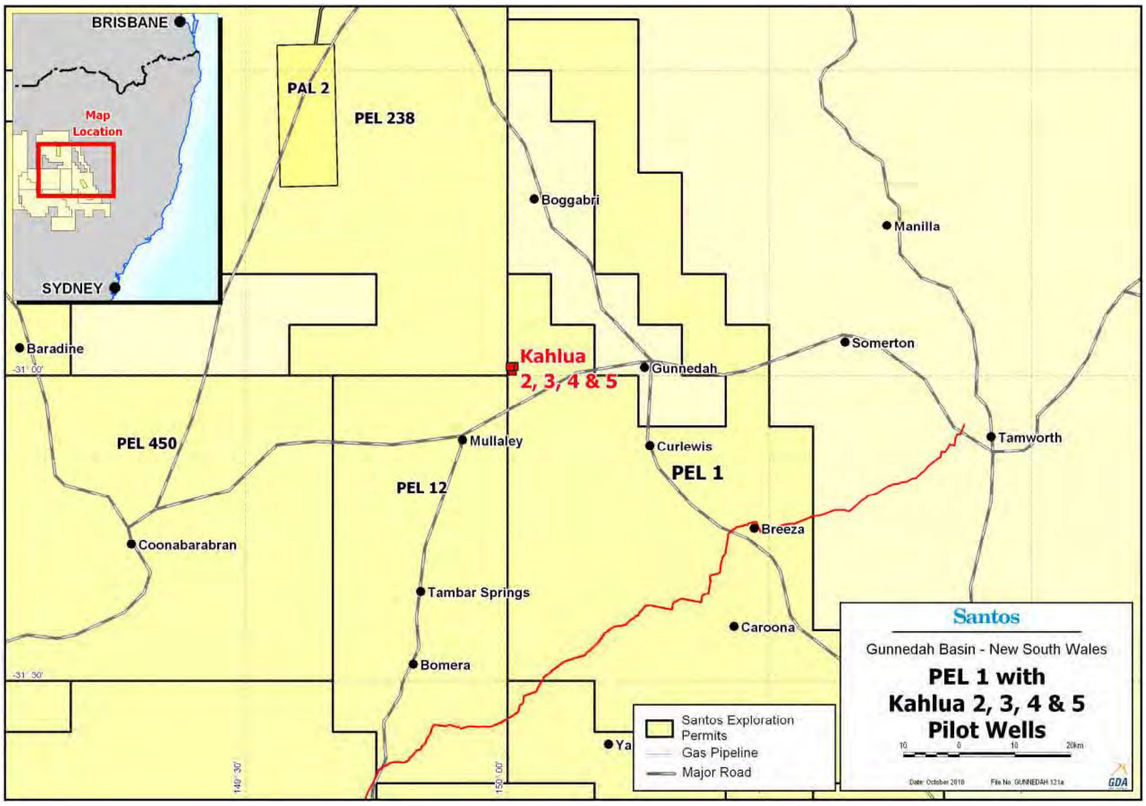
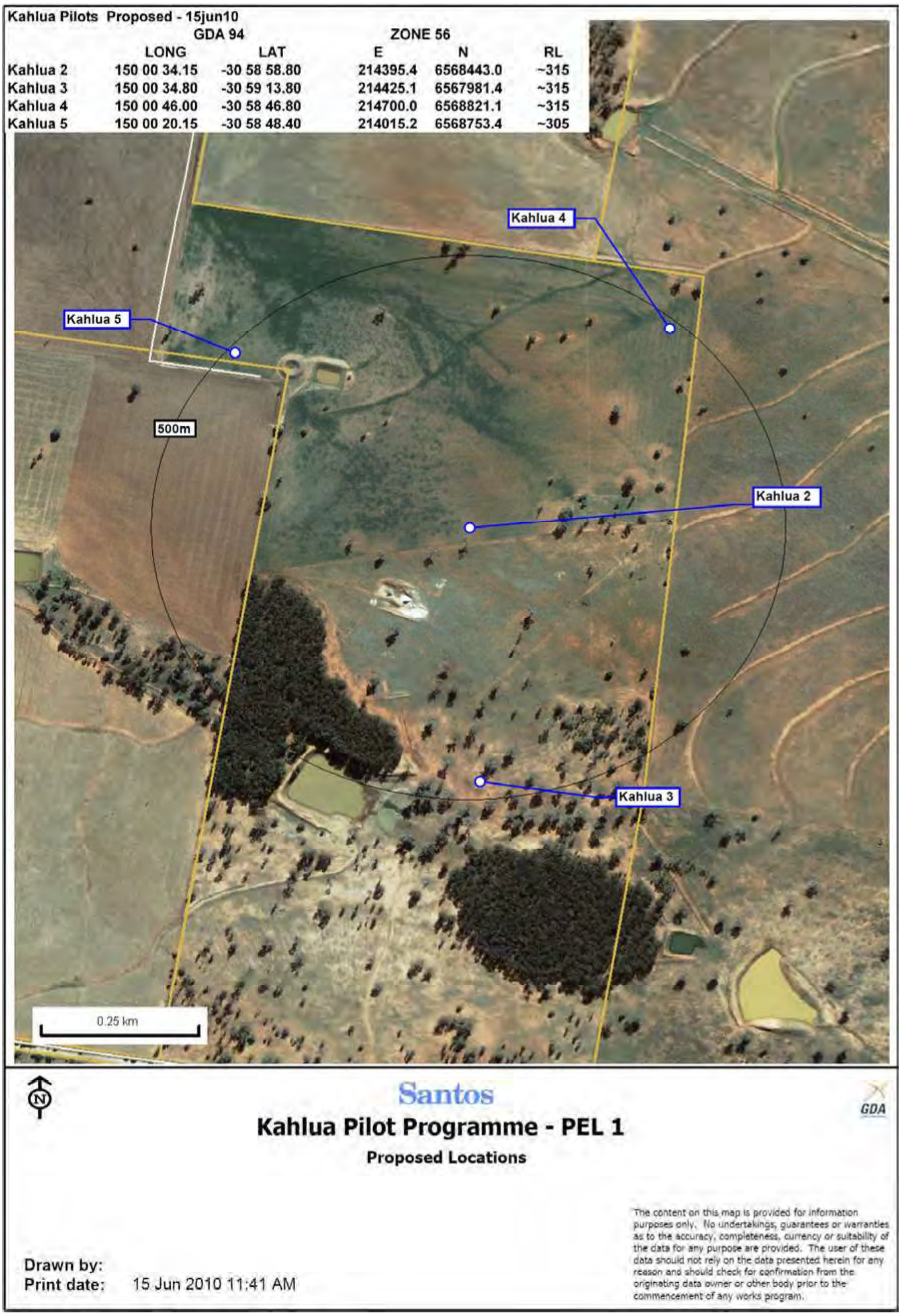


Figure 2: Aerial Photo of Site Location



2 WELL HISTORY

2.1 General Data

Well Name and Number:		Kahlua 4
Location:	Latitude:	30° 58'46.994" S (GDA 94)
	Longitude:	150°00'45.500" E (GDA 94)
MGA Easting (m E):		214686.85
MGA Northing (m N):		6568814.77
Zone		56
Elevations:	G.L.(m):	313.70m A.S.L.
	K.B.(m):	317.70m A.S.L.
Petroleum Tenement:		PEL 1
Permit Operator:		SANTOS QNT PTY LTD Level 22 Santos Place 32 Turbot Street Brisbane Qld 4000
Drilling Contractor:		Eastern Well Drilling Pty Ltd 371 Taylor Street TOOWOOMBA QLD 4350
Drilling Rig:		EWG 103
Date Drilling Commenced:		21:30hrs on 04 November 2010
Date Drilling Completed:		10:00hrs on 07 November 2010
Date Rig Released:		22:00hrs on 10 November 2010
Drilling time (Spud to Rig Release):		6.02 days
Total Depth: Driller		409.00m
	Logger	409.20m
Status:		Suspended Gas Well

2.2 Drilling Data

2.2.1 Introduction

Below is the operations summary for Kahlua 4. It has been compiled from the daily drilling reports (**Appendix 1**) as sent in from the rig-site. A Santos Drilling Supervisor was present on-site at all times to supervise drilling operations, manage third party contractors as well as monitor safety and environmental concerns at the rig-site.

The well lease was prepared by Daracon Pty Ltd and a final well location was surveyed by Stewart Surveys Pty Ltd with the details included in **Appendix 2**.

2.2.2 Kahlua 4 Drilling Summary

2.2.2.1 Conductor Casing

Size: 17.5” (445mm)
Interval: 0.00m – ~11.00 m
Drilling Fluid: Air

The conductor hole 17.5” (445mm) was drilled by Daracon prior to well spud. The 14” (356mm) conductor casing was installed and cemented from surface down to a depth of ~11.00mGL on the same day.

2.2.2.2 Surface Hole

Size: 12.25” (311mm)
Interval: ~11.00m – 232.00m (shoe at 230.60m)
Drilling Fluid: Water and KCl

Kahlua 4 spudded at 21:30 hrs on 4th November 2010. The surface hole section 12.25” (311mm) was drilled using an 12.25” PDC bit to a depth of 232.0mRT. No problems were encountered while drilling out this section of the borehole. A total of 19 joints of 9.625” (245mm) K-55, BTC casing were run in to a shoe depth of 230.60mRT and fully cemented to surface. A total of 424 sacks of cement were used to produce a lead slurry at 12.50ppg to cement from 155.00m to surface, a further 149 sacks were used to produce a tail slurry at 14.80ppg to cement from casing shoe to 155.00m. Cement returns were good, circulating, pumping and displacing returned 24.5 barrels of cement to surface. The casing was then pressure tested to 1000psi for 5 minutes.

2.2.2.3 Production Hole

Size: 8.5” (216mm)
Interval: 232.00m – 409.00m
Drilling Fluid: Water and KCl

The 8.5” hole section was drilled from 232.00 to 409.00mGL using a 8.5” PDC bit. After TD had been reached production casing was run with a shoe depth of 409.00m and fully cemented to surface. A total of 32 joints of 7” (178mm) steel and fibreglass casing was used with 30 joints of steel K-55, 23lbs/ft, BTC casing and 2 joints of fibreglass DHC350, 7.6lbs/ft, 4rd casing set over the target seams. A total of 207 sacks of cement were used to produce a lead slurry at 12.00ppg to cement from 261.00m to surface, a further 143 sacks were used to produce a tail slurry at 14.00ppg to cement from casing shoe to 261.00m. Cement returns were good, circulating, pumping and displacing returned 11.2 barrels of cement to surface. The casing was then pressure tested to 1500psi for 5 minutes. Once the casing was set the borehole was then underreamed from 290.00 to 300.00m over the Hoskissons Coal Members.

The rig was released at 22:00 hrs on the 10th November 2010.

2.2.3 Casing and Cementing

Refer to the Well Schematic (**Figure 4** and **Table 2**) for the Casing and Cementing Summary details at Kahlua 4.

Table 2: Casing and Cementing Summary

Conductor		
Hole/Casing Size	-	17.5" / 14" (445mm / 356mm)
Weight	-	54.5lbs/ft
Grade	-	
Shoe Setting Depth	-	~11.0 m
Interval Cemented	-	~11.0 m – to surface
Surface		
Hole/Casing Size	-	12.25" / 9.625" (311mm / 245mm)
Weight	-	36.0lbs/ft
Grade	-	K-55
Shoe Setting Depth	-	240.6 m
Interval Cemented	-	230.60m – to surface
Production		
Hole/Casing Size	-	8.5" / 7" (216mm / 178mm)
Weight	-	23lbs/ft / 7.6lbs/ft
Grade	-	K-55 / DHC350
Shoe Setting Depth	-	409.00m
Quantity of Cement	-	207 sacks at 12.00ppg / 143 sacks at 14.00ppg
Interval Cemented	-	409.00m – to surface

2.2.4 Deviation Surveys

The largest deviation recorded at Kahlua 4 was 1.4° and was recorded between 250.00 and TD.

2.2.5 Drilling Fluid Data

Materials used in the mud system whilst drilling included salt (KCl) and fresh water sourced locally. KCl (3-6%) was used to assist in maintaining mud weight and minimise clay swelling.

a) 0.00 – ~11.00 m Air
b) ~11.00 – 232.00m Water and KCl
c) 232.00 – 409.00m Water and KCl

2.2.6 Water Supply

Drilling water supply was obtained from dams near location and trucked to site.

2.3 Drilling Contractors and Personnel

Project Leader	:	P Rhabraian
Drilling Engineer/Supervisor	:	B Goosem
Drilling Rig Representative	:	K Parker/S Hobday/E Bennett/D Malone
Drilling	:	Eastern Well Drilling Pty Ltd
Wellsite Geologist	:	A Price
Field Testing	:	Earth Data Pty Ltd
Cementing	:	Halliburton Pty Ltd
Mud Engineering	:	Eastern Well Drilling Pty Ltd
Wireline Logging	:	Weatherford Australia Wireline Pty Ltd
Well Testing	**:**	DST Australia
Casing Perforation	**:**	Not Conducted

Figure 3: Kahlua 4 Time-Depth Curve

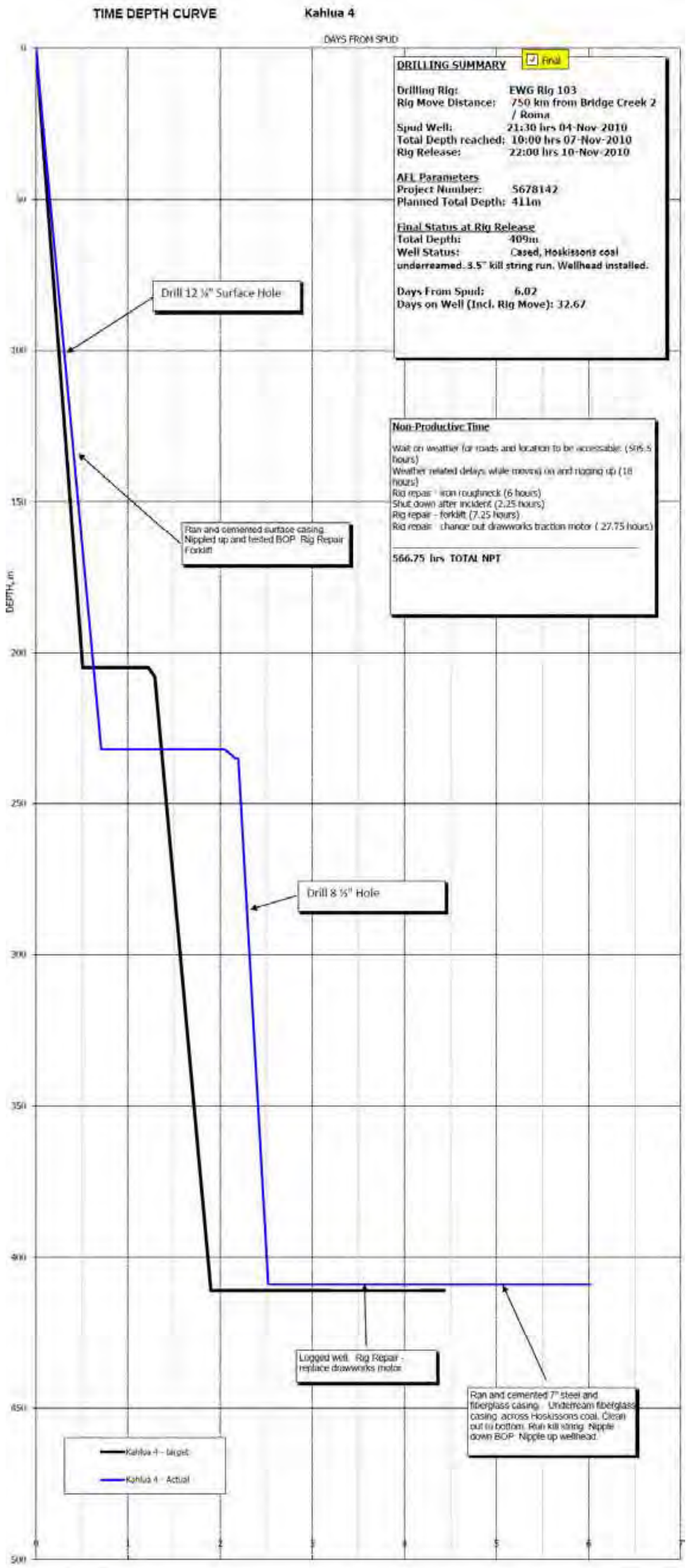
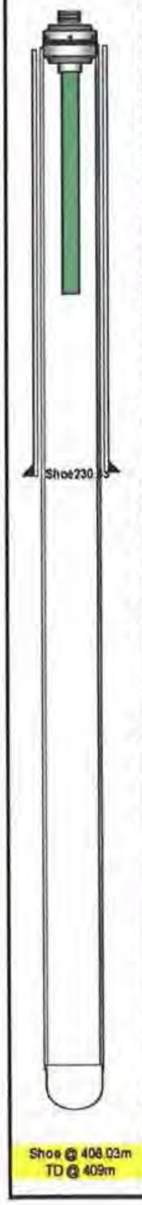


Figure 4: Kahlua 4 Well Schematic

Santos
Santos Ltd A.C.N 007 550 923

KAHLUA 4

Latitude:	30° 58' 46.994" S	Well spudded 4-11-2010	Ground Level:	313.65 m
Longitude:	150° 00 45.500" E	Last activity: 10-10-2010	RT elevation:	317.69 m



ITEM No	DESCRIPTION	LTH (m)	DTH KB (m)	MIN I.D.	MAX O.D.
	KB to top of tubing spool flange	3.95	3.95		
1	3 1/2 Back pressure profile tubing hanger (Nested Hanger)		3.95		
2	6 jnts 3 1/2" eue tubing 3 1/2" tubing set @ 61.79m	57.39	61.79		
	Wood Group single stage conventional well head option 7A (Compact well head)				
	A Section - Top of 11"3M x 9 5/8" BTC wellhead at 0.05m above ground level				
	11" x 3m x 7-1/16" x 3M DSA				
	7-1/16" x 3-1/8" 3M SSA				
	3-1/8" x 3M universal C-section Valve				
	NOTE- 3" BPV not installed				

BRIEF HISTORY ON WELL

Kahlua 4 was spudded by EWG Rig #103 on the 4th November 2010 @ 21.30hrs. 12-1/4" surface hole was drilled to 232m and 9-5/8" casing was RIH and cemented @ 230.63m. An 9 5/8" x 11" 3K BTC wellhead installed. The shoe was drilled out and an LOT was performed to an EMW of 20.8ppg. The 8.5" production hole section was drilled from 232m to 409m TD. 7" 23 lb/ft casing and fibre glass casing was run to 408.03m. Ran in and under reamed the fibreglass casing across the Hoskissons coal from 290m to 300m to 12 1/4" OD. Well was cleaned out and displaced to 3% KCL and Idoide 20 was added. A 3 1/2" EUE kill string was run and landed @ 61.79m with a 11" x 3 1/2" EUE nested hanger. 11" x 3m x 7-1/16" x 3M DSA, 7-1/16" x 3-1/8" 3M SSA and a 3-1/8" x 3M universal C-section Valve was installed and tested by Wood Group.
Rig released at 22:00 hrs on 10th November 2010.

CASING DETAILS		CEMENTING DETAILS:
Size:	9-5/8"	Cement 9 5/8" casing as per program.
Weight:	36 lb/ft	Pump 10 bbls of Preflush, Pressure test surface lines to 3000 psi/5 minutes.
Grade:	K-55	Pump 10 bbls of preflush. Mix & pump 151sxs (66.3bbls) of 12.5ppg Lead cement
Depth Set:	230.63	Mix & pump 83sxs (18.7bbls) of 14.8ppg Tail cement
		Drop top plug & Displace with 60bbls of water (Cement returns at surface after 38bbls of displacement pumped)
		Bump plug with 200psi @ 1.8bpm. Pressure test 9 5/8" casing to 1000psi/5minutes
		Bleed back 0.5bbl - Float holding
		**Note- Full returns during the cement job **

PRODUCTION

CASING DETAILS		CEMENTING DETAILS:
Size:	7"	Pump 10 bbls weighted spacer (8.8ppg) Pressure test lines to 2000 psi. Pump 10 bbls weighted spacer.
Weight:	23ppf	Mix and pump 26bbls (65sx) EconoCem 12 ppg Lead cement.
Grade:	K-55	18bbls (65sx) CBMCem 14 ppg Tail cement.
Depth Set:	408.03	Flush surface lines Drop top plug and displace with 52.2 bbls of fresh water.
ID:	6.366	Cement returns to surface after 41 bbls of displacement pumped. 11.2 bbls of cement to surface.
Capacity:	.0394lb/ft	Bump plug with 480 psi @ 1.5 bpm. Pressure test 7" casing to 1500 psi for 5 min.
		Bleed back 0.5 bbls floats holding.
		Full returns throughout job.

FORMATION	(mKB)	GUN: SIZE	GUN: TYPE	CHARGES: SPF	CHARGES: TYPE	WT(g)
	Hoskissons Coal from 290.4m to 298.1m					
	Melvilles Coal from 341m to 344.3m					
PRESSURE						
TEMPERATURE						

TAGGED DEPTHS:	
ANNULUS FLUID:	
INDICATED STRING WEIGHT:	
CALCULATED STRING WEIGHT:	
LANDED WEIGHT:	
REMARKS:	

NOT TO SCALE	WELLSITE SUPERVISOR: Dean Malone	
PROPOSED:	TUBING INSTALLATION / LAST WORKOVER	None
COMPLETION:	DRAFTED BY:	DATE:
RE-COMPLETION:	REVISED BY:	DATE:
OTHER:	CHECKED BY:	DATE:

2.4 Formation Sampling and Evaluation

2.4.1 Well site Geologist

Earth Data Pty Ltd ("Earth Data") provided onsite geological supervision and desorption testing at Kahlua 4. A composite log summarising geological activities is included in **Appendix 4**.

2.4.2 Mud logging

A mud logging unit services were not used whilst drilling this well and no record of conventional hydrocarbon shows were made. No drilling breaks or gains/losses in drilling fluid were noted whilst drilling through the potential gas-bearing sandstones.

2.4.3 Ditch Cutting Samples

Cuttings were collected from the surface to TD. The sampling intervals for Kahlua 4 are outlined in **Table 3** below.

Interval/Formation	Sample Type (and recipient)	Sample Volume and Frequency
Surface – 409.0mRT	Cuttings Samples	Cuttings collected every 6m

Table 3: Sampling Intervals at Kahlua 4

2.4.4 Wireline Logs

Weatherford Australia Pty Ltd provided slimhole mineral logging services at Kahlua 4. A complete suite of wireline logs was run in multiple runs at Kahlua 4 (**Table 4**). Wireline logging was carried on the 8th November 2010.

Table 4: Wireline Logging Summary

SUITE	RUN	TOOL STRING	INTERVAL (m GL)	TIME SINCE CIRC.
1	1	SuperCombo	5.00 – 409.20	5hrs
1	2	CMI + Verticality	5.00 – 405.00	7hrs 50min

2.4.5 Temperature Surveys

The highest recorded temperature at Kahlua 4 was 35 degrees Celsius at the bottom of the hole.

2.4.6 Drill Stem Tests ("DST")

No DST tests were performed at Kahlua 4.

3 GEOLOGY

3.1 Reasons for Drilling

The Kahlua 4 borehole is part of the Santos Gunnedah Gas Pilot drilling program which is designed to provide information on the hydrocarbon potential of PEL 1. In conjunction with the Kahlua 2, 3 and 5 boreholes, Kahlua 4 will be an observation well used to appraise the deliverability of the Hoskissons and Melvilles coal seams. Results from the previously drilled Kahlua 1 corehole were encouraging and suggested potential hydrocarbon resources in the region.

3.2 Regional Geology of the Gunnedah Basin (taken from Tadros, 1993)

The effective Basement of the Gunnedah Basin sequence consists of the Boggabri Volcanics and Werrie Basalts (Late Carboniferous to Early Permian age) that make up the economic floor of the basin. These units contain un-deformed lavas, tuffs and intercalated sediments. The top of these basal volcanics is deeply weathered, indicating an unconformity with the overlying units.

The Leard and Goonbri Formations unconformably overlie Basement (**Figure 5**). The Leard Formation comprises Early Permian pelletal flint claystone, conglomerate, sandstone and siltstone, commonly interbedded with coal. It forms a discontinuous thin veneer deposited in the more deeply eroded and weathered basement structure. The Goonbri Formation unconformably overlies the Boggabri Volcanics and the Leard Formation. It is a regressive lacustrine sequence comprising predominantly bioturbated organic-rich siltstone and thin coal, coarsening upwards to laminated siltstone and fine grained sandstone and then moderately well sorted medium grained sandstone.

The Maules Creek Formation is an Early Permian alluvial to fluvial system which overlies and onlaps both the Leard and Goonbri Formations. In the Mullaley Sub-basin, the Maules Creek Formation is subdivided into a northern zone containing quartz rich sandstone; a central zone of volcanogenic sediments; and a south eastern zone consisting of fine grained sediments rich in coal. The boundary with the overlying Porcupine Formation is disconformable and the two formations inter-finger each other.

The Porcupine Formation is a late Permian fan delta marine incursion into the Gunnedah Basin. The unit is a fining up sequence from a para-conglomerate with a poorly sorted sandstone and siltstone matrix at the base through an ortho-conglomerate with moderately sorted sandstone and siltstone matrix to a homogeneous bioturbated sandstone and mudstone. The conglomerate clasts are dominantly siliceous volcanics. The upper boundary with the overlying Watermark Formation is gradational. In the western margin of the Basin, the Porcupine Formation is approximately 10m thick.

The lower part of the Watermark Formation represents the maximum extent of the Late Permian transgression. The upper part is a marine regression associated with the overlying Black Jack delta system. The lower part is characterized by a fining up sequence from sandy siltstone at the base to siltstone / claystone laminate at the top. The upper part consists of a major coarsening up succession consisting of two distinctive units; the lower unit which is finely laminated siltstone and claystone with sporadic “dropped pebbles”; and the upper unit which consists of well

developed coarsening up sequences of siltstone, sandy siltstone to interbedded siltstone and sandstone, the percentage of sandstone increases up the sequence.

The Late Permian Black Jack Group is divided into a deltaic lower unit containing the target coals and an upper fluvial-lacustrine unit.

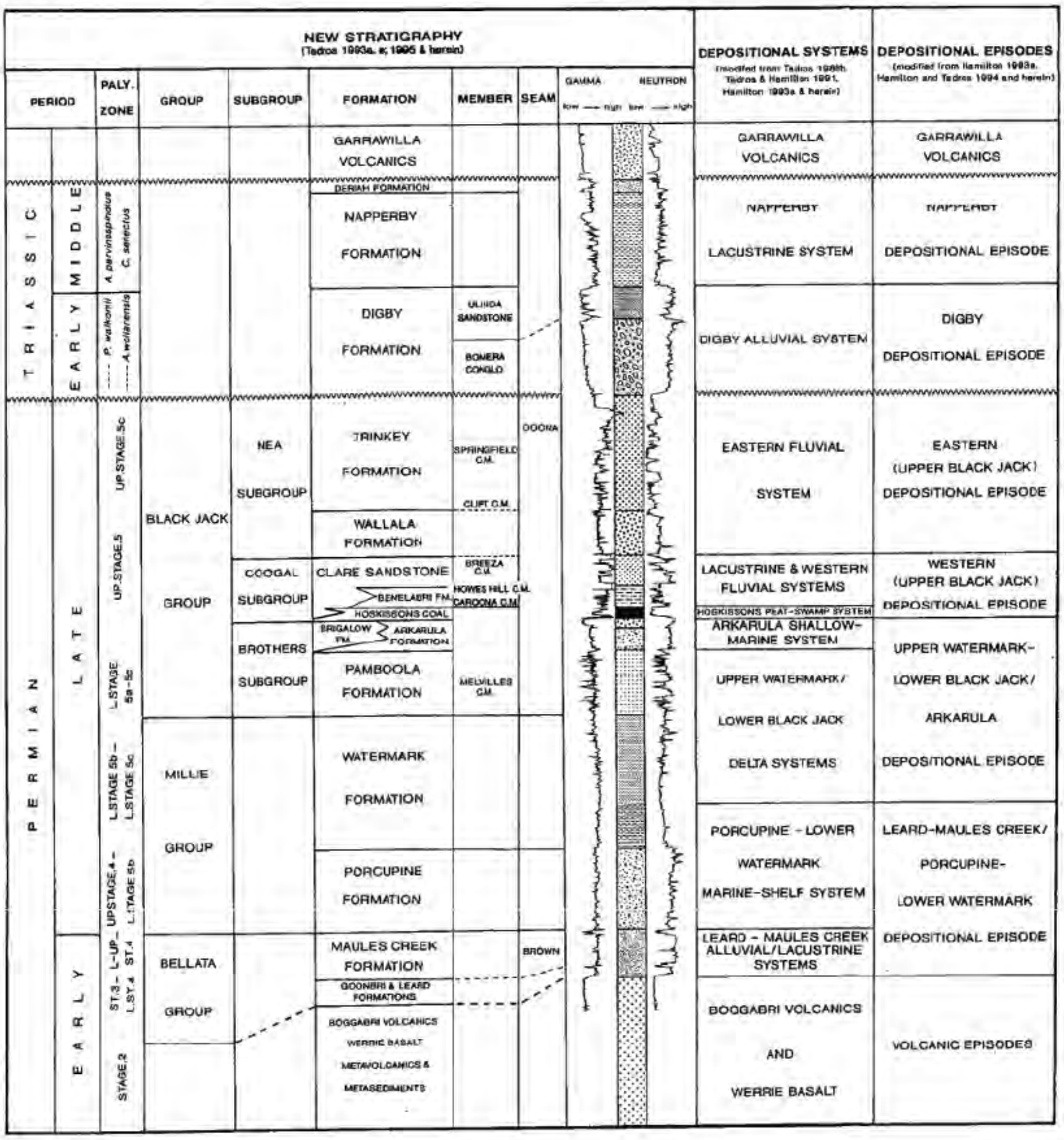
- A basal lithic unit consisting of sandstone, siltstone, claystone, conglomerate and intercalated coals thins towards, and onlaps, the western margin of the basin. The Melvilles Coal Member within this unit is not thought to be present within PEL450. The lithic unit is followed by the Arkarula Sandstone, a fine – medium grained lithic unit which is in turn overlain, in the Mullaley Sub-basin, by medium – coarse – pebbly quartz rich sandstone with a sharp erosive contact.
- The upper part of the Black Jack Group includes the Hoskissons Coal (primary target). The coal consists of predominantly vitrinite poor/inertinite rich coal with subordinate layers of fine sandstone, carbonaceous siltstone/claystone and tuff. The peat swamps developed as a result of marine regression and are fluvial influenced with westerly sourced quartzose channel fills seen along the western margin. The coal is overlain by the coarse grained to conglomeratic, quartz rich Clare Sandstone Member, followed by a lithic conglomerate and finally a fine grained tuffaceous coaly unit

The Early Triassic Digby Formation unconformably overlies the Permian sequence. The Formation consists of a lower lithic conglomerate unit, quartz–lithic sandstone unit and an upper quartzose unit. The lithic conglomerate unit formed as a result of an alluvial fan system and consists of clast supported conglomerate with subordinate lithic sandstone. The clasts comprise green and red jasper, chert and siliceous and mafic volcanics. The middle quartz –lithic sandstone comprises approximately equal parts of quartz and lithics, locally conglomeratic towards the base. The upper quartzose unit comprises predominantly quartzose sandstone with subordinate conglomerate and claystone. Lithics are generally less than 25% of the composition.

The Early–Mid Triassic Napperby Formation is an overall upward coarsening sequence. The lower part consists of dark grey claystone and finely interlaminated sandstone and mudstone. The middle becomes increasingly silty and the upper unit comprises mainly off-white, medium grained lithic sandstone. The Napperby Formation is unconformably overlain by the Late Triassic–Early Jurassic Garrawilla Volcanics. These comprise alkali basalt flows, tuffs and intrusives with weathered surfaces occurring sporadically. Flows are commonly vesicular and contain common secondary zeolite mineralization.

The Garrawilla Volcanics are unconformably overlain by the Jurassic Purlawaugh Formation and Pilliga Sandstone of the Surat Basin sequence. These are respectively flood plain and braided stream deposits equivalent to the Hutton Sandstone sequence to the north.

Figure 5: Generalised Stratigraphy of the Gunnedah Basin, NSW (Tadros, 1999)



3.3 Stratigraphic Prognosis

Well control for Kahlua 4 was provided by surrounding wells STO Kahlua 1, DM Benelabri DDH 1 and ACM Longlea 1. STO Kahlua 1 was the closest corehole (1.6km to the N) and acted as the primary offset for the Kahlua portion of the Gunnedah gas pilot program.

Table 5 summarises the actual formation top depths, thickness and difference to prognosis. Formation tops are interpreted from electric logs data, ditch cuttings descriptions along with the core data and adjacent well control.

FORMATION	FORMATION TOPS				
	ACTUAL TOP		High / Low	PROGNOSED TOP	
	(MDmRT)	(TVDmSS)	Prognosis (m)	(MDmRT)	(TVDmSS)
Quaternary Alluvium	4	313.69	0	4	313.69
Napperby Fm	24	293.69	10m Low	34	283.69
Digby Fm	168	149.69	20m Low	148	169.69
Ulinda Sandstone	*168*	*149.69*	*20m Low*	*148*	*169.69*
Bomera Conglomerate	*174*	*143.69*	*12m Low*	*162*	*155.69*
Black Jack Group	**197**	**120.69**	**28m Low**	**169**	**148.69**
Trinkey Fm	197	120.69	28m Low	169	148.69
Wallala Fm	222	95.69	22m Low	200	117.69
Breeza CM	262	55.69	15m Low	247	70.69
Benelabri Fm	276	41.69	3m High	279	38.69
Hoskissons CM	292	25.69	22m High	314	3.69
Arkarula Fm	300	17.69	26m High	326	-8.31
Pamboola Fm	316	1.69	30m High	346	-28.31
Melvilles CM	340	-22.31	31m High	371	-53.31
Millie Group	**384**	**-66.31**	**17m High**	**401**	**-83.31**
Watermark Fm	384	-66.31	17m High	401	-83.31
Total Depth	**409**	**-91.31**	**2m High**	**411**	**-93.31**

Table 5: Kahlua 4 Stratigraphy Summary

3.4 Stratigraphy Penetrated

Kahlua 4 spudded into the Napperby Formation below a thin layer of alluvium. Following this the well penetrated Jurassic & Triassic sediments before drilling into the Late Permian sediments of the Black Jack Group at 197.00mRT. The well was open holed or "chipped" down to TD of 409.00mRT (driller) within the Watermark Formation. Below is a summary of the stratigraphy penetrated at Kahlua 4 utilising field geology logs and is described in more detail in the well site geologist field logs (**Appendix 4**).

3.4.1 Napperby Formation (24.0 –168.0m)

The Napperby Formation consists of an upper band of siltstone and mudstone while the majority of the remainder of the formation consists of very fine to fine grained quartz-lithic sandstone interbedded with siltstone. This gradational change from a fine siltstone to increasingly coarser sandstones through the formation correlates with the interpretation of the unit being deposited in a lacustrine delta environment.

3.4.2 Digby Formation (168.0 – 197.0m)

The Digby formation is typically comprised of two main units, an upper sandstone dominated unit and a lower conglomerate dominated unit, at Kahlua 4 both the Ulinda Sandstone and the Digby or Bomera Conglomerate were visible. The Ulinda Sandstone consisted of a band of primarily very fine grained sandstone. The Bomera Conglomerate was comprised of thick units of multicoloured lithics and volcanic pebbles within a sandy matrix. The Digby formation has been interpreted as being derived from massive alluvial systems flowing from the New England Fold Belt.

3.4.3 Trinkey Formation (197.0 – 222.0m)

The Trinkey Formation at Kahlua 4 was dominated by white to grey tuffs and coal bands. A fine to medium grained quartzose sandstone band was noted in the middle of the unit. The high tuffaceous content of the unit can be attributed to the tephra ejected from the volcanoes of the New England region.

3.4.4 Wallala Formation (234.0 – 262.0m)

The Wallala Formation at Kahlua 4 is coarse grained sandstone – conglomerate dominated unit with occasional tuffaceous sections associated with minor coal seams. The conglomerates comprising the most significant portion of the unit contained granule to pebble sized clasts similar in appearance to those of the Digby Formation with within a coarse grained sandy matrix. The intermediate casing was set at 240.60mRT within this unit. The Wallala Formation is interpreted as being formed from an eastern fluvial system.

3.4.5 Breeza Coal Measures (262.0 – 264.0m)

No coal profiling was performed at Kahlua 4 however occasional tuffaceous fragments were noted in the Breeza Coal Member.

3.4.6 Benelabri Formation (264.00 – 292.00m)

The Benelabri Formation at Kahlua consisted of interbedded medium grained sandstone and mudstone layers. No coal was noted in the unit however occasional carbonaceous mudstone bands with minor coaly fragments were seen. The contact with the underlying Hoskissons Coal Member was a fine grained quartz lithic sandstone with on top of a mudstone band with minor coaly fragments. The Benelabri Formation is believed to be the result of a large lake system.

3.4.7 Hoskissons Coal Measures (292.00 – 300.00m)

The Hoskissons Coal at Kahlua 4 was intersected below the Benelabri Formation. No coal profiling was performed.

3.4.8 Arkarula Formation (300.00 – 316.0m)

The Arkarula Formation is present immediately following the Hoskissons coal. The upper contact of the unit with the Hoskissons coal is defined by a mudstone unit which grades to a silitstone. The base of the unit is comprised of quartz lithic sandstone which is typical of the Arkarula formation throughout the basin. The formation is interpreted as having originated in a wave-dominated delta system as a part of the Arkarula shallow marine system.

3.4.9 Pamboola Formation (316.0 – 384.0m)

The Pamboola Formation at Kahlua 4 is an interbedded very fine to medium grained quartz lithic sandstone and mudstone unit. The unit contains occasional carbonaceous traces and the Mellviles Coal Member were intersected near the top of the unit. The Pamboola Formation is interpreted as being the product of deposition within a major delta system.

3.4.10 Melvilles Coal Measures (340.0 – 344.0m)

The Melvilles Coal Member at Kahlua 4 are located within the Pamboola Formation. The overlying contact with the coal is a very fine to fine grained quartzose sandstone unit while the underlying unit is a mudstone unit. No coal profiling was performed.

3.4.11 Watermark Formation (384.0 –409.0m)

The Watermark Formation at Kahlua 4 transitions from a very fine to fine grained quartzose sandstone unit to a siltstone unit towards TD. The upper Watermark is interpreted as having formed in a marine delta system while the lower Watermark is interpreted as forming in the same marine-shelf as the Porcupine Formation.

3.4.12 Total Depth

Driller:	409.00m
Logger:	409.20m

3.5 Coal Results

Approximately 27.40m of gross coal was recorded during drilling operations at Kahlua 2. No coal profiling was conducted and no samples were sent for analysis.

Due to previous drilling and correlation work in the area coals intersected can be assigned to a known coal sections. The major coals penetrated and their approximate thicknesses after reconciliation with wireline logs are detailed below:

- Breeza Coal Member: ~0.50m
- Hoskissons Coal Member (Target): ~7.25m
- Melvilles Coal Member (Target): ~3.12m

3.6 Hydrocarbon Shows

No gas detector was used onsite to record hydrocarbon shows.

4 DISCUSSION AND CONCLUSIONS

Kahlua 4 was the first well drilled for Gunnedah Gas Pilot Project initiating the Kahlua portion of the investigation into PEL 1. As the well has been suspended the success of the program in assessing the hydrocarbon potential of PEL 1 and the deliverability of the Hoskissons and Melvilles Coal Members is yet to be determined.

An approximate total of 27.40 metres of coal from the Black Jack Group was intersected throughout the borehole. The target Hoskissons Coal Member presented with a thickness of ~7.25m and the Melvilles Coal Member presented with a thickness of ~3.12m. No coal profiling was performed by the wellsite geologist as no core was collected.

Upon conclusion of drilling activities the borehole was suspended and the drill rig was released on 10th November 2010.

5 REFERENCES

Tadros N.Z. (1999)	Permian stratigraphy of the Gunnedah Basin, pp120-152. In Coalfield Geology Council of New South Wales, Bulletin 1.
Tadros, N.Z. (Ed.) 1993	The Gunnedah Basin, New South Wales. Geological Survey of New South Wales, Memoir Geology 12, 649 pp.

SANTOS QNT PTY LTD

Kahlua 5

WELL COMPLETION REPORT

PEL 1 - NSW

SANTOS QNT PTY LTD
A.B.N. 33 083 077 196
Level 22 Santos Place
32 Turbot Street
Brisbane Qld 4000

March 2011

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ENCLOSURES

Table 1: Well Data Card

Well Name:	Kahlua 5	**Well Type:**	CSG Pilot

POST WELL CARD

Licence: PEL 1	**Joint Venture:** ACM / Santos	**Latitude: (GDA94, MGA55)**	30° 58'48.340" S / 214016.24m
Equity:	**Budget Status:** Budget Item	**Longitude: (GDA94, MGA55)**	150°00'20.191" E / 6568755.23m
		Seismic Reference:	N/A

	Voting (%)
Santos QNT Pty Ltd	25
ACM	75

Ground Level:	307.6m A.S.L
Rotary Table:	311.6m A.S.L
Rig:	EWG 103
Nearby Facilities:	N/A

Drilling Timing

Spud Date:	12:00hrs on 13 November 2010
TD Reached Date:	13:00hrs on 16 November 2010
Rig Release Date:	09:00hrs on 18 November 2010

Drilling Details

TD (driller):	410.0mGL (-98.4m ASL)
TD (logger):	410.2mGL (-98.6m ASL)
Well Status:	Suspended Gas Well (SUG)

Net Pay

Coal Seam	Top (mGL)	Base (mGL)	Net Coal (m)
Hoskissons Coal	302.9	310.0	6.8
Melvilles Coal	349.6	352.6	2.8

Stratigraphy (from wireline logs)

Formation	Depth (m GL)	mSS (m)	Thickness (m)
Quaternary Alluvium (Surface)	4.0	307.6	13.4
Napperby Formation	17.4	294.2	158.4
Digby Formation	175.8	135.8	
Ulinda Sandstone	175.8	135.8	8.6
Bomera Conglomerate	184.4	127.2	30.1
Black Jack Group	214.5	97.1	
Trinkey Formation	214.5	97.1	30.4
Wallala Formation	244.9	66.7	22.9
Breeza Coal Measures	267.8	43.8	18.0
Benelabri Formation	285.8	25.8	17.1
Hoskissons Coal Measures	**302.9**	**8.7**	7.1
Arkarula Formation	310.0	1.6	26.0
Pamboola Formation	336.0	-24.4	66.0
Melvilles Coal Measures	**349.7**	**-38.1**	
Millie Group	402.0	-90.4	
Watermark Formation	402.0	-90.4	
Total Depth	410.0	-98.4	

Formation Evaluation

Wireline Logging:

Run	Log	From	To	Run	Log	From	To (mGL)
1	Super Combo	410.0	4.0				
2	CMI	410.0	245.0				

SWC's:	Nil
MDT's:	Nil
Velocity Survey:	Nil

Formation Testing:

DST No.	Interval (mRT)	ISIP Out	FSIP Out (psi)	Max surf pres	Recovery
None					

Coring: Conventionally Cored: 295.0m - 312.5m & 345.6m - 363.0m

Desorption Samples (mGL): Nil

Hole Design / Drilling

Well Class:	Appraisal Pilot
Hole Type:	Suspended Pilot

Hole Size	Depth (m)	Casing Size
12.25"	245.0	9.625"
8.5"	410.0	7.0"

Drill Fluid: Formation Water and KCL

Deviation Data:

MD (mRT)	TVD (mRT)	Incl (°)	Azim (°)
51.00	51.00	0.2	129.40
101.00	101.00	0.4	186.60
151.00	151.00	0.2	139.80
201.00	201.00	0.3	136.90
251.00	251.00	0.1	241.90
301.00	301.00	0.3	37.10
351.00	351.00	0.5	52.60
407.00	406.99	0.6	52.80

Mud Logging: One set of ditch cuttings was collected and bagged at 6m intervals from surface to TD.

Nearby Wells:
STO Kahlua 1 (1.6 km to the N)
DM Benelabri DDH 1 (2.2 km to the N)
ACM Longlea 1 (5.5 km to SW)

General Comments :

Personnel:

Project Leader	Final Wellcard Compiled By	Operations Geology	Drilling Engineer
Parisa Rhabraian	David Adderley	Andy Pietsch / Jim Day	Bob Goosem

1 INTRODUCTION

Kahlua 5 was the third well to be drilled as part of the Santos (QNT) Pty Ltd, Gunnedah Gas Pilot Project. Kahlua 5 along with Kahlua 3 and 4 will act as observation wells whilst Kahlua 2 is to act as the central pumping well. Broadly the project seeks to follow previous exploration within PEL 1 to determine the hydrocarbon potential of the license and assess the deliverability of the Hoskissons and Melvilles Coal Members. The project is also an extension of the farm-in commitment that Santos has in PEL 1 with Australia Coalbed Methane (ACM) Pty Ltd.

Kahlua 5 spudded at 12:00 hours on 13th November 2010. The well penetrated a sequence containing the early to mid Triassic Napperby Formation, the early Triassic Digby Formation, and the late Permian Black Jack Group. The hole reached Total Depth (TD) within the Late Permian Watermark Formation.

The 17.5" (445mm) conductor hole was drilled to ~11m and 14" (356mm) conductor pipe cemented in place. The surface hole 12.25" (311mm) was drilled to 245.00m and 9.625" (245mm) casing cemented to surface within the Wallala Formation. Drilling continued utilising an 8.5" (216mm) PDC bit and an 8.5" core bit over target seams until Total Depth "TD" was reached at 13:00 hours on 16th November 2010 with a final depth of 410.00mRT (driller). 4.0" core was retrieved conventionally from the Hoskissons and Melvilles Coal Members for the collection of geomechanical samples. Earth Data Pty Ltd. provided the well-site geological supervision at Kahlua 5.

A complete set of wireline logs was run at TD and the rig was released at 9:00 hours on the 18th November 2010.

Figure 1: Location Map of Kahlua 2-5

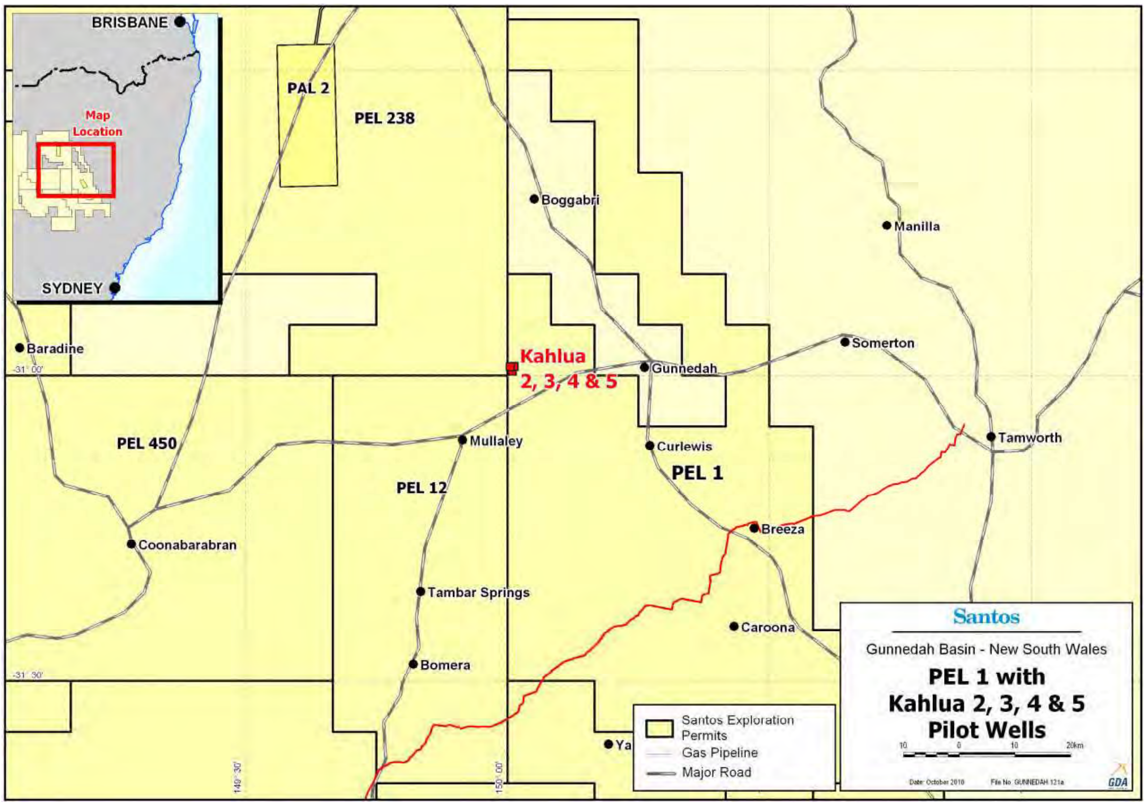
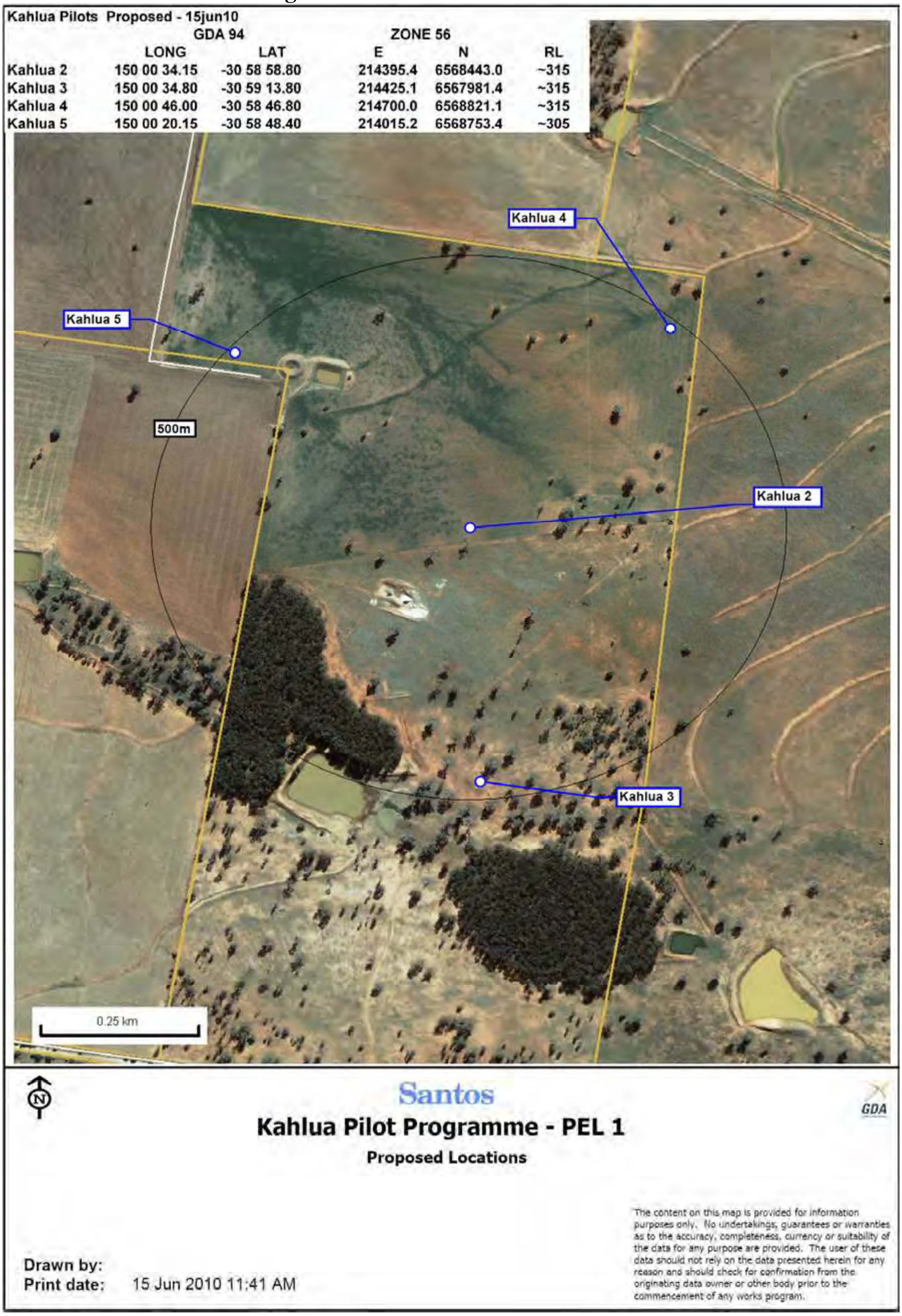


Figure 2: Aerial Photo of Site Location



2 WELL HISTORY

2.1 General Data

Well Name and Number:		Kahlua 5
Location:	Latitude:	30° 58'48.340" S (GDA 94)
	Longitude:	150°00'20.191" E (GDA 94)
MGA Easting (m E):		214016.24
MGA Northing (m N):		6568755.23
Zone		56
Elevations:	G.L.(m):	307.60m A.S.L.
	K.B.(m):	311.60m A.S.L.
Petroleum Tenement:		PEL 1
Permit Operator:		SANTOS QNT PTY LTD Level 22 Santos Place 32 Turbot Street Brisbane Qld 4000
Drilling Contractor:		Eastern Well Drilling Pty Ltd 371 Taylor Street TOOWOOMBA QLD 4350
Drilling Rig:		EWG 103
Date Drilling Commenced:		12:00hrs on 13 November 2010
Date Drilling Completed:		13:00hrs on 16 November 2010
Date Rig Released:		9:00hrs on 18 November 2010
Drilling time (Spud to Rig Release):		4.83 days
Total Depth: Driller		410.00m
Logger		410.20m
Status:		Suspended Gas Well

2.2 Drilling Data

2.2.1 Introduction

Below is the operations summary for Kahlua 5. It has been compiled from the daily drilling reports (**Appendix 1**) as sent in from the rig-site. A Santos Drilling Supervisor was present on-site at all times to supervise drilling operations, manage third party contractors as well as monitor safety and environmental concerns at the rig-site.

The well lease was prepared by Daracon Pty Ltd and a final well location was surveyed by Stewart Surveys Pty Ltd with the details included in **Appendix 2**.

2.2.2 Kahlua 5 Drilling Summary

2.2.2.1 Conductor Casing

Size: 17.5” (445mm)
Interval: 0.00m – ~11.00 m
Drilling Fluid: Air

The conductor hole 17.5” (445mm) was drilled by Daracon prior to well spud. The 14” (356mm) conductor casing was installed and cemented from surface down to a depth of ~11.00mGL on the same day.

2.2.2.2 Surface Hole

Size: 12.25” (311mm)
Interval: ~11.00m – 245.00m (shoe at 243.30m)
Drilling Fluid: Water and KCl

Kahlua 5 spudded at 12:00 hrs on 13th November 2010. The surface hole section 12.25” (311mm) was drilled using an 12.25” PDC bit to a depth of 245.0mRT. No problems were encountered while drilling out this section of the borehole. A total of 20 joints of 9.625” (245mm) K-55, BTC casing were run in to a shoe depth of 243.30mRT and fully cemented to surface. A total of 557 sacks of cement were used to produce a lead slurry at 12.50ppg to cement from 175.00m to surface, a further 151 sacks were used to produce a tail slurry at 14.80ppg to cement from casing shoe to 175.00m. Cement returns were good, circulating, pumping and displacing returned 42.2 barrels of cement to surface. The casing was then pressure tested to 1000psi for 5 minutes.

2.2.2.3 Production Hole

Size: 8.5” (216mm)
Interval: 245.00m – 410.00m (shoe at 409.34m)
Drilling Fluid: Water and KCl

The 8.5” hole section was drilled from 245.00 to 410.00mRT alternating between an 8.5” PDC bit and an 8.5” coring bit. 4” Core was collected from 295.00-312.5mRT and 345.59-363.00mRT over the target Hoskissons and Melvilles Coal Member to provide geotechnical samples. After TD had been reached production casing was run with a shoe depth of 409.34m and fully cemented to surface. A total of 33 joints of 7" (178mm) steel and fibreglass casing was used with 31 joints of steel K-55, 23lbs/ft, BTC casing and 2 joints of fibreglass DHC350, 7.6lbs/ft, 4rd casing set over the target seams. A total of 207 sacks of cement were used to produce a lead slurry at 12.00ppg to cement from 262.00m to 15.00m, a further 143 sacks were used to produce a tail slurry at 14.00ppg to cement from casing shoe to 262.00m. No cement returns were seen at surface with spacer filling in from 15.00m to surface. The casing was then pressure tested to 1500psi for 5 minutes. Once the casing was set the borehole was then underreamed from 302.00 to 310.60m over the Hoskissons Coal Member.

The rig was released at 9:00 hrs on the 18th November 2010.

2.2.3 Casing and Cementing

Refer to the Well Schematic (**Figure 4** and **Table 2**) for the Casing and Cementing Summary details at Kahlua 5.

Table 2: Casing and Cementing Summary

Conductor		
Hole/Casing Size	-	17.5" / 14" (445mm / 356mm)
Weight	-	54.5lbs/ft
Grade	-	
Shoe Setting Depth	-	~11.0 m
Interval Cemented	-	~11.0 m – to surface
Surface		
Hole/Casing Size	-	12.25" / 9.625" (311mm / 245mm)
Weight	-	36.0lbs/ft
Grade	-	K-55
Shoe Setting Depth	-	240.6 m
Interval Cemented	-	243.30m – to surface
Production		
Hole/Casing Size	-	8.5" / 7" (216mm / 178mm)
Weight	-	23lbs/ft / 7.6lbs/ft
Grade	-	K-55 / DHC350
Shoe Setting Depth	-	409.34m
Quantity of Cement	-	207 sacks at 12.00ppg / 143 sacks at 14.00ppg
Interval Cemented	-	409.34m – 15.00m

2.2.4 Deviation Surveys

The largest deviation recorded at Kahlua 5 was 0.6° and was recorded 407.00m.

2.2.5 Drilling Fluid Data

Materials used in the mud system whilst drilling included salt (KCl) and fresh water sourced locally. KCl (3-6%) was used to assist in maintaining mud weight and minimise clay swelling.

a) 0.00 – ~11.00 m Air
b) ~11.00 – 245.00m Water and KCl
c) 245.00 – 410.00m Water and KCl

2.2.6 Water Supply

Drilling water supply was obtained from dams near location and trucked to site.

2.3 Drilling Contractors and Personnel

Project Leader	:	P Rhabraian
Drilling Engineer/Supervisor	:	B Goosem
Drilling Rig Representative	:	E Bennett/D Malone
Drilling	:	Eastern Well Drilling Pty Ltd
Wellsite Geologist	:	L. Karlson/J. Morgan-Moodie
Field Testing	:	Earth Data Pty Ltd
Cementing	:	Halliburton Pty Ltd
Mud Engineering	:	Eastern Well Drilling Pty Ltd
Wireline Logging	:	Weatherford Australia Wireline Pty Ltd
Well Testing	**:**	DST Australia
Casing Perforation	**:**	Not Conducted

Figure 3: Kahlua 5 Time-Depth Curve

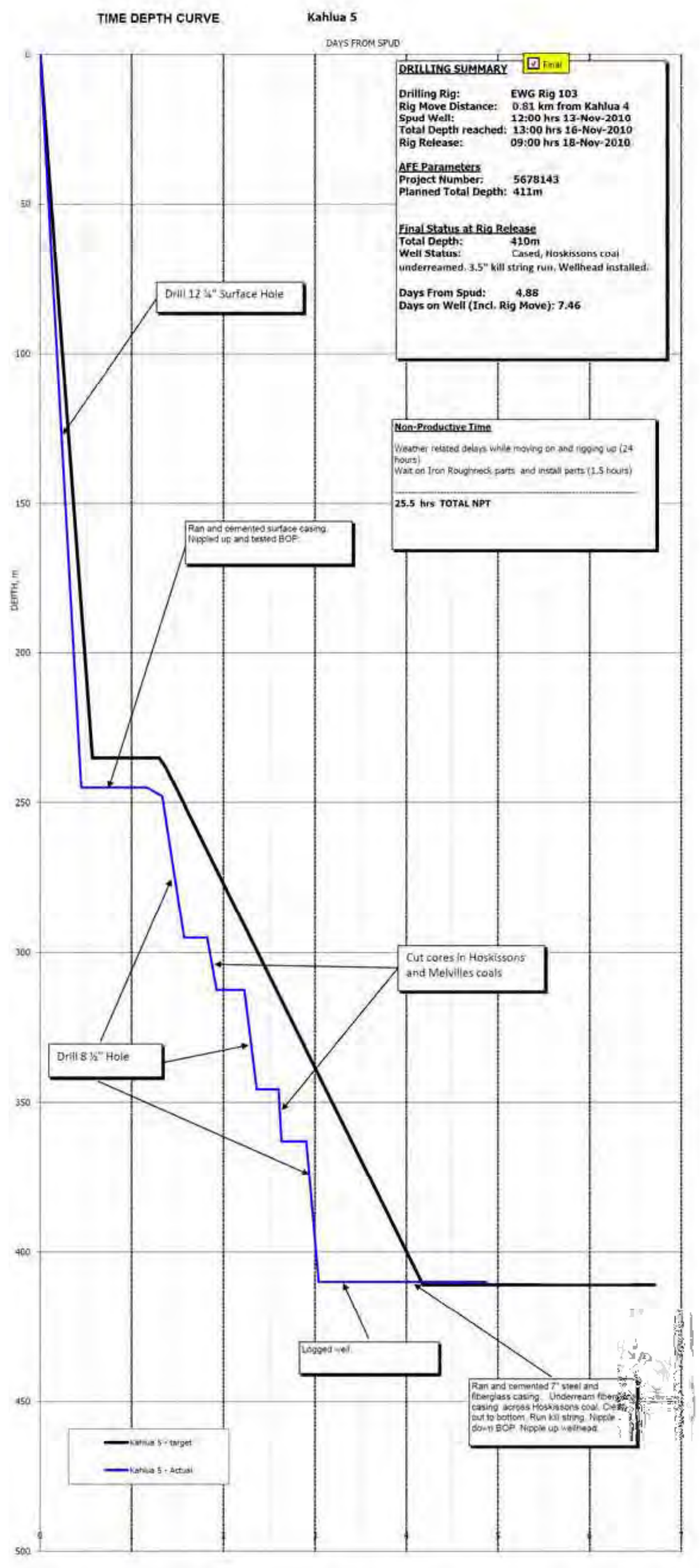


Figure 4: Kahlua 5 Well Schematic

Santos

Santos Ltd A.C.N 007 550 923

KAHLUA 5

Latitude: 30° 58' 48.340" S	**Well spudded** 13-11-2010	**Ground Level:**	307.56 m
Longitude: 150° 00 20.191" E	**Last activity:** 18-11-2010	**RT elevation:**	311.56 m

ITEM No	DESCRIPTION	LTH (m)	DTH KB (m)	MIN I.D.	MAX O.D.
	KB to top of tubing spool flange	4.08	4.08		
1	3 1/2 Back pressure profile tubing hanger (Nested Hanger)		4.08		
2	6 jnts 3 1/2" eue tubing plus hanger and nipple. 3 1/2" tubing set @ 61.92m	57.84	61.92		
	Wood Group single stage conventional well head option 7A (Compact well head)				
	A Section - Top of 11"3M x 9 5/8" BTC wellhead at 0.08m below ground level				
	11" x 3m x 7-1/16" x 3M DSA				
	7-1/16" x 3-1/8" 3M SSA				
	3-1/8" x 3M universal C-section Valve				
	NOTE- 3" BPV not installed				

BRIEF HISTORY ON WELL

Kahlua 5 was spudded by EWG Rig #103 on the 13th November 2010 @ 12:00hrs. 12-1/4" surface hole was drilled to 245m and 9-5/8" casing was RIH and cemented @ 243.3m. An 9 5/8" x 7" 3K BTC wellhead installed. The shoe was drilled out and an LOT was performed to an EMW of 22.3ppg. The 8.5" production hole section was drilled from 245m to 295m to first core point. Cored from 295m to 312.5m 100% recovery. The 8.5" production hole section was drilled from 312.5m to 345m to second core point. Cored from 345.50m to 363m 100% recovery The 8.5" production hole section was drilled from 363m to TD of 410m. 7" casing and fibre glass casing was run to 409.32m. Under ream from 302m to 310.6m. A 3 1/2" EUE kill string was run and landed @ 61.92m with a 11" x 3 1/2" EUE nested hanger (RSG) 11" x 3m x 7-1/16" x 3M DSA, 7-1/16" x 3-1/8" 3M SSA and a 3-1/8" x 3M universal C-section Valve was installed and tested by Wood Group

Rig released at 09:00 hrs on 18 November 2010.

CASING DETAILS		CEMENTING DETAILS:
Size	9-5/8"	Cement 9 5/8" casing as per program.
Weight	36 lb/ft	Pump 10 bbls of Preflush, Pressure test surface lines to 3000 psi/5 minutes.
Grade	K-55	Pump 10 bbls of preflush.
Depth Set	243.3	Mix & pump 181sxs (70bbls) of 12.5ppg Lead cement
		Mix & pump 83sxs (18bbls) of 14.8ppg Tail cement.
		Drop top plug & Displace with 63.2bbls of water (Cement returns at surface after 21bbls of displacement pumped) 42.2bbls of cement to surface
		Bump plug with 160psi @ 1.5bpm, Pressure test 9 5/8" casing to 1000psi/5minutes.
		Bleed back 0.5bbl - Float holding
		Note- Full returns during the cement job *

PRODUCTION

CASING DETAILS		CEMENTING DETAILS:
Size	7"	Pump 10 bbls weighted spacer (8.5ppg) Pressure test lines to 3000 psi. Pump 10 bbls weighted spacer. Mix and pump 26 bbls (65sx) EconoCem 12 ppg Lead cement
Weight	23ppf	18 bbls (65sx) CBMCem 14 ppg Tail cement. Flush surface lines Drop top plug and displace with 51.5 bbls of fresh water
Grade	K-55	Spacer returns to surface after 33 bbls displacement pumped. No cement to surface. Estimated Top of lead cement @ 15m. 16.5 bbls of spacer to surface
Depth Set	409.32	Bump plug with 500 psi @ 0.5 bpm. Pressure test 7" casing to 1500 psi for 5 min. Bleed back 0.5 bbls floats holding.
I.D.	6.366	Constant returns throughout cement job.
Capacity	.0394lb/ft	

FORMATION	(mKB)	GUN: SIZE	GUN: TYPE	SPF	TYPE	CHARGES: WT(g)
Hoskissons Coal and Melvilles Coal	Hoskissons = 303.1m to 310.1m					
	Melvilles = 349.7m to 352.6m					
PRESSURE						
TEMPERATURE						

TAGGED DEPTHS:	
ANNULUS FLUID:	
INDICATED STRING WEIGHT:	
CALCULATED STRING WEIGHT:	
LANDED WEIGHT:	
REMARKS:	

	WELLSITE SUPERVISOR: Dean Malone		
PROPOSED:	TUBING INSTALLATION / LAST WORKOVER	None	
COMPLETION:	DRAFTED BY:	DATE	
RE-COMPLETION:	REVISED BY:	DATE	
OTHER:	CHECKED BY:	DATE	

2.4 Formation Sampling and Evaluation

2.4.1 Well site Geologist

Earth Data Pty Ltd ("Earth Data") provided onsite geological supervision and desorption testing at Kahlua 5. A composite log summarising geological activities is included in **Appendix 4**.

2.4.2 Mud logging

A mud logging unit services were not used whilst drilling this well and no record of conventional hydrocarbon shows were made. No drilling breaks or gains/losses in drilling fluid were noted whilst drilling through the potential gas-bearing sandstones.

2.4.3 Ditch Cutting Samples

Cuttings were collected from the surface to TD while 4" core was collected only over the target coal seams. Geotechnical samples were collected from the cored sections for later testing. The sampling intervals for Kahlua 5 are outlined in **Table 3** below.

Interval/Formation	Sample Type (and recipient)	Sample Volume and Frequency
Surface – 295.0mRT	Cuttings Samples	Cuttings collected every 6m
295.0m – 312.5mRT	4" Core	Continuous Core
312.5m – 345.6mRT	Cuttings Samples	Cuttings collected every 6m
345.6m – 363.0mRT	4" Core	Continuous Core
363.0m – 410.0mRT	Cuttings Samples	Cuttings collected every 6m
	Geomechanical Samples (Strata Testing Services)	At Santos specified intervals around target seams

Table 3: Sampling Intervals at Kahlua 5

2.4.4 Wireline Logs

Weatherford Australia Pty Ltd provided slimhole mineral logging services at Kahlua 5. A complete suite of wireline logs was run in multiple runs at Kahlua 5 (**Table 4**). Wireline logging was carried on the 17th November 2010.

Table 4: Wireline Logging Summary

SUITE	RUN	TOOL STRING	INTERVAL (m GL)	TIME SINCE CIRC.
1	1	SuperCombo	10.00 – 410.20	4.25hrs
1	2	CMI + Verticality	15.00 – 407.00	7hrs 7min

2.4.5 Temperature Surveys

The highest recorded temperature at Kahlua 5 was 35 degrees Celsius at the bottom of the hole.

2.4.6 Drill Stem Tests ("DST")

No DST tests were performed at Kahlua 5.

3 GEOLOGY

3.1 Reasons for Drilling

The Kahlua 5 borehole is part of the Santos Gunnedah Gas Pilot drilling program which is designed to provide information on the hydrocarbon potential of PEL 1. In conjunction with the Kahlua 2, 3 and 4 boreholes, Kahlua 5 will be an observation well used to appraise the deliverability of the Hoskissons and Melvilles coal seams. Results from the previously drilled Kahlua 1 corehole were encouraging and suggested potential hydrocarbon resources in the region.

3.2 Regional Geology of the Gunnedah Basin (taken from Tadros, 1993)

The effective Basement of the Gunnedah Basin sequence consists of the Boggabri Volcanics and Werrie Basalts (Late Carboniferous to Early Permian age) that make up the economic floor of the basin. These units contain un-deformed lavas, tuffs and intercalated sediments. The top of these basal volcanics is deeply weathered, indicating an unconformity with the overlying units.

The Leard and Goonbri Formations unconformably overlie Basement (**Figure 5**). The Leard Formation comprises Early Permian pelletal flint claystone, conglomerate, sandstone and siltstone, commonly interbedded with coal. It forms a discontinuous thin veneer deposited in the more deeply eroded and weathered basement structure. The Goonbri Formation unconformably overlies the Boggabri Volcanics and the Leard Formation. It is a regressive lacustrine sequence comprising predominantly bioturbated organic-rich siltstone and thin coal, coarsening upwards to laminated siltstone and fine grained sandstone and then moderately well sorted medium grained sandstone.

The Maules Creek Formation is an Early Permian alluvial to fluvial system which overlies and onlaps both the Leard and Goonbri Formations. In the Mullaley Sub-basin, the Maules Creek Formation is subdivided into a northern zone containing quartz rich sandstone; a central zone of volcanogenic sediments; and a south eastern zone consisting of fine grained sediments rich in coal. The boundary with the overlying Porcupine Formation is disconformable and the two formations inter-finger each other.

The Porcupine Formation is a late Permian fan delta marine incursion into the Gunnedah Basin. The unit is a fining up sequence from a para-conglomerate with a poorly sorted sandstone and siltstone matrix at the base through an ortho-conglomerate with moderately sorted sandstone and siltstone matrix to a homogeneous bioturbated sandstone and mudstone. The conglomerate clasts are dominantly siliceous volcanics. The upper boundary with the overlying Watermark Formation is gradational. In the western margin of the Basin, the Porcupine Formation is approximately 10m thick.

The lower part of the Watermark Formation represents the maximum extent of the Late Permian transgression. The upper part is a marine regression associated with the overlying Black Jack delta system. The lower part is characterized by a fining up sequence from sandy siltstone at the base to siltstone / claystone laminate at the top. The upper part consists of a major coarsening up succession consisting of two distinctive units; the lower unit which is finely laminated siltstone and claystone with sporadic “dropped pebbles”; and the upper unit which consists of well

developed coarsening up sequences of siltstone, sandy siltstone to interbedded siltstone and sandstone, the percentage of sandstone increases up the sequence.

The Late Permian Black Jack Group is divided into a deltaic lower unit containing the target coals and an upper fluvial-lacustrine unit.

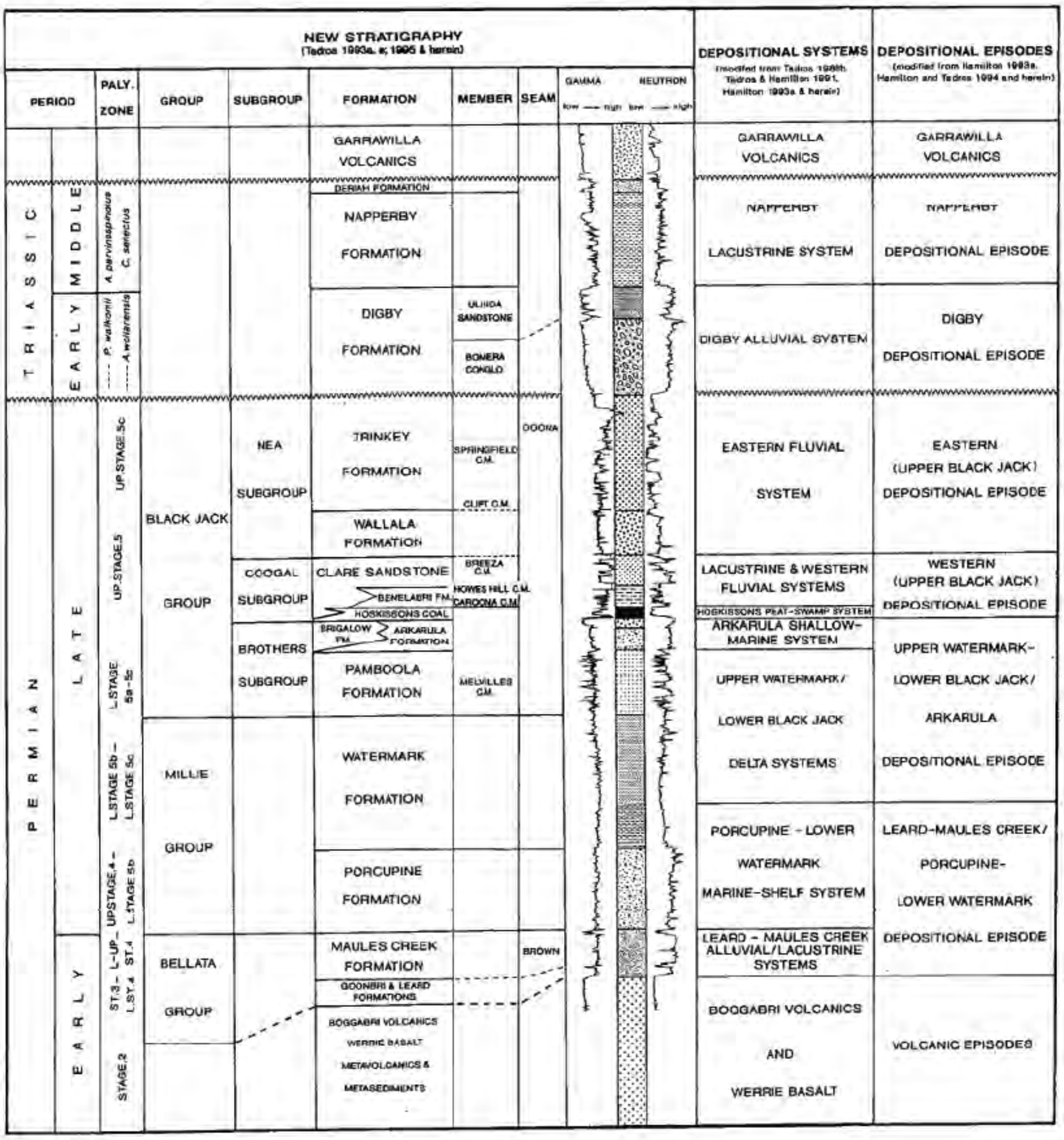
- A basal lithic unit consisting of sandstone, siltstone, claystone, conglomerate and intercalated coals thins towards, and onlaps, the western margin of the basin. The Melvilles Coal Member within this unit is not thought to be present within PEL450. The lithic unit is followed by the Arkarula Sandstone, a fine – medium grained lithic unit which is in turn overlain, in the Mullaley Sub-basin, by medium – coarse – pebbly quartz rich sandstone with a sharp erosive contact.
- The upper part of the Black Jack Group includes the Hoskissons Coal (primary target). The coal consists of predominantly vitrinite poor/inertinite rich coal with subordinate layers of fine sandstone, carbonaceous siltstone/claystone and tuff. The peat swamps developed as a result of marine regression and are fluvial influenced with westerly sourced quartzose channel fills seen along the western margin. The coal is overlain by the coarse grained to conglomeratic, quartz rich Clare Sandstone Member, followed by a lithic conglomerate and finally a fine grained tuffaceous coaly unit.

The Early Triassic Digby Formation unconformably overlies the Permian sequence. The Formation consists of a lower lithic conglomerate unit, quartz–lithic sandstone unit and an upper quartzose unit. The lithic conglomerate unit formed as a result of an alluvial fan system and consists of clast supported conglomerate with subordinate lithic sandstone. The clasts comprise green and red jasper, chert and siliceous and mafic volcanics. The middle quartz –lithic sandstone comprises approximately equal parts of quartz and lithics, locally conglomeratic towards the base. The upper quartzose unit comprises predominantly quartzose sandstone with subordinate conglomerate and claystone. Lithics are generally less than 25% of the composition.

The Early–Mid Triassic Napperby Formation is an overall upward coarsening sequence. The lower part consists of dark grey claystone and finely interlaminated sandstone and mudstone. The middle becomes increasingly silty and the upper unit comprises mainly off-white, medium grained lithic sandstone. The Napperby Formation is unconformably overlain by the Late Triassic–Early Jurassic Garrawilla Volcanics. These comprise alkali basalt flows, tuffs and intrusives with weathered surfaces occurring sporadically. Flows are commonly vesicular and contain common secondary zeolite mineralization.

The Garrawilla Volcanics are unconformably overlain by the Jurassic Purlawaugh Formation and Pilliga Sandstone of the Surat Basin sequence. These are respectively flood plain and braided stream deposits equivalent to the Hutton Sandstone sequence to the north.

Figure 5: Generalised Stratigraphy of the Gunnedah Basin, NSW (Tadros, 1999)



3.3 Stratigraphic Prognosis

Well control for Kahlua 5 was provided by surrounding wells STO Kahlua 1, DM Benelabri DDH 1 and ACM Longlea 1. STO Kahlua 1 was the closest corehole (1.6km to the N) and acted as the primary offset for the Kahlua portion of the Gunnedah gas pilot program. Previous drilling in the gas pilot program was used to refine local models and predictions.

Table 5 summarises the actual formation top depths, thickness and difference to prognosis. Formation tops are interpreted from electric logs data, ditch cuttings descriptions along with the core data and adjacent well control.

FORMATION	FORMATION TOPS				
	ACTUAL TOP		High / Low	PROGNOSED TOP	
	(MDmRT)	(TVDmSS)	Prognosis (m)	(MDmRT)	(TVDmSS)
Alluvium	4	307.56	0	4	307.56
Napperby Fm	18.00	293.56	High 7.40	25.4	286.16
Digby Fm	180.00	131.56	Low 18.30	161.7	149.86
Ulinda Sandstone	*180.00*	*131.56*	*Low 18.30*	*161.7*	*149.86*
Bomera Conglomerate	*189.00*	*122.56*	*Low 16.10*	*172.9*	*138.66*
Black Jack Group	**214.00**	**97.56**	**Low 21.90**	**192.1**	**119.46**
Trinkey Formation	214.00	97.56	Low 21.90	192.1	119.46
Wallala Fm	242.00	69.56	Low 18.90	223.1	88.46
Breeza CM	278.00	33.56	Low 22.30	255.7	55.86
Benelabri Fm	282.00	29.56	Low 12.10	269.9	41.66
Hoskissons CM	303.49	8.07	Low 16.09	287.4	24.16
Arkarula Fm	311.15	0.41	Low 16.15	295	16.56
Pamboola Fm	330.00	-18.44	Low 6.70	323.3	-11.74
Melvilles CM	349.11	-37.55	Low 11.21	337.9	-26.34
Millies Group	**402.00**	**-90.44**	**Low 21.30**	**380.7**	**-69.14**
Watermark Fm	402.00	-90.44	Low 21.30	380.7	-69.14
Total Depth	**410**	**-98.44**	**Low 19.00**	**391**	**-79.44**

Table 5: Kahlua 5 Stratigraphy Summary

3.4 Stratigraphy Penetrated

Kahlua 5 spudded into the Napperby Formation below a thin layer of alluvium. Following this the well penetrated Jurassic & Triassic sediments before drilling into the Late Permian sediments of the Black Jack Group at 214.00mRT. The well was open holed or "chipped" down to TD with cored sections over the Hoskissons and Melvilles Coal Members, TD was reached at 410.00mRT (driller) within the Watermark Formation. Below is a summary of the stratigraphy penetrated at Kahlua 5 utilising field geology logs and is described in more detail in the well site geologist field logs (**Appendix 4**).

3.4.1 Napperby Formation (18.0 –180.0m)

The Napperby Formation at Kahlua 5 grades from interbedded siltstone and mudstone through to interbedded fine to medium grained quartz-lithic sandstone and siltstone. Igneous rock was noted in chips sampled between 12.00 and 18.00 metres from the base of the formation indicating a possible intrusion. This gradational change from a fine siltstone to increasingly coarser sandstones through the formation correlates with the interpretation of the unit being deposited in a lacustrine delta environment.

3.4.2 Digby Formation (180.0 – 214.0m)

The Digby formation is typically comprised of two main units, an upper sandstone dominated unit and a lower conglomerate dominated unit, at Kahlua 5 both the Ulinda Sandstone and the Digby or Bomera Conglomerate were visible. The Ulinda Sandstone consisted of a band of primarily fine grained quartz-lithic sandstone. The Bomera Conglomerate was comprised of thick units of multicoloured lithics and volcanic pebbles within a sandy matrix. The Digby formation has been interpreted as being derived from massive alluvial systems flowing from the New England Fold Belt.

3.4.3 Trinkey Formation (214.0 – 242.0m)

The Trinkey Formation at Kahlua 5 was dominated by white to grey tuffs and coal bands. A fine grained lithic sandstone and siltstone band was noted towards the top of the unit before grading into the tuffs and coals. The high tuffaceous content of the unit can be attributed to the tephra ejected from the volcanoes of the New England region.

3.4.4 Wallala Formation (242.0 – 278.0m)

The Wallala Formation at Kahlua 5 was a predominately medium grained sandstone and conglomerate unit with occasional tuffaceous sections associated with minor coal seams. The conglomerates of the formation contained granule to pebble sized clasts similar in appearance to those of the Digby Formation with within a coarse grained sandy matrix. The intermediate casing was set at 243.30mRT within this unit. The Wallala Formation is interpreted as being formed from an eastern fluvial system.

3.4.5 Breeza Coal Measures (278.0 – 282.0m)

No coal profiling was performed Kahlua 5 on the Breeza Coal Member however occasional tuffaceous fragments were noted.

3.4.6 Benelabri Formation (282.00 – 303.49m)

The Benelabri Formation at Kahlua 5 consisted of interbedded fine grained sandstone and carbonaceous mudstone layers with minor coal and tuffaceous bands throughout the unit. The contact with the underlying Hoskissons Coal Member was a heavily fractured carbonaceous mudstone unit. The first coring section commenced within the formation at 295.00mRT. The Benelabri Formation is believed to be the result of a large lake system.

3.4.7 Hoskissons Coal Measures (303.49 – 311.15m)

The Hoskissons Coal at Kahlua 5 was cored allowing coal profiling to be performed. As is typical for the Hoskissons, the coal was heavily fractured with minimal to no cleating with a dull to dull banded brightness profile and minor tuff bands delineating seams.

3.4.8 Arkarula Formation (311.15 – 330.0m)

The Arkarula Formation is present immediately following the Hoskissons coal. The upper contact of the unit with the Hoskissons coal is defined by a mudstone unit with tuffaceous lenses. The base of the unit is comprised of a quartz lithic sandstone which is typical of the Arkarula formation throughout the basin. The first cored section finished at 312.50mRT within the formation. The formation is interpreted as having originated in a wave-dominated delta system as a part of the Arkarula shallow marine system.

3.4.9 Pamboola Formation (330.0 – 402.0m)

The Pamboola Formation at Kahlua 4 is an interbedded very fine to medium grained lithic sandstone unit with occasional siltstone and mudstone beds. The second cored section was conducted over the Melvilles coals within the Pamboola Formation between 345.59 and 363.00mRT. The unit contains occasional carbonaceous traces and the Mellviles Coal Member were intersected near the top of the unit. The Pamboola Formation is interpreted as being the product of deposition within a major delta system.

3.4.10 Melvilles Coal Measures (349.11 – 352.62m)

The Melvilles Coal Member at Kahlua 5 are located at the top of the Pamboola Formation. The overlying contact with the coal is an interbedded fine grained lithic sandstone and siltstone unit with a fine to medium grained lithic sandstone as the basal unit. The coal was uniformly dull minor bright in profile with fracturing and minor cleating throughout, a minor tuff band splits the coal measures.

3.4.11 Watermark Formation (384.0 –409.0m)

The Watermark Formation at Kahlua 5 transitions from a fine grained lithic sandstone unit to an increasingly silty unit towards TD. The upper Watermark is interpreted as having formed in a marine delta system while the lower Watermark which was not observed at Kahlua 5 is interpreted as forming in the same marine-shelf as the underlying Porcupine Formation

3.4.12 Total Depth

Driller:	410.00m
Logger:	410.20m

3.5 Coal Results

Approximately 20.72m of gross coal was recorded during drilling operations at Kahlua 5 with 10.53m recovered in cored sections. Coal profiling was conducted over the cored sections with mostly dull to dull banded coal seen; this is typical of coals in the Gunnedah Basin. No coal samples were sent for further analysis.

Due to previous drilling and correlation work in the area coals intersected can be assigned to a known coal measure. The major coal measures penetrated and their approximate thicknesses after reconciliation with wireline logs are detailed below:

- Breeza Coal Member: ~1.00m
- Hoskissons Coal Member (Target): 7.16m
- Melvilles Coal Member (Target): 3.37m

3.6 Hydrocarbon Shows

No gas detector was used onsite to record hydrocarbon shows.

4 DISCUSSION AND CONCLUSIONS

Kahlua 5 was the first well drilled for Gunnedah Gas Pilot Project initiating the Kahlua portion of the investigation into PEL 1. As the well has been suspended the success of the program in assessing the hydrocarbon potential of PEL 1 and the deliverability of the Hoskissons and Melvilles Coal Members is yet to be determined.

An approximate total of 20.72 metres of coal from the Black Jack Group was intersected throughout the borehole. The target Hoskissons Coal Member presented in core with a thickness of 7.16m and the Melvilles Coal Member presented with a thickness of 3.37m. Coal profiling was performed by the wellsite geologist with coals typically dull to dull banded.

Upon conclusion of drilling activities the borehole was suspended and the drill rig was released on 10th November 2010.

5 REFERENCES

Tadros N.Z. (1999)	Permian stratigraphy of the Gunnedah Basin, pp120-152. In Coalfield Geology Council of New South Wales, Bulletin 1.
Tadros, N.Z. (Ed.) 1993	The Gunnedah Basin, New South Wales. Geological Survey of New South Wales, Memoir Geology 12, 649 pp.

Appendix C

Water NSW monitoring well logs

WaterNSW
Work Summary

GW036495

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore - Nested (2)
Work Status: Manual Observations,Monthly
Construct.Method: Rotary Mud
Owner Type: NSW Office of Water

Commenced Date:
Completion Date: 01/03/1984

Final Depth: 34.00 m
Drilled Depth: 38.00 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	POTTINGER	DENISON	RD ADJ 87//755491
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:

CMA Map: 8836-S
Grid Zone:
Scale:

Elevation: 271.20 m (A.H.D.)
Elevation Source: (unknown)

Northing: 6572969.000
Easting: 775823.000

Latitude: 30°56'40.3"S
Longitude: 149°53'13.1"E

GS Map: -
MGA Zone: 55
Coordinate Source: SURV,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure

Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	28.50	28.90				
1		Casing	Casing Protector	-1.51	3.00	203			
1	1	Casing	P.V.C.	-1.50	28.50	101			Seated on Bottom
1		Casing	Casing Protector	0.00	2.80	152			
1	1	Opening	Slots - Horizontal	23.00	26.00	101		1	Slotted On Site, A: 3.00mm
2		Backfill	Backfill	34.00	38.00				
2		Casing	Casing Protector	-1.59	5.00	152			
2	2	Casing	P.V.C.	-1.50	34.00	101			Seated on Bottom
2	2	Opening	Slots - Horizontal	28.00	31.00	101		2	Slotted On Site, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
15.00	28.90	13.90	Unconsolidated			0.31			
27.00	29.00	2.00	Unconsolidated			1.00			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.50	1.50	Topsoil	Topsoil	
1.50	3.00	1.50	Clay Grey	Clay	
3.00	6.00	3.00	Clay	Clay	
6.00	7.50	1.50	Clay Grey	Clay	
7.50	15.00	7.50	Clay Red	Clay	
15.00	21.00	6.00	Sand Gravel Water Supply	Sand	
21.00	24.00	3.00	Sand Fine Water Supply	Sand	
24.00	25.50	1.50	Sand Gravel Water Supply	Sand	
25.50	27.00	1.50	Sand Water Supply	Sand	
27.00	29.00	2.00	Sand Gravel Water Supply	Sand	
29.00	38.00	9.00	Clay	Clay	

Remarks

01/11/1985: GOOLHI RD.
01/11/1985: ROADSIDE ADJ TO PORTION 83.
01/11/1985: HOLE 1-28.5M CAS NO 1-4 SCN NO 1.
01/11/1985: HOLE 2-34M CAS NO 6-8 SCN NO 3.
21/10/2008: Nat Carling, 21-Oct-2008: Updated RL's, cadastre (was entered as '83') & casing protector details (based on RL's), based in info provided in State Water Survey database, provided by Jim Salmon.

***** End of GW036495 *****

WaterNSW
Work Summary

GW036496

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Manual Observations,Monthly
Construct.Method: Rotary Mud
Owner Type: NSW Office of Water

Commenced Date:
Completion Date: 01/03/1984

Final Depth: 28.00 m
Drilled Depth: 54.20 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	POTTINGER	DENISON	83//755491
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:

CMA Map: 8836-S
Grid Zone:
Scale:

Elevation: 274.00 m (A.H.D.)
Elevation Source: (unknown)

Northing: 6573403.000
Easting: 773337.000

Latitude: 30°56'28.3"S
Longitude: 149°51'39.1"E

GS Map: -
MGA Zone: 55
Coordinate Source: SURV,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure

Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	28.00	54.20				
1	1	Casing	P.V.C.	-1.50	28.00	101			Seated on Bottom
1		Casing	Casing Protector	-1.09	2.50	152			
1	1	Opening	Slots - Horizontal	21.00	25.00	101		1	Slotted On Site, A: 6.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
21.00	25.00	4.00	Unconsolidated			0.05			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.50	1.50	Clay Dark Grey	Clay	
1.50	4.50	3.00	Clay	Clay	
4.50	6.00	1.50	Clay Light Brown	Clay	
6.00	7.50	1.50	Clay Yellow	Clay	
7.50	9.00	1.50	Clay Brownish Yellow	Clay	
9.00	15.00	6.00	Clay Light Brown	Clay	
15.00	16.50	1.50	Clay White Light Brown	Clay	
16.50	21.00	4.50	Clay Light Brown	Clay	
21.00	22.50	1.50	Clay Light Grey Coarse Sand	Clay	
22.50	27.00	4.50	Clay Light Brown Light Grey	Clay	
27.00	28.50	1.50	Clay Light Grey	Clay	
28.50	40.50	12.00	Clay Light Brown	Clay	
40.50	42.00	1.50	Clay	Clay	
42.00	43.50	1.50	Clay Light Brown	Clay	
43.50	45.00	1.50	Clay Light Brown	Clay	
45.00	52.50	7.50	Clay	Clay	
52.50	54.20	1.70	Clay Light Yellow Very Fine Sandy	Clay	
54.20	54.21	0.01	Sandstone Hard	Sandstone	
43.50	45.00	1.50	Sand Fine Gravel	Sand	

Remarks

01/11/1985: GOOLHI RD.
01/11/1985: ROADSIDE ADJ TO PORTION 83.
21/10/2008: Nat Carling, 21-Oct-2008: Updated RL's, cadastre (was entered as '83') & casing protector details (based on RL's), based in info provided in State Water Survey database, provided by Jim Salmon.

***** End of GW036496 *****

WaterNSW
Work Summary

GW036497

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Manual Observations,Monthly
Construct.Method: Rotary Mud
Owner Type: NSW Office of Water

Commenced Date:
Completion Date: 01/03/1984

Final Depth: 28.00 m
Drilled Depth: 82.30 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description: Good
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	POTTINGER	BENELABRI	103//755472
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:

CMA Map: 8836-S
Grid Zone:
Scale:

Elevation: 269.70 m (A.H.D.)
Elevation Source: (unknown)

Northing: 6572675.000
Easting: 778844.000

Latitude: 30°56'47.3"S
Longitude: 149°55'07.1"E

GS Map: -
MGA Zone: 55
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure

Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	28.00	82.30				
1		Casing	Casing Protector	-1.56	5.40	203			
1	1	Casing	P.V.C.	-1.50	28.00	101			Seated on Bottom
1	1	Opening	Slots - Horizontal	18.00	20.00	101		1	Slotted On Site, A: 6.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
16.50	21.00	4.50	Unconsolidated	1.50		1.51			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.00	3.00	Topsoil	Topsoil	
3.00	6.00	3.00	Clay Hard Siliceous Band	Clay	
6.00	7.50	1.50	Clay	Clay	
7.50	10.50	3.00	Clay Sandy	Clay	
10.50	12.00	1.50	Clay Grey Sandy	Clay	
12.00	13.50	1.50	Clay	Clay	
13.50	15.00	1.50	Sand Gravel	Sand	
15.00	16.50	1.50	Sand	Sand	
16.50	21.00	4.50	Sand Gravel	Sand	
21.00	24.00	3.00	Sand Gravel	Sand	
24.00	25.50	1.50	Sand Gravel	Sand	
25.50	27.00	1.50	Gravel	Gravel	
27.00	28.50	1.50	Clay Red	Clay	
28.50	30.00	1.50	Clay Red Grey	Clay	
30.00	37.50	7.50	Clay Red	Clay	
37.50	72.00	34.50	Clay	Clay	
72.00	82.00	10.00	Clay Yellow	Clay	
82.00	82.30	0.30	Siltstone Dark Green Very Decomposed Cored	Siltstone	
12.00	13.50	1.50	Sand Gravel	Sand	
15.00	16.50	1.50	Clay	Clay	
21.00	24.00	3.00	Clay Sandy	Clay	
25.50	27.00	1.50	Clay	Clay	
72.00	82.00	10.00	Ironstone Hard Bands	Ironstone	
82.00	82.30	0.30	Or Fine Sandstone Ironstone	Unknown	

Remarks

01/11/1985: GOOLHI RD.
01/11/1985: ROADSIDE ADJ TO PORTION 103.
21/10/2008: Nat Carling, 21-Oct-2008: Updated RL's, cadastre (was entered as '103') & casing protector details (based on RL's), based in info provided in State Water Survey database, provided by Jim Salmon.

*** End of GW036497 ***

WaterNSW
Work Summary

GW036499

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore - Nested (3)
Work Status: Manual Observations,Monthly
Construct.Method: Rotary Mud
Owner Type: NSW Office of Water

Commenced Date:
Completion Date: 01/04/1984
Final Depth: 66.00 m
Drilled Depth: 71.00 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	POTTINGER	BENELABRI	7010//1062637
Licensed:			

Region: 90 - Barwon
CMA Map: 8836-S
River Basin: 419 - NAMOI RIVER
Grid Zone:
Scale:
Area/District:

Elevation: 269.40 m (A.H.D.)
Elevation Source: (unknown)
Northing: 6572685.000
Easting: 777250.000
Latitude: 30°56'48.3"S
Longitude: 149°54'07.1"E

GS Map: -
MGA Zone: 55
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure

Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	28.00	29.00				
1	1	Casing	P.V.C.	-1.50	28.00	101			Seated on Bottom
1		Casing	Casing Protector	-1.45	5.00	203			
1	1	Opening	Slots - Horizontal	20.00	23.00	101		1	Slotted On Site, A: 6.00mm
2		Backfill	Backfill	48.00	50.00				
2	2	Casing	P.V.C.	-1.50	48.00	101			Seated on Bottom
2		Casing	Casing Protector	-1.45	5.00	203			
2	2	Opening	Slots - Horizontal	42.00	44.00	101		2	Slotted On Site, A: 6.00mm
3		Backfill	Backfill	66.00	71.00				
3		Casing	Casing Protector	-1.51	5.60	203			
3	3	Casing	P.V.C.	-1.50	66.00	101			Seated on Bottom
3	3	Opening	Slots - Horizontal	57.00	59.00	101		3	Slotted On Site, A: 6.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
20.00	24.00	4.00	Unconsolidated	15.60					
32.00	44.00	12.00	Unconsolidated						
54.00	60.00	6.00	Unconsolidated	15.60					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	Topsoil	Topsoil	
2.00	8.00	6.00	Clay	Clay	
8.00	10.00	2.00	Clay Sandy	Clay	
10.00	12.00	2.00	Sand Fine	Sand	
12.00	14.00	2.00	Sand Fine-medium	Sand	
14.00	18.00	4.00	Clay Sandy	Clay	
18.00	20.00	2.00	Gravel Fine Sand	Gravel	
20.00	24.00	4.00	Clay Red Sandy Water Bearing	Clay	
24.00	28.00	4.00	Clay	Clay	
28.00	30.00	2.00	Clay Sandy	Clay	
30.00	32.00	2.00	Gravel Fine Multicoloured	Gravel	
32.00	44.00	12.00	Gravel Fine Multicoloured Water Supply	Gravel	
44.00	46.00	2.00	Gravel Fine Multicoloured	Gravel	
46.00	48.00	2.00	Clay Grey Sandy	Clay	
48.00	50.00	2.00	Clay Very Sandy	Clay	
50.00	52.00	2.00	Sand Medium Clay	Sand	
52.00	54.00	2.00	Sand Medium	Sand	
54.00	60.00	6.00	Clay Water Bearing	Clay	
60.00	66.00	6.00	Clay Sandy	Clay	
66.00	70.00	4.00	Clay	Clay	
70.00	71.00	1.00	Mudstone Weathered Cored	Mudstone	
32.00	44.00	12.00	Sand	Unknown	

44.00	46.00	2.00	Medium Sand	Unknown	
52.00	54.00	2.00	Clay	Clay	

Remarks

01/11/1985: GOOLHI RD.
01/11/1985: ROADSIDE ADJ TO PORTION 103.
01/11/1985: HOLE 1-28M CAS NO 1-3 SCN NO 1.
01/11/1985: HOLE 2-48M CAS NO 5-7 SCN NO 3.
01/11/1985: HOLE 3-66M CAS NO 9-11 SCN NO 5.
21/10/2008: Nat Carling, 21-Oct-2008: Updated RL's, cadastre (was entered as '103') & casing protector details (based on RL's), based in info provided in State Water Survey database, provided by Jim Salmon.

***** End of GW036499 *****

WaterNSW
Work Summary

GW036515

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore - Nested (3)
Work Status: Instrumented
Construct.Method: Rotary Mud
Owner Type: NSW Office of Water

Commenced Date:
Completion Date: 01/09/1984

Final Depth: 118.00 m
Drilled Depth: 126.50 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	POTTINGER	COOGAL	197//704764
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:

CMA Map: 8835-1N
Grid Zone:
Scale:

Elevation: 280.02 m (A.H.D.)
Elevation Source: R.L. at W.L.M.Pt.

Northing: 6565642.000
Easting: 773084.000

Latitude: 31°00'40.0"S
Longitude: 149°51'37.1"E

GS Map: -
MGA Zone: 55
Coordinate Source: PR.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure

Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	P.V.C.	-1.50	30.00	101			Seated on Bottom
1		Casing	Casing Protector	-1.21	5.40	203			
1	1	Opening	Slots - Horizontal	20.00	23.00	101		1	Slotted On Site, A: 3.00mm
2	2	Casing	P.V.C.	-1.50	71.00	101			Seated on Bottom
2		Casing	Casing Protector	-1.21	5.90	203			
2	2	Opening	Slots - Horizontal	63.00	65.00	101		2	Slotted On Site, A: 3.00mm
3		Backfill	Backfill	118.00	126.50				
3		Casing	Casing Protector	-1.42	6.10	203			
3	3	Casing	P.V.C.	-1.00	118.00	101			Seated on Bottom
3	3	Opening	Slots - Horizontal	106.00	112.00	101		3	Slotted On Site, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
20.00	27.00	7.00	Unconsolidated						
62.00	66.00	4.00	Unconsolidated						
104.00	116.00	12.00	Unconsolidated	14.60					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	Topsoil	Topsoil	
2.00	16.00	14.00	Clay	Clay	
16.00	20.00	4.00	Clay Sandy	Clay	
20.00	22.00	2.00	Clay Grey Sandy Water Bearing	Clay	
22.00	27.00	5.00	Sand Gravel Water Bearing	Sand	
27.00	62.00	35.00	Clay Sandy	Clay	
62.00	66.00	4.00	Sand Gravel Water Bearing	Sand	
66.00	84.00	18.00	Clay Sandy	Clay	
84.00	93.00	9.00	Clay Sandy	Clay	
93.00	97.00	4.00	Sand Some Wood	Sand	
97.00	104.00	7.00	Sand Some Gravel	Sand	
104.00	110.00	6.00	Gravel Water Bearing	Gravel	
110.00	116.00	6.00	Sand Gravel Water Bearing	Sand	
116.00	124.00	8.00	Clay Sandy Some Gravel	Clay	
124.00	126.50	2.50	Grey Hard Cored	(Unknown)	

Remarks

01/11/1985: PLAIN VIEW.
01/11/1985: ROADSIDE ADJ TO PORTION 193.
01/11/1985: HOLE 1-30M CAS NO 1-2 SCN NO 1.
01/11/1985: HOLE 2-71M CAS NO 4-5 SCN NO 3.
01/11/1985: HOLE 3-118M CAS NO 7-9 SCN NO 5.
21/10/2008: Nat Carling, 21-Oct-2008: Updated RL's, cadastre (was entered as '193') & casing protector details (based on RL's), based in info provided in State Water

Survey database, provided by Jim Salmon.
09/12/2011: Karla Abbs, 9-Dec-2011: Entered geology log
04/03/2016: Primary Client changed from GWA to IPART on 04/03/2016.

***** End of GW036515 *****

WaterNSW
Work Summary

GW036543

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Manual Observations,Monthly
Construct.Method: Rotary Mud
Owner Type: NSW Office of Water

Commenced Date:
Completion Date: 01/11/1984

Final Depth: 103.00 m
Drilled Depth: 105.00 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	POTTINGER	BRIGALOW	RD ADJ 332//755479
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:

CMA Map: 8835-1N
Grid Zone:
Scale:

Elevation: 284.20 m (A.H.D.)
Elevation Source: (unknown)

Northing: 6566032.000
Easting: 769882.000

Latitude: 31°00'30.4"S
Longitude: 149°49'36.1"E

GS Map: -
MGA Zone: 55
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure

Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	103.00	105.00				
1		Casing	Casing Protector	-1.03	6.00	203			
1	1	Casing	P.V.C.	-1.00	103.00	101			Seated on Bottom
1	1	Opening	Slots - Horizontal	93.30	97.30	101		1	Slotted On Site, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
88.00	103.00	15.00	Unconsolidated						

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	Topsoil	Topsoil	
2.00	8.00	6.00	Clay	Clay	
8.00	12.00	4.00	Clay Some Fine Gravel	Clay	
12.00	16.00	4.00	Clay Grey	Clay	
16.00	21.00	5.00	Clay	Clay	
21.00	27.00	6.00	Clay Sandy	Clay	
27.00	28.00	1.00	Sand Fine	Sand	
28.00	79.00	51.00	Clay Sandy	Clay	
79.00	86.00	7.00	Clay Grey	Clay	
86.00	88.00	2.00	Gravel Claybound	Gravel	
88.00	103.00	15.00	Clay Water Bearing	Clay	
103.00	105.00	2.00	Sandstone Weathered Cored	Sandstone	

Remarks

01/11/1985: PLAIN VIEW.
21/10/2008: Nat Carling, 21-Oct-2008: Updated RL's, cadastre (was entered as '332') & casing protector details (based on RL's), based in info provided in State Water Survey database, provided by Jim Salmon.
09/12/2011: Karla Abbs, 9-Dec-2011: Entered geology log

***** End of GW036543 *****

WaterNSW
Work Summary

GW036544

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore - Nested (3)
Work Status: Manual Observations,Monthly
Construct.Method: Rotary Mud
Owner Type: NSW Office of Water

Commenced Date:
Completion Date: 01/12/1984

Final Depth:
Drilled Depth:

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	POTTINGER	BENELABRI	7010//1062637
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:

CMA Map: 8836-S
Grid Zone:
Scale:

Elevation: 268.20 m (A.H.D.)
Elevation Source: (unknown)

Northing: 6572608.000
Easting: 777859.000

Latitude: 30°56'50.3"S
Longitude: 149°54'30.1"E

GS Map: -
MGA Zone: 55
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure

Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	26.00	27.00				
1		Casing	Casing Protector	-1.07	4.90	152			
1	1	Casing	P.V.C.	-1.00	26.00	101			Seated on Bottom
1	1	Opening	Slots - Horizontal	14.00	20.00	101		1	Mechanically Slotted, A: 3.00mm
2		Backfill	Backfill	36.00	91.00				
2	2	Casing	P.V.C.	-1.50	36.00	101			Seated on Bottom
2		Casing	Casing Protector	-1.38	6.00	152			
2	2	Opening	Slots - Horizontal	30.00	33.00	101		2	Mechanically Slotted, A: 3.00mm
3		Backfill	Backfill	78.00	84.00				
3	3	Casing	P.V.C.	-1.50	78.00	101			Seated on Bottom
3		Casing	Casing Protector	-1.39	4.80	203			
3	3	Opening	Slots - Horizontal	68.00	72.00	101		3	Mechanically Slotted, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
14.00	20.00	6.00	Unconsolidated						
29.00	31.00	2.00	Unconsolidated						
70.00	73.00	3.00	Unconsolidated						

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	Topsoil	Topsoil	
2.00	7.00	5.00	Clay	Clay	
7.00	9.00	2.00	Clay Grey	Clay	
9.00	10.50	1.50	Sand Fine Gravel	Sand	
10.50	14.00	3.50	Sand Grey Clay	Sand	
14.00	29.00	15.00	Sand Gravel Water Bearing	Sand	
29.00	31.00	2.00	Gravel Water Bearing	Gravel	
31.00	36.00	5.00	Gravel Claybound	Gravel	
36.00	38.00	2.00	Sand Gravel	Sand	
38.00	40.00	2.00	Gravel Claybound	Gravel	
40.00	70.00	30.00	Clay Sandy	Clay	
70.00	73.00	3.00	Sand Gravel Water Bearing	Sand	
73.00	80.00	7.00	Gravel Fine Claybound	Gravel	
80.00	84.00	4.00	Clay	Clay	

Remarks

09/03/1987: GOLHI RD.
09/03/1987: RESERVE 21293 ADJ TO PORTION 105.
09/03/1987: HOLE 1-26M CAS NO 1-3 SCN NO 1.
09/03/1987: HOLE 2-36M CAS NO 5-7 SCN NO 3.
09/03/1987: HOLE 3-78M CAS NO 9-11 SCN NO 5.

21/10/2008: Nat Carling, 21-Oct-2008: Updated RL's, cadastre (was entered as 'RES 21293') & casing protector details (based on RL's), based in info provided in State Water Survey database, provided by Jim Salmon.

***** End of GW036544 *****

WaterNSW
Work Summary

GW036545

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Manual Observations,Monthly
Construct.Method: Rotary Mud
Owner Type: NSW Office of Water

Commenced Date:
Completion Date: 01/12/1984

Final Depth: 33.50 m
Drilled Depth: 80.00 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	POTTINGER	BENELABRI	3//1026324
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:

CMA Map: 8836-S
Grid Zone:
Scale:

Elevation: 269.80 m (A.H.D.)
Elevation Source: (unknown)

Northing: 6572505.000
Easting: 779424.000

Latitude: 30°56'52.3"S
Longitude: 149°55'29.1"E

GS Map: -
MGA Zone: 55
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure

Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	33.50	80.00				
1	1	Casing	P.V.C.	-1.50	33.50	64			Seated on Bottom
1		Casing	Casing Protector	-0.97	5.50	203			
1	1	Opening	Slots - Horizontal	24.40	27.40	64		1	Mechanically Slotted, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
24.00	28.00	4.00	Unconsolidated						

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	Topsoil	Topsoil	
2.00	12.00	10.00	Clay	Clay	
12.00	20.00	8.00	Clay Sandy	Clay	
20.00	22.00	2.00	Sand Fine	Sand	
22.00	24.00	2.00	Sand Grey Clay	Sand	
24.00	28.00	4.00	Sand Gravel Water Bearing	Sand	
28.00	49.00	21.00	Clay	Clay	
49.00	68.00	19.00	Clay Sandy Sand Fine Bands	Clay	
68.00	72.00	4.00	Clay Green	Clay	
72.00	79.00	7.00	Clay Sandy	Clay	
79.00	80.00	1.00	Rock Very Hard Cored	Rock	

Remarks

09/03/1987: GOLHI RD.
21/10/2008: Nat Carling, 21-Oct-2008: Updated RL's, cadastre (was entered as '16') & casing protector details (based on RL's), based in info provided in State Water Survey database, provided by Jim Salmon.

*** End of GW036545 ***

WaterNSW
Work Summary

GW036676

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore - Nested (2)
Work Status: Manual Observations,Monthly
Construct.Method: Cable Tool
Owner Type: NSW Office of Water

Commenced Date:
Completion Date: 01/12/1986

Final Depth: 86.00 m
Drilled Depth: 86.00 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	POTTINGER	DENISON	RD ADJ 86//755491
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:

CMA Map: 8836-S
Grid Zone:
Scale:

Elevation: 277.50 m (A.H.D.)
Elevation Source: (unknown)

Northing: 6573760.000
Easting: 771795.000

Latitude: 30°56'18.0"S
Longitude: 149°50'40.7"E

GS Map: -
MGA Zone: 55
Coordinate Source: Surveyed

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure

Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Casing	Casing Protector	-1.13	0.00				
1	1	Casing		0.00	0.00				
1	1	Opening	Slots	30.50	34.00	63		1	Mechanically Slotted, A: 3.00mm
1		Casing	Casing Protector	-1.13	0.00				
1	2	Opening	Slots	49.00	51.50	63		2	Mechanically Slotted, A: 3.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
30.50	34.00	3.50	(Unknown)	24.10		1.52			
49.00	51.50	2.50	Unconsolidated						

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.50	2.50	Topsoil	Topsoil	
2.50	6.00	3.50	Clay Red Sticky	Clay	
6.00	7.80	1.80	Clay Yellow Grey	Clay	
7.80	9.00	1.20	Clay Yellow Grey	Clay	
9.00	22.00	13.00	Clay Red	Clay	
22.00	25.00	3.00	Clay Grey Sandy	Clay	
25.00	28.00	3.00	Clay Red	Clay	
28.00	30.50	2.50	Clay Grey	Clay	
30.50	34.00	3.50	Sandstone Clay Bands Water Supply	Sandstone	
34.00	40.00	6.00	Clay Red	Clay	
40.00	41.50	1.50	Clay Gravel	Clay	
41.50	44.00	2.50	Clay Red	Clay	
44.00	44.50	0.50	Clay Gravel	Clay	
44.50	49.00	4.50	Clay Red	Clay	
49.00	51.50	2.50	Clay Red Water Supply	Clay	
51.50	56.00	4.50	Clay Red	Clay	
56.00	59.00	3.00	Clay Red Sandy	Clay	
59.00	60.00	1.00	Clay Red	Clay	
60.00	69.00	9.00	Clay Yellow Grey Sticky	Clay	
69.00	79.00	10.00	Clay Shaley	Clay	
79.00	86.00	7.00	Shale Grey Hard	Shale	

Remarks

16/10/2008: Nat Carling, 16-Oct-2008: Updated RL's (no date found), coordinates, casing protector details (based on RL's) & cadastre (was entered as '86'), based in info provided in State Water Survey database, provided by Jim Salmon.

***** End of GW036676 *****

WaterNSW
Work Summary

GW093067

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Equipped
Construct.Method: Rotary Air
Owner Type: NSW Office of Water

Commenced Date:
Completion Date: 08/02/2014

Final Depth: 171.00 m
Drilled Depth: 171.00 m

Contractor Name: NOW GROUNDWATER DRILLING
Driller: John Brien
Assistant Driller: Peter Bramble

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	POTTINGER	BENELABRI	7010//1062637
Licensed:			

Region: 90 - Barwon
CMA Map: 8836-S

River Basin: 419 - NAMOI RIVER
Grid Zone:
Scale:
Area/District:

Elevation: 287.27 m (A.H.D.)
Elevation Source: R.L. at W.L.M.Pt.

Northing: 6570864.000
Easting: 213604.000

Latitude: 30°57'39.6"S
Longitude: 150°00'06.8"E

GS Map: -
MGA Zone: 56
Coordinate Source: SURV,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure

Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	6.00	288			Rotary Air
1		Hole	Hole	6.00	84.00	200			Rotary Air
1		Hole	Hole	84.00	171.00	150			Rotary Air
1		Annulus	Cement	0.00	84.00	200	185		
1	1	Casing	Pvc Class 18	0.00	168.00	109	89		Cemented, Screwed, S: 159.00-168.00m
1	1	Casing	Steel - Erw	2.00	6.00	230	210		Cemented, Screwed
1	1	Casing	Steel - Erw	6.00	84.00	185	165		Cemented, Screwed
1	1	Opening	Slots - Horizontal	144.00	147.00			1	Casing - Perforated in hole, PVC
1	1	Opening	Slots - Horizontal	153.00	159.00	109		0	Casing - Perforated in hole, PVC

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
153.00	159.00	6.00	Unknown						

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.00	3.00	Clay; red with medium Gravel	Clay	
3.00	6.00	3.00	Clay; orange & Gravel	Clay	
6.00	8.00	2.00	Gravel, & Clay	Gravel	
8.00	12.00	4.00	Clay; red	Clay	
12.00	18.00	6.00	Clay; white with small gravel	Clay	
18.00	25.00	7.00	Clay; brown with small gravel	Clay	
25.00	27.00	2.00	Clay; white, with small gravel	Clay	
27.00	33.00	6.00	Clay; white with sand	Clay	
33.00	50.00	17.00	Sandstone; banded	Sandstone	
50.00	79.00	29.00	Siltstone; with sand	Siltstone	
79.00	88.00	9.00	Sandstone; grey	Sandstone	
88.00	100.00	12.00	Conglomerate	Conglomerate	
100.00	136.00	36.00	Siltstone	Siltstone	
136.00	141.00	5.00	Conglomerate	Conglomerate	
141.00	152.00	11.00	Siltstone	Siltstone	
152.00	159.00	7.00	Coal	Coal	
159.00	162.00	3.00	Siltstone	Siltstone	
162.00	168.00	6.00	Coal	Coal	
168.00	171.00	3.00	Siltstone	Siltstone	

Remarks

08/02/2014: Form A Remarks:
Nat Carling, 24-Nov-2014; GPS provided by hydrogeologist.
04/01/2016: Nat Carling, 4-Jan-2016; Updated screen details, as provided by Ross Beasley, active screen is at 144-147m.
04/03/2016: Primary Client changed from GWA to IPART on 04/03/2016.

***** End of GW093067 *****

WaterNSW
Work Summary

GW093068

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Equipped
Construct.Method: Rotary Mud
Owner Type: NSW Office of Water

Commenced Date:
Completion Date: 27/03/2014

Final Depth: 307.25 m
Drilled Depth: 309.40 m

Contractor Name: NOW GROUNDWATER DRILLING
Driller: Matthew John Lazarou
Assistant Driller: John Brien

Property:
GWMA:
GW Zone:

Standing Water Level (m): -1.500
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	POTTINGER	MELVILLE	6//586978
Licensed:			

Region: 90 - Barwon
River Basin: 419 - NAMOI RIVER
Area/District:

CMA Map: 8936-3S
Grid Zone:
Scale:

Elevation: 271.00 m (A.H.D.)
Elevation Source: R.L. at W.L.M.Pt.

Northing: 6572696.000
Easting: 777276.000

Latitude: 30°56'48.1"S
Longitude: 149°54'07.9"E

GS Map: -
MGA Zone: 55
Coordinate Source: SURV,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure

Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	6.00	305			Rotary Mud
1		Hole	Hole	6.00	117.00	225			Rotary Mud
1		Hole	Hole	117.00	309.00	152			Rotary Mud
1		Annulus	Cement	0.00	114.00	225	178		PL:Reverse Circulated
1	1	Casing	Steel - Erw	-1.15	307.25	115			Cemented, Screwed, S: 243.50-307.25m
1	1	Casing	Pressure Cemented	0.00	114.00	178			Cemented, Screwed
1	1	Casing	Pressure Cemented	0.00	6.00	305			Cemented, Screwed
1	1	Opening	Slots	240.50	243.50	114		0	Casing - Perforated in hole, Steel - ERW

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
19.00	27.00	8.00	Unknown						
240.00	244.00	4.00	Unknown	-1.50					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	9.00	9.00	Clay; alluvial, dark brown, sandy	Clay	
9.00	12.00	3.00	Clay; medium, orange/brown	Clay	
12.00	19.00	7.00	Clay, Sandy	Clay	
19.00	24.00	5.00	Sand; coarse, subrounded to rounded, clay lenses, quartz	Sand	
24.00	25.00	1.00	Gravel; fine, moderately sorted up to 6mm	Gravel	
25.00	28.00	3.00	Gravel; medium, up to 10mm poorly sorted	Gravel	
28.00	32.00	4.00	Clay; orange/brown	Clay	
32.00	33.00	1.00	Clay; gravelly, orange/brown, gravel up to 10mm, as above	Clay	
33.00	43.00	10.00	Clay; Gravel up to 6mm quartz, rich rounded, clay soft orange/brown	Clay	
43.00	46.00	3.00	Clay; gravelly, sticky, orange/brown, gravel as above up to 6mm	Clay	
46.00	49.00	3.00	Clay, gravel up to 8mm rounded to subrounded, quartz, medium to light orange clay	Clay	
49.00	50.00	1.00	Clay; gravelly, soft, orange/brown, gravel as above up to 8mm	Clay	
50.00	110.00	60.00	Clay, Gravelly; as above	Clay	
110.00	120.00	10.00	Clay, gravelly; as above gravel up to 20mm	Clay	
120.00	123.00	3.00	Sandstone; grey, fine medium grained, siltstone	Sandstone	
123.00	126.00	3.00	Sandstone; white/grey, fine-medium grained, banded, siltstone, black/grey	Sandstone	
126.00	132.00	6.00	Claystone; white/grey interbedded sandstone/stilstone as above	Claystone	
132.00	136.00	4.00	Siltstone/Sandstone; banded, siltstone dom grey, sandstone as above	Siltstone	
136.00	142.00	6.00	Sandstone/Siltstone; banded sandstone dom as above, siltstone as above	Sandstone	

142.00	144.00	2.00	Siltstone/Sandstone, banded, siltstone dom as above	Siltstone	
144.00	147.00	3.00	Claystone; banded sandstone/siltstone	Claystone	
147.00	149.00	2.00	Sandstone/Siltstone; banded, sandstone dom as above	Sandstone	
149.00	195.00	46.00	Siltstone/Sandstone; banded	Siltstone	
195.00	198.00	3.00	Volcanic; intrusive, dark grye, fine grained, hard	Volcanic	
198.00	202.00	4.00	Claystone; light	Claystone	
202.00	205.00	3.00	Claystone/Siltstone/Sandstone; banded	Claystone	
205.00	209.00	4.00	Claystone; dark grey, very 'puggy' sample	Claystone	
209.00	210.00	1.00	Siltstone/Claystone; banded, dark grey	Siltstone	
210.00	212.00	2.00	Claystone; dark grey, soft	Claystone	
212.00	220.00	8.00	Siltstone/Sandstone; banded	Siltstone	
220.00	225.00	5.00	Claystone; soft, light coloured	Claystone	
225.00	227.00	2.00	Sandstone/Claystone; light, clayey, some sand particles	Sandstone	
227.00	229.00	2.00	Sandstone/Siltstone; banded, light & dark particles	Sandstone	
229.00	230.00	1.00	Siltstone; black	Siltstone	
230.00	231.00	1.00	Sandstone/Siltstone; banded	Sandstone	
231.00	233.00	2.00	Sandstone; light	Sandstone	
233.00	241.00	8.00	Sandstone/Siltstone; banded	Sandstone	
241.00	243.00	2.00	Siltstone; black	Siltstone	
243.00	244.00	1.00	Sandstone; light	Sandstone	
244.00	252.00	8.00	Claystone; very soft	Claystone	
252.00	255.00	3.00	Siltstone; black	Siltstone	
255.00	267.00	12.00	Sandstone; light	Sandstone	
267.00	270.00	3.00	Conglomerate; multi coloured, green/orange	Conglomerate	
270.00	273.00	3.00	Siltstone; light	Siltstone	
273.00	275.00	2.00	Siltstone; coaly	Siltstone	
275.00	276.00	1.00	Sandstone/Siltstone; banded	Sandstone	
276.00	283.00	7.00	Coal/Coaly Siltstone	Coal	
283.00	294.00	11.00	Siltstone/Sandstone; banded	Siltstone	
294.00	297.00	3.00	Conglomerate; banded, multi coloured & Sandstone	Conglomerate	
297.00	298.00	1.00	Coal/Coaly Siltstone	Coal	
298.00	299.00	1.00	Siltstone/Sandstone; banded	Siltstone	
299.00	302.00	3.00	Coal/Coaly Siltstone	Coal	
302.00	304.00	2.00	Siltstone/Sandstone; banded	Siltstone	
304.00	306.00	2.00	Coal/Coaly Siltstone	Coal	
306.00	309.00	3.00	Sandstone/Siltstone; banded	Sandstone	
309.00	309.40	0.40	Coal/Coaly Siltstone	Coal	

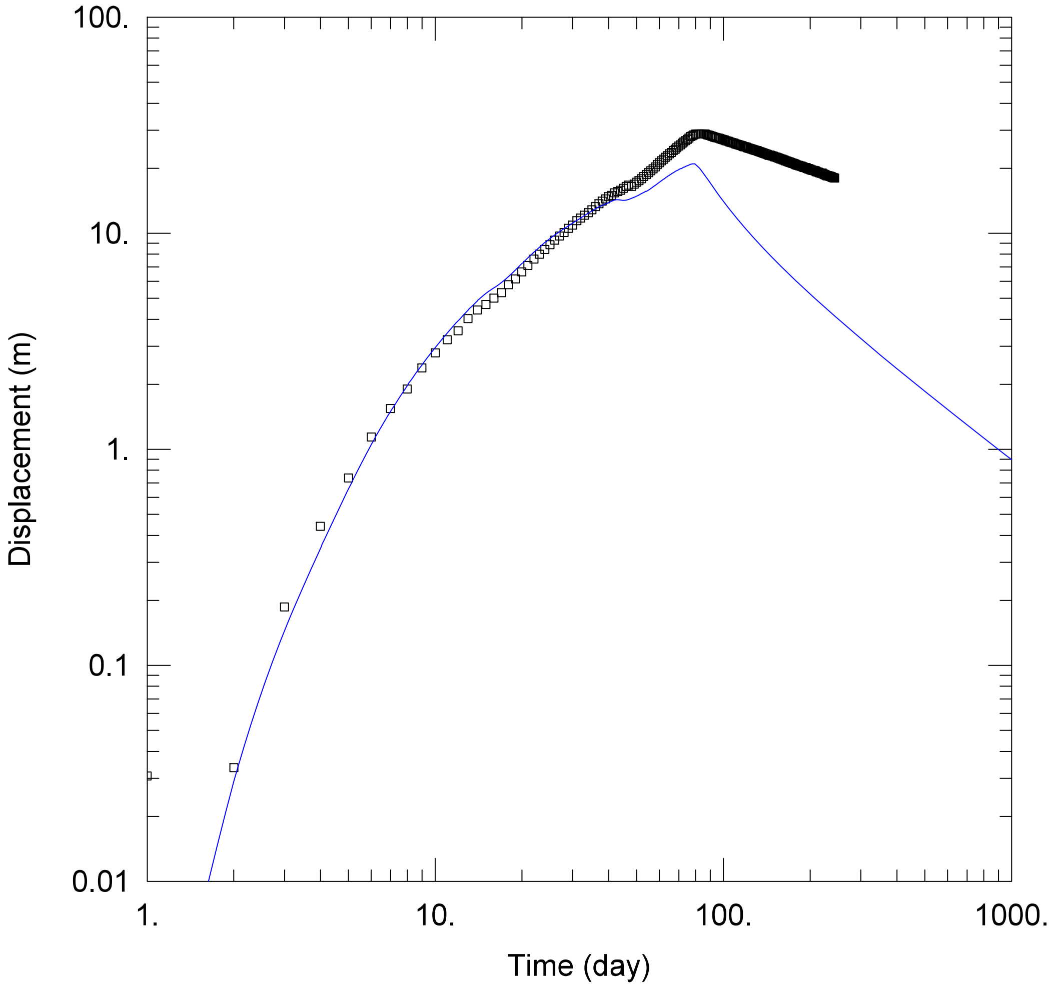
Remarks

27/03/2014: Form A Remarks:
Nat Carling, 24-Nov-2014; GPS provided by hydrogeologist.
04/03/2016: Primary Client changed from GWA to IPART on 04/03/2016.

***** End of GW093068 *****

Appendix D

AQTESOLV hydraulic testing outputs



WELL TEST ANALYSIS

Data Set: N:\...\K3_T_HJ_Early.aqt
Date: 05/05/20 Time: 08:56:41

PROJECT INFORMATION

Company: GHD
Client: SANTOS
Project: 2122463
Location: Kahlua2
Test Well: Kahlua2
Test Date: 01/09/2011

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Kahlua2	214443.7	6568423.73

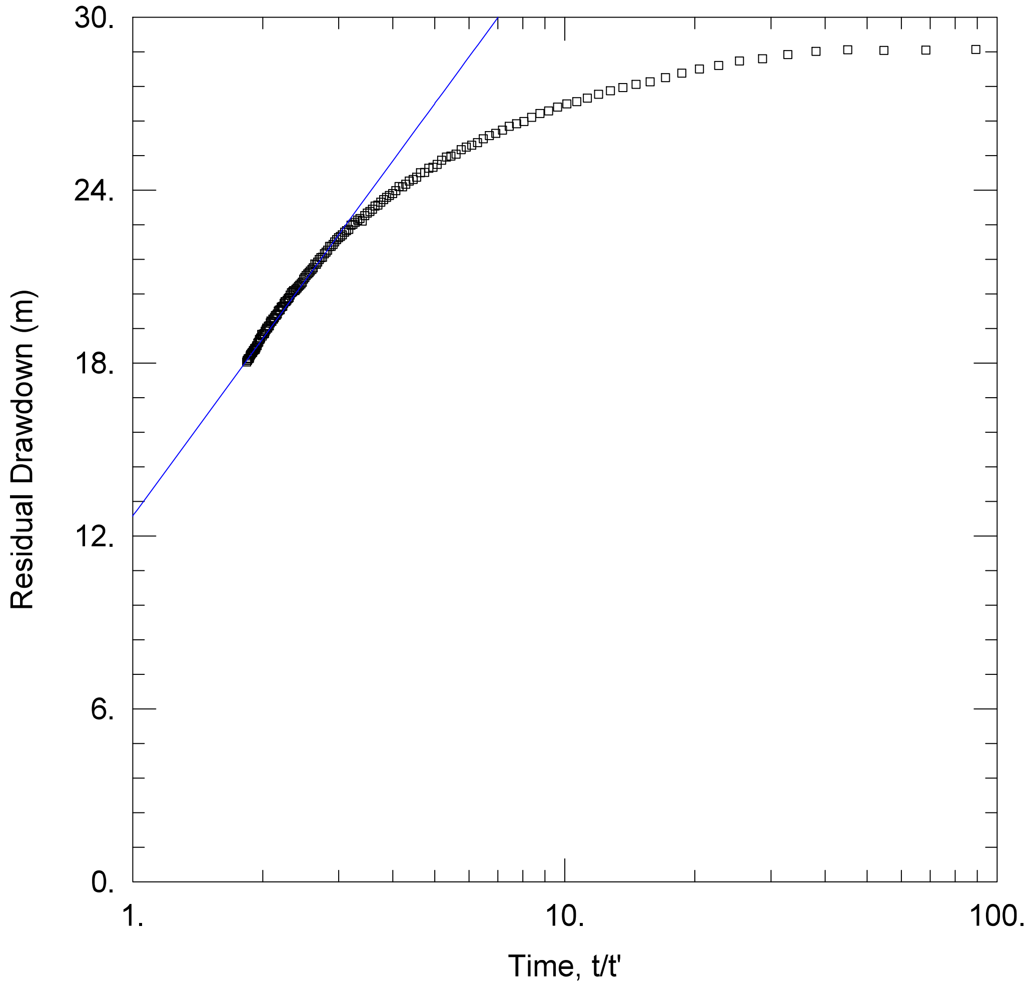
Observation Wells

Well Name	X (m)	Y (m)
□ Kahlua 3	214436.48	6567996.9

SOLUTION

Aquifer Model: Confined
Solution Method: Theis/Hantush

T = 0.08 m^2/day
S = 1.4E-5
Kz/Kr = 0.1
b = 7.6 m



WELL TEST ANALYSIS

Data Set: N:\...\K3_T_HJ_Late_Recovery.aqt
Date: 05/05/20 Time: 09:03:25

PROJECT INFORMATION

Company: GHD
Client: SANTOS
Project: 2122463
Location: Kahlua2
Test Well: Kahlua2
Test Date: 01/09/2011

AQUIFER DATA

Saturated Thickness: 7.6 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Kahlua2	214443.7	6568423.73

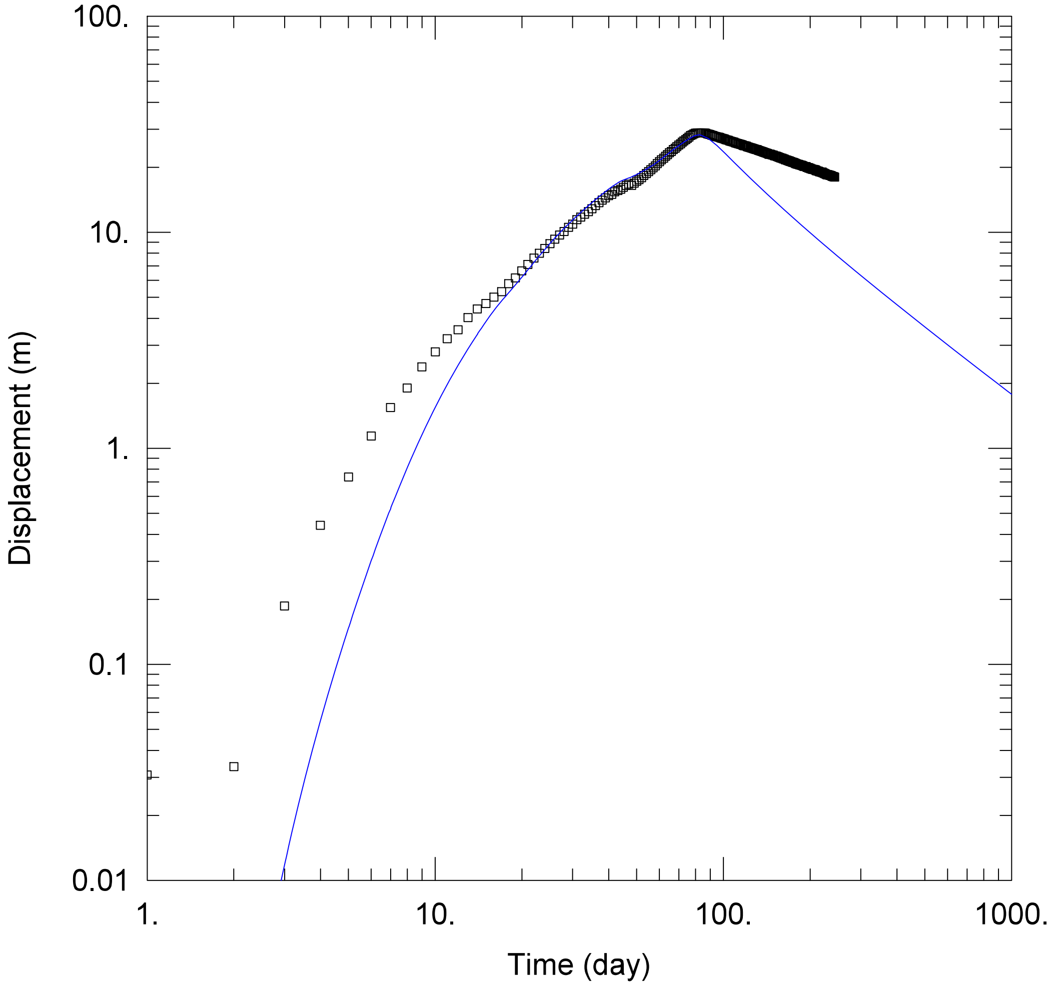
Observation Wells

Well Name	X (m)	Y (m)
□ Kahlua 3	214436.48	6567996.9

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 0.064 m^2/day S/S' = 0.24



WELL TEST ANALYSIS

Data Set: N:\...\K3_T_HJ_MID.aqt
Date: 05/05/20 Time: 08:59:16

PROJECT INFORMATION

Company: GHD
Client: SANTOS
Project: 2122463
Location: Kahlua2
Test Well: Kahlua2
Test Date: 01/09/2011

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Kahlua2	214443.7	6568423.73

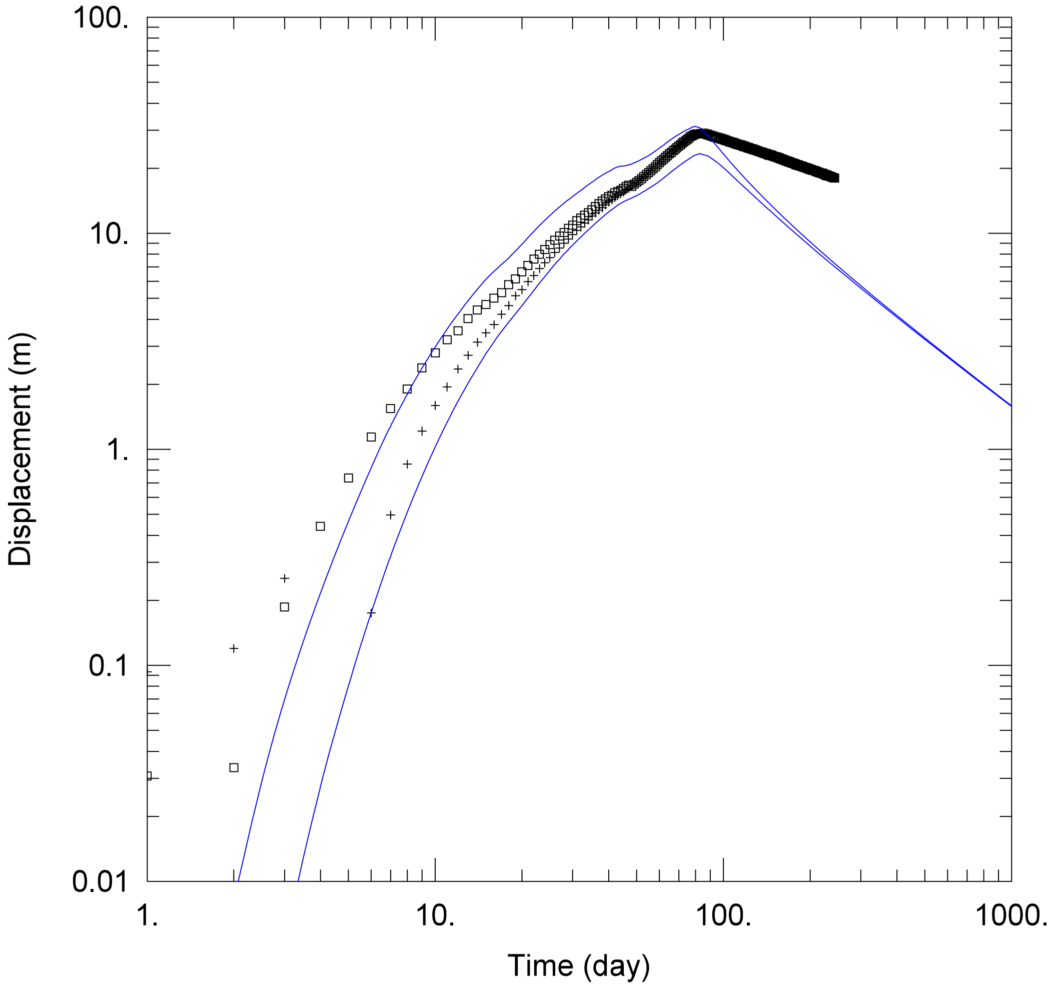
Observation Wells

Well Name	X (m)	Y (m)
□ Kahlua 3	214436.48	6567996.9

SOLUTION

Aquifer Model: Confined
Solution Method: Theis/Hantush

T = 0.04 m^2/day
S = 1.4E-5
Kz/Kr = 0.1
b = 7.6 m



WELL TEST ANALYSIS

Data Set: N:\...\K3_and_K5_Theis_H_Pumping.aqt
Date: 05/05/20 Time: 11:30:49

PROJECT INFORMATION

Company: GHD
Client: SANTOS
Project: 2122463
Location: Kahlua2
Test Well: Kahlua2
Test Date: 01/09/2011

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Kahlua2	214443.7	6568423.73

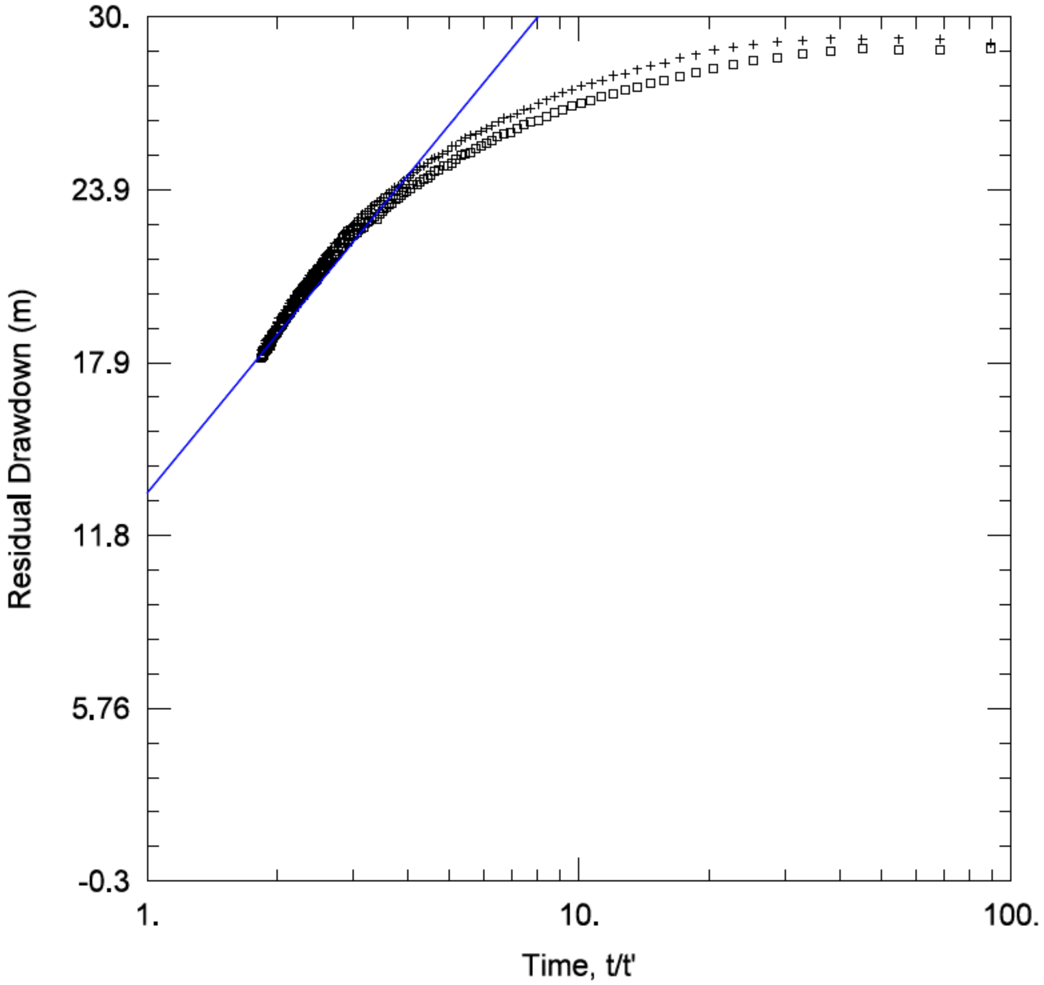
Observation Wells

Well Name	X (m)	Y (m)
□ Kahlua 3	214436.48	6567996.9
+ Kahlua 5	214016.24	6568755.23

SOLUTION

Aquifer Model: Confined
Solution Method: Theis/Hantush

T = 0.045 m^2/day
S = 1.1E-5
Kz/Kr = 0.1
b = 7.6 m



WELL TEST ANALYSIS

Data Set: N:\...\K3_and_K5_Theis_Late_Recovery.aqt
Date: 05/05/20 Time: 11:35:49

PROJECT INFORMATION

Company: GHD
Client: SANTOS
Project: 2122463
Location: Kahlua2
Test Well: Kahlua2
Test Date: 01/09/2011

AQUIFER DATA

Saturated Thickness: 7.6 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Kahlua2	214443.7	6568423.73

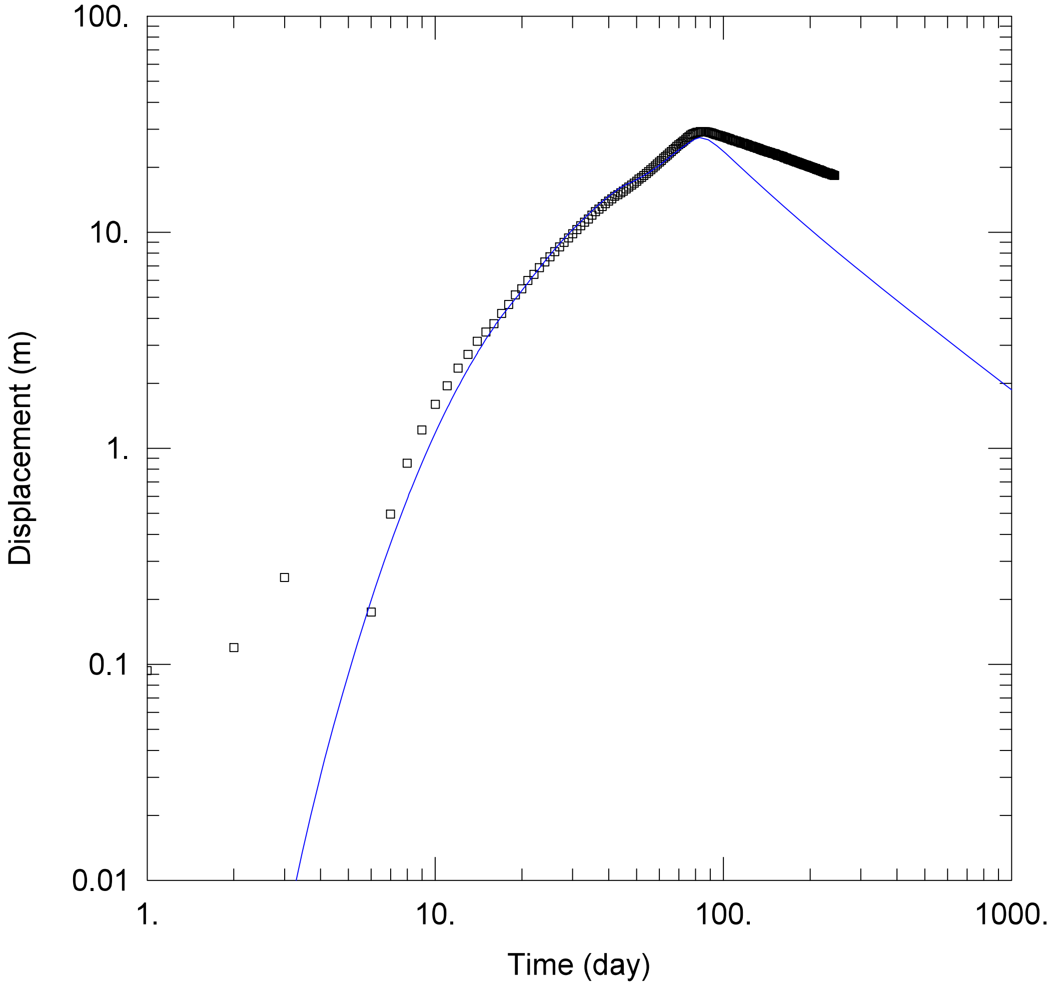
Observation Wells

Well Name	X (m)	Y (m)
□ Kahlua 3	214436.48	6567996.9
+ Kahlua 5	214016.24	6568755.23

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 0.071 m^2/day S/S' = 0.19



WELL TEST ANALYSIS

Data Set: N:\...\K5_Theis_H_Pumping.aqt
Date: 05/05/20
Time: 11:00:10

PROJECT INFORMATION

Company: GHD
Client: SANTOS
Project: 2122463
Location: Kahlua2
Test Well: Kahlua2
Test Date: 01/09/2011

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Kahlua2	214443.7	6568423.73

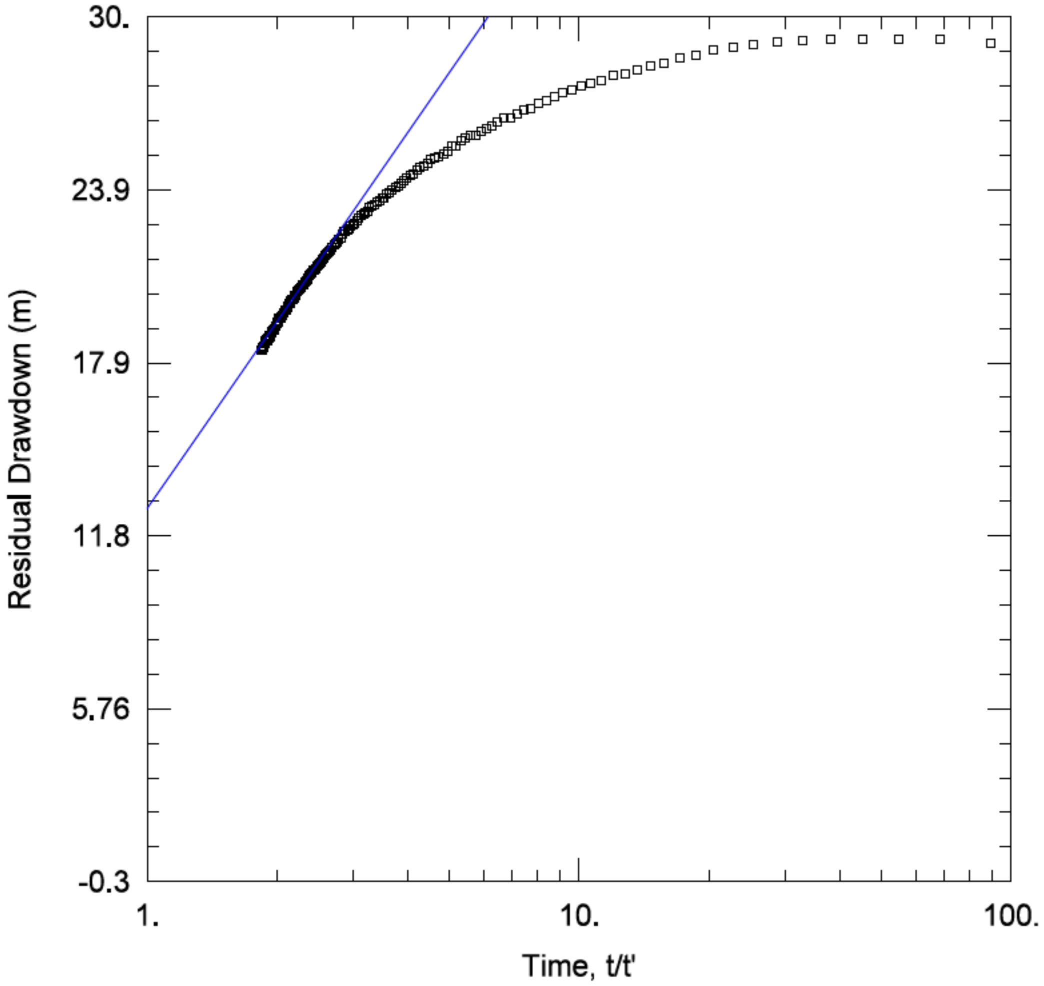
Observation Wells

Well Name	X (m)	Y (m)
□ Kahlua 5	214016.24	6568755.23

SOLUTION

Aquifer Model: Confined
Solution Method: Theis/Hantush

T = 0.038 m^2/day
S = 9.4E-6
Kz/Kr = 0.1
b = 7.6 m



WELL TEST ANALYSIS

Data Set: N:\...\K5_Theis_Late_Recovery.aqt
Date: 05/05/20 Time: 10:57:41

PROJECT INFORMATION

Company: GHD
Client: SANTOS
Project: 2122463
Location: Kahlua2
Test Well: Kahlua2
Test Date: 01/09/2011

AQUIFER DATA

Saturated Thickness: 7.6 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Kahlua2	214443.7	6568423.73

Observation Wells

Well Name	X (m)	Y (m)
□ Kahlua 5	214016.24	6568755.23

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 0.06 m^2/day S/S' = 0.26

Appendix E

Registered groundwater bores

HydroID	HydroCode	StateBoreID	BoreDepth (m)	DrilledDate	Latitude	Longitude	Easting	Northing	FTypeClass	Strata at base	Impact assessment strata	Impact assessment layer
10000172	GW017112.1.1	GW017112	82.9	1/8/1958	-30.9550958	150.043642	217577	6571625	Stock and Domestic	Black Jack Group - Wallala Fm	Black Jack Group - Wallala Fm	15
10000301	GW031084.1.1	GW031084	79.2		-30.9809296	149.9714213	783787	6568721	Irrigation	Napperby Formation 3	Napperby Formation 3	7
10007772	GW023448.1.1	GW023448	36.5	1/1/1965	-30.9584297	149.9608655	782844	6571244	Irrigation	Napperby Formation 3	Napperby Formation 3	7
10009084	GW008793.1.1	GW008793	36.6	1/1/1961	-31.0237073	149.9989216	786286	6563907	Unknown	Napperby Formation 5	Napperby Formation 5	11
10009173	GW022608.1.1	GW022608	27.4	1/5/1965	-30.9659291	150.0503087	218246	6570440	Stock and Domestic	Digby Sandstone	Digby Sandstone	13
10009882	GW068036.1.1	GW068036	34.5		-31.0233346	150.0244979	215949	6564009	Unknown	Napperby Formation 5	Napperby Formation 5	11
10012148	GW969979.1.1	GW969979	42	26/11/2009	-31.0295909	150.0477549	218189	6563374	Water Supply	Napperby Formation 1	Napperby Formation 1	3
10013361	GW017155.1.1	GW017155	23.8	1/1/1961	-30.9934291	150.059198	219176	6567413	Stock and Domestic	Quaternary	Napperby Formation 5	11
10018682	GW023328.1.1	GW023328	60.9	1/1/1965	-30.9520406	149.985865	785253	6571888	Stock and Domestic	Black Jack Group - Wallala Fm	Black Jack Group - Wallala Fm	15
10019551	GW011107.1.1	GW011107	39.6	1/1/1954	-30.990374	149.9791991	784502	6567654	Stock and Domestic	Napperby Formation 5	Napperby Formation 5	11
10020071	GW969532.1.1	GW969532	90	4/2/2010	-30.9999711	150.0700346	220230	6566715	Water Supply	Digby Sandstone	Digby Sandstone	13
10020720	GW008813.1.1	GW008813	32		-31.0234293	150.0244768	215948	6563998	Unknown	Napperby Formation 5	Napperby Formation 5	11
10021212	GW023450.1.1	GW023450	69.4	1/10/1965	-30.9559297	149.9650321	783250	6571510	Irrigation	Quaternary	Quaternary	1
10024460	GW022806.1.1	GW022806	44.2	1/7/1965	-30.970929	150.0658642	219747	6569925	Stock and Domestic	Digby Sandstone	Digby Sandstone	13
10026861	GW010367.1.1	GW010367	200.5	1/10/1952	-30.9903741	149.9678104	783414	6567683	Water Supply	Napperby Formation 5	Napperby Formation 5	11
10028449	GW027071.1.1	GW027071	68.6	1/1/1967	-30.9681515	150.020587	215412	6570118	Irrigation	Napperby Formation 4	Napperby Formation 4	9
10030584	GW051034.1.1	GW051034	21.3	1/5/1980	-31.0189852	149.9683664	783382	6564509	Water Supply	Napperby Formation 5	Napperby Formation 5	11
10032696	GW000334.1.1	GW000334	214	1/6/1919	-30.9431514	150.0319753	216426	6572920	Unknown	Watermark Formation	Watermark Formation	23
10033818	GW031081.1.1	GW031081	36.5	1/4/1965	-30.9681519	149.9608657	782816	6570165	Irrigation	Napperby Formation 2	Napperby Formation 2	5
10037210	GW020405.1.1	GW020405	20.7	1/6/1960	-30.9892625	150.051698	218447	6567856	Stock and Domestic	Quaternary	Napperby Formation 5	11
10039670	GW027073.1.1	GW027073	160	1/1/1965	-30.9734293	150.0191982	215295	6569529	Irrigation	Digby Sandstone	Digby Sandstone	13
10040575	GW023142.1.1	GW023142	59.4	1/10/1965	-30.9312073	149.9875313	785474	6574194	Stock and Domestic	Black Jack Group - Breeza CM	Black Jack Group - Breeza CM	17
10041389	GW031085.1.1	GW031085	36.5		-30.9809297	149.9608659	782778	6568748	Irrigation	Napperby Formation 1	Napperby Formation 1	3
10043106	GW007311.1.1	GW007311	40.2	1/1/1947	-30.9762075	149.9600325	782712	6569274	Stock and Domestic	Napperby Formation 1	Napperby Formation 1	3
10047807	GW008792.1.1	GW008792	29.3	1/1/1961	-31.035374	149.9908664	785482	6562634	Unknown	Glenrowan Intrusives	Glenrowan Intrusives	1
10052803	GW966696.1.1	GW966696	3.9	12/7/1990	-31.0276513	150.0406373	217504	6563571	Unknown	Napperby Formation 5	Napperby Formation 5	11
10057401	GW022653.1.1	GW022653	44.8	1/1/1964	-31.0012073	149.9847548	785000	6566439	Unknown	Napperby Formation 5	Napperby Formation 5	11
10058200	GW017232.1.1	GW017232	36.5		-30.9631519	149.9669766	783414	6570704	Irrigation	Napperby Formation 4	Napperby Formation 4	9
10060821	GW017223.1.1	GW017223	61	1/10/1961	-30.9373179	150.0519749	218321	6573617	Water Supply	Black Jack Group - Benelabri Fm	Black Jack Group - Benelabri Fm	17
10061471	GW010764.1.1	GW010764	144.2	1/3/1954	-30.9998182	150.0189209	215347	6566602	Stock and Domestic	Napperby Formation 3	Napperby Formation 3	7
10061737	GW017117.1.1	GW017117	23.2	1/8/1957	-30.9906514	150.0558647	218849	6567713	Stock and Domestic	Quaternary	Napperby Formation 5	11
10065161	GW966159.1.1	GW966159	0	19/2/2004	-31.0195464	150.0573965	219080	6564512	Unknown	No data	Napperby Formation 3	7
10065296	GW970169.1.1	GW970169	36.6	29/6/2011	-30.9983375	149.9963879	786120	6566727	Water Supply	Napperby Formation 5	Napperby Formation 5	11
10065352	GW017225.1.1	GW017225	68.5		-30.9800963	149.9689213	783550	6568820	Stock and Domestic	Napperby Formation 2	Napperby Formation 2	5
10069251	GW035640.1.1	GW035640	13.7	1/1/1923	-31.0300963	149.9730888	783800	6563265	Stock and Domestic	Napperby Formation 5	Napperby Formation 5	11
10074689	GW031082.1.1	GW031082	48.7		-30.971763	149.9650324	783203	6569754	Irrigation	Napperby Formation 3	Napperby Formation 3	7
10075217	GW970846.1.1	GW970846	222.6	14/11/2013	-31.0293604	150.036526	217116	6563371	Water Supply	Napperby Formation 5	Napperby Formation 5	11
10075826	GW010740.1.1	GW010740	61	1/1/1954	-31.0056515	150.036143	217009	6565999	Irrigation	Napperby Formation 3	Napperby Formation 3	7
10078386	GW008785.1.1	GW008785	12.8	1/1/1961	-31.0314852	149.9833664	784777	6563085	Unknown	Glenrowan Intrusives	Glenrowan Intrusives	1
10079061	GW901767.1.1	GW901767	19.2	31/7/1995	-31.0232737	150.0468043	218080	6564072	Water Supply	Napperby Formation 1	Napperby Formation 1	3
10080342	GW023449.1.1	GW023449	60.9	1/1/1965	-30.9356517	149.9955868	786231	6573681	Stock and Domestic	Black Jack Group - Breeza CM	Black Jack Group - Breeza CM	17
10081023	GW022857.1.1	GW022857	29.9	1/1/1964	-31.0206518	149.9794774	784438	6564296	Stock and Domestic	Glenrowan Intrusives	Glenrowan Intrusives	1
10081199	GW022650.1.1	GW022650	41.5	1/1/1965	-31.0248185	149.9836441	784824	6563823	Unknown	Glenrowan Intrusives	Glenrowan Intrusives	1
10086904	GW902081.1.1	GW902081	24.7	24/8/1998	-31.0195875	150.0563319	218979	6564505	Water Supply	Glenrowan Intrusives	Napperby Formation 3	7
10087353	GW008808.1.1	GW008808	27.4	1800/01/01	-31.0039847	150.0489206	218225	6566217	Unknown	Quaternary	Napperby Formation 4	9
10087885	GW027074.1.1	GW027074	54.9	1/5/1965	-30.9937071	150.021143	215541	6567286	Unknown	Napperby Formation 1	Napperby Formation 1	3
10088300	GW008809.1.1	GW008809	28	1/1/1958	-31.0031514	150.0591982	219204	6566335	Unknown	Napperby Formation 5	Napperby Formation 5	11
10088360	GW010741.1.1	GW010741	23.5	1/2/1954	-31.0059291	150.0597538	219265	6566028	Irrigation	Quaternary	Napperby Formation 4	9
10089688	GW017109.1.1	GW017109	32.9	1/7/1958	-30.9606513	150.0539197	218575	6571035	Stock and Domestic	Glenrowan Intrusives	Glenrowan Intrusives	1
10089916	GW966651.1.1	GW966651	4.4	16/6/1992	-31.0067445	150.0196968	215442	6565836	Unknown	Napperby Formation 5	Napperby Formation 5	11
10095081	GW026532.1.1	GW026532	82.3	1/1/1966	-30.9939849	150.0178097	215223	6567246	Water Supply	Napperby Formation 2	Napperby Formation 2	5
10097163	GW027072.1.1	GW027072	109.7	1/1/1965	-30.9728737	150.0275314	216090	6569612	Irrigation	Digby Sandstone	Digby Sandstone	13
10098718	GW049476.1.1	GW049476	65.5	1/2/1979	-30.9445402	150.0530861	218448	6572819	Water Supply	Black Jack Group - Benelabri Fm	Black Jack Group - Benelabri Fm	17
10101144	GW010679.1.1	GW010679	21.3	1/2/1954	-31.0073182	150.0125322	214759	6565754	Stock and Domestic	Napperby Formation 5	Napperby Formation 5	11
10103142	GW017224.1.1	GW017224	38.1		-30.974263	149.9683657	783514	6569469	Stock and Domestic	Napperby Formation 2	Napperby Formation 2	5
10108312	GW008795.1.1	GW008795	29.3	1/1/1961	-31.0309295	150.0005884	213689	6563105	Unknown	Glenrowan Intrusives	Glenrowan Intrusives	1
10109251	GW017111.1.1	GW017111	7	1/8/1958	-30.9675958	150.0422533	217481	6570235	Stock and Domestic	Napperby Formation 4	Napperby Formation 4	9
10109731	GW022654.1.1	GW022654	26.8	1/3/1965	-31.0237074	149.9822552	784694	6563950	Stock and Domestic	Glenrowan Intrusives	Glenrowan Intrusives	1
10111114	GW970482.1.1	GW970482	73.1	29/6/2011	-31.0027914	150.0179819	215266	6566270	Water Supply	Napperby Formation 5	Napperby Formation 5	11
10112072	GW004928.1.1	GW004928	45.7		-30.936763	149.970865	783864	6573621	Unknown	Quaternary	Quaternary	1
10113104	GW021121.1.1	GW021121	38.4	1/2/1965	-31.0089847	150.0636427	219646	6565699	Stock and Domestic	Napperby Formation 5	Napperby Formation 5	11
10114031	GW031292.1.1	GW031292	29	1/1/1968	-30.9748179	150.0628087	219466	6569486	Stock and Domestic	Glenrowan Intrusives	Glenrowan Intrusives	1
10114725	GW900367.1.1	GW900367	15.85	1/7/1995	-31.0043458	150.0566427	218964	6566196	Water Supply	Quaternary	Napperby Formation 4	9
10115095	GW008796.1.1	GW008796	70.1		-30.9937073	149.9844769	784996	6567271	Unknown	Napperby Formation 1	Napperby Formation 1	3
10115221	GW015686.1.1	GW015686	61	1/6/1957	-31.010096	150.0130878	214820	6565447	Irrigation	Napperby Formation 5	Napperby Formation 5	11
10115455	GW068864.1.1	GW068864	162.4	19/10/1992	-30.9764205	149.9827911	784886	6569192	Water Supply	Digby Sandstone	Digby Sandstone	13
10124647	GW034910.1.1	GW034910	44.8	1/1/1930	-30.940929	150.0594748	219048	6573236	Stock and Domestic	Black Jack Group - Breeza CM	Black Jack Group - Breeza CM	17
10127478	GW017110.1.1	GW017110	37.2	1/7/1958	-30.9542623	150.061975	219326	6571764	Stock and Domestic	Black Jack Group - Wallala Fm	Black Jack Group - Wallala Fm	15
10128107	GW010943.1.1	GW010943	104.9	1/10/1954	-30.9454291	150.0405807	217255	6572689	Water Supply	Black Jack Group - Benelabri Fm	Black Jack Group - Benelabri Fm	17
10130905	GW021127.1.1	GW021127	20.4	1/2/1965	-31.0059291	150.0661426	219876	6566044	Stock and Domestic	Glenrowan Intrusives	Napperby Formation 5	11
10136101	GW017227.1.1	GW017227	45.7		-30.9959298	149.9497552	781672	6567113	Unknown	Quaternary	Quaternary	1
10153065	GW903214.1.1	GW903214	60	10/9/2017	-30.9948246	149.9813686	211744.5	6567059.1	Stock and Domestic	Napperby Formation 5	Napperby Formation 5	11
10153495	GW971558.1.1	GW971558	42	21/3/2016	-30.9423641	150.0461032	217774.3	6573042.8	Water Supply	Black Jack Group - Wallala Fm	Black Jack Group - Wallala Fm	15
10154527	GW903213.1.1	GW903213	30	9/9/2017	-31.0173354	150.020229	215523.9	6564662.9	Stock and Domestic	Napperby Formation 5	Napperby Formation 5	11
10154661	GW971585.1.1	GW971585	102	8/4/2016	-30.9272579	150.0452009	217643.6	6574715.7	Water Supply	Black Jack Group - below Hoskissons Coal Seam	Black Jack Group - below Hoskissons Coal Seam	21

Appendix F

Noise and vibration report

Kahlua Pilot Reactivation

Noise and vibration impact assessment

Santos Limited

December 2022

Project name	Santos Narrabri GDP EIS						
Document title	Kahlua Pilot Reactivation | Noise and vibration impact assessment						
Project number	2122463						
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Contents

Figure index

Table index

1. Introduction

Santos QNT Pty Ltd (Santos) proposes to carry out the Kahlua Pilot Reactivation at a site located on Lot 6 DP586978 in Marys Mount about 20 kilometres west of Gunnedah, NSW.

The site contains existing coal seam gas exploration infrastructure including four exploration wells (Kahlua (K) 2, K3, K4 and K5), access tracks, water storage and gas flaring infrastructure.

The purpose of the proposed activity is to continue exploration and appraisal activities at the site utilising the existing coal seam gas exploration infrastructure. It includes some minor additional civil and construction works including installation of buried gas and water gathering, power cables, upgrade of the gas flare, establishment of central power generation infrastructure and 65 kilolitre diesel storage, followed by workovers and completions, and appraisal activities.

This report provides a noise impact assessment for the reactivation of the proposed activity. This assessment provides the environmental noise emission criteria for both construction and operational phases in accordance with the relevant environment protection licence (EPL) for the activity EPL 20351, and an assessment of noise for both phases.

2. Noise criteria

2.1 Noise sensitive receivers

A review of aerial photography of the subject site and surrounding area has been undertaken. Three residential receivers have been identified that are presented in Table 2.1 and Figure 2.1. A residential dwelling is situated approximately 1,100 m to the north, located within the same lot as the Kahlua site. This lot is leased by Santos, with the dwelling uninhabited. Considering this, it will not be considered part of the scope of this assessment.

Table 2.1 Nearby sensitive receivers

Receiver ID	X	Y	Distance from site
R1	786462	6567387	1,080 m
R2	788250	6566748	1,400 m
R3	785005	6569188	2,000 m

Figure 2.1 Nearby sensitive receivers

2.2 Background noise levels

In lieu of background noise monitoring, background noise levels for this assessment are assumed to be the minimum background noise levels presented in Table 2.1 of the *Noise Policy for Industry (NPfI)* (NSW EPA 2017) and are presented below in Table 2.2.

Table 2.2 Minimum assumed background noise levels

Time of day	Minimum assumed rating background noise level, dB(A)
Day (7:00 am to 6:00 pm)	35
Evening (6:00 pm to 10:00 pm)	30
Night (10:00 pm to 7:00 am)	30

2.3 Construction noise criteria

The relevant construction noise limits for the proposed activity is found in limit L4 in EPL 20351, as stipulated below.

L4 Hours of operation

Construction activities limits

L4.1 Standard construction hours

Unless otherwise specified by any other condition of this licence, all construction activities are:

a. restricted to between the hours of 7:00am and 6:00pm Monday to Friday;

b. restricted to between the hours of 8:00am and 1:00pm Saturday; and

c. not to be undertaken on Sundays or Public Holidays.

L4.2 Exceptions to standard construction hours

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

a. *Construction work that causes LAeq(15minute) noise levels that are:*
   i. *no more than 5dB above rating background level at any residence not subject to a private negotiated agreement, in accordance with the Interim Construction Noise Guideline (DECC, 2009); and*
   ii. *no more than the noise management levels specified Table 3 of the Interim Construction Noise Guideline (DECC, 2009) at other sensitive land uses.*

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

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

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

The construction noise limits as specified in EPL 20351 are provided below in Table 2.3. Where construction noise exceeds the limits provided in Table 2.3, a private negotiated agreement with the affected landowner or residence would be required in order for construction works to be undertaken during that time period. Noise management levels have also been provided for construction works occurring within standard construction hours, which are included in this assessment to assess where reasonable and feasible management measures should be implemented during standard construction hours. These are based on the NML in accordance with the *Interim Construction Noise Guideline (DECC, 2009)* (ICNG), and are also provided in Table 2.3.

Table 2.3 Construction noise limits (EPL 20351)

Time of day	Background noise level	Criteria, $L_{Aeq(15min)}$
Outside standard hours – day	35 dB(A)	40 dB(A) Noise limit
Outside standard hours – evening	30 dB(A)	35 dB(A) Noise limit
Outside standard hours – night	30 dB(A)	35 dB(A) Noise limit
Standard construction hours	35 dB(A)	45 dB(A) Noise Management Level

2.4 Operational noise criteria

The relevant construction noise limits for the proposed activity is found in limit L3 in EPL 20351, as stipulated below.

L3 Noise limits

Operational activities limits

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

Location	*Day Noise Limit LAeq(15minute)*	*Evening Noise Limit (LAeq (15 minute)*	*Night Noise Limit (LAeq (15 minute)*
any residential sensitive receptor not subject to a private negotiated agreement	*35dB(A)*	*35dB(A)*	*35dB(A)*

L3.2 For the purpose of Condition 3.1:

a. *Day is defined as the period from 7am to 6pm Monday to Saturday and 8am to 6pm Sundays and Public Holidays;*

b. *Evening is defined as the period from 6pm to 10pm; and*

c. *Night is defined as the period from 10pm to 7am Monday to Saturday and 10pm to 8am Sundays and Public Holidays.*

L3.3 To determine compliance:

a. *with the Leq(15 minute) noise limits in condition L3.1, the noise measurement equipment must be located:*
   - *approximately on the property boundary, where any dwelling is situated 30m or less from the property boundary closest to the premises; or*
   - *within 30 metres of a dwelling facade, but not closer than 3m, where any dwelling on the property is situated more than 30 metres from the property boundary closest to the premises; or, where applicable*
   - *within approximately 50 meters of the boundary of a National Park or a Nature Reserve.*

b. *with the noise limits in condition L3.1, the noise measurements equipment must be located:*
   - *at the most affected point at a location where there is no dwelling at the location; or*
   - *at the most affected point within an area at a location prescribed by condition L3.2.*

L3.4 For the purposes of determining the noise generated at the premises the modification factors in Section 4 of the NSW Industrial Noise Policy must be applied, as appropriate, to the noise levels measured by the noise monitoring equipment.

2.4.1 Modifying factor corrections

The NPfI requires that modifying factor corrections are applied if the noise sources contain tonal, intermittent, or low frequency characteristics, which have the potential to increase annoyance. The modifying factor corrections are detailed in Table 2.4.

Table 2.4 Modifying factor corrections

Factor	Assessment/ measurement	When to apply	Correction[1,2]
Tonal noise	One-third octave or narrow band analysis	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: – 5 dB or more if the centre frequency of the band containing the tone is above 400 Hz – 8 dB or more if the centre frequency of the band containing the tone is 160 to 400 Hz inclusive – 15 dB or more if the centre frequency of the band containing the tone is below 160 Hz.	5 dB(A)[2]
Low frequency noise	Measurement of C-weighted and A-weighted level	Measure/assess C and A weighted $L_{eq,T}$ levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more and: – Where any of the one-third octave noise levels in Table C2 are exceeded by up to and including 5 dB and cannot be mitigated, a 2 dB(A) positive adjustment to measured/predicted A-weighted levels for the evening/night period. – Where any of the one-third octave noise levels in Table C2 are exceeded by more than 5 dB(A) and cannot be mitigated, a 5 dB(A) positive adjustment to measured/predicted A-weighted noise levels applies for the evening/night period and a dB(A) positive adjustment for the daytime period.	5 dB(A)[2]
Impulsive noise	A-weighted fast response and impulse response	If the difference in A-weighted maximum noise levels between fast response and impulse response is greater than 2 dB.	Apply the difference in measured noise levels as the correction up to a maximum of 5 dB(A)
Intermittent noise	Subjectively assessed	When the night-time noise level drops to that of the background noise level with a noticeable change in noise level of at least 5 dB(A).	5 dB(A)

Notes: 1. Where two or more modifying factors are present the maximum correction is limited to 10 dB(A).
2. Where a source emits a tonal and low-frequency noise, only one 5 dB correction should be applied if the tone is in the low frequency range.

2.4.2 Sleep disturbance criteria

The NPfI recommends a detailed maximum noise level event assessment be undertaken where night-time noise levels from a development exceed the following levels when assessed externally at the nearest residential location:

– $L_{Aeq(15min)}$ 40 dB(A) or the prevailing RBL + 5 dB(A) (whichever is greater); and/or

– L_{AFmax} 52 dB(A) or the prevailing RBL + 15 dB(A) (whichever is greater).

3. Noise impact assessment

3.1 Noise modelling

Noise impacts have been predicted using CadnaA Version 2020. CadnaA is a computer program for the calculation, assessment, and prognosis of noise exposure. CadnaA calculates environmental noise propagation according to *The propagation of noise from petroleum and petrochemical complexes to neighbouring communities, Report Number 4/81*, (CONCAWE 1981) algorithm to predict the effects of construction and operational related noise under defined meteorological stability classes.

The construction and operational noise impact assessment involved the following:

– Establishing appropriate site-specific conditions. The following noise model assumptions were made with regard to the study area:
  - The surrounding area is soil on rural land with some small, forested areas. The CONCAWE algorithm applies a ground absorption coefficient of 1 to represent acoustic propagation over soft ground.
  - Terrain topography of the study area is flat and has been modelled as such.

– Determining appropriate meteorological conditions for the noise modelling process. Meteorological conditions were calculated using *The propagation of noise from petroleum and petrochemical complexes to neighbouring communities, Report Number 4/81* (CONCAWE 1981) algorithm based on stability classes. The NPfI Fact Sheet D provides the following meteorological conditions which have been applied to the noise modelling scenarios:
  - Standard meteorological conditions: Pasquill Stability Class D atmospheric conditions during the day, evening and night-time period and wind of up to 0.5 m/s.
  - Noise enhancing meteorological conditions during the night time period: Pasquill Stability Class F atmospheric conditions (to represent a moderate temperature inversion) with a 2 m/s wind from source to receiver.
  - Air absorption based on typical worst case noise propagation conditions of 10 °C and 90 per cent humidity.

3.2 Construction noise

3.2.1 Construction works program

The plant and equipment likely to be required throughout each stage of construction have been estimated based on previously provided information. They have been used to predict the noise levels that would be expected during construction works. The predicted noise levels were assessed against the noise criteria presented in Section 3.2.2.

All works are located within or adjacent to the proposal site. The modelling scenario assumes all construction equipment would be operating at the same time and assumes a ‘worse-case’ to identify where noise impacts could be a concern and assists in the formulation of where mitigation is required. The construction activities associated equipment and noise levels are presented below in Table 3.1.

Assessment of the provided noise source data indicates that there are no tonal or low frequency characteristics associated with the drill rig noise source therefore no modifying factor adjustments have been applied to the assessment.

Table 3.1 Construction activity scenarios and noise levels

Stage	Description	Equipment	Sound power level, L_{Aeq}, dB(A)
CS1 – Workover operations[1]	Conduct workover on an existing well and install new completion equipment (each piece of equipment is operated independent of each other)	Circulating with air/mist	120
		Tripping operations overbalance only	106
		Circulating with rig Mud pumps only (no air packs	108
		Using Primary jet for tripping operations	120
CS2 – Trenched gathering line installation	Installation of gathering lines under or adjacent to existing access tracks	Excavator	107
		Roller	108
		Water cart	107
Note 1: Anticipated equipment and source noise levels have been provided as part of attended noise monitoring survey from *Detailed Modelling Sound Level Summary – VENTIA 29 Workover Rig Drilling Operations* (Patching Associates, September 2022).			

3.2.2 Construction noise impacts and discussion

Predicted noise levels at the nearby sensitive receivers are presented below in Table 3.2.

Workover operations

Noise predictions indicate that construction noise levels are exceeding the noise limits outside standard construction hours in the day, evening and night period during noise enhancing meteorological conditions. This is due to the use of workover rig, with the airpacks circulating downhole, and the primary jet. An exceedance of the night time criteria is also predicted during standard meteorological conditions from the same equipment. It is recommended that a negotiated agreement is sought with the exceeding receivers R1 and R2 for works involving the workover rig outside of standard construction hours. It is predicted that construction noise levels are compliant with the adopted NML inside standard construction hours.

Trenched gathering line installation

Noise predictions indicate that construction noise levels are predicted to comply with the noise limits outside standard construction hours in the night period during noise enhancing meteorological conditions.

Construction noise sleep disturbance impacts

The assessment of construction sleep disturbance impacts on nearby sensitive receivers is assessed for the following maximum noise event against the construction sleep disturbance impacts criteria presented in Section 2.3.

– Maximum noise event being the banging of a dropped piece of metal, a high-pressure air release, or the work over rig air packs or jets with a maximum noise level of L_{Amax} 123 dB(A)

The highest L_{Amax} noise level at a residential receiver is predicted to be 47 dB(A) well below the sleep disturbance screening criteria of 52 dB(A). There is the potential for exceedances to the 40 dBA $L_{Aeq(15min)}$ screening criteria during the night time period.

Table 3.2 Predicted construction noise levels at nearby residential receivers

Construction scenario	Weather conditions	Time period	Noise limit	Receiver ID		
				R1	R2	R3
Bold indicates an exceedance of the noise limit, and requires engagement with affected residential receivers						
CS01 – Workover operations VENITA 29 Workover Rig, Airpacks circulating downhole	Standard	Standard hours	45 NML	39	35	30
		OOHW – day	40	39	35	30
		OOHW – evening and night	35	**39**	35	30
	Noise enhancing	Standard hours	45 NML	44	41	35
		OOHW – day	40	**44**	**41**	35
		OOHW – evening and night	35	**44**	**41**	35
CS01 – Workover operations Tripping operations overbalance only	Standard	Standard hours	45 NML	25	21	16
		OOHW – day	40	25	21	16
		OOHW – evening and night	35	25	21	16
	Noise enhancing	Standard hours	45 NML	30	27	21
		OOHW – day	40	30	27	21
		OOHW – evening and night	35	30	27	21
CS01 – Workover operations Circulating with rig Mud pumps only (no air packs)	Standard	Standard hours	45 NML	27	23	18
		OOHW – day	40	27	23	18
		OOHW – evening and night	35	27	23	18
	Noise enhancing	Standard hours	45 NML	32	29	23
		OOHW – day	40	32	29	23
		OOHW – evening and night	35	32	29	23
CS01 – Workover operations VENITA 29 Workover Rig, Silvent primary jet	Standard	Standard hours	45 NML	39	35	30
		OOHW – day	40	39	35	30
		OOHW – evening and night	35	**39**	35	30
	Noise enhancing	Standard hours	45 NML	44	41	35
		OOHW – day	40	**44**	**41**	35
		OOHW – evening and night	35	**44**	**41**	35
CS02 – Trenched gathering line installation	Standard	Standard hours	45 NML	31	27	22
		OOHW – day	40	31	27	22
		OOHW – evening and night	35	31	27	22
	Noise enhancing	Standard hours	45 NML	35	32	26
		OOHW – day	40	35	32	26
		OOHW – evening and night	35	35	32	26

3.3 Operational noise

3.3.1 Operational noise sources

Noise associated with the operation of the Kahlua well appraisal testing will include the following:

– Diesel generator power unit with acoustic enclosure at K2 operating 24 hours a day

– Well head drive motors at each well operating 24 hours a day
– Water truck vehicle movements along internal access roads. Assumed to be entering and exiting the site within a 15-minute period, equating to 2 vehicle movements/15-minutes
– A pilot flare with the orifice located at a height of 6 metres above the ground, potentially operating 24 hours a day with an assumed maximum flow rate of 820 thousand standard cubic feet of gas per day.

Table 3.3 below details the noise sources used for this operational noise impacts assessment.

Table 3.3 Operational noise source levels

Equipment	Overall, dB(A)	Octave band frequency (Hz), dB(A)								
		31.5	63	125	250	500	1000	2000	4000	8000
Diesel generator power unit (Pad K2)	75	21	35	47	56	61	64	68	71	69
Calculated based on manufacturer specifications of 67.4 dB(A) at 1 meter for a CAT XQE200 diesel generator provided by Santos.										
Well head drive motor	82	32	44	60	70	75	77	76	71	65
Calculated based on a 75 Kw 750 rpm 3-phase electric motor using VDI 3736 *Emission benchmarks of technical sound sources, rotating electrical machines, asynchronous machines, April 1984*. Spectrum calculated based on H.Schmidt Technical sound pocket book, VDI publications Düsseldorf (1996).										
Water truck movements	107	85	90	86	94	98	103	101	97	87
Vehicle movements of a water truck as part of operations. 1 water truck assumed to be entering and exiting the site via internal access roads within a 15 minute period (2 vehicle movements / 15 minutes). Water truck sound power level based off previously provided information, similar to that used in construction noise assessment.										
Pilot flare	103	39	57	73	83	91	96	99	98	93
Noise level and spectra calculated based on the ground based flare noise emission equations provided in *VDI 3732 Characteristic noise emission values of technical noise sources – Flares* (1999) using a flow rate of 820 thousand standard cubic feet of gas per day.										

3.3.2 Operational noise assessment results

The predicted noise levels for operational noise of the well production tests is presented below in Table 3.4. It has been assessed against night time criteria of the NPfI as operations are to occur 24 hours a day and the night time criteria is the most stringent.

Table 3.4 Operational noise results

Operational noise source	Weather conditions	Noise limit, dB(A)	Receiver ID, dB(A)		
			R1	R2	R3
Diesel generator power unit	Standard	35	0	0	0
	Noise enhancing		0	0	0
Well head drive motors	Standard		0	0	3
	Noise enhancing		5	0	9
Water truck	Standard		11	8	13
	Noise enhancing		15	13	17
Pilot flare	Standard		14	7	18
	Noise enhancing		19	12	23
Total	Standard		16	11	19

Operational noise source	Weather conditions	Noise limit, dB(A)	Receiver ID, dB(A)		
			R1	R2	R3
	Noise enhancing		21	16	24

3.3.3 Discussion of operational noise results

The results of the operational noise assessment indicate that noise emission from the well head power unit, drive motors, water truck movements and pilot flare is compliant with the operational noise criteria of the NPfI, both in standard and noise enhancing weather conditions.

No impulsive noise characteristics or maximum noise events are associated with operations. As such, the received noise level should not cause any sleep disturbance impacts.

4. Mitigation measures

4.1 Construction noise and vibration

The following mitigation recommendations are provided in Table 4.1 to reduce the noise levels from the construction activities.

– Site inductions for the work crew would include the specific noise issues and mitigation measures required for the site. The induction would include:
  - all relevant project specific and standard noise mitigation measures
  - relevant licence and approval conditions
  - permissible hours of work
  - location of sensitive receivers that may exceed construction noise limits
  - construction employee parking areas
  - designated loading/ unloading areas and procedures
  - site opening/closing times (including deliveries)
  - behavioural practices that minimise noise
  - avoiding dropping materials from height and avoiding metal to metal contact on material.

– Incorporate the use of two-way radios over loudspeakers when communicating across longer distances

– Maximise the distance between plant and equipment and sensitive receivers where practicable. For example, vehicle movements and generator storage would be located as far as practical from sensitive receivers.

– The use of broadband reversing alarms.

– Use quieter and lower vibration emitting construction methods where available.

– Vehicles, plant, and equipment would be regularly maintained and kept in good operating condition.

– Where feasible and reasonable, reducing the number of plant and equipment used during the out of hours periods to reduce noise emission levels.

– Scheduling noisier activities during recommended standard construction hours and minimise the use of heavy machinery during the out of hours periods.

4.2 Additional mitigation measures for workover activities

Workover activities may need to be undertaken 24 hours a day and in some locations, this could result in noise exceeding the out of hours noise limit of 35 dB(A). Exceedances to the construction noise limits at sensitive receivers would be temporary, typically lasting days to several weeks.

In order to reduce noise levels associated with 24-hour workover activities, the mitigation and management measures shown in Table 4.1 would be considered where feasible and reasonable in respect of activities that were predicted to result in noise levels greater than the noise limit.

Table 4.1 Additional mitigation measures for managing 24 hour drill and completion rig operations

Treatment type	Component	Treatment (where feasible and reasonable)
At source treatments	Engine compartment treatment	Acoustic treatment to the generator, power pack engine compartments.
Private negotiated agreements	Alternative arrangements	Private negotiated agreements could be entered into with the potentially affected residential receiver.
Work scheduling	-	Work is scheduled to occur when there is a low probability of noise enhancing meteorological conditions.

5. Conclusion

Noise impacts for the construction and operational phases of the proposed activity have been assessed using minimum background noise levels as presented in the NPfI against the construction and operational noise limits in accordance with EPL 20351.

5.1 Construction noise

Construction noise impacts have been assessed against the construction noise limits and exceedances are predicted where workover activities and trenching are to be undertaken outside of recommended standard hours. Mitigation and management measures are recommended where feasible and reasonable in respect of activities that were predicted to result in noise levels greater than the noise limit.

5.2 Operational noise

Potential noise impacts from the proposed activity during the operational phase has been assessed against the operational noise criteria presented in Section 2.4. Noise levels from the K2 well head power unit, drive motors, water truck movements and pilot flare are predicted to comply with the noise criteria.

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→ The Power of Commitment

Appendix G

Biodiversity report

Kahlua Pilot Reactivation

Biodiversity assessment report

Santos Limited

December 2022

Project name	Santos Narrabri GDP EIS
Document title	Kahlua Pilot Reactivation | Biodiversity assessment report
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S4	0	[redacted]	[redacted]		[redacted]		15/12/22

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Contents

Table index

Figure index

Appendices

1. Introduction

1.1 Background

Santos proposes to carry out the Kahlua Pilot Reactivation at a site located on Lot 6 DP586978 in Marys Mount about 20 kilometres west of Gunnedah, NSW. The site contains existing coal seam gas exploration infrastructure including four exploration wells (K2, K3, K4 and K5), access tracks between the wells, and water storage and gas flaring infrastructure located at well K2.

The purpose of the proposed activity is to continue exploration and appraisal activities at the site utilising the existing coal seam gas exploration infrastructure. It includes some minor additional civil and construction works including installation of gathering lines and upgrade of the existing gas flare, gas well workovers and completions, and appraisal activities described in section 2. The site of the proposed activity and infrastructure layout is shown in Figure 1.1.

Coal seam gas exploration at the site is authorised under petroleum exploration licence (PEL) 1, held by Australian Coalbed Methane Pty Ltd and Santos QNT Pty Ltd (Santos). The proposed activity classifies as an assessable prospecting operation and therefore requires an activity approval under the *Petroleum (Onshore) Act 1991*.

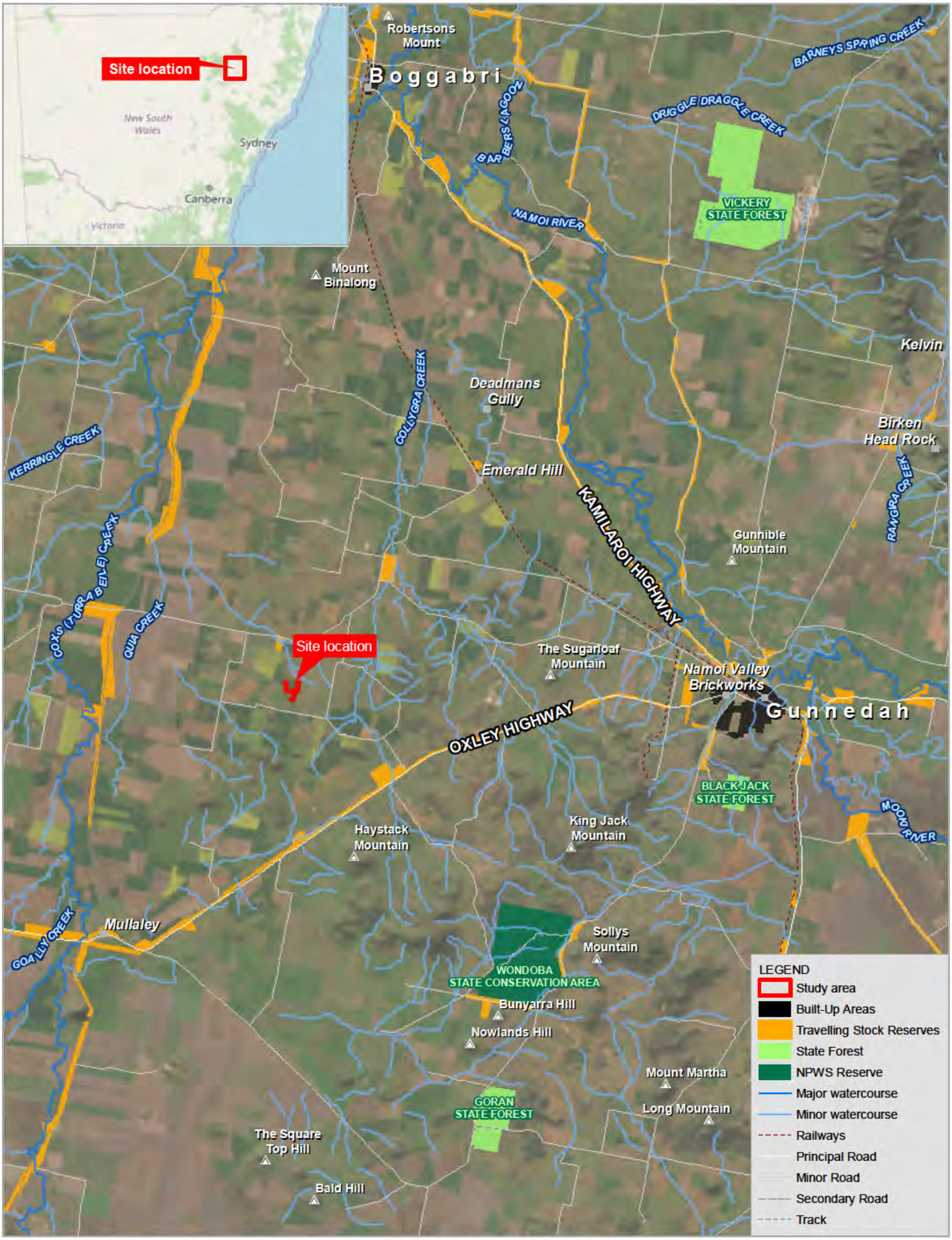
The project is being assessed under Part 5, Division 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), and the NSW Resource Regulator is the determining authority for this project. A Review of Environmental Factors (REF) is required for activities to be determined under Part 5 of the EP&A Act. This biodiversity assessment report has been prepared to support the REF.

This report has taken into account the findings of the REF prepared for the original installation of existing coal seam gas exploration infrastructure, prepared by Alison Hunt and Associates (2010).

1.2 Purpose of this report

The aim of this biodiversity assessment report is to:

- Describe the existing environment within the investigation area, including soils, topography, hydrology, vegetation types, fauna habitats and flora and fauna species known or likely to occur
- Assess the value and conservation significance of native vegetation and habitats in the investigation area
- Compile a list of threatened biota listed under the NSW *Biodiversity Conservation Act* 2016 (BC Act) and *Fisheries Management Act 1994* (FM Act) and Matters of National Environmental Significance (MNES) listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) previously recorded or predicted to occur in the locality and assess their potential to occur in the investigation area
- Assess the likely impacts on threatened biota from the proposed works
- Recommend mitigation measures to reduce impacts on biodiversity values
- Provide concluding statements regarding the likely significance of impact of the proposed development on threatened biota listed under the BC Act and FM Act or MNES listed under the EPBC Act, and the requirement or otherwise for further assessment or approvals at the State or federal level.



Paper Size ISO A4

0 5 10

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

GHD

Santos
Kahlua Pilot

Site location

Project No. 2122436
Revision No. 0
Date 15/12/2022

FIGURE 1-1

G:\21\22463\GIS\Maps\Deliverables\Kahlua_Pilot\Biodiversity\21_22463_Z193_KahluaPilot_Biodiversity_SiteLocation.mxd
Print date: 15 Dec 2022 - 15:55

Data source: General topo - NSW LPI DTDB 2015 & Geoscience Australia, TSR - NSW Government; Site layout - Santos 2020; Aerial imagery & inset map - esri 2020 © OpenStreetMap (and) contributors, CC-BY-SA, Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: ebbertson

1.3 Terms and definitions

The following definitions have been used in this report:

– The '**proposal site**' or '**site**' refers to the areas identified on Figure 1.1, which includes the existing coal seam gas exploration infrastructure, including four exploration wells (K2, K3, K4 and K5), access tracks between the wells, water storage tanks and gas flaring infrastructure located at well K2.
– The '**proposal**' or '**proposed works**' refers to:
  - Minor civil and construction works, including:
    – installation of gathering lines adjacent to access tracks
    – upgrade of the existing gas flaring infrastructure at well K2
  - Workovers and completions of four existing gas exploration wells
  - Appraisal activities, including water and gas production rates and gas flaring
  - Decommissioning and rehabilitation activities.
– The '**investigation area**' refers to the area that was the focus of the field survey for this biodiversity assessment.
– The '**locality**' is the area within a 20-kilometre radius of the proposal site.

1.4 Abbreviations

Abbreviation	Definition
AHD	Australian Height Datum
BAM	Biodiversity Assessment Method
BC Act	*Biodiversity Conservation Act 2016* (NSW)
BDAR	Biodiversity Development Assessment Report
BOS	Biodiversity Offsets Scheme
CEEC	Critically endangered ecological community
CEMP	Construction environmental management plan
CMA	Catchment Management Authority
DAWE	Department of Agriculture, Water and Environment
DPI	Department of Primary Industries
DPIE	Department of Planning, Industry and Environment
EEC	Endangered ecological community
EES	Environment, Energy and Science group within NSW DPIE
EP&A Act	*Environmental Planning and Assessment Act* 1979 (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
FM Act	*Fisheries Management Act 1994* (NSW)
GIS	Geographic information system
ha	Hectare
km	Kilometre
KTP	Key threatening process
LGA	Local Government Area
m	Metre
mm	Millimetre
MNES	Matter of national environmental significance

Abbreviation	Definition
NSW	New South Wales
OEH	Previously the NSW Office of Environment and Heritage, now the EES group within DPIE
PCT	Plant community type
PMST	Protected Matters Search Tool
REF	Review of Environmental Factors
SIS	Species Impact Statement
TEC	Threatened ecological community
VEC	Vulnerable ecological community
VIS	NSW Vegetation Information System

1.5 Scope and limitations

This report: has been prepared by GHD for Santos and may only be used and relied on by Santos for the purpose agreed between GHD and Santos as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Santos arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer sections 1.1 and 1.5 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Santos and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

1.6 Assumptions

GHD has prepared this assessment on the assumption that works would be undertaken within the four pad locations associated with the existing wells, and adjacent to the existing access tracks.

2. Legislative context

2.1 NSW State legislation

2.1.1 Environmental planning and assessment Act 1979 (EP&A Act)

The EP&A Act forms the legal and policy platform for proposal assessment and approval in NSW and aims to, amongst other things, 'encourage the proper management, development and conservation of natural and artificial resources'. All development in NSW is assessed in accordance with the provisions of the EP&A Act and the *Environmental Planning and Assessment Regulation 2000*.

The proposed works is a Part 5 activity under the EP&A Act. The determining authority for the proposal is the NSW Resources Regulator.

The EP&A Act is subject to the provisions of Part 7 of the BC Act and Part 7A of the *Fisheries Management Act 1994* (FM Act). Part 7.3 of the *Biodiversity Conservation Act 2016* (BC Act) and section 220ZZ of the FM Act list factors that must be taken into account when determining the significance of potential impacts of a proposed activity on threatened species, populations or ecological communities (or their habitats) listed under the BC Act and the FM Act. The 'assessment of significance' is used to assist in the determination of whether a proposal is 'likely' to impose 'a significant effect' on threatened biota and thus whether a species impact statement (SIS) is required under the BC Act or FM Act. Under the BC Act, there is also the option to prepare a Biodiversity Development Assessment Report (BDAR) rather than an SIS, where a significant impact is likely.

Assessments of significance have been prepared for threatened biota that would be impacted or are likely to be impacted by the proposal and are provided in Appendix C.

2.1.2 Biodiversity Conservation Act 2016

The BC Act provides legal status for biota of conservation significance in NSW. The BC Act aims to, amongst other things, 'maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development'. It provides for the listing of threatened species and communities, establishes a framework to avoid, minimise and offset the impacts of proposed development (the Biodiversity Offsets Scheme [BOS]), and establishes a scientific method for assessing the likely impacts on biodiversity values and calculating measures to offset those impacts (the Biodiversity Assessment Method [BAM]). As this project is being assessed under Part 5 of the EP&A Act, assessment in accordance with the BAM is not required unless there is likely to be a significant impact on threatened biota.

The BC Act has been addressed in this assessment through:

– Desktop review to determine the threatened species, populations or ecological communities that have been previously recorded within the locality and hence could occur subject to the habitats present
– Field surveys for listed threatened species, populations and ecological communities
– Assessment of the potential for threatened species (or their habitat) to occur and be impacted
– Assessment of potential impacts on listed threatened species, populations and ecological communities
– Assessment of the likely significance of impacts and requirement or otherwise for a species impact statement (SIS) or biodiversity development assessment report (BDAR)
– Identification of suitable impact mitigation and environmental management measures.

Threatened biota recorded or likely to occur in the investigation area are detailed further in section 5.

2.1.3 Fisheries Management Act 1994

The objectives of the FM Act are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. It provides for the listing of threatened species, populations and ecological communities, key threatening processes and requirements or otherwise for the preparation of a SIS. One of the objectives of the FM Act is to 'conserve key fish habitats' which includes aquatic habitats that are important to the maintenance of fish populations generally and the survival and recovery of threatened aquatic species. To assist in the protection of key fish habitats, Department of Primary Industries (DPI) has produced the *Policy and guidelines for fish habitat conservation and management* (DPI 2013).

The FM Act has been addressed in this assessment through undertaking:

– A desktop review to determine the aquatic threatened species, populations or ecological communities that have been previously recorded within the locality of the proposal and hence could occur subject to the habitats present
– Assessment of potential impacts on aquatic habitats, including identification of key threatening processes of relevance to the proposal, impacts on key fish habitat and fish passage
– Assessment of the potential for impacts on listed aquatic threatened species, populations and ecological communities and the requirement or otherwise for an SIS
– Identification of suitable impact mitigation and environmental management measures to avoid or mitigate impacts on the aquatic environment.

Aquatic habitat is discussed in section 4.3.2, and potential impacts are identified in section 6.

2.1.4 Biosecurity Act 2015

The *Biosecurity Act 2015* provides for risk-based management of biosecurity in NSW. It provides a statutory framework to protect the NSW economy, environment and community from the negative impact of pests, diseases and weeds.

The primary object of the Act is to provide a framework for the prevention, elimination and minimisation of biosecurity risks posed by biosecurity matter, dealing with biosecurity matter, carriers and potential carriers, and other activities that involve biosecurity matter, carriers or potential carriers.

In NSW, all plants are regulated with a general biosecurity duty to prevent, eliminate or minimise any biosecurity risk they may pose. Any person who deals with any plant, who knows (or ought to know) of any biosecurity risk, has a duty to ensure the risk is prevented, eliminated or minimised, so far as is reasonably practicable.

Priority weeds that were identified in the investigation area are discussed in section 4.2.3.

2.2 Commonwealth legislation

2.2.1 Environment Protection and Biodiversity Conservation Act 1999

The purpose of the EPBC Act is to ensure that actions likely to cause a significant impact on ‘matters of national environmental significance’ (MNES) or the environment of Commonwealth land undergo an assessment and approval process. Under the EPBC Act, an action includes a proposal, a development, an undertaking, an activity or a series of activities, or an alteration of any of these things. An action that ‘has, will have or is likely to have a significant impact on a matter of national environmental significance’ or a significant impact to the environment of Commonwealth land is deemed to be a ‘controlled action’ and may not be conducted without prior approval from the Australian Minister for the Environment.

Potential MNES of relevance to this assessment include:

– Threatened species and ecological communities
– Migratory species.

The EPBC Act has been addressed in this assessment through:

– Desktop review to determine the listed biodiversity matters that are predicted to occur within the locality of the proposal and hence could occur, subject to the habitats present
– Field surveys for listed threatened biota and migratory species and to identify potential habitat
– Assessment of potential impacts on threatened and migratory biota

– Identification of suitable impact mitigation and environmental management measures
– Likely significance of impacts and the requirement or otherwise for further assessment or approvals at the federal level.

Threatened biota recorded or likely to occur in the investigation area are detailed further in section 5 and potential impacts are identified in section 6.

2.3 Other planning instruments

2.3.1 State Environmental Planning Policy (Biodiversity and Conservation) 2021 (Biodiversity and Conservation SEPP)

During completion of this report, several changes to State Environmental Planning Policies (SEPPs) that relate to Koalas were announced.

In March 2021, State Environmental Planning Policy (Koala Habitat Protection) 2021 was made and commenced. This SEPP reinstated the framework of SEPP (Koala Habitat Protection) 2020 to all land zonings in nine LGAs in metropolitan Sydney along with the Central Coast LGA, however did not apply to land zoned RU1 Primary Production, RU2 Rural Landscape or RU3 Forestry in all other LGAs. For all RU1, RU2 and RU3 zoned land outside of the Sydney Metropolitan Area and the Central Coast, Koala SEPP 2020 continued to apply. This had been identified as an interim measure while new codes are developed under the Local Land Services Act.

In March 2022, State Environmental Planning Policy (Biodiversity and Conservation) 2021 (Biodiversity and Conservation SEPP) came into force, replacing previous SEPPs that dealt with Koala habitat protection.

The aims of Chapter 3 of the Biodiversity and Conservation SEPP are to “encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas to ensure a permanent free-living population over their present range and reverse the current trend of koala population decline:

(a) by requiring the preparation of plans of management before development consent can be granted in relation to areas of core koala habitat, and

(b) by encouraging the identification of areas of core koala habitat, and

(c) by encouraging the inclusion of areas of core koala habitat in environment protection zones”.

Irrelevant of which EPI is in force, these SEPPS do not apply to projects being assessed under Part 5 of the EP&A Act. The definitions of core and potential Koala habitat have been considered here in the context of assessing Koala habitat within the investigation area.

3. Methods

3.1 Database and literature review

A desktop database review was carried out to create a list of threatened flora and fauna species, populations and ecological communities (biota) listed under the BC Act and FM Act, and MNES listed under the EPBC Act that could be expected to occur in the locality based on previous records, known distribution ranges, and habitats present. The database review assisted with focusing field survey techniques and effort. Biodiversity databases and references pertaining to the investigation area and locality (i.e., within a 20-kilometre radius of the investigation area) that were reviewed prior to conducting field investigations included:

– The Department of Planning, Industry and Environment (DPIE) BioNet Atlas for records of threatened species listed under the BC Act and EPBC Act which have been recorded within the locality (DPIE 2020a)
– The Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW) Protected Matters Search Tool for MNES listed under the EPBC Act which may occur in the locality (DCCEEW 2022a)
– DPIE threatened species profiles online database (DPIE 2020b)
– DCCEEW online species profiles and threats database (DCCEEW 2022b)
– Department of Primary Industries (DPI freshwater threatened species viewer (DPI 2020a)
– The NSW BioNet Vegetation Classification (VIS 2.1) - Community Identification (DPIE 2020c) to identify matching plant community types (PCTs) in the investigation area
– Previous reports relating to the installation of the existing coal seam gas exploration infrastructure present on site, including the *Ecological Assessment Report* prepared by Alison Hunt and Associates (2010) to support the REF completed for the establishment of the existing coal seam gas exploration infrastructure (Santos, 2010)
– Priority weed declarations for the Gunnedah local government area (LGA) (DPI 2020b)
– Aerial photography of the investigation area.

Following collation of database records and species and community profiles, a 'likelihood of occurrence' assessment was prepared with reference to the broad habitats in the investigation area. This was further refined following field surveys and assessment of habitats present and took into account results of the previous assessment completed by Alison Hunt and Associates (2010). The results of this assessment are presented in Appendix A.

3.2 Field survey

3.2.1 Overview

Field surveys of the investigation area were conducted by a senior GHD ecologist on 7 October 2020. The field surveys focussed on the identification of vegetation types, condition and conservation significance and an assessment of the value of habitats for threatened biota known or predicted to occur in the locality in the investigation area. Limitations and survey conditions are discussed in section 3.2.6.

3.2.2 Flora survey

Given the highly modified nature of the site, its history of disturbance associated with cropping and agricultural practices and the works involved in establishing the existing infrastructure on site, and the extent of the proposed works, plot/transect surveys were not warranted. Instead, each pad location was traversed on foot, along with the locations of all proposed works. A list of all flora species seen was created, to provide an indication of the suite of species present, in order to compare with potential PCTs and TECs of relevance. The highly modified nature of the site means that traditional plot/transect surveys would likely fail to provide sufficient information to allow vegetation on site to be allocated to a PCT, if appropriate.

All flora species within the construction corridor were identified according to the nomenclature of the RBGT (2020). Vegetation within the investigation area was assessed against identification criteria for State and Commonwealth listed threatened ecological communities (critically endangered ecological communities (CEECs), endangered ecological communities (EECs) and vulnerable ecological communities (VECs)). Vegetation and habitats were compared with descriptions provided in published threatened species profiles and management plans.

The overall condition of vegetation was assessed through general observation, verbal history of the site provided by the site manager (ie which areas had been cropped or cleared of vegetation historically) and comparison against the PCT condition benchmark data if relevant, as well as using parameters such as species diversity, history of disturbance, weed invasion and canopy health.

3.2.3 Threatened flora searches

Threatened flora searches were conducted across the investigation area for threatened flora species that are detectable in spring, targeting those identified by the desktop review. In addition, habitat suitability was assessed for species not detectable in spring. Threatened flora searches involved traversing the investigation area on foot, visually scanning for threatened flora species.

3.2.4 Fauna habitat assessment

General fauna habitat assessments were undertaken throughout the investigation area, including active searches for potential shelter, basking, roosting, nesting and/or foraging sites. Specific habitat features and resources such as water bodies, food trees, hollow-bearing trees, the density of understorey vegetation, the composition of ground cover, the soil type, presence of hollow-bearing trees, leaf litter and ground debris were noted.

Indicative habitat criteria for targeted threatened species (i.e., those determined as having the potential to occur within the indicative construction area following the desktop review) were identified prior to fieldwork. Habitat criteria were based on information provided in OEH and DAWE threatened species profiles, field guides, and the knowledge and experience of the GHD field ecologist.

Habitat assessments included searches for resources of potential value to threatened fauna including:

– Trees with hollows, bird nests or other potential fauna roosts including stag trees
– Rock outcrops or overhangs providing potential shelter sites for fauna
– Burrows, dens and warrens
– Distinctive scats or latrine sites, owl whitewash and regurgitated pellets under roost sites
– Tracks or animal remains
– Evidence of activity such as feeding scars, scratches and diggings
– Specific food trees and evidence of foraging
– Waterbodies suitable for frogs.

The locations and quantitative descriptions of habitat features were captured with a handheld GPS unit and photographed where appropriate.

Opportunistic observations of fauna species were recorded at all times during field surveys.

3.2.5 Koala surveys

Confirming the presence of Koalas on site was a focus of the current survey and assessment. The species were found to use the site during the previous assessment of the site completed by Alison Hunt and Associates (2010), and discussions with the Santos Land Access manager responsible for the site indicate that Koalas are known to frequent the local area and site.

Given the scarcity of canopy species within the site, a full Spot Assessment Technique as described by Phillips and Callaghan (2011) was not considered appropriate. Instead, the technique was modified and every canopy tree within and adjacent to the project footprint was visually searched for Koalas, and the base of each tree was scanned for Koala faecal pellets (scats). A sample of scats found within the investigation area was collected to allow for expert verification of the source species.

3.2.6 Limitations and weather conditions

Surveys were conducted over one day in spring, in early October 2020. Survey effort was appropriate for the site conditions, given the key disturbance area (the existing pads, access tracks and adjacent areas) have been heavily modified in the past.

Conditions were sunny, hot and windy, with a temperature range of 15.2 to 29.7°C (BOM, 2020). The relatively hot and dry conditions may have limited the suitability for some bird species to be actively foraging during the field survey, and it is likely that additional species use the site regularly (e.g., early in the morning or late in the afternoon). The previous survey (Alison Hunt and Associates, 2010) was similarly brief, taking place on a cool day in late Autumn, in 2010.

3.3 Likelihood of occurrence of threatened and migratory biota

Following collation of database records and review of species and community profiles, a 'likelihood of occurrence' assessment was prepared with reference to the habitats contained within the site. Identification of potential habitat for threatened and migratory species was based on information provided in the species profiles (DAWE 2020b, OEH 2020b), recovery plans, journal articles, and the field staff knowledge of species habitat requirements. The likelihood of occurrence assessment was refined following the field survey. The likelihood of threatened and migratory biota occurring in the investigation area was assessed based on presence of records from the locality for the last 20 years (since 1999), species distribution and habitat preferences, and the suitability of potential habitat present in the site. The results of this assessment are provided in Appendix A. The likelihood of occurrence was compiled with reference to the findings from the previous biodiversity assessment (Alison Hunt and Associates, 2010), and focussed on confirming their assumptions, as well as considering any threatened or migratory biota that have been listed in the 10 years since the original surveys and assessment were completed.

Table 3.1 provides a key to the likelihood of occurrence in the investigation area of threatened biota known or likely to occur in the locality. The likely impact of the proposal on those species recorded ('present') or likely to occur was considered.

Table 3.1 Key to likelihood of occurrence for threatened species

Likelihood	Definition
Present	The species or community was observed in the investigation area during the current survey.
Likely	It is highly likely that a species inhabits the investigation area and is dependent on identified suitable habitat (ie for breeding or important life cycle periods such as winter flowering resources), or has been recorded recently in the locality (20 km) and is known or likely to maintain resident populations in the investigation area. Also includes species known or likely to visit the investigation area during regular seasonal movements or migration.
Possible	Potential habitat is present in the investigation area. Species unlikely to maintain sedentary populations, however may seasonally use resources within the investigation area opportunistically or during migration. The species is unlikely to be dependent (i.e., for breeding or important life cycle periods such as winter flowering resources) on habitat within the investigation area, or habitat is in a modified or degraded state. Includes cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded.
Unlikely	It is unlikely that the species inhabits the investigation area and has not been recorded recently in the locality (20 km). It may be an occasional visitor, but habitat similar to the investigation area is widely distributed in the local area, meaning that the species is not dependent (i.e., for breeding or important life cycle periods such as winter flowering resources) on available habitat. Specific habitat is not present in the investigation area or the species is a non-cryptic perennial flora species that was specifically targeted by surveys and not recorded.
Nil	Species not previously recorded within a 20 km radius of the investigation area, suitable habitat not recorded within investigation area, and/or investigation area outside species known distribution.

3.4 Project team qualifications

The qualifications and experience of the project team involved in the preparation of this assessment are presented in Table 3.2.

Table 3.2 Staff qualifications

Name	Position/Project Role	Qualifications	Relevant Experience
[redacted]	Senior Ecologist/desktop assessment, field surveys and reporting	BEnvSc (hons) Accredited BAM Assessor	11+ years
[redacted]	Technical Director Biodiversity/technical review	BSc Masters Environmental Law	24+ years
[redacted]	Ecologist/desktop assessment	BSc, MPhil by research	5+ years

4. Existing environment

The investigation area is within the Brigalow Belt South IBRA Bioregion, and Liverpool Plains IBRA subregion, about 22 kilometres to the west of Gunnedah in NSW. Additional detailed information relating to the existing environment is available in the main REF document.

4.1.1 Existing disturbance

The investigation area has been used for cropping and agricultural purposes for over 60 years, and much of the investigation area was covered in a barley crop at the time of the site visit. The existing coal seam gas exploration infrastructure (wells K2, K3, K4 and K5, access tracks between the wells, and water storage and gas flaring infrastructure located at well K2) are all established, and the pads around each of the wells were cleared of vegetation when they were constructed. Some vegetation has since re-established, primarily exotic herbs and grasses and pasture species such as Barley.

There are scattered paddock trees around the investigation area, and several small, fragmented patches of native woodland vegetation occur outside of the investigation area. The surrounding landscape is typical of regional NSW areas dominated by agriculture, with large expanses of cleared land and small patches of vegetation typically restricted to waterways and travelling stock routes, interspersed with paddock trees and roadside vegetation.

4.2 Vegetation and flora

Vegetation within the proposal site has been extensively modified by historical and ongoing agricultural activities, most notably, vegetation clearing and cropping. There are no intact stands of native vegetation within the investigation area.

There are scattered paddock trees and occasional large shrubs, over a predominantly exotic understorey, with scattered native grass and herb species present. There are patches of intact native vegetation to the south of the investigation area, but these will not be impacted by the proposal and were not surveyed as part of the current assessment. These findings are similar to those presented in the previous biodiversity assessment (Alison Hunt and Associates, 2010).

Of note since the previous assessment was completed, is that wells K2, K3, K4 and K5, access tracks between the wells, and water storage and gas flaring infrastructure located at well K2 have been constructed, resulting in further disturbance to the investigation area.

It is likely that prior to historical vegetation clearing, the site would have supported a form of White Box – Yellow Box – Blakely’s Red Gum Grassy Woodland, as the nearest mapped plant community type (PCT) is PCT 433, White Box grassy woodland to open woodland on basalt flats and rises in the Liverpool Plains sub-region, BBS Bioregion. The NSW NPWS (undated) *Identification Guidelines for Endangered Ecological Communities: White Box Yellow Box Blakely’s Red Gum Woodland (Box-Gum Woodland)* provides the following guidance to determine if vegetation is part of the BC Act-listed Threatened Ecological Community (TEC):

1. Whether the site is within the area defined in the Determination. Yes, the site is within the area identified in the determination.
2. Whether the characteristic trees of the site are (or are likely to have been) White Box, Yellow Box or Blakely’s Red Gum. Yes, there are scattered White Box trees still present as paddock trees on site.
3. *Whether the site is mainly grassy.* Yes. The site is likely to have once supported a native grassy understorey, however, is now dominated by exotic species, comprising grass and herbaceous species. There are no areas dominated by native grass species.
4. *Whether any of the listed characteristic species occur (including as part of the seedbank in the soil).* Yes, there are some of the characteristic species present, restricted to the bases of the large mature paddock trees within the site.
5. *If the site is degraded, whether there is potential for assisted natural regeneration of the overstorey or understorey*. No. Many decades of agricultural use for cropping and grazing means that the site is unlikely to respond to assisted natural regeneration techniques.

The guidelines also provide the following advice on degraded remnants:

The definition of the Box-Gum Woodland explicitly recognises that some remnants are degraded. Highly disturbed sites that have few if any native species in the understorey are specifically included in the community provided "vegetation, either understorey or overstorey or both, would, under appropriate management, respond to assisted natural regeneration, such as where the natural soil and associated seed bank are still at least partially intact."

In some parts of NSW Box-Gum Woodlands are only represented by isolated paddocks trees with a highly modified understorey. Such remnants or vestiges of the community may still constitute valuable fauna habitat in agricultural areas and may provide a valuable source of seed for potential future regeneration.

Determining whether the vegetation will respond to assisted natural regeneration will often be highly problematic. Sites where there is unlikely to be sufficient seed remaining in the soil for the understorey or overstorey to regenerate are not part of the EEC. For example, trees under which intensive cropping of annual crop species has occurred and is ongoing, and trees within urban backyards are unlikely to be part of the community. Conversely, trees with exotic pastures underneath and those in larger urban open spaces will generally be part of the community (NSW NPWS, undated).

While the site does comprise scattered paddock trees over a highly modified understorey with a few grazing tolerant native species present (refer to Appendix B), the history of disturbance at the site, including decades of cropping and grazing, means that the soil seed bank is unlikely to be intact. The site is therefore unlikely to respond to assisted regeneration (i.e., removal of grazing pressure or weeds). As such, the site is not considered to support even a degraded form of this TEC. This finding aligns with the previous assessment of the site by Alison Hunt and Associates (2010).

4.2.1 Flora species

A flora species list is available in Appendix B. Given there was no intact native vegetation present, a detailed discussion of vegetation zones is not provided. Instead, a summary of the dominant species is presented below.

4.2.2 Dominant native flora species

There were three species of canopy trees recorded within the site: White Box (*Eucalyptus albens*), Bimble Box (*Eucalyptus populnea*) and White Cypress Pine (*Callitris glaucophylla*), all of which occur as isolated paddock trees (see Figure 4.1) within the investigation area. There were scattered occurrences of the shrub Wilga (*Geijera parviflora*), sometimes at the base of mature White Box trees, and sometimes as isolated individuals.

All of the paddock trees recorded were mature, and most supported extensive hollows and fissures. Photos 1-4 below show the nature of the site at the time of the site visit.

Photo 1 *Existing access track, barley paddock on right, paddock tree in distance*

Photo 2 *Kahlua 2 (K2) well and flare site to the right, with barley paddock to the left*

Photo 3 *Kahlua 3 (K3) well with patch of intact native vegetation and large farm dam in background (outside of investigation area)*

Photo 4 *Kahlua 4 (K4) well, situated within a field of barley. Intact native vegetation outside of the investigation area visible in background*

Photo 5 *Kahlua 5 (K5) within a field of barley*

Photo 6 *Paddock dominated by exotic understorey species with White Cypress Pine paddock trees to the north of water tanks*

4.2.3 Priority weeds

Table 4.1 summarises the declared priority weeds for the North West region (which includes the local council areas of Gunnedah, Gwydir, Liverpool Plains, Moree Plains, Narrabri, Tamworth and Walgett) that were recorded in the investigation area during the field survey.

Table 4.1 Priority weeds within the investigation area

Scientific name	Common name	Biosecurity duty
Lycium ferocissimum	African Boxthorn	Prohibition on dealings: Must not be imported into the State or sold. Regional Recommended Measure: Land managers should mitigate the risk of new weeds being introduced to their land. Land managers should mitigate spread from their land. Land managers reduce impacts from the plant on priority assets.
Opuntia stricta	Common Pear	Prohibition on dealings: Must not be imported into the State or sold.

4.3 Fauna habitats and species

4.3.1 Fauna species

A low diversity of fauna was recorded during the field survey, dominated by birds. This is likely a result of the short duration of the field survey and the lack of intact native vegetation. Species recorded were characteristic of rural and agricultural landscapes on the Liverpool Plains, and included raptors (e.g., the Nankeen Kestrel), woodland birds (eg Apostle Birds, Pied Butcherbird and Australian Raven) and parrots (including the Galah, Mulga Parrot and Red-rumped Parrot, as well as common and widespread reptiles (eg Dark-flecked Garden Sunskink and Jacky Lizard).

Two threatened fauna species were recorded, the Grey-crowned Babbler (*Pomatostomus temporalis temporalis*) and the Koala (*Phascolarctos cinereus*). These species are discussed further in section 5.3.

4.3.2 Fauna habitats

The site has limited habitat value for many fauna species having limited structural and floristic diversity or complexity due to past disturbance and vegetation clearing. Threatened species such that require intact native vegetation (e.g., the Varied Sittella or Regent Honeyeater), large amounts of fallen timber (eg the Brown Treecreeper) or large remnants (eg the Speckled Warbler or Dusky Woodswallow) to persist would not occur within the study area (refer to Appendix A). The scattered paddock trees contain hollows that may be used by more mobile hollow-dependant fauna, potentially including some birds and micro-bats.

The canopy trees in the investigation area (Bimble Box; *Eucalyptus populnea*, White Cypress Pine; *Callitris glaucophylla* and White Box; *Eucalyptus albens*), are food tree species for the Koala (OEH 2018) (see Figure 4.1). *State Environmental Planning Policy (Biodiversity and Conservation) 2021* includes all of these species as Koala use tree species within the Northwest Slopes Koala Management Area.

The investigation area is assumed to represent core Koala habitat as defined under State Environmental Planning Policy (Biodiversity and Conservation) 2021, as it has "an area of land with a resident population of koalas, evidenced by attributes such as breeding females, being females with young, and recent sightings of and historical records of a population". Given the presence of numerous Koala scats under all potential Koala feed/use tree species within the investigation area, and observation of the species on site over numerous years, the investigation area meets the definition as per the SEPP.

Modified grassland and cropped areas may provide foraging habitat for ground-foraging birds on occasion. Threatened species such as the Superb Parrot and Turquoise Parrot may forage within the study area on occasion, as part of a wider area of potential foraging habitat.

There is no aquatic habitat present within the study area, nor any nearby that would be impacted by the proposal.

The key fauna habitats in the investigation area comprising cropped fields, modified grassland, and paddock trees are described in Table 4.2 to Table 4.4.

There are areas of suitable habitat for threatened species known or predicted to occur in the locality by the desktop review to the south of the investigation area, including within the stand of intact native vegetation and farm dam. These areas will not be affected by the proposal. The farm dam to the south of the site is shown in Photo 7 below. This dam will not be impacted by the proposal but provides potential habitat for several threatened species which require aquatic habitats to persist, and which may travel into and around the investigation area on occasion.

Photo 7 Farm dam to the south of the site

Table 4.2 Fauna habitats: cropped fields

Cropped fields	
Description	Cropped fields have been planted with Barley and provide limited habitat for native fauna species. There are no native flora species present, and the ground has been ploughed and planted with various crops for many years. These cropped areas provide foraging habitat for highly mobile species such as birds which may feed on grain as it ripens. Groundcover vegetation would provide basking, shelter and foraging substrate for reptiles and invertebrates.
Threatened fauna recorded or which may occur	No threatened fauna species were observed within cropped fields at the time of the field survey. These areas may provide foraging habitat for granivorous bird species, as well as hunting habitat for birds of prey and microbats.
Photo: Cropped field with Barley	

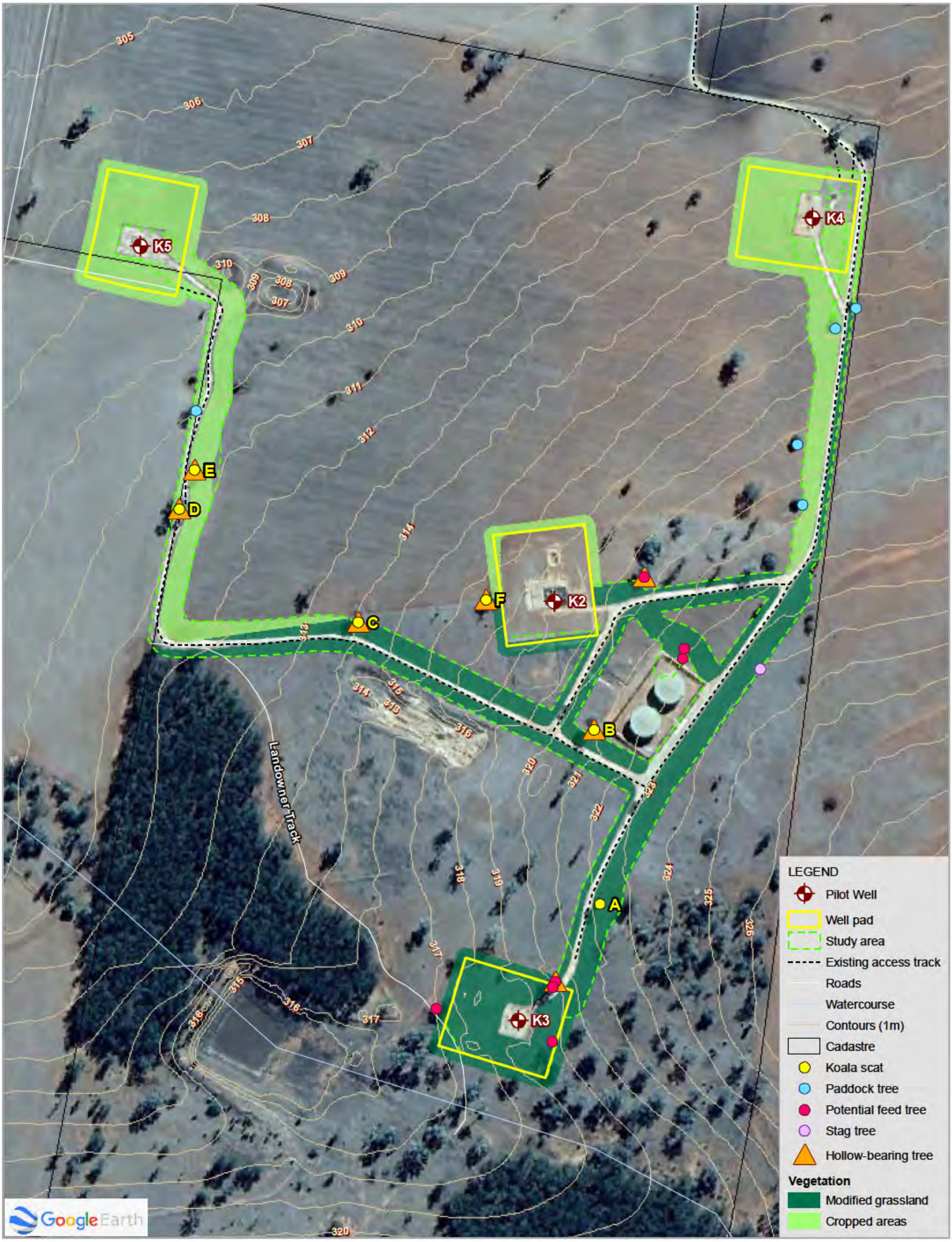
Table 4.3 Fauna habitats: modified grassland

Modified grassland	
Description	Modified grassland within the investigation area is dominated by exotic herbaceous and grass species with scattered native grasses and herbs. These areas have been historically cleared of native vegetation but have not been cropped recently. This vegetation would provide limited foraging and hunting habitat for a range of mobile fauna species such as birds and microbats and may also provide shelter habitat for less mobile species such as reptiles.
Threatened fauna recorded or which may occur	No threatened fauna species were observed within areas of modified grassland at the time of the field survey. These areas may provide foraging habitat for ground-foraging bird species, as well as hunting habitat for birds of prey and microbats that forage over open areas. Modified grassland may provide suitable foraging habitat for the Grey-headed Babbler, which was recorded to the north of the study area during the field survey. Groundcover vegetation, and leaf litter and woody debris would provide basking, shelter and foraging substrate for reptiles, frogs and invertebrates.
Photo: Modified grassland dominated by exotic species	

Table 4.4 Fauna habitats: paddock trees

Paddock trees	
Description	Paddock trees within the investigation area were sparse and scattered, investigation area but have high biodiversity value providing food trees for the local Koala population and roost and potential nest sites for more mobile fauna, such as birds and bats. All species recorded are known Koala feed tree species (based on the definition provided in OEH, 2018) (Bimble Box; *Eucalyptus populnea*, White Cypress Pine; *Callitris glaucophylla* and White Box; *Eucalyptus albens*), and are likely to provide important refuge and stepping stones for the species within a highly cleared landscape. Koala scats were recorded under six feed trees (*Eucalyptus albens* and *Eucalyptus populnea*) within the investigation area. Most of the paddock trees supported multiple hollows or fissures, ranging in size from <5 cm diameter to >25 cm diameter. Hollows observed would provide suitable roosting and nesting habitat for birds (including parrots and cockatoos) and mammals such as microbats.
Threatened fauna recorded	Koalas scats were found under many of the paddock trees within the investigation area. Paddock trees provide important stepping stone and refuge habitat for many fauna species, in addition to the Koala (as noted above). Species such as the Grey-crowned Babbler, which was recorded about 2 km to the north of the investigation area. This species was observed moving through the landscape using paddock trees and is likely to utilise trees within the investigation area as stepping stones. The species may also forage on tree trunks for insects in the bark as well as on the ground. The Grey-crowned Babbler would be unlikely to nest within the site, but may use the more heavily vegetated areas to the south of the site, in addition to the more connected patches along the road reserve to the north of the site where they were observed.

Paddock trees	
Photo: Paddock tree	



Paper Size ISO A4

0 50 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Santos
Kahlua Pilot

Vegetation, habitat features and threatened biota

Project No. 2122436
Revision No. 0
Date 29/05/2020

FIGURE 4-1

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Print date: 15 Dec 2022 - 15:58

Data source: General topo - NSW LPI DTDB 2015. Site layout - Santos 2020; Aerial imagery - Google Earth Pro (image date 13/08/2018, image extracted 04/09/2020).
Created by: ebbertson

5. Conservation significance

5.1 Threatened ecological communities

The vegetation within the investigation area is not commensurate with any threatened ecological communities listed under the BC Act or EPBC Act.

As outlined in section 4.2, it is likely that vegetation on the site would have once been a form of White Box - Yellow Box - Blakely's Red Gum Grassy Woodland, listed as a critically endangered ecological community (CEEC) under the BC Act and EPBC Act, but the degree of disturbance, lack of intact soil profile, and ongoing cropping and agricultural activities mean the site is unlikely to contain a representative soil seed bank and be capable of recovery and therefore is no longer commensurate with the CEEC (refer to section 4.2 for more detail).

There is a stand of vegetation to the south of the study area that is likely to be commensurate with White Box - Yellow Box - Blakely's Red Gum Grassy Woodland CEEC, as listed under the BC Act and EPBC Act. This stand of vegetation would not be impacted by the proposal.

5.2 Threatened flora species

No threatened flora species were recorded during the field surveys, nor have any been recorded within the investigation area in the past.

Eleven threatened flora species have been previously recorded or are predicted to occur in the locality of the investigation area (<20 kilometres) based on the database search results. These are listed in Appendix A. Of the threatened flora species known or predicted to occur, two species have the potential to occur within areas of modified grassland or at the base of paddock trees:

– Bluegrass (Dichanthium setosum)
– Slender Darling Pea (*Swainsona murrayana*).

A full list of threatened flora species predicted to occur in the locality, and an assessment of their likelihood of occurrence in the investigation area is provided in Appendix A.

5.3 Threatened fauna species

Koala (*Phascolarctos cinereus*) faecal pellets (scats) were found under six paddock trees (Bimble Box and White Box) within the investigation area, as shown on Figure 4.1. The scats were positively identified by Georgeanna Story (PhD Candidate) of Scats About (refer to Appendix D). There were relatively plentiful scats detected, with between eight to twenty scats found under each tree. Most of the scats collected were quite dry, which is not surprising given the generally hot and dry conditions experienced in the region prior to the survey. Based on information provided by Mark Rodgers (Santos Land Access manager), Koalas are often observed in and around the investigation area. Mr Rodgers noted that due to the current drought conditions, local Koalas were likely to have moved into the more vegetated, hilly portions of the locality, to the south of the site, to seek shelter, but that local landowners were still reporting observations of individuals.

The threatened Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*) was recorded about 2 kilometres to the north of the site. This species is likely to occur within the intact native vegetation to the south of the site and may use trees within the investigation area as stepping stones between intact patches of vegetation. It is assumed that this species would also utilise modified grassland within the investigation area for foraging on occasion. The species would not breed within the study area, as it typically nests as a family group and would generally require patches of vegetation that support numerous trees to allow for establishment of multiple nests close together. A total of 41 threatened fauna species have been previously recorded or are predicted to occur in the locality of the investigation area (<20 kilometres) based on the database searches. These are listed in Appendix A. Of the threatened fauna species known or predicted to occur, excluding the two species recorded during the field survey, a number of other species have the potential to occur within the investigation area, based on the presence of broadly suitable habitat (refer to Appendix A). This assessment has assumed that there would be no impact to hollow-bearing trees as a result of the proposal. Most of these species are highly mobile and the proposal is unlikely to have an impact on any important habitat for these species, and if they do occur within the study area, they would be able to continue to use habitats in the study area during and after the proposed works.

Raptors with the potential to occur are unlikely to roost within the investigation area but may utilise habitats present for hunting. No raptor nests were observed during the field survey. Raptors may use paddock trees for perching while hunting. The majority of the other species with the potential to occur are hollow-dependant species, that may utilise the hollow-bearing trees present within the investigation area for roosting and/or breeding. The remaining species are likely to forage over the investigation area.

A full list of threatened species recorded in the locality, and an assessment of their likelihood of occurrence in the investigation area is provided in Appendix A.

5.4 Migratory fauna species

A number of migratory birds may occur at in the investigation area on occasion, however none were recorded during the field survey. As noted above, habitat for fauna species has been impacted by historical disturbance, agriculture and vegetation clearing.

Important habitat for migratory birds is defined in the significance criteria for listed migratory species (DoE 2013) as follows:

– Habitat utilised by a migratory species occasionally or periodically within the region that supports an ecologically significant proportion of the population of the species
– Habitat that is of critical importance to the species at particular life-cycle stages
– Habitat utilised by a migratory species which is at the limit of the species range
– Habitat within an area where the species is declining.

A full list of migratory fauna species recorded in the locality or predicted to occur is provided in Appendix A, together with their habitat requirements and likelihood of occurrence.

The investigation area would not provide important breeding or foraging habitat for any of these species. While these species may occur on occasion, they would not rely on the habitats present for their survival in the locality.

6. Potential impacts

6.1 Impact avoidance

The proposal involves upgrades to existing infrastructure, as well as installation of new components. To minimise impacts to features with biodiversity value such as paddock trees, existing disturbed areas will be used, such as cropped paddocks or existing access tracks, wherever practicable. The proponent has indicated that exclusion zones will be established around all hollow-bearing trees and Koala feed tree species, based on advice provided following the field survey about the potential for impacts to threatened biota if these habitat resources are affected by the proposal. These habitat features provide foraging and refuge habitat for the Koala and potential foraging and nesting/roosting habitat for a number of more mobile bird and bat species.

These areas do not support native vegetation and contain limited habitat value for threatened species. This assessment has been prepared on the assumption that no hollow-bearing trees or paddock trees as identified on Figure 4.1 would be impacted.

6.2 Direct impacts

6.2.1 Removal of vegetation

Vegetation that would be impacted by the proposal includes cropped Barley fields and areas of modified grassland dominated by exotic species. Vegetation would be impacted during the construction and installation of the proposed infrastructure, and some may also be squashed or trampled by site workers and vehicles. Any such impacts are likely to be temporary in nature; once the proposed works have been completed, the site will be able to naturally regenerate into a state comparable to what is there now.

There would be no direct impacts to hollow-bearing paddock trees as identified on Figure 4.1, which is likely to mean that self-recruited native understorey species that occur around the base of these paddock trees are also protected as a result.

Vegetation at the site has been modified historically, with canopy and midstorey vegetation largely removed, and the understorey impacted by many years of continuous agricultural activity, including grazing and cropping. There is however, evidence of self-recruitment or persistence of several small herbaceous and grass understorey species around the base of paddock trees, scattered amongst the exotic species that otherwise dominate the understorey.

Mitigation measures to minimise impacts on nearby native vegetation during the proposed works are recommended in section 7.1. Potential impacts to threatened flora species are discussed in section 5.2.

6.2.2 Removal of fauna habitats

The proposal would result in impacts to areas of modified grassland and cropped land. As outlined in section 4.3.2, these portions of the site provide potential foraging habitat for a number of highly mobile species such as ground-feeding birds, raptors and microbats. Groundcover vegetation, and leaf litter and woody debris would provide basking, shelter and foraging substrate for reptiles, frogs and invertebrates.

The proposal would not remove any Koala feed tree/use tree species, as identified on Figure 4.1, and so impacts to the Koala are likely to be negligible. There would be a temporary increase to the degree of disturbance on site during the construction phase. The Koala has persisted on site despite the establishment of the existing infrastructure, and regular visitation associated with agricultural activities.

Koala feed tree/use tree species within the investigation area are likely to contribute to a wider network of resources used by the Koala to facilitate movement throughout the landscape. In the context of impacts on the Koala by the fire events of 2019/2020, all remaining Koala habitat is likely to be important to the continued survival of the species. Any impacts to Koala food trees as a result of the proposal would require additional assessment.

There would be no impact to hollow-bearing trees or Koala feed trees as a result of the proposal, and all paddock trees would be avoided.

6.2.3 Fauna injury and mortality

More mobile native fauna such as native birds and terrestrial mammals that may be sheltering in vegetation in the site are likely to evade injury during clearing. The proposal may result in the injury or mortality of some individuals of less mobile fauna species such as nestlings and other small terrestrial fauna such as small reptiles that may be sheltering in vegetation within the footprint during clearing activities.

Increased visitation at the site during construction would result in greater risk of vehicle strike to species such as the Koala. The construction phase of the proposal also has the potential to result in an increase in stress to the Koala, if they are present in trees in close proximity to loud construction noise and disturbance. The species may already be stressed by impacts relating to drought and fire. An increase in stress induced by proximate noise and disturbance may result in the species becoming more susceptible to disease or behaving unpredictably, which may in turn result in an increased risk of vehicle strike. If Koalas are deterred from using the site, they may be at a greater risk of mortality from predators such as dogs if they attempt to disperse away from the site on the ground.

Mitigation measures to reduce the potential for direct and indirect impacts on native fauna are described in section 7, and include fauna management procedures.

6.3 Indirect impacts

6.3.1 Habitat fragmentation

Assuming no hollow-bearing trees are impacted by the proposal, and that all paddock trees are retained as far as practicable, the proposal is unlikely to result in an increase to the degree of habitat fragmentation within an already heavily modified and cleared landscape.

The importance of hollow-bearing paddock trees has been acknowledged by the proponent, and an exclusion zone would be established around the hollow-bearing trees identified on Figure 4.1.

As outlined in section 6.2.2, the proposal would not impact any Koala feed tree species, as identified on Figure 4.1. Koala feed tree species within the investigation area are likely to contribute to a wider network of resources used by the Koala to facilitate movement throughout the landscape. In the context of impacts on the Koala by the fire events of 2019/2020, all remaining Koala habitat is likely to be important to the continued survival of the species. Any impacts to Koala feed trees as a result of the proposal would require additional assessment.

The proposed works would be completed in an already highly modified area (without intact native vegetation present). The site is nearby to a small area of intact native vegetation, shown on Figure 4.1. Figure 1.1 shows the location of Travelling Stock Routes in the local area, which are often the most intact areas of native vegetation in highly cleared landscapes, and which comprise the primary biodiversity corridors of relevance to the local area. These areas would not be affected by the proposal, and would continue to provide biodiversity corridors that facilitate the movement of fauna species throughout the landscape.

No habitat would be isolated as a result of the proposed works, assuming hollow-bearing paddock trees and Koala feed trees are not impacted.

6.3.2 Noise and vibration

The construction phase of the proposal is likely to result in a temporary increase to the amount of noise and vibration experienced on site. Impacts would be limited to the construction phase, after which they would return to relatively low levels, not dissimilar to those currently in place.

These impacts may deter native fauna species that utilise the site, including those species that roost in hollow-bearing trees within the site, as well as mobile species that forage on the site from time to time.

6.3.3 Animal stress

The proposal has the potential to result in temporary impacts to fauna species during construction, as a result of a temporary increase in noise, light, vibration and visitation. This increase in disturbance may deter Koalas during the day, while works are being undertaken, however the species may move into the area at night, and then experience stress when works commence again in the morning. Mitigation measures are proposed in section 7 to limit the potential for stress on fauna species such as the Koala as a result of the proposal.

6.3.4 Weed invasion

There are numerous weed species present within the investigation area, which is not surprising given the history of agricultural use of the site. Numerous weed species were identified within the investigation area considered by Alison Hunt and Associations (2010), and the installation of the existing infrastructure on site does not appear to have resulted in a noticeable increase to the weeds present within the site compared to surrounding areas that were not subject to disturbance.

The proposal has the potential to result in the establishment of new weed species within and around the investigation area during the proposed works. Weeds may be introduced or spread during the proposed works via plant, machinery and site vehicles, as well as on tools and equipment used on site.

Mitigation measures to reduce the potential for direct and indirect impacts are described in section 7, and include appropriate weed management during works and stabilisation of disturbed surfaces following completion of the proposal.

6.3.5 Soil and water pollution

The proposal has the potential to result in sedimentation, pollution, runoff or erosion within the site and adjoining native vegetation and nearby aquatic habitats. Potential sources of soil and water pollution include:

- Soil disturbance during excavation and construction works
- Inappropriate management of soil and material stockpiles
- Hydrocarbon leaks or spills from vehicles or equipment used in construction
- Increased sediment transfer and erosion potential in areas cleared of vegetation.

Erosion has the potential to impact the nearby dam to the south west of the investigation area. Mitigation measures to reduce the potential for indirect impacts on nearby aquatic habitats will be implemented during works (see section 7).

6.3.6 Introduction of pathogens

Construction activities have the potential to introduce or spread pathogens such as Phytophthora (*Phytophthora cinnamomi*) and Myrtle Rust (*Uredo rangelii*) and Chytrid fungus (*Batrachochytrium dendrobatidis*) in the site through vegetation disturbance and increased visitation. Phytophthora and Myrtle Rust may result in the dieback or modification of native vegetation and damage to fauna habitats. Chytrid fungus affects both tadpoles and adult frogs and can result in the mortality of entire populations once introduced into an area. While there is no aquatic habitat within the site, there is a large dam to the south that is likely to provide habitat for a number of common frog species, which may be susceptible to Chytrid.

The potential for impacts associated with these pathogens is low, given the disturbed nature of much of the investigation area, existing visitation and disturbance levels, and the environmental safeguards that would be implemented during the proposed works (see section 7).

6.4 Key threatening processes

A key threatening process (KTP) is a process that threatens, or may threaten, the survival, abundance or evolutionary development of a native species or ecological community. A process can be listed as a KTP if it could either:

– Cause a native species or ecological community to become eligible for inclusion in a threatened list (other than the conservation dependent category)
– Cause an already listed threatened species or threatened ecological community to become more endangered
– Adversely affect two or more listed threatened species or threatened ecological communities (DPIE 2020g).

KTPs are listed under the BC Act, FM Act and EPBC Act. Some KTPs are listed under more than one Act. KTPs of relevance to the proposal are discussed in Table 6.1. Mitigation measures to limit the impacts of these KTPs are discussed in (see section 7).

Table 6.1 Key threatening processes of relevance to the proposal

KTP	Status	Comment
Clearing of native vegetation	BC Act; EPBC Act	Clearing of native vegetation refers to the removal of one or more strata within a stand of native vegetation. There are numerous impacts as a result of clearing native vegetation, including: destruction of habitat causing a loss of biological diversity; fragmentation of populations; riparian zone degradation; disturbed habitat which may permit the establishment and spread of exotic species; and loss of leaf litter, removing habitat for a wide variety of vertebrates and invertebrates (OEH, 2020g). Clearing of native vegetation has occurred historically across the site, for agricultural purposes and more recently with the removal of several scattered trees during establishment of the existing coal seam gas exploration infrastructure on site. No intact native vegetation would be impacted by the proposal, and paddock trees would be avoided wherever practicable. A small area of modified grassland dominated by exotic species, as well as areas of cropped Barley fields, would be impacted. Implementation of vegetation management measures would minimise impacts on nearby native vegetation, as well as paddock and hollow-bearing trees within the site, where practicable (see section 7).
Removal of dead wood and dead trees	BC Act	Some small amounts of fallen timber are present near the base of paddock trees around the site. These habitat resources are unlikely to be impacted by the proposal. Given the threatened species with the potential to occur within the locality, this fallen timber is unlikely to provide important habitat for any threatened species but may provide refuge and shelter habitat for various common fauna species. Fallen timber is to be relocated to adjacent forested areas, or into areas outside of the construction corridor where possible (see section 7), if it cannot remain where it is during the construction phase.
Loss of hollow-bearing trees	BC Act	Several hollow-bearing trees were observed in the investigation area, as shown on Figure 4.1. There will be no removal of hollow-bearing trees for the proposal (see section 7). Any impact to hollow-bearing trees would require additional assessment.
Invasion of plant communities by perennial exotic grasses	BC Act	Exotic perennial grasses of concern include *Hyparrhenia hirta, Cortaderia* spp., *Sporobolus fertilis, Nassella neesiana, Nassella trichotoma* and *Eragrostis curvula*. There is evidence that these perennial grass species have significant adverse impacts on biodiversity, including increases to fuel loads that result in changes to fire regimes that can alter the structure of native vegetation communities and lead to local extinctions of some native species (DPIE 2020g). There are no exotic perennial grasses of concern (as defined by DPIE 2020g) within the investigation area. Movement of plant, machinery and vehicles during the proposed works has the potential to result in the introduction of exotic species, including perennial grasses, into the investigation area. As such, strict adherence to weed management procedures must be implemented to avoid the spread of weeds as a result of the proposal (see section 7).

KTP	Status	Comment
Introduction and spread of Phytophthora and Myrtle Rust	BC Act; EPBC Act	Works associated with the proposal have the potential to introduce diseases that can result in dieback of native vegetation. The fungus can be introduced in spores in water, moist soil or other debris. Implementation of hygiene protocols would minimise the risk of introduction or spread of these pathogens (see section 7).

6.5 Potential impacts on threatened biota and migratory species

6.5.1 Threatened ecological communities

No threatened ecological communities occur in the investigation area.

There would be no impact to native vegetation to the south of the site that is likely to be commensurate with White Box - Yellow Box - Blakely's Red Gum Grassy Woodland, listed as a CEEC under the BC Act and EPBC Act,. Indirect impacts are unlikely given the distance of the CEEC from proposed works. Mitigation measures would be implemented to further minimise the risk of any indirect impacts, including establishment of exclusion zones and worker inductions prior to the commencement of works.

6.5.2 Threatened species

Threatened flora species

There is limited potential for impacts to threatened flora species, given the lack of any known occurrences within the investigation area, the small area of disturbance associated with the proposal, and the already modified condition of the site.

As outlined in section 5.2, there is broadly suitable habitat within the investigation area for two threatened flora species:

– Bluegrass (Dichanthium setosum)
– Slender Darling Pea (*Swainsona murrayana*).

These species are considered to have a 'possible' likelihood of occurrence, and the proposed works would result in the removal of low-quality potential habitat for these species. Only one of these species has been recorded in the locality in the past (Bluegrass *Dichanthium setosum*), which has been recorded once since 1999. Given the lack of local records of these species, the history of disturbance and cropping across much of the site, and the limited extent of works, the proposal is unlikely to result in an impact to a substantial area of potential habitat for any of these species.

An assessment of significance pursuant to Section 7.3 of the BC Act (5-part test) has been prepared for impacts on potential habitat for Bluegrass (*Dichanthium setosum*) and Slender Darling Pea (*Swainsona murrayana*) (Appendix C). The outcome of the assessment is that the proposal would be unlikely to have a significant impact on these species, given:

– The proposal would not result in any impacts to known occurrences of these species and is unlikely to result in an adverse effect on the life cycle of the species such that a viable local population is placed at risk of extinction.
– The proposal would only result in the removal of a small area of low-quality potential habitat for these species, with no known individuals, populations or known habitat for these species impacted by the proposal.
– The proposal will not result in fragmentation or isolation of any known or potential habitat for these species.
– The proposal would not result in the establishment of any permanent or long-term barriers to movement of potential pollinators for these species.
– The vegetation to be removed represents low quality potential habitat at best and is unlikely to be important to the long-term persistence of the species in the locality.

– The proposal would not result in any impacts to areas of intact native vegetation or less disturbed remnants in roadsides or TSRs that represent better quality potential habitat for these species, given less historical disturbance associated with land use.

Consequently, a species impact statement would not be required for Bluegrass (*Dichanthium setosum*) or the Slender Darling Pea (*Swainsona murrayana*).

Threatened fauna species

This assessment has been completed on the assumption that no hollow-bearing trees would be impacted by the proposal. If it is necessary to impact hollow-bearing trees, additional assessments would be required for all hollow-dependant fauna, including microbats, birds, arboreal mammals and reptiles.

Assuming that all hollow-bearing trees within the site are retained, the proposal is likely to have negligible impacts on threatened biota given the modified nature of the small areas to be disturbed. Potential impacts are further minimised given that hollow-bearing trees would be retained.

An assessment of significance pursuant to Section 7.3 of the BC Act (5-part test) has been provided for the Koala and Grey-crowned Babbler as they were recorded during the field survey.

The proposal is unlikely to have a significant impact on the Koala or Grey-crowned Babbler given:

– No Koala feed trees or Grey-crowned Babbler breeding habitat would be removed.
– The small patches of modified grassland or cropped areas that would be impacted by the proposal are not likely to be important for the persistence of these species in the locality.
– The proposal would not result in the permanent isolation or fragmentation of any areas of potential habitat for these species.
– The proposal would not result in the increase of any KTPs of relevance to these species.

If hollow-bearing trees or Koala feed trees are to be impacted, additional assessment would be required.

The results of the 5-part test have been considered against the DotE (2013) *Matters of National Environmental Significance Significant impact guidelines 1.1* for the Koala. Given there would be no impact to Koala feed tree/use trees as a result of the proposal, no MNES assessment of significance has been completed for the species and the proposal is considered unlikely to result in a significant impact on the Koala. Should impacts to Koala feed tree/use trees become necessary, additional assessment would be required.

The potential for impacts on nearby aquatic habitats such as the dam to the south is low given the distance from the site and proposed mitigation measures. No assessments of significance are considered necessary for fauna that may be associated with the dam habitats. Similarly, no assessments of significance have been prepared for hollow-dependant fauna as it has been assumed that all hollow-bearing trees would be retained. Fauna that may possibly use these trees are highly mobile and would not be affected by the proposed works in any other way.

6.5.3 Migratory species

As summarised in section 5.4, habitat within the site does not comprise ‘important habitat’ for migratory species, as defined by DEWHA (2013). The proposal is unlikely to directly impact any migratory fauna species. Some migratory woodland birds may temporarily roost and forage in the investigation area but would not breed in the site.

7. Mitigation

7.1 Mitigating impacts

The environmental safeguards outlined in Table 7.1 would be implemented to address the potential impacts of the proposal on biodiversity values. A Construction Environmental Management Plan (CEMP) will be prepared, that would identify the specific measures to be implemented during the 'Pre-construction' and 'Construction' stages of the proposal and would include work methods, contingencies, roles and responsibilities.

Table 7.1 Environmental safeguards

Issue	Safeguard	Timing	Responsibility
Environmental management	A CEMP will be prepared, including the specific mitigation/management measures and sub-plans listed below along with work methods, contingencies, roles and responsibilities. The mitigation/management measures included in the CEMP and sub-plans would be implemented during pre-construction and construction stages.	Pre-construction	Construction contractor
Worker inductions	Ensure all workers are provided with an environmental induction prior to starting construction activities on site. This would include information on the ecological values of the site and protection measures to be implemented to protect biodiversity during construction.	Pre-construction	Construction contractor
Vegetation management	Avoid impacts to all hollow-bearing trees and all Koala feed trees. Tree protection zones should be marked to prevent accidental damage, and there should be no disturbance within the tree protection zones. If there is a choice between cutting down or removing a paddock tree, or just impacting its root system, even to the point where it may die, it is preferable to impact the root system and allow it to die slowly, as the dead or dying tree will still provide important habitat for native and potentially threatened species, in a highly cleared landscape. Ensure all workers are informed of the boundary to the site, and that no parking or laydown areas are placed in tree protection zones. A suitably qualified ecologist must be engaged prior to any works at the site, to physically delineate the boundary of clearing and trees to be protected and supervise installation of appropriate signage and flagging tape or similar prior to works commencing as required. Fencing and signage must be maintained for the duration of the construction period. Sediment fences should be installed to prevent transfer of sediments into adjacent vegetation. Implement hygiene protocols to prevent the introduction and spread of weed propagules and soil pathogens. This would include exclusion zones around retained areas of native vegetation.	Pre-construction/ construction	Construction contractor. Site ecologist/ environmental officer
Fauna management	Pre-clearance surveys will be undertaken by a qualified ecologist as required and the required methodology will be developed for target species as part of the CEMP. Surveys should include: Avoid clearing of hollow-bearing trees and minimise impacts within the tree protection zone. Visually scanning the site for Koalas prior to commencement of works. If any animals are observed, move away and wait for the Koala to move on of its' own volition before works commence, to limit trauma and exposure to noise and disturbance during construction period.	Pre-construction/ construction	Construction contractor. Site ecologist/ environmental officer

Issue	Safeguard	Timing	Responsibility
	If signs of stress or disease in Koalas is observed at any time, a suitably qualified local wildlife rescue service should be contacted to assist with rescue and/or rehabilitation of the animal. Pre-clearance surveys of any fallen timber or paddock trees that will be impacted by the proposal, by a suitably qualified ecologist or wildlife handler as required. An experienced, licenced wildlife carer or ecologist would be present to supervise clearing and capture and relocate fauna (if required). Any open trenching would be backfilled or covered (e.g., with boards) at the completion of construction each day to minimise the risk of injury or mortality to animals as a result of falling into the excavated trench line. Open trenches would be checked each morning, before the start of construction, to salvage any fauna that have fallen in, and move them to a safe (and appropriate) nearby location. Protocols would be developed to deal with the removal of injured or dangerous animals (e.g., snakes). Salvage and relocation of habitat features (e.g., hollow logs and branches) into adjacent areas of retained vegetation, taking care not to spread any weed propagules or material. Pre-clearance surveys will be undertaken by a qualified ecologist prior to clearing of vegetation at the proposal site to identify any fauna that may require rescue or relocation as required. The ecologist would also undertake supervision of clearing if necessary. Any resident, non-mobile fauna, are to be relocated to an adjacent habitat or transferred to the care of a suitably qualified wildlife carer if necessary. Any fallen timber and logs within the footprint are to be relocated to adjacent forested areas or placed under paddock trees. If native fauna is encountered on site, stop work and allow the fauna to move away un-harassed. A local wildlife rescue service or the ecologist responsible for pre-clearing surveys should be engaged to assist with fauna removal and rescue if fauna fails to move away on its own. Limits on vehicle speed for all site works should be introduced to minimise the potential risk of vehicle strike on the Koala. A speed limit of approximately 30-40 km/hr should be implemented for all site vehicles. Signage should be erected across the site warning of the likely presence of Koalas and reinforcing speed limits. This matter should also be raised in daily toolbox talks, with any recent sightings reported to the site environmental representative.		
Weeds	Weed management and control would be undertaken and would include: All equipment used on site is to be free of any weed propagules, seeds or vegetative material prior to being used. Rapid stabilisation of disturbed areas following clearing to prevent weed establishment and spread.	Pre-construction/ construction	Construction contractor
Aquatic habitats and water quality	The following measures should be incorporated into the CEMP to manage impacts on aquatic habitats and water quality: Implement reasonable and feasible water quality control measures to prevent pollution of waterways and drainage lines in areas downstream of the proposed works.	Pre-construction/ construction	Construction contractor
Protection of threatened species	If any threatened species (flora or fauna) is discovered during the works, stop work immediately and notify the Santos Environmental Representative. Work will only recommence once the impact on the species has been assessed and appropriate control measures provided.	Pre-construction/ Construction	Construction contractor. Site ecologist/ environmental officer

Issue	Safeguard	Timing	Responsibility
Erosion and sediment	Erosion and sediment control plans would be established prior to the commencement of works. Controls would be managed and maintained in accordance with the CEMP to ensure their ongoing functionality. Erosion and sediment controls would be regularly inspected, particularly following rainfall events, to ensure their ongoing functionality. All stockpiled material should be stored in bunded areas and kept away from waterways to avoid sediment or contaminants entering waterways.	Pre-construction/ construction	Construction contractor. Site ecologist/ environmental officer

8. Conclusion

Santos proposes to carry out the Kahlua Pilot Reactivation at a site located about 20 kilometres west of Gunnedah in NSW. The site contains existing coal seam gas exploration infrastructure including four exploration wells (K2, K3, K4 and K5), access tracks between the wells, and water storage and gas flaring infrastructure located at well K2. The proposal is to allow for continued exploration and appraisal activities at the site utilising the existing infrastructure as well as installation of gathering lines and upgrade of the existing gas flare, gas well workovers and completions, and appraisal activities.

To allow for the proposed activity to occur, there would be impacts to modified grassland and cropped fields. All paddock and hollow-bearing trees would be avoided where practicable, with exclusion zones established around them. There would be no impact to intact native vegetation to the south of the site.

Most impacts as a result of the proposal would be to non-native vegetation, comprising modified grassland and cropped pasture. There are no intact patches of native vegetation present on site, nor are there any areas of derived native grassland. Modified grassland is dominated by exotic species and is unlikely to support even a partially intact native seed bank given the history of the site. There are several individual hollow-bearing trees within the site, as well as individual Koala feed tree species and paddock trees that provide important refuge and foraging habitat in the disturbed and over-cleared landscape in which the proposal will take place. The importance of maintaining Koala feed trees at the site has been considered in the context of the recent bushfires across NSW, which decimated large tracts of Koala habitat.

Vegetation to be impacted is not commensurate with any TECs listed under the BC Act or EPBC Act and impacts to any nearby TECs as a result of the proposal are unlikely.

No threatened flora species have been recorded in the investigation area. The proposal would remove a small area of broadly suitable, low quality potential habitat for Bluegrass (*Dichanthium setosum*) and Slender Darling Pea (*Swainsona murrayana*), which are listed as vulnerable species under the BC Act and EPBC Act. No known individuals would be impacted.

Assessments of the likely significance of impacts of the proposal on threatened flora that may occur and be impacted by the proposal have been prepared pursuant to Section 7.3 of the BC Act. The proposal is unlikely to have a significant impact on these threatened species.

Impacts on the Koala, which is known to occur on site, are unlikely, given feed trees would be retained and there would be no impact to existing habitat connectivity. There would be negligible impacts on the Grey-crowned Babbler, which may occur on occasion as paddock trees that may be used for movement throughout the landscape would be retained, and only small areas of potential foraging habitat would be impacted. There would be no impact to any breeding habitat.

The site may provide habitat for a number of other highly mobile threatened species, however given the retention of hollow-bearing trees, and lack of impacts to native vegetation, impacts to these species are unlikely to be significant.

Assessments of the likely significance of impacts of the proposal on threatened fauna species that may occur and be impacted by the proposal have been prepared pursuant to Section 7.3 of the BC Act. The proposal is unlikely to have a significant impact on these threatened species.

As the proposal is unlikely to result in a significant impact on any threatened biota listed under the BC Act, the proposal will not trigger the Biodiversity Offsets Scheme (BOS) and assessment and biodiversity offset under the Biodiversity Assessment Methodology (BAM) via a Biodiversity Development Assessment Report (BDAR) or Species Impact Statement (SIS) are not required.

The proposal is unlikely to result in a significant impact on threatened biota or migratory species listed under the EPBC Act and Referral of the proposal to the Australian Minister for the Environment is therefore not considered necessary.

This assessment has been prepared noting that Koala feed trees and hollow-bearing trees will not be impacted by the proposal. If for any reason impacts to hollow-bearing trees or Koala feed trees cannot be avoided, additional assessments to determine the significance of the proposal would be required.

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Appendix A

Likelihood of occurrence for threatened and migratory biota

Likelihood of occurrence of threatened flora at the site

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Androcalva procumbens		V	V	Species or species habitat likely to occur within 20 km (DCCEEW 2022a)	Mainly confined to the Dubbo-Mendooran-Gilgandra region, but also in the Pilliga and Nymagee areas and recent collections from the Upper Hunter. Grows on sandy soils, often on roadsides. Has been recorded in Tumbledown Red Gum and Mugga Ironbark communities, Broombush scrub, under mallee eucalypts with a Common Fringe-myrtle understorey, and in a recently burnt Ironbark and *Callitris* area. Also in *Eucalyptus fibrosa* subsp. *nubila*, Tumbledown Red Gum, White Box and White Cypress Pine woodlands north of Dubbo.	Unlikely. No sandy soils on site.	Nil
Cadellia pentastylis	Ooline	V	V	6 records within 20 km (DPIE 2020a); Species or species habitat likely to occur within 20 km (DCCEEW 2022a)	Relic rainforest species. Occurs along the western edge of the North West Slopes from north of Gunnedah to west of Tenterfield. Forms a closed or open canopy mixing with eucalypt and cypress pine species. Presence appears to be strongly correlated with low-medium nutrient soils of sandy clay or clay consistency. Flowers spasmodically, during a general flowering period of October to January.	Unlikely. This tree was not identified within the investigation area.	Nil
Dichanthium setosum	Bluegrass	V	V	1 record within 20 km (DPIE 2020a); Species or species habitat likely to occur within 20 km (DCCEEW 2022a)	Occurs on the New England Tablelands, North-west Slopes and Plains and the Central-west Slopes. Associated with heavy basaltic black soils and red-brown loams with clay subsoil. Often found in moderately disturbed areas such as cleared woodland, grassy roadside remnants and highly disturbed pasture. Appears to have wide environmental tolerances.	Possible. Broadly suitable habitat present in areas of modified grassland and around the base of paddock trees.	Low
Digitaria porrecta	Finger Panic Grass	E		19 records within 20 km (DPIE 2020a)	In NSW found on the North West Slopes and Plains, from near Moree south to Tambar Springs and from Tamworth to Coonabarabran. Inhabits native grasslands, woodland and open forests with grassy understorey on richer soils. Often found along roadsides and travelling stock routes where there is light grazing and occasional fire.	Unlikely. The investigation area has been subject to intense agricultural practices. No intact native vegetation present in investigation area.	Nil

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Euphrasia arguta		CE	CE	Species or species habitat may occur within 20 km (DCCEEW 2022a)	Recently rediscovered near Nundle on the north-western slopes and tablelands, once known from scattered locations between Sydney, Bathurst and Walcha. Known populations occur in eucalypt forest with a mixed grass/shrub understorey, while previous records are described as occurring in open forest, grassy country and river meadows. Dense stands observed in cleared firebreak areas, suggesting it may respond well to disturbance.	Unlikely. No local records. Investigation area is to the west of the predicted distribution of this species.	Nil
Lepidium monoplocoides	Winged Pepper-cress	E	E	Species or species habitat may occur within 20 km (DCCEEW 2022a)	There is a single collection from Broken Hill and only two collections since 1915, the most recent being 1950. Also previously recorded from Bourke, Cobar, Urana, Lake Cargelligo, Balranald, Wanganella and Deniliquin. Recorded more recently from the Hay Plain, south-eastern Riverina, and from near Pooncarie. Predominant vegetation is usually an open woodland dominated by Allocasuarina luehmannii (Bulloak) and/or eucalypts, particularly Eucalyptus largiflorens (Black Box) or Eucalyptus populnea (Poplar Box).	Unlikely. No local records. Associated vegetation not present.	Nil
Lepidium aschersonii	Spiny Pepper-cress			Species or species habitat may occur within 20 km (DCCEEW 2022a)	Found on ridges of gilgai clays dominated by Brigalow (Acacia harpophylla), Belah (Casuarina cristata), Buloke (Allocasuarina luehmanii) and Grey Box (Eucalyptus microcarpa). In the south has been recorded growing in Bull Mallee (Eucalyptus behriana).	Unlikely. No local records. Associated vegetation not present.	Nil
Prasophyllum sp. Wybong			CE	Species or species habitat may occur within 20 km (DCCEEW 2022a)	Endemic to NSW, it is known from near Ilford, Premer, Muswellbrook, Wybong, Yeoval, Inverell, Tenterfield, Currabubula and the Pilliga area. Known to occur in open eucalypt woodland and grassland.	Unlikely. No local records. No woodland or native grassland present.	Nil
Swainsona murrayana	Slender Darling Pea	V	V	Species or species habitat likely to occur within 20 km (DCCEEW 2022a)	Found in a variety of vegetation types including bladder saltbush, black box and grassland communities on level plains, floodplains and depressions and is often found with Maireana species. Plants have been found in remnant native grasslands or grassy woodlands that have been intermittently grazed or cultivated. The species may require some disturbance and has been known to occur in paddocks that have been moderately grazed or occasionally cultivated.	Possible. Broadly suitable habitat present in areas of modified grassland and around the base of paddock trees.	Low
Thesium australe	Austral Toadflax	V	V	Species or species habitat may occur within 20 km (DCCEEW 2022a)	Found in small, scattered populations along the east coast, northern and southern tablelands. Occurs in grassland or grassy woodland and is often found in association with Kangaroo Grass.	Unlikely. No local records, no *Themeda* recorded during field survey.	Nil

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Tylophora linearis		V	E	2 records within 20 km (DPIE 2020a); Species or species habitat known to occur within 20 km (DCCEEW 2022a)	Majority of records occur in the central western region from Goonoo, Pilliga West, Pillaga East, Bibblewindi, Cumbil and Eura State Forests, Coolbaggie NR, Goobang NP and Beni SCA. Grows in dry scrub and open forest on low-altitude sedimentary flats.	Unlikely. No intact native vegetation present on site.	Nil

Notes: V= vulnerable, E= endangered, CE= critically endangered

Likelihood of occurrence of threatened fauna at the site

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Birds							
Calidris ferruginea	Curlew Sandpiper	E	CE,C,J,K	Species may occur within 20 km (DCCEEW 2022a)	The Curlew Sandpiper is distributed around most of the Australian coastline (including Tasmania). It occurs along the entire coast of NSW, particularly in the Hunter Estuary, and sometimes in freshwater wetlands in the Murray-Darling Basin. Inland records are probably mainly of birds pausing for a few days during migration. The Curlew Sandpiper breeds in Siberia and migrates to Australia (as well as Africa and Asia) for the non-breeding period, arriving in Australia between August and November, and departing between March and mid-April. It generally occupies littoral and estuarine habitats, and in New South Wales is mainly found in intertidal mudflats of sheltered coasts. It also occurs in non-tidal swamps, lakes and lagoons on the coast and sometimes inland. It forages in or at the edge of shallow water, occasionally on exposed algal mats or waterweed, or on banks of beach-cast seagrass or seaweed.	Nil. No suitable habitat present.	Nil
Calyptorhynchus lathami lathami	Glossy Black-cockatoo	V	V	Species may occur within 20 km (DCCEEW 2022a)	Inhabits open forest and woodlands of the coast and the Great Dividing Range where stands of sheoak occur. Black Sheoak (Allocasuarina littoralis) and Forest Sheoak (A. torulosa) are important foods.	Unlikely. No sheoak species present.	Nil
Chthonicola sagittata	Speckled Warbler	V		19 records within 20 km (DPIE 2020a)	The Speckled Warbler has a patchy distribution throughout south-eastern Queensland, the eastern half of NSW and into Victoria, as far west as the Grampians. The species is most frequently reported from the hills and tablelands of the Great Dividing Range, and rarely from the coast. There has been a decline in population density throughout its range, with the decline exceeding 40% where no vegetation remnants larger than 100 ha survive. The Speckled Warbler lives in a wide range of Eucalyptus dominated communities that have a grassy understorey, often on rocky ridges or in gullies, typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy. Large, relatively undisturbed remnants are required for the species to persist in an area.	Unlikely. Species requires large intact remnants to persist. No intact native vegetation within investigation area.	Nil
Circus assimilis	Spotted Harrier	V		2 records within 20 km (DPIE 2020a)	The Spotted Harrier occurs throughout the Australian mainland, except in densely forested or wooded habitats of the coast, escarpment and ranges, and rarely in Tasmania.	Possible. Suitable foraging habitat present.	Low

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
					Individuals disperse widely in NSW and comprise a single population. The species occurs in grassy open woodland including Acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe. It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands.		
Hamirostra melanosternon	Black-breasted Buzzard	V		1 record within 20 km, last recorded 1996 (DPIE 2020a)	The Black-breasted Buzzard is found sparsely in areas of less than 500 mm rainfall, from north-western NSW and north-eastern South Australia to the east coast at about Rockhampton, then across northern Australia south almost to Perth, avoiding only the Western Australian deserts. The species lives in a range of inland habitats, especially along timbered watercourses which is the preferred breeding habitat. Also hunts over grasslands and sparsely timbered woodlands.	Possible. Broadly suitable hunting habitat present (grassland), but no breeding habitat present.	Low
Hieraaetus morphnoides	Little Eagle	V		1 record within 20 km, last recorded 1996 (DPIE 2020a)	The Little Eagle is found throughout the Australian mainland excepting the most densely forested parts of the Dividing Range escarpment. It occurs as a single population throughout NSW. The species occupies open eucalypt forest, woodland or open woodland. Sheoak or Acacia woodlands and riparian woodlands of interior NSW are also used. It nests in tall living trees within a remnant patch, where pairs build a large stick nest in winter.	Possible. Broadly suitable hunting habitat present (grassland), but no breeding habitat present.	Low
Hirundapus caudacutus	White-throated Needletail		V,C,J,K	Species habitat may occur within 20 km (DoEE 2020a)	White-throated Needletails often occur in large numbers over eastern and northern Australia. White-throated Needletails are aerial birds and for a time it was commonly believed that they did not land while in Australia. It has now been observed that birds will roost in trees, and radio-tracking has since confirmed that this is a regular activity.	Possible. May occur but would not breed.	Low
Lophoictinia isura	Square-tailed Kite	V		2 records within 20 km (DPIE 2020a)	The Square-tailed Kite ranges along coastal and subcoastal areas from south-western to northern Australia, Queensland, NSW and Victoria. In NSW, scattered records of the species throughout the state indicate that the species is a regular resident in the north, north-east and along the major west-flowing river systems. It is a summer breeding migrant to the south-east, including the NSW south coast, arriving in September and leaving by March. The species is found in a variety of timbered habitats including dry woodlands and open forests. Shows a particular preference for timbered watercourses. In arid north-western NSW, it has been observed in stony country with a ground cover of	Possible. Broadly suitable hunting habitat present (grassland), but no breeding habitat present.	Low

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
					chenopods and grasses, open acacia scrub and patches of low open eucalypt woodland.		
Oxyura australis	Blue-billed Duck	V		1 record within 20 km (DPIE 2020a)	The Blue-billed Duck is endemic to south-eastern and south-western Australia. It is widespread in NSW, but most common in the southern Murray-Darling Basin area. The species disperses during the breeding season to deep swamps up to 300 km away and is generally only during summer or in drier years that they are seen in coastal areas. The Blue-billed Duck prefers deep water in large permanent wetlands and swamps with dense aquatic vegetation. The species is completely aquatic, swimming low in the water along the edge of dense cover. It will fly if disturbed but prefers to dive if approached.	Unlikely. No aquatic habitat present within investigation area. May utilise large dam to south west of investigation area.	Nil
Botaurus poiciloptilus	Australasian Bittern	E	E	Species habitat may occur within 20 km (DCCEEW 2022a)	Australasian Bitterns are widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west. The Species favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (*Typha* spp.) and spikerushes (*Eleocharis* spp.), it hides during the day amongst dense reeds or rushes and feed mainly at night on frogs, fish, yabbies, spiders, insects and snails. The species may construct feeding platforms over deeper water from reeds trampled by the bird; platforms are often littered with prey remains.	Nil. No aquatic habitat present within investigation area. May utilise large dam to south west of investigation area.	Nil
Artamus cyanopterus cyanopterus	Dusky Woodswallow	V		6 records within 20 km (DPIE 2020a)	The Dusky Woodswallow is widespread from the coast to inland, including the western slopes of the Great Dividing Range and farther west. It is often recorded in woodlands and dry open sclerophyll forests, and has also been recorded in shrublands, heathlands regenerating forests and very occasionally in moist forests or rainforests. The understorey is typically open with sparse eucalypt saplings, acacias and other shrubs, often with coarse woody debris. It is also recorded in farmland, usually at the edges of forest or woodland or in roadside remnants or wind breaks with dead timber. The nest is an open shallow untidy cup frequently built in an open hollow, crevice or stump. Although Dusky Woodswallows have large home ranges, individuals may spend most of their time in about a 2 ha range and defend an area about 50 m around the nest. Dusky Woodswallows prefer larger remnants over smaller remnants. Competitive exclusion by Noisy Miners (*Manorina melanocephala*) is a significant threat to this species.	Unlikely. Species prefers large remnants. The investigation area supports only scattered trees.	Nil

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V		9 records within 20 km (DPIE 2020a)	The western boundary of the range of the Brown Treecreeper runs approximately through Corowa, Wagga Wagga, Temora, Forbes, Dubbo and Inverell and along this line the subspecies intergrades with the arid zone subspecies of Brown Treecreeper which then occupies the remaining parts of the state. The species is often found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and River Red Gum (*Eucalyptus camaldulensis*) Forest bordering wetlands with an open understorey of acacias, saltbush, lignum, cumbungi and grasses; usually not found in woodlands with a dense shrub layer; fallen timber is an important habitat component for foraging; also recorded, though less commonly, in similar woodland habitats on the coastal ranges and plains.	Unlikely. No intact native vegetation present within the investigation area. Minimal fallen timber present.	Nil
Stagonopleura guttata	Diamond Firetail	V		2 records within 20 km (DPIE 2020a)	The Diamond Firetail is endemic to south-eastern Australia, extending from central Queensland to the Eyre Peninsula in South Australia. It is widely distributed in NSW, with a concentration of records from the Northern, Central and Southern Tablelands, the Northern, Central and South Western Slopes and the North West Plains and Riverina. Not commonly found in coastal districts, though there are records from near Sydney, the Hunter Valley and the Bega Valley. This species has a scattered distribution over the rest of NSW, though is very rare west of the Darling River. The species is found in grassy eucalypt woodlands, including Box-Gum Woodlands and Snow Gum *Eucalyptus pauciflora* Woodlands. It also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities, and often found in riparian areas (rivers and creeks), and sometimes in lightly wooded farmland.	Possible. Broadly suitable habitat present.	Low

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Falco hypoleucos	Grey Falcon	E		Species habitat likely to occur within 20 km (DCCEEW 2022a)	The Grey Falcon is sparsely distributed in NSW, chiefly throughout the Murray-Darling Basin, with the occasional vagrant east of the Great Dividing Range. The species is usually restricted to shrubland, grassland and wooded watercourses of arid and semi-arid regions, although it is occasionally found in open woodlands near the coast. It also occurs near wetlands where surface water attracts prey.	Possible. Broadly suitable hunting habitat present, but no breeding habitat present.	Low
Falco subniger	Black Falcon	V		2 records within 20 km (DPIE 2020a)	The Black Falcon is widely, but sparsely, distributed in New South Wales, mostly occurring in inland regions. Some reports of 'Black Falcons' on the tablelands and coast of New South Wales are likely to be referable to the Brown Falcon. Occurs in plains, grasslands, foothills, timbered watercourses, wetland environs, crops, and occasionally over towns and cities. Breeding occurs along timbered waterways in in land areas.	Possible. Broadly suitable hunting habitat present (grassland), but no breeding habitat present.	Low
Leipoa ocellata	Malleefowl	E	V	Species habitat likely to occur within 20 km (DCCEEW 2022a)	The stronghold for the Malleefowl in NSW is the mallee in the south west centred on Mallee Cliffs NP and extending east to near Balranald and scattered records as far north as Mungo NP. West of the Darling River a population also occurs in the Scotia mallee including Tarawi NR and Scotia Sanctuary and is part of a larger population north of the Murray River in South Australia.	Nil. No local records. Species not known from the region.	Nil
Anthochaera phrygia	Regent Honeyeater	CE	CE	Species foraging, feeding or related behaviour likely to occur within 20 km (DCCEEW 2022a)	The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. Once recorded between Adelaide and the central coast of Queensland, its range has contracted dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland. There are only three known key breeding regions remaining: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years flocks converge on flowering coastal woodlands and forests. The species inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River Sheoak. Regent Honeyeaters inhabit woodlands that support a significantly high abundance and species richness of bird species. These woodlands have significantly large numbers	Unlikely. No local records. Species prefer wooded areas that support large numbers of mature trees and high canopy cover. Investigation area does not support these habitats.	Nil

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
					of mature trees, high canopy cover and abundance of mistletoes.		
Grantiella picta	Painted Honeyeater	V	V	1 record within 20 km, last recorded 1996 (DPIE 2020a); Species habitat known to occur within 20 km (DCCEEW 2022a)	The Painted Honeyeater is nomadic and occurs at low densities throughout its range. The greatest concentrations of the bird and almost all breeding occurs on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland. During the winter it is more likely to be found in the north of its distribution. The species inhabits Boree/ Weeping Myall (*Acacia pendula*), Brigalow (*A. harpophylla*) and Box-Gum Woodlands and Box-Ironbark Forests. It is a specialist feeder on the fruits of mistletoes growing on woodland eucalypts and acacias. Prefers mistletoes of the genus *Amyema*.	Possible. Suitable habitat present (mistletoes of the genus Amyema).	Low
Daphoenositta chrysoptera	Varied Sittella	V		5 records within 20 km (DPIE 2020a)	The Varied Sittella is sedentary and inhabits most of mainland Australia except the treeless deserts and open grasslands. Distribution in NSW is nearly continuous from the coast to the far west. The species inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland.	Unlikely. Species does not typically use open grassland such as the investigation area. May utilise more vegetated areas to the south of the investigation area.	Nil
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V		16 records within 20 km (DPIE 2020a)	In NSW, the Grey-crowned Babbler occurs on the western slopes of the Great Dividing Range, and on the western plains reaching as far as Louth and Balranald. It also occurs in woodlands in the Hunter Valley and in several locations on the north coast of NSW. It may be extinct in the southern, central and New England tablelands. The species inhabits open Box-Gum Woodlands on the slopes, and Box-Cypress-pine and open Box Woodlands on alluvial plains. Woodlands on fertile soils in coastal regions.	Likely. Species recorded about 2 km north of the investigation area, in vegetation comparable to that within the investigation area. Assumed to utilise habitat within the investigation area on occasion.	Low

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Glossopsitta pusilla	Little Lorikeet	V		12 records within 20 km (DPIE 2020a)	The Little Lorikeet is distributed widely across the coastal and Great Divide regions of eastern Australia from Cape York to South Australia. NSW provides a large portion of the species' core habitat, with lorikeets found westward as far as Dubbo and Albury. Nomadic movements are common, influenced by season and food availability, although some areas retain residents for much of the year and 'locally nomadic' movements are suspected of breeding pairs. The species forages primarily in the canopy of open Eucalyptus forest and woodland, yet also finds food in Angophora, Melaleuca and other tree species. Riparian habitats are particularly used, due to higher soil fertility and hence greater productivity.	Possible. Suitable nesting and foraging habitat present.	Low
Lathamus discolor	Swift Parrot	E	CE	1 record within 20 km, last recorded 1996 (DPIE 2020a); Species habitat may occur within 20 km (DCCEEW 2022a)	The Swift Parrot breeds in Tasmania during spring and summer, migrating in the autumn and winter months to south-eastern Australia from Victoria and the eastern parts of South Australia to south-east Queensland. In NSW mostly occurs on the coast and south west slopes. On the mainland the species occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Their favoured feed trees include winter flowering species such as Swamp Mahogany *Eucalyptus robusta*, Spotted Gum *Corymbia maculata*, Red Bloodwood *C. gummifera*, Forest Red Gum *E. tereticornis*, Mugga Ironbark *E. sideroxylon*, and White Box *E. albens*.	Possible. Suitable foraging habitat present. May use tree hollows on occasion but would not breed within the investigation area.	Low
Neophema pulchella	Turquoise Parrot	V		6 records within 20 km (DPIE 2020a)	The Turquoise Parrot's range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range. The species typically lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland.	Possible. Suitable nesting and foraging habitat present.	Low

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Polytelis swainsonii	Superb Parrot	V	V	Predicted by Alison Hunt and Associates (2010); Species habitat may occur within 20 km (DCCEEW 2022a)	Found throughout eastern inland NSW. Inhabit Box-Gum, Box-Cypress-pine and Boree Woodlands and River Red Gum Forest. In the Riverina the birds nest in the hollows of large trees (dead or alive) mainly in tall riparian River Red Gum Forest or Woodland. On the South West Slopes nest trees can be in open Box-Gum Woodland or isolated paddock trees. Species known to be used are Blakely's Red Gum, Yellow Box, Apple Box and Red Box. Feed in trees and understorey shrubs and on the ground and their diet consists mainly of grass seeds and herbaceous plants. Also eaten are fruits, berries, nectar, buds, flowers, insects and grain.	Possible. Suitable nesting and foraging habitat present.	Low
Rostratula australis	Australian Painted Snipe	E	E	Species habitat likely to occur within 20 km (DCCEEW 2022a)	In NSW many records of the Australian Painted Snipe are from the Murray-Darling Basin including the Paroo wetlands, Lake Cowal, Macquarie Marshes, Fivebough Swamp and more recently, swamps near Balldale and Wanganella. Other important locations with recent records include wetlands on the Hawkesbury River and the Clarence and lower Hunter Valleys. The species prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber.	Nil. No aquatic habitat present within the investigation area. May utilise large dam to the south west of the investigation area.	Nil
Ninox connivens	Barking Owl	V		Predicted by Alison Hunt and Associates (2010)	Found throughout continental Australia except for the central arid regions. Core populations exist on the western slopes and plains and in some northeast coastal and escarpment forests. Many populations crashed as woodland on fertile soils was cleared over the past century, leaving linear riparian strips of remnant trees as the last inhabitable areas. Inhabits woodland and open forest, including fragmented remnants and partly cleared farmland. It is flexible in its habitat use, and hunting can extend in to closed forest and more open areas. Sometimes able to successfully breed along timbered watercourses in heavily cleared habitats (eg western NSW) due to the higher density of prey found on these fertile riparian soils. Roost in shaded portions of tree canopies, including tall midstorey trees with dense foliage such as Acacia and Casuarina species.	Possible. Suitable foraging habitat present.	Low

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Tyto novaehollandiae	Masked Owl	V		2 records within 20 km (DPIE 2020a)	The Masked Owl occurs from the coast where it is most abundant to the western plains. Overall records for this species fall within approximately 90% of NSW, excluding the most arid north-western corner. There is no seasonal variation in its distribution. This species lives in dry eucalypt forests and woodlands from sea level to 1100 m an often hunts along the edges of forests, including roadsides. Roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting.	Possible. Suitable foraging habitat present.	Low
Mammals							
Dasyurus maculatus	Spotted-tailed Quoll	V	E	2 records within 20 km (DPIE 2020a); Species habitat known to occur within 20 km (DCCEEW 2022a)	The range of the Spotted-tailed Quoll has contracted considerably since European settlement. It is now found in eastern NSW, eastern Victoria, south-east and north-eastern Queensland, and Tasmania. Only in Tasmania is it still considered relatively common. The species has been recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Individual animals use hollow-bearing trees, fallen logs, small caves, rock outcrops and rocky-cliff faces as den sites. Females occupy home ranges of 200-500 hectares, while males occupy very large home ranges from 500 to over 4000 hectares. Are known to traverse their home ranges along densely vegetated creeklines.	Unlikely. Species prefers to travel across the landscape via densely vegetated creeklines. No equivalent habitat present within the investigation area.	Nil
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V		3 records within 20 km (DPIE 2020a)	The Yellow-bellied Sheathtail-bat is a wide-ranging species found across northern and eastern Australia. In the most southerly part of its range - most of Victoria, south-western NSW and adjacent South Australia - it is a rare visitor in late summer and autumn. There are scattered records of this species across the New England Tablelands and North West Slopes. It forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory.	Possible. Suitable roosting habitat in hollow-bearing trees on site.	Low

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Pseudomys pilligaensis	Pilliga Mouse	V	V	Species habitat known to occur within 20 km (DCCEEW 2022a)	The Pilliga Mouses distribution is restricted to the Pilliga region of New South Wales. However, a Pilliga Mouse was reportedly trapped in the Warrumbungles after a major wildfire in January 2013, suggesting a sparse local population may have previously existed that could now respond to early stages of the post-fire succession. The Pilliga Mouse typically occurs at low densities and appears to prefer areas with sparse ground cover. Evidence exists of marked population fluctuations. Within the Pilliga region this species is largely restricted to low-nutrient deep sand soils which are recognised as supporting a distinctive vegetation type referred to as the Pilliga Scrub.	Unlikely. Species is associated with Pilliga Scrub vegetation and there is no equivalent habitat present within the investigation area.	Nil
Petaurus norfolcensis	Squirrel Glider	V		1 record within 20 km, last recorded 1996 (DPIE 2020a)	The Squirrel Glider is widely though sparsely distributed in eastern Australia, from northern Queensland to western Victoria. The species inhabits mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range and Blackbutt-Bloodwood forest with heath understorey in coastal areas.	Unlikely. No suitable habitat present within the investigation area.	Nil
Phascolarctos cinereus	Koala	E	E	570 records within 20 km (DPIE 2020a); Species habitat known to occur within 20 km (DCCEEW 2022a)	The Koala has a fragmented distribution throughout eastern Australia from north-east Queensland to the Eyre Peninsula in South Australia. In New South Wales, koala populations are found on the central and north coasts, southern highlands, southern and northern tablelands, Blue Mountains, southern coastal forests, with some smaller populations on the plains west of the Great Dividing Range. The species inhabit eucalypt woodlands and forests, and feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area will select preferred browse species.	Present. Scats located under trees within the investigation area.	Moderate
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Species foraging, feeding or related behaviour may occur within 20 km (DCCEEW 2022a)	Grey-headed Flying-foxes are generally found within 200 km of the eastern coast of Australia, from Rockhampton in Queensland to Adelaide in South Australia. In times of natural resource shortages, they may be found in unusual locations. The species occur in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy.	Nil. Species is restricted to within 200 km of the east coast, site is nearly 300 km inland.	Nil

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Species habitat known to occur within 20 km (DCCEEW 2022a)	The Large-eared Pied Bat is found mainly in areas with extensive cliffs and caves, from Rockhampton in Queensland south to Bungonia in the NSW Southern Highlands. It is generally rare with a very patchy distribution in NSW. There are scattered records from the New England Tablelands and North West Slopes. The species roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin (*Petrochelidon ariel*), frequenting low to mid-elevation dry open forest and woodland close to these features. Females have been recorded raising young in maternity roosts (c. 20-40 females) from November through to January in roof domes in sandstone caves and overhangs. It is found in well-timbered areas containing gullies.	Nil. No local records. No breeding (cave) habitat present within the investigation area. No well-timbered areas within investigation area.	Nil
Chalinolobus nigrogriseus	Hoary Wattled Bat	V		1 record within 20 km, last recorded 1996 (DPIE 2020a)	In north east NSW the distribution of the Hoary Wattle Bat extends from Port Macquarie in the south, north to the Queensland border. The species has been recorded as far west as Armidale and Ashford. In NSW the Hoary Wattled Bat occurs in dry open eucalypt forests, favouring forests dominated by Spotted Gum, boxes and ironbarks, and heathy coastal forests where Red Bloodwood and Scribbly Gum are common. Because it flies fast below the canopy level, forests with naturally sparse understorey layers may provide the best habitat. The species roosts in hollows and rock crevices.	Unlikely. No records since 1996, typically limited distribution between the coast and Armidale - the investigation area is more than 150 km further inland than Armidale.	Nil
Nyctophilus corbeni	Corben's Long-eared Bat	V	V	5 records within 20 km (DPIE 2020a); Species habitat known to occur within 20 km (DCCEEW 2022a)	This Corben's Long-eared Bat is found throughout the Murray-Darling Basin and the Pilliga Scrub region being the distinct stronghold for this species. The species inhabits a variety of vegetation types, including mallee, bulloak *Allocasuarina leuhmanni* and box eucalypt dominated communities, but it is distinctly more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland. It roosts in tree hollows, crevices, and under loose bark.	Possible. Suitable roosting habitat in hollow-bearing trees on site.	Low

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Vespadelus troughtoni	Eastern Cave Bat	V		1 record within 20 km (DPIE 2020a)	The Eastern Cave Bat is found in a broad band on both sides of the Great Dividing Range from Cape York to Kempsey, with records from the New England Tablelands and the upper north coast of NSW. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW, east of the ACT. The Eastern Cave Bat is a cave-roosting species that is usually found in dry open forest and woodland, near cliffs or rocky overhangs; has been recorded roosting in disused mine workings, occasionally in colonies of up to 500 individuals. This species is occasionally found along cliff-lines in wet eucalypt forest and rainforest. They forage over a small area but are capable of flying 500 m over clear paddocks.	Unlikely. No suitable roosting (cave) habitat present within 500 m of investigation area.	Nil
Reptiles							
Hoplocephalus bitorquatus	Pale-headed Snake	V		1 record within 20 km, last recorded 1996 (DPIE 2020a)	In NSW the Pale-headed Snake has historically been recorded from as far west as Mungindi and Quambone on the Darling Riverine Plains, across the north west slopes, and from the north coast from Queensland to Sydney. A small number of historical records are known for the New England Tablelands from Glenn Innes and Tenterfield; however, the majority of records appear to be from sites of relatively lower elevation. Although the Pale-headed snake distribution is very cryptic, it now appears to have contracted to a patchy and fragmented distribution. The species is found mainly in dry eucalypt forests and woodlands, cypress forest and occasionally in rainforest or moist eucalypt forest.	Possible. Broadly suitable habitat present in hollow-bearing trees present in the investigation area. Unlikely to occur in highly fragmented environment, but given cryptic nature, has conservatively been assumed to have the potential to occur.	Low

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Uvidicolus sphyrurus	Border Thick-tailed Gecko	V	V	1 record within 20 km, last recorded 1996 (DPIE 2020a); Species or species habitat may occur within 20 km (DCCEEW 2022a)	The Border Thick-tailed Gecko is found only on the tablelands and slopes of northern NSW and southern Queensland, reaching south to Tamworth and west to Moree. Most common in the granite country of the New England Tablelands. Occurs at sites ranging from 500 to 1100 m elevation. Populations are mostly fragmented, with over 50 discrete sites currently known that are separated by at least 2 km. As implied by another of its common names (Granite Thick-tailed Gecko), this species often occurs on steep rocky or scree slopes, especially granite. This species favours forest and woodland areas with boulders, rock slabs, fallen timber and deep leaf litter and occupies sites often have a dense tree canopy that helps create a sparse understorey. These Geckos are active at night and shelter by day under rock slabs, in or under logs, and under the bark of standing trees.	Unlikely. No rocky habitat present.	Nil
Aprasia parapulchella	Pink-tailed Legless Lizard	V	V	Species or species habitat likely to occur within 20 km (DCCEEW 2022a)	The Pink-tailed Legless Lizard is only known from the Central and Southern Tablelands, and the South Western Slopes. There is a concentration of populations in the Canberra/Queanbeyan Region. Other populations have been recorded near Cooma, Yass, Bathurst, Albury and West Wyalong. This species is also found in the Australian Capital Territory. It's found to inhabit sloping, open woodland areas with predominantly native grassy groundlayers, particularly those dominated by Kangaroo Grass (*Themeda australis*). The sites are typically well-drained, with rocky outcrops or scattered, partially-buried rocks. They are commonly found beneath small, partially-embedded rocks and appear to spend considerable time in burrows below these rocks; the burrows have been constructed by and are often still inhabited by small black ants and termites.	Unlikely. No local records. Species not known from the region.	Nil
Hemiaspis damelii	Grey Snake		E	Species or species habitat may occur within 20 km (DCCEEW 2022a)	"In NSW, this species occurs as separate subpopulations, predominantly associated with the lower reaches of major westerly flowing rivers, including the Gwydir, Namoi, Castlereagh, Macquarie, Lachlan and Murrumbidgee River systems. Key attributes of grey snake habitat are the floodplains and ephemeral wetlands which provide breeding habitat for the frog species that are its main prey, the presence of the frog species themselves, and the heavy clay soils which provide and cracks and crevices that the species uses in its hunting strategy and for shelter."	Unlikely. No local records. Suitable habitat not present	

Notes: E= endangered, V= vulnerable, C= listed under the Chinese-Australia migratory bird agreement (CAMBA), J= listed under the Japan-Australia migratory bird agreement (JAMBA), K= listed under the Korea-Australia migratory bird agreement (KAMBA)

Likelihood of occurrence of migratory fauna at the site

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Apus pacificus	Fork-tailed Swift		C,J,K	1 record within 20 km (DPIE 2020a); Species breeding habitat may occur within 20 km (DoEE 2020a)	The Fork-tailed Swift is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher. In Australia, they mostly occur over inland plains but sometimes above foothills or in coastal areas. They often occur over cliffs and beaches and also over islands and sometimes well out to sea. They also occur over settled areas, including towns, urban areas and cities. They mostly occur over dry or open habitats, including riparian woodland and tea-tree swamps, low scrub, heathland or saltmarsh. They are also found at treeless grassland and sandplains covered with spinifex, open farmland and inland and coastal sand-dunes. The sometimes occur above rainforests, wet sclerophyll forest or open forest or plantations of pines.	Possible. May overfly.	Nil
Hirundapus caudacutus	White-throated Needletail		V,C,J,K	Species breeding habitat may occur within 20 km (DoEE 2020a)	White-throated Needletails often occur in large numbers over eastern and northern Australia. White-throated Needletails are aerial birds and for a time it was commonly believed that they did not land while in Australia. It has now been observed that birds will roost in trees, and radio-tracking has since confirmed that this is a regular activity.	Possible. May occur but would not breed.	Low
Myiagra cyanoleuca	Satin Flycatcher		BONN	Species breeding habitat known to occur within 20 km (DoEE 2020a)	The Satin Flycatcher is found along the east coast of Australia from far northern Queensland to Tasmania, including south-eastern South Australia. It is also found in New Guinea. The Satin Flycatcher is not a commonly seen species, especially in the far south of its range, where it is a summer breeding migrant. The Satin Flycatcher is found in tall forests, preferring wetter habitats such as heavily forested gullies, but not rainforests.	Unlikely. No suitable habitat present.	Nil
Motacilla flava	Yellow Wagtail		C,J,K	Species breeding habitat may occur within 20 km (DoEE 2020a)	The Yellow Wagtail breeds in temperate Europe and Asia. They occur within Australia in open country habitat with disturbed ground and some water. Recorded in short grass and bare ground, swamp margins, sewage ponds, saltmarshes, playing fields, airfields, ploughed land and town lawns.	Possible. May occur but would not breed.	Low

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Rhipidura rufifrons	Rufous Fantail		BONN	Species breeding habitat may occur within 20 km (DoEE 2020a)	The Rufous Fantail is found along NSW coast and ranges. Inhabits rainforest, dense wet forests, swamp woodlands and mangroves. During migration, it may be found in more open habitats or urban areas.	Possible. May occur on occasion.	Low
Actitis hypoleucos	Common Sandpiper		C,J,K, BONN	Species breeding habitat may occur within 20 km (DoEE 2020a)	Does not breed in Australia. When in Australia it is found on all coastlines and in inland areas, but is concentrated in the north and west with important areas in WA, the NT and Qld. Utilises a wide range of coastal and inland wetlands with varying salinity levels.	Nil. No suitable habitat present.	Nil
Calidris acuminata	Sharp-tailed Sandpiper		C,J,K, BONN	Species breeding habitat may occur within 20 km (DoEE 2020a)	Spends the non-breeding season in Australia with small numbers occurring regularly in New Zealand. Most of the population migrates to Australia, mostly to the south-east and are widespread in both inland and coastal locations and in both freshwater and saline habitats. Many inland records are of birds on passage. In Australasia, prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation. Breeds in northern Siberia.	Nil. No suitable habitat present.	Nil
Calidris ferruginea	Curlew Sandpiper	E	CE,C,J ,K, BONN	Species breeding habitat may occur within 20 km (DoEE 2020a); Species breeding habitat may occur within 20 km (DoEE 2020a)	The Curlew Sandpiper is distributed around most of the Australian coastline (including Tasmania). It occurs along the entire coast of NSW, particularly in the Hunter Estuary, and sometimes in freshwater wetlands in the Murray-Darling Basin. Inland records are probably mainly of birds pausing for a few days during migration. The Curlew Sandpiper breeds in Siberia and migrates to Australia (as well as Africa and Asia) for the non-breeding period, arriving in Australia between August and November, and departing between March and mid-April. It generally occupies littoral and estuarine habitats, and in New South Wales is mainly found in intertidal mudflats of sheltered coasts. It also occurs in non-tidal swamps, lakes and lagoons on the coast and sometimes inland. It forages in or at the edge of shallow water, occasionally on exposed algal mats or waterweed, or on banks of beach-cast seagrass or seaweed.	Nil. No suitable habitat present.	Nil

Scientific name	Common name	BC Status	EPBC Status	Source	Habitat description	Likelihood of occurrence	Likelihood of impact
Calidris melanotos	Pectoral Sandpiper		J,K, BONN	Species breeding habitat may occur within 20 km (DoEE 2020a)	Widespread but scattered records across NSW, east of the divide and in the Riverina and Lower Western regions. Breeds in the northern hemisphere. In Australasia, prefers shallow fresh to saline wetlands and is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands. Usually in coastal or near-coastal habitats, and prefers wetlands with open mudflats and low emergent or fringing vegetation such as grass or samphire.	Nil. No suitable habitat present.	Nil
Gallinago hardwickii	Latham's Snipe		J,K, BONN	Species breeding habitat may occur within 20 km (DoEE 2020a)	Latham's Snipe is a non-breeding migrant to the south east of Australia including Tasmania, passing through the north and New Guinea on passage. Latham's Snipe breed in Japan and on the east Asian mainland. Latham's Snipe are seen in small groups or singly in freshwater wetlands on or near the coast, generally among dense cover. They are found in any vegetation around wetlands, in sedges, grasses, lignum, reeds and rushes and also in saltmarsh and creek edges on migration. They also use crops and pasture.	Unlikely. No suitable habitat present. May use large dam to the south west of the investigation area on occasion.	Nil

Notes: E= endangered, V= vulnerable, C= listed under the Chinese-Australia migratory bird agreement (CAMBA), J= listed under the Japan-Australia migratory bird agreement (JAMBA), K= listed under the Korea-Australia migratory bird agreement (KAMBA)

Appendix B

Species recorded during field surveys

Flora species recorded in the investigation area

Family	Exotic	Scientific Name	Common Name	BC Status	EPBC Status
Amaranthaceae	*	*Alternanthera pungens*	Khaki Weed		
Loranthaceae		*Amyema* spp.	Mistletoe		
Poaceae		*Aristida ramosa*	Purple Wiregrass		
Rubiaceae		*Asperula conferta*	Common Woodruff		
Chenopodiaceae		*Atriplex semibaccata*	Creeping Saltbush		
Poaceae		*Austrostipa scabra*	Speargrass		
Poaceae		*Austrostipa verticillata*	Slender Bamboo Grass		
Poaceae	*	*Avena fatua*	Wild Oats		
Nyctaginaceae		*Boerhavia dominii*	Tarvine		
Brassicaceae	*	*Brassica tournefortii*	Mediterranean Turnip		
Asteraceae		*Calotis cuneifolia*	Purple Burr-Daisy		
Asteraceae		*Calotis hispidula*	Bogan Flea		
Asteraceae	*	*Carthamus lanatus*	Saffron Thistle		
Poaceae	*	*Cenchrus* spp.			
Euphorbiaceae		*Chamaesyce drummondii*	Caustic Weed		
Poaceae		*Chloris ventricosa*	Tall Chloris		
Asteraceae	*	*Cirsium vulgare*	Spear Thistle		
Cucurbitaceae	*	*Citrullus lanatus* var. *lanatus*	Wild Melon		
Convolvulaceae		*Convolvulus erubescens*	Pink Bindweed		
Crassulaceae		*Crassula colorata*	Dense Stonecrop		
Cucurbitaceae	*	*Cucumis myriocarpus* subsp. *leptodermis*	Paddy Melon		
Solanaceae	*	*Datura ferox*	Fierce Thornapple		
Apiaceae		*Daucus glochidiatus*	Native Carrot		
Convolvulaceae		*Dichondra repens*	Kidney Weed		
Poaceae	*	*Digitaria* spp.	A Finger Grass		
Chenopodiaceae		*Einadia nutans*	Climbing Saltbush		

Family	Exotic	Scientific Name	Common Name	BC Status	EPBC Status
Poaceae		*Eragrostis brownii*	Brown's Lovegrass		
Geraniaceae		*Erodium crinitum*	Blue Crowfoot		
Myrtaceae		*Eucalyptus albens*	White Box		
Myrtaceae		*Eucalyptus populnea*	Bimble Box		
Euphorbiaceae	*	*Euphorbia* spp.			
Rutaceae		*Geijera parviflora*	Wilga		
Geraniaceae		*Geranium solanderi*	Native Geranium		
Fabaceae (Faboideae)		*Glycine tabacina*	Variable Glycine		
Goodeniaceae		*Goodenia cycloptera*	Cut-leaf Goodenia		
Goodeniaceae		*Goodenia pinnatifida*	Scrambled Eggs		
Dilleniaceae		*Hibbertia circumdans*			
Poaceae	*	*Hordeum vulgare*	Barley		
Apiaceae		*Hydrocotyle laxiflora*	Stinking Pennywort		
Asteraceae	*	*Lactuca serriola*	Prickly Lettuce		
Solanaceae	*	*Lycium ferocissimum*	African Boxthorn		
Chenopodiaceae		*Maireana enchylaenoides*	Wingless Fissure-weed		
Fabaceae (Faboideae)	*	*Medicago polymorpha*	Burr Medic		
Cactaceae	*	*Opuntia stricta*	Common Prickly Pear		
Oxalidaceae		*Oxalis perennans*			
Poaceae	*	*Paspalum dilatatum*	Paspalum		
Polygonaceae	*	*Polygonum aviculare*	Wireweed		
Polygonaceae		*Rumex brownii*	Swamp Dock		
Polygonaceae	*	*Rumex crispus*	Curled Dock		
Poaceae		*Rytidosperma racemosum*	Wallaby Grass		
Chenopodiaceae		*Sclerolaena birchii*	Galvanised Burr		
Poaceae	*	*Setaria* spp.			
Malvaceae		*Sida corrugata*	Corrugated Sida		
Verbenaceae	*	*Verbena* spp.			

Family	Exotic	Scientific Name	Common Name	BC Status	EPBC Status
Asteraceae		*Vittadinia cuneata*	A Fuzzweed		
Campanulaceae		*Wahlenbergia communis*	Tufted Bluebell		
Asteraceae	*	*Xanthium spinosum*	Bathurst Burr		

Notes: * – exotic

Fauna species recorded in the investigation area

Class	Family	Exotic	Scientific Name	Common Name	NSW Status	EPBC Status
Aves	Corcoracidae		*Struthidea cinerea*	Apostlebird		
Aves	Artamidae		*Cracticus tibicen*	Australian Magpie		
Aves	Corvidae		*Corvus coronoides*	Australian Raven		
Aves	Cacatuidae		*Eolophus roseicapillus*	Galah		
Aves	Pomatostomidae		*Pomatostomus temporalis temporalis*	Grey-crowned Babbler (eastern subspecies)	V	
Aves	Monarchidae		*Grallina cyanoleuca*	Magpie-lark		
Aves	Psittacidae		*Psephotus varius*	Mulga Parrot		
Aves	Falconidae		*Falco cenchroides*	Nankeen Kestrel		
Aves	Artamidae		*Cracticus nigrogularis*	Pied Butcherbird		
Aves	Artamidae		*Strepera graculina*	Pied Currawong		
Aves	Psittacidae		*Psephotus haematonotus*	Red-rumped Parrot		
Aves	Threskiornithidae		*Threskiornis spinicollis*	Straw-necked Ibis		
Mammalia	Canidae	*	*Vulpes vulpes*	Fox		
Mammalia	Bovidae	*	*Capra hircus*	Goat		
Mammalia	Phascolarctidae		*Phascolarctos cinereus*	Koala	E	E
Reptilia	Scincidae		*Lampropholis delicata*	Dark-flecked Garden Sunskink		
Reptilia	Agamidae		*Amphibolurus muricatus*	Jacky Lizard		

Notes: V – vulnerable species, * – exotic

Appendix C

Assessments of significance

Statutory requirement

The likely significance of impacts on threatened species, populations and ecological communities, or their habitat known or considered likely to occur and be affected by the proposal has been assessed pursuant to Section 7.3 of the BC Act.

An assessment of the likely significance of impacts has been prepared for the following threatened species listed under the BC Act:

– Bluegrass (Dichanthium setosum)
– Slender Darling Pea (*Swainsona murrayana*)
– Koala (Phascolarctos cinereus)
– Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*).

Bluegrass (*Dichanthium setosum*) and Slender Darling Pea (*Swainsona murrayana*)

Bluegrass (*Dichanthium setosum*) and Slender Darling Pea (*Swainsona murrayana*) are listed as vulnerable species under the BC Act and EPBC Act.

Bluegrass (*Dichanthium setosum*) is associated with heavy basaltic black soils and red-brown loams with clay subsoil and occurs on the New England Tablelands, North West Slopes and Plains and the Central Western Slopes of NSW. The species is often found in moderately disturbed areas such as cleared woodland, grassy roadside remnants and highly disturbed pasture. Locally common or found as scattered clumps in broader populations. The extensive distribution and wide environmental tolerances make predictions about suitable habitat difficult (DPIE, 2020b).

Slender Darling Pea (*Swainsona murrayana*) is found throughout NSW on clay-based soils, in remnant native grasslands or grassy woodlands that have been intermittently grazed or cultivated. The species may require some disturbance (DPIE, 2020b).

There is one record of Bluegrass from the locality in the last 20 years, and it is predicted to occur by the desktop review (DPIE, 2020b). Slender Darling Pea was predicted to occur by the desktop review, however there are no local records of this species. (DPIE, 2020b). The proposal would result in impacts to a small area of broadly suitable potential habitat for these species, comprising modified grassland. However, these species are unlikely to occur within the site given the long history of agricultural land use and disturbance and the associated loss of any potential seed from the soil seed bank.

Bluegrass (Dichanthium setosum) and Slender Darling Pea (Swainsona murrayana)
a) In the case of a threatened species, whether the proposed development or activity 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.
Habitat within the site is marginal at best, given the history of agricultural use spanning more than 50 years. The proposal would result in the removal of a small area of broadly suitable, low quality habitat comprising modified grassland for these species, with no known individuals or populations impacted by the proposal. The proposal would also not result in the establishment of any permanent or long-term barriers to movement of potential pollinators or mechanisms of dispersal for these species. Given there are no known occurrences of these species within the study area, the proposal is unlikely to result in an adverse effect on the life cycle of the species such that a viable local population is placed at risk of extinction.
b) In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: (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
Not applicable to these threatened species.
(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,
Not applicable to these threatened species.
c) 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 proposed development or activity and
The proposal would result in the removal and disturbance of a small area of broadly suitable, low quality (given historical agricultural activities) habitat for these species, with no known individuals or populations impacted by the proposal. Works associated with the proposal are likely to be temporary in nature. Once the gathering lines are installed, land impacted would be allowed to return to a state comparable to what is currently present. Works to pad areas would not result in impacts to any habitat for these species. Both of these species are widespread, with Bluegrass (Dichanthium setosum) found on the New England Tablelands, North West Slopes and Plains and the Central Western Slopes of NSW, extending to northern Queensland and Slender Darling Pea (Swainsona murrayana) found throughout NSW, with records in the Jerilderie and Deniliquin areas of the southern riverine plain, the Hay plain as far north as Willandra National Park, near Broken Hill and in various localities between Dubbo and Moree (DPIE, 2020b).

Bluegrass (Dichanthium setosum) and Slender Darling Pea (Swainsona murrayana)
Taking the widespread distribution of these species, the lack of any known records within or close to the investigation area, and the history of disturbance at the site into consideration, the proposal is unlikely to result in a substantial removal or modification of any potential habitat for these species.
(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
The site is within a highly cleared landscape that is dominated by agricultural practices such as cropping and grazing. There are occasional patches of native vegetation throughout the landscape, typically associated with road reserves, travelling stock routes and scattered patches on private land. As outlined above, while broadly suitable habitat for these species is present within the site (ie areas of modified grassland), any such potential habitat would be of low quality, given the disturbance history associated with the site. The proposal would result in impacts to a small area of this habitat. The clearing of modified exotic understorey vegetation from the site will not result in fragmentation or isolation of any known or potential habitat for these species and would instead result in the reduction in the total available amount of broadly suitable habitat for these species from within the locality. The proposal would also not result in the establishment of any permanent or long-term barriers to movement of potential pollinators or mechanisms of dispersal for these species.
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
As outlined above, the site represents a small area of poor quality potential habitat for these species. There are no known previous records of these species within the site, nor were they recorded during the field surveys. Both of these species are widespread, with Bluegrass found on the New England Tablelands, North West Slopes and Plains and the Central Western Slopes of NSW, extending to northern Queensland and Slender Darling Pea found throughout NSW, with records in the Jerilderie and Deniliquin areas of the southern riverine plain, the Hay plain as far north as Willandra National Park, near Broken Hill and in various localities between Dubbo and Moree (DPIE, 2020b). The proposal would not result in any impacts to any of the known areas of occurrence of these species. The proposal would result in impacts to a small amount of potential habitat for these species, that, when considered in terms of the known range of these species, and lack of local populations, is unlikely to be of importance to these species. While these species are known to occur in disturbed sites, including those that have been subject to cropping and grazing (DPIE, 2020b), the intensity of agricultural practices within the site is likely to mean that the site comprises very poor quality habitat and there is a low likelihood of them actually occurring, despite the presence of broadly suitable habitat. There are other areas within the locality where these species are more likely to occur, such as the various road reserves and TSRs (as shown on Figure 1.1), which have not been subject to such extensive disturbance. Removal of a small area of modified, low quality potential habitat is unlikely to be important for the persistence of the species in the locality, as there is only one record of one of these species from the locality in the last 20 years. The proposal is unlikely to result in any modification to known habitat for this species, and is unlikely to impact on any aspect of the life cycle of known populations of these species. Taking these points into consideration, the proposal is unlikely to result in impacts to potential habitat that is important to the long-term survival of these species in the locality.
d) whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),
The proposal will not have an impact on areas of outstanding biodiversity value.
e) Whether the proposed development or activity constitutes or is part of a key threatening process or is likely to increase the impact of, a key threatening process
The proposal has the potential to introduce or increase the operation of the following KTP of relevance to these species through soil disturbance and increased visitation to the area: Invasion of plant communities by perennial exotic grasses The proposal has the potential to introduce new species of weeds that are not already present, some of which are particularly prone to invading disturbed roadside edges, and which are not already present within the investigation area. Mitigation measures to minimise indirect impacts, including the introduction or further spread of weeds and pathogens, would be included in the CEMP (see section 5).
Conclusion of Assessment of Significance
Based on consideration of the above criteria, the proposal is unlikely to have a significant effect on any local occurrence of Bluegrass or Slender Darling Pea, pursuant to Section 7.3 of the BC Act, given: – The proposal would not result in any impacts to known occurrences of these species, and is unlikely to result in an adverse effect on the life cycle of the species such that a viable local population is placed at risk of extinction. – The proposal would only result in the removal of a small area of low quality habitat for these species, with no known individuals, populations or known habitat for these species impacted by the proposal.

Bluegrass (Dichanthium setosum) and Slender Darling Pea (Swainsona murrayana)
– The proposal will not result in fragmentation or isolation of any known or potential habitat for these species. – The proposal would not result in the establishment of any permanent or long-term barriers to movement of potential pollinators or seed dispersal agents for these species. – The vegetation to be removed represents low quality potential habitat at best, and is unlikely to be important to the long term persistence of these species in the locality. Consequently, a species impact statement would not be required for Bluegrass or Slender Darling Pea.

Koala (Phascolarctos cinereus)

The Koala (*Phascolarctos cinereus*) is listed as an endangered species under the BC Act and EPBC Act. The species was positively identified on site via scat (faecal pellet) analysis, with scats found under six trees within the study area. No Koalas were observed during the field survey, but individuals are often observed in and around the investigation area (M Rodgers, Santos Land Access Manager, *pers comm.*). Mr Rodgers noted that due to the current drought conditions, local Koalas were likely to have moved into the more vegetated, hilly portions of the locality, to the south of the site, to seek shelter, but that local landowners were still reporting observations of individuals.

There are known feed tree/use tree species for the Koala within the investigation area (White Cypress Pine; *Callitris glaucophylla,* White Box; *Eucalyptus albens* and Bimble Box; *Eucalyptus populnea*) as defined by State Environmental Planning Policy (Biodiversity and Conservation) 2021 and OEH (2018).

The proposal would not remove any feed tree species for the Koala. The proponent has indicated that exclusion zones would be established around feed tree species for the Koala, and they will be protected from impacts during the construction phase of the proposal.

Koala (Phascolarctos cinereus)
a) In the case of a threatened species, whether the proposed development or activity is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.
The Koala was positively identified on site via scat (faecal pellet) analysis, with scats found under six isolated paddock trees within the study area. Koalas use the site for foraging and are likely to move between nearby intact native vegetation, via paddock trees within the site. As such, paddock trees within the site are important for facilitating dispersal of the species, including movements of young animals, and of males seeking mates throughout an over-cleared landscape. There are existing disturbances at the site, including regular vehicle movements associated with routine maintenance of the existing infrastructure and agricultural activities. The proposed works would not result in a substantial long-term increase to the level of disturbance experienced on site. Given the highly cleared landscape in which the site exists, all feed tree species for the Koala are important for their continued persistence in the locality. Any removal of feed trees from the site would result in a loss of stepping stone habitat and may impact the species' ability to move throughout the landscape, in turn, disrupting their life cycle. No feed tree species would be removed as a result of the proposal, and the proposal would not result in the creation of any barriers to movement for the species. As such, their life cycle should not be impacted long term. There may be some increased disturbance to the species during construction of the proposal, and an increase in vehicle movements on site which would increase the risk of mortality as a result of vehicle strike. Mitigation measures are included in section 7 to limit the potential risk to the species. Assuming there would be no change to the species ability to move throughout the landscape as a result of the proposal, the proposal is unlikely to impact the lifecycle of the species such that a viable local population is placed at risk of extinction.
b) In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: (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
Not applicable to these threatened species.
(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,
Not applicable to these threatened species.
c) 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 proposed development or activity, and

Koala (Phascolarctos cinereus)
An exclusion zone would be established around feed tree species for the Koala during the construction process. This would ensure that species used by the Koala for foraging, shelter and dispersal would be retained on site, and would be protected through the creation of exclusion zones throughout the construction phase, which would enable their continued movement throughout the landscape. There would be a temporary increase in the amount of personnel and vehicles on site during the construction phase of the project. This would result in additional noise, and potential additional stress for any individuals using or passing through the site. There would also be an increase in the risk of vehicle strike during the construction phase, as well as during operation of the infrastructure when site personnel are present on site. Habitat on site is already modified as a result of historical agricultural activities, and there is existing gas infrastructure present on site. The proposal will not result in the establishment of any new barriers to movement for the species, or further fragment or isolate potential habitat for this species. Mitigation measures are provided to limit the risk of substantial impacts to the species. No habitat would be removed or permanently modified for the Koala as a result of the proposal.
(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
An exclusion zone would be established around feed tree species for the Koala during the construction process. This would ensure that species used by the Koala for foraging, shelter and dispersal would be retained on site, which would enable their continued movement through the landscape. The site exists in a highly cleared landscape, and all remaining feed trees are of high importance for enabling Koala movement through the locality. No Koala feed trees would be removed as a result of the proposal. There would be no permanent or long-term barriers to movement created for this species as a result of the proposal.
(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,
Taking into consideration the impacts of the 2019/2020 bushfires on Koala populations in NSW, all habitat trees and dispersal corridors are regarded as important to the long-term survival of the species. Based on the number of scats found during the site visit, the scats located during the previous field survey (Alison Hunt and Associates, 2010), and the verbal accounts provided by Mark Rodgers (Santos Land Access manager) the trees within the study area are being used by Koalas on a regular basis for foraging and to disperse through the landscape. As such, they are considered to be important to the long-term survival of the species in the locality. The proposal would avoid impacts to all Koala feed tree species at the site, and would not impose any barriers to movement, which would allow the species to continue to move throughout the landscape. Taking these points into consideration, the proposal is unlikely to result in impacts to potential habitat that is important to the long-term survival of this species in the locality.
d) whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),
The proposal will not have an impact on areas of outstanding biodiversity value.
e) Whether the proposed development or activity constitutes or is part of a key threatening process or is likely to increase the impact of, a key threatening process
The proposal has the potential to introduce or increase the operation of the following KTPs of relevance to this species through soil disturbance and increased visitation to the area: Infection of native plants by Phytophthora cinnamomi and Myrtle Rust. Mitigation measures to minimise indirect impacts, including the introduction or further spread of weeds and pathogens, would be included in the CEMP (see section 5).
Conclusion of Assessment of Significance
Based on consideration of the above criteria, the proposal is unlikely to have a significant effect on the local occurrence of the Koala, pursuant to Section 7.3 of the BC Act, given: – The proposal is unlikely to impact the species life cycle such that a viable local population is placed at risk of extinction. – No feed trees or trees used for movement and refuge at the site would be removed. – The proposal would not result in the permanent isolation or fragmentation of any areas of habitat for this species or form a barrier to movement between areas of habitat. Consequently, a species impact statement would not be required for the Koala. Mitigation measures to minimise potential residual impacts on this species would be included in the CEMP (see section 7).

Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*)

The Grey-crowned Babbler is listed as a vulnerable species under the BC Act. A group of four individuals were observed foraging in scattered paddock trees along a fence, about 2 kilometres to the north of the site during the field survey. Given the presence of comparable habitat on the site, a conservative approach has been taken and the species has been assumed to forage within the site on occasion as well.

The species would not nest within the study area, given the lack of intact native vegetation that would provide suitable nesting habitat for a family group, but would likely forage within the site as part of a wider home range.

Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*)
a) In the case of a threatened species, whether the proposed development or activity 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.
A group of four individuals were observed foraging in scattered paddock trees along a fence, about 2 km to the north of the site during the field survey. Given the presence of comparable habitat on the site, the species is assumed to forage within the site on occasion as well. There are 16 records of this species from the locality in the last 20 years (DPIE, 2020a), but it is likely that this is an underestimate of the local population size. Given the species was observed about 2 km to the north of the site, the site itself would make up only a small proportion of the home range of a family group of these relatively mobile birds, which have territories that range from one to fifty hectares, but which are usually around ten hectares (DPIE, 2020b). There is only limited foraging habitat for this species in the study area given the existing degree of disturbance and highly cleared landscape in which the site lies. The species would likely utilise areas under paddock trees and areas of modified grassland to forage in but would not breed on the site. Given the home range of the species, and that it was not actually observed on site, and there would be no impacts on any nest sites, the proposal is unlikely to impact the lifecycle of the species such that a viable local population is placed at risk of extinction.
b) In the case of an endangered ecological community or critically endangered ecological community, whether the proposed development or activity: (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
Not applicable to these threatened species.
(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,
Not applicable to these threatened species.
c) 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 proposed development or activity and
The proposal would result in impacts to a small area of modified grassland, which represents potential foraging habitat for this species. This potential foraging habitat is already in a disturbed state, as a result of historical agricultural activities within the site. The species would likely utilise areas under paddock trees and areas of modified grassland to forage in but would not breed on the site. Paddock trees would be avoided wherever practicable, which in turn would limit the potential for impacts on habitat for this species. The proposal would not result in any impacts to paddock trees, or to any nesting areas for the species.
(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and
The site sits within a highly cleared landscape, where patches of native vegetation are already heavily fragmented. Many of the wildlife corridors in the locality would be associated with road reserves and TSRs, that link larger patches of vegetation within the reserve network, in addition to patches of vegetation within private land. The proposal would result in a small reduction in the amount of modified grassland, which represents potential foraging habitat for this species. Clearing of this exotic vegetation for the proposal is unlikely to result in the fragmentation of habitat for this species given its mobility and typically relatively large home ranges. There would be no impact to nesting habitat for this species. There would be no permanent or long-term barriers to movement for this species as a result of the proposal.

Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*)
(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,
The proposal would impact a small area of modified grassland, which represents potential foraging habitat for this species. There would be no impact to nesting habitat for this species as a result of the proposal, and no fragmentation or isolation of habitat. There are 16 records of this species from the locality in the last 20 years (DPIE, 2020a), but it is likely that this is an underestimate of the local population size. Given the species was observed about 2 km to the north of the site, the site itself would make up only a small proportion of the home range of a family group of these relatively mobile birds, which have territories that range from one to fifty hectares, but which are usually around ten hectares (DPIE, 2020b). Foraging habitat within the site represents a very small amount of available potential habitat for the species within the locality. The small area of vegetation within the site is not likely to be important for the persistence of the species in the locality because of the absence of suitable breeding habitat. The species would feed occasionally in the site but would not depend solely on the site for its foraging habitats. Impacts on potential habitat for this species are likely to be temporary in nature, restricted to impacts to areas of modified grassland during the construction phase of the proposal. The most important likely habitat components for this species within the site comprise paddock trees and the associated understorey, leaf litter and fallen timber that occur below them These areas would be avoided wherever practicable. Taking these points into consideration, the proposal is unlikely to result in impacts to potential habitat that is important to the long-term survival of this species in the locality.
d) whether the proposed development or activity is likely to have an adverse effect on any declared area of outstanding biodiversity value (either directly or indirectly),
The proposal will not have an impact on areas of outstanding biodiversity value.
e) Whether the proposed development or activity constitutes or is part of a key threatening process or is likely to increase the impact of, a key threatening process
The proposal has the potential to introduce or increase the operation of the following KTPs of relevance to this species through soil disturbance and increased visitation to the area: Infection of native plants by *Phytophthora cinnamomi* and Myrtle Rust. Pathogens such as these are relevant to this species as they have the potential to impact paddock trees, which are used by the Grey-crowned Babbler. Mitigation measures to minimise indirect impacts, including the introduction or further spread of weeds and pathogens, would be included in the CEMP (see section 5).
Conclusion of Assessment of Significance
Based on consideration of the above criteria, the proposal is unlikely to have a significant effect on the local occurrence of the Grey-crowned Babbler, pursuant to Section 7.3 of the BC Act, given: – No breeding habitat would be removed. – The proposal would result in the removal of a small area of potential foraging habitat, comprising modified exotic grassland. – The proposal would not result in the permanent isolation or fragmentation of any areas of potential habitat for this species. – Vegetation proposed for removal is not likely to be important for the persistence of the species in the locality. Consequently, a species impact statement would not be required for the Grey-crowned Babbler. Mitigation measures to minimise residual impacts on this species or potential habitat would be included in the CEMP (see section 5).

Appendix D

Koala scat identification report

SCATSABOUT ECOLOGICAL

Georgeanna Story

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Level 15 133 Castlereagh Street
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[redacted]

Re: Gunnedah scat samples

Below are the results for the scat samples collected from a site at Gunnedah of possible koala origin.

The criteria used to distinguish between koala from possums were:

- Oval shape with rounded or pointed ends.
- Ridged surface
- Hardness of scat
- Eucalyptus odour
- Usually an absence of grooming hair in koala scats, possum scats frequently include grooming hair
- Scat content of finely leaf fragments

Older samples that displayed a majority but not all characteristics were identified as probable.

No.	Site	Site	Species	Species
1	Gunnedah	A	Phascolarctos cinereus (probable)	Sheep/goat
2	Gunnedah	B	Phascolarctos cinereus	
3	Gunnedah	C	Phascolarctos cinereus	
4	Gunnedah	D	Phascolarctos cinereus	
5	Gunnedah	E	Phascolarctos cinereus	
6	Gunnedah	F	Phascolarctos cinereus (probable)	

Please let me know if you have any questions regarding the results.

Kind regards
[redacted]

ghd.com

→ The Power of Commitment

Appendix H

Aboriginal heritage report

View northeast of a portion of the study area on Milroy Road.

Aboriginal Heritage Due Diligence Assessment Report

Gunnedah Work Program

Gunnedah Shire Council Local Government Area (LGA), NSW.

May 2022

Report prepared by

OzArk Environment & Heritage

for Santos (QNT) Pty Ltd

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DOCUMENT CONTROLS

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Document Description	Aboriginal Due Diligence Assessment: Gunnedah Works Program, Gunnedah Shire Council Local Government Area (LGA), NSW.		
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Acknowledgement

OzArk acknowledge the traditional custodians of the area on which this assessment took place and pay respect to their beliefs, cultural heritage, and continuing connection with the land. We also acknowledge and pay respect to the post-contact experiences of Aboriginal people with attachment to the area and to the Elders, past and present, as the next generation of role models and vessels for memories, traditions, culture and hopes of local Aboriginal people.

EXECUTIVE SUMMARY

OzArk Environment & Heritage (OzArk) has been engaged by Santos Pty Ltd (Santos) to complete an Aboriginal due diligence heritage assessment for the Gunnedah Works Program (the proposal). The proposal is in the Gunnedah Shire Council Local Government Area (LGA).

The visual inspection of the study areas was undertaken by OzArk Director, Doctor Jodie Benton, on 29 and 30 March 2022. No members of the local Aboriginal Community were present during the visual inspection.

No Aboriginal objects were recorded because of this assessment, although four previously recorded Aboriginal sites, all modified trees, were located. Of these, only two are within five metres (m) of the proposed seismic line and will require the implementation of management measures to ensure they are protected.

The undertaking of the due diligence process resulted in the conclusion that the proposed works will have an impact on the ground surface, however, no Aboriginal objects or intact archaeological deposits will be harmed by the proposal. This moves the proposal to the following outcome:

> *Aboriginal Heritage Impact Permit (AHIP) application not necessary. Proceed with caution. If any Aboriginal objects are found, stop work, and notify Heritage NSW* (02 9873 8500; heritagemailbox@environment.nsw.gov.au). *If human remains are found, stop work, secure the site, and notify NSW Police and Heritage NSW.*

To ensure the greatest possible protection to the area's Aboriginal cultural heritage values, the following recommendations are made:

1) The proposed work may proceed at the Gunnedah Works Programs project without further archaeological investigation under the following conditions:

    a) All land and ground disturbance activities must be confined to within the study areas, as this will eliminate the risk of harm to Aboriginal objects in adjacent landforms. Should the parameters of the proposal extend beyond the assessed areas, then further archaeological assessment may be required.

    b) All staff and contractors involved in the proposed work should be made aware of the legislative protection requirements for all Aboriginal sites and objects.

2) This assessment has concluded that there is a low likelihood that the proposed work will adversely harm Aboriginal cultural heritage items or sites. If during works, however, Aboriginal artefacts or skeletal material are noted, all work should cease and the procedures in the *Unanticipated Finds Protocol* (**Appendix 2**) should be followed.

3) AHIMS sites 29-1-0113 and 29-1-0117, both modified trees, are within 5 m of the proposed seismic line (coordinates provided in **Table 3-2**). These modified trees should

be temporarily fenced off with appropriate signage to indicate a no access area during the seismic work.

4) The work crew should be provided with the location of these AHIMS sites, and the sites must be avoided.

5) Inductions for work crews should include a cultural heritage awareness procedure to ensure they recognise Aboriginal artefacts (see **Appendix 3**) and are aware of the legislative protection of Aboriginal objects under the *National Parks and Wildlife Act 1974* and the contents of the *Unanticipated Finds Protocol.*

6) The information presented here meets the requirements of the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales*. It should be retained as shelf documentation for five years as it may be used to support a defence against prosecution in the event of unanticipated harm to Aboriginal objects.

CONTENTS

FIGURES

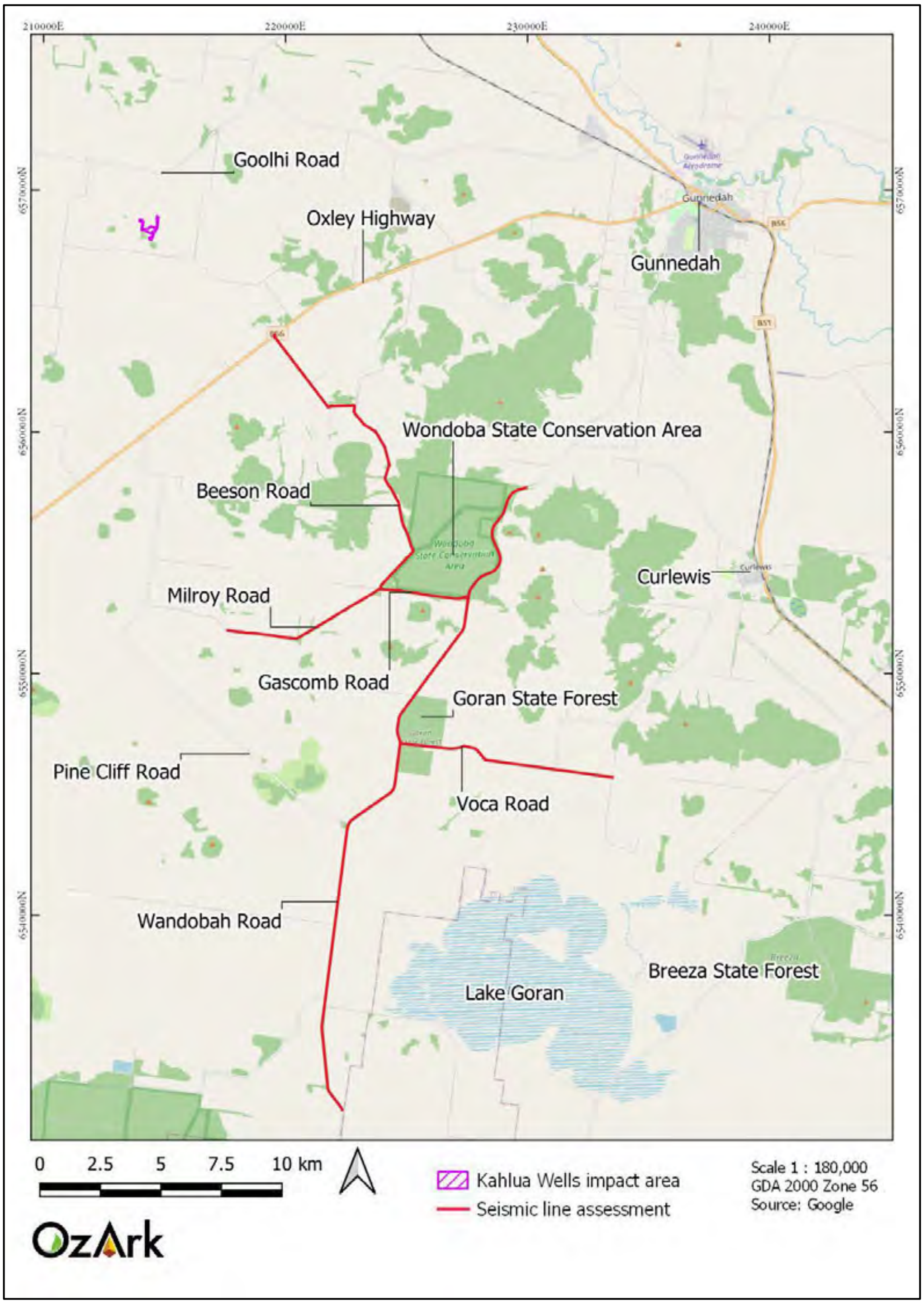
TABLES

1 INTRODUCTION

1.1 BRIEF DESCRIPTION OF THE PROPOSAL

OzArk Environment & Heritage (OzArk) has been engaged by Santos Pty Ltd (Santos) to complete an Aboriginal heritage due diligence assessment for the Gunnedah Works Program (the proposal). The proposal is in the Gunnedah Shire Council Local Government Area (LGA) at multiple locations to the west of Gunnedah, with the closest points being between 13 to 22 kilometres (km) from Gunnedah (**Figure 1-1**).

Figure 1-1. Map showing the location of the proposal.



1.2 STUDY AREAS

The proposal includes two work components, and as such, two study areas. The first is the study area for the Kahlua Wells impact area, located approximately 22 km west of Gunnedah and approximately 2 km northwest of the intersection of Marys Mount Road and Collygra Road. The second study area is for the seismic line and extends along multiple road corridors located to the southwest of Gunnedah bordered by the Oxley Highway and Kamilaroi Highway as seen in **Figure 1-1**. The study areas are shown in **Figure 1-2** for the Kahlua Wells impact area and in **Figure 1-3** for the seismic line assessment.

For the seismic line we have anticipated a potential impact width of five metres (m) from the centreline of the road / track along which the lines run, however, OzArk understands that mature vegetation will not be cleared.

1.3 ASSESSMENT APPROACH

Aboriginal cultural heritage

The desktop and visual inspection component for the study area follows the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (due diligence; DECCW 2010). The field inspection followed the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in New South Wales* (OEH 2011).

Figure 1-2: Aerial showing the study area for the Kahlua Wells impact area.

Figure 1-3: Aerial showing the study area for the seismic line assessment.

2 ABORIGINAL DUE DILIGENCE ASSESSMENT

2.1 INTRODUCTION

Section 57 of the National Parks and Wildlife Regulation 2019 (NPW Regulation) made under the *National Parks and Wildlife Act 1974* (NPW Act) advocates a due diligence process to determining likely impacts on Aboriginal objects. Carrying out due diligence provides a defence to the offence of harming Aboriginal objects and is an important step in satisfying Aboriginal heritage obligations in NSW.

2.2 DEFENCES UNDER THE NPW REGULATION 2019

2.2.1 Low impact activities

The first step before application of the due diligence process itself is to determine whether the proposed activity is a "low impact activity" for which there is a defence in the NPW Regulation. The exemptions are listed in Section 58 of the NPW Regulation (DECCW 2010: 6).

The nature of the proposed work varies between the two study areas assessed in this report. The works being proposed for the Kahlua Wells study area involve the reactivation of the well site. A document provided by Santos providing a description of works which occur at well sites describes various earthworks, as well as civil and access works that could occur. As the Kahlua Wells site is a pre-existing site, works there could potentially involve the construction, upgrading and/or maintenance works for infrastructure such as roads, water bores, storage pads and / or traffic infrastructure. As such, the activities being undertaken by Santos at the Kahlua Wells impact area are not considered a 'low impact activity' for which there is a defence under Section 58 of the NPW Regulation and the due diligence process must be applied.

The seismic line assessment will be the subject of seismic survey work. This activity is considered a low impact activity under Section 58 of the NPW Regulation. However, a description of the works provided by Santos mentions the use of bulldozers or graders, which is not considered a low impact activity. In addition to this, this defence does not apply to situations where there is reason to suspect that an Aboriginal object may be present. As the proposed work is occurring in road corridors with known, previously recorded Aboriginal sites such as culturally modified trees nearby, the due diligence process must be applied.

2.2.2 Disturbed lands

Relevant to this process is the assessed levels of previous land-use disturbance.

The NPW Regulation Section 58 (DECCW 2010: 18) define disturbed land as follows:

> *Land is disturbed if it has been the subject of a human activity that has changed the land's surface, being changes that remain clear and observable.*

Examples include ploughing, construction of rural infrastructure (such as dams and fences), construction of roads, trails and tracks (including fire trails and tracks and walking tracks), clearing vegetation, construction of buildings and the erection of other structures, construction or installation of utilities and other similar services (such as above or below ground electrical infrastructure, water or sewerage pipelines, stormwater drainage and other similar infrastructure) and construction of earthworks.

As the work occurring at the Kahlua Wells study area is over an established pre-existing well site, portions of the study area are considered disturbed. However, since some proposed work may not be in areas where the land's surface has been changed in a clear and observable manner, the due diligence process must be applied.

The works occurring in the study area for the seismic line assessment are along approximately 50 km of existing roads and access tracks. While the actual road corridors and tracks are clearly disturbed, activities may be in less disturbed land, including vegetated corridors along roads, and consequently the due diligence process must be applied.

In summary, it is determined that the proposal must be assessed under the Due Diligence Code. The reasoning for this determination is set out in **Table 2-1**.

Table 2-1: Determination of whether Due Diligence Code applies.

Item	Reasoning	Answer
Is the activity to be assessed under Division 4.7 (state significant development) or Division 5.2 (state significant infrastructure) of the EP&A Act?	The proposal will be assessed under Part 4 of the EP&A Act.	No
Is the activity exempt from the NPW Act or NPW Regulation?	The proposal is not exempt under this Act or Regulation.	No
Do either or both apply: Is the activity in an Aboriginal place? Have previous investigations that meet the requirements of this Code identified Aboriginal objects?	The activity will not occur in an Aboriginal place. No previous investigations have been undertaken for this proposal.	No
Is the activity a low impact one for which there is a defence in the NPW Regulation?	The proposal is not a low impact activity for which there is a defence in the NPW Regulation.	No
Is the activity occurring entirely within areas that are assessed as 'disturbed lands'?	The proposal is not entirely within areas of high modification.	No
Due Diligence Code of Practice assessment is required		

2.3 Application of the Due Diligence Code of Practice to the proposal

To follow the generic due diligence process, a series of steps in a question/answer flowchart format (DECCW 2010: 10) are applied to the proposed impacts and the study area, and the responses documented.

2.3.1 Step 1

Will the activity disturb the ground surface or any culturally modified trees?

Yes, the proposal will impact the ground surface and may impact culturally modified trees.

The works at Kahlua Wells study area may involve earth works and/or the construction of infrastructure necessary to running the facility. These works would require actions that impact the ground surface. From a desktop level it also appears that there are several trees in this study area. Since it cannot be determined if they are mature and/or native from the desktop review, it is possible they may be both, and could potentially be culturally modified. As such it is possible that culturally modified trees may be impacted by the proposal.

The works involved with the seismic line assessment will be occurring in road corridors and access tracks, including those bordering or within the Wondoba State Conservation Area. As such, it is possible that direct or indirect impact could occur to culturally modified trees as there is an abundance of mature, native vegetation in the area.

2.3.2 Step 2a

Are there any relevant confirmed site records or other associated landscape feature information on AHIMS?

There are no previously recorded sites within the Kahlua Wells study area, however, there are recorded sites within proximity of the proposed seismic line.

A search of the Aboriginal Heritage Information Management System (AHIMS) on 24 March 2022 was undertaken over Eastings 206000–235000 and Northings 6529600–6571600 (GDA Zone 56) covering an approximate area of 29 km by 42 km centred on the study areas. The search returned 65 previously registered Aboriginal sites within the search area.

Artefact scatters represent the most frequent site type in the search area, accounting for 29 of the 65 results (44.6%). The next most frequent site type, which accounts for 25 of the 65 registered sites, are culturally modified trees (38.5%). When accounting for sites with multiple site features, these counts become 30 (46.15%) for artefact scatters and 26 for culturally modified trees (40%). Other site types registered in this area include grinding grooves (four sites; 6.2%) and isolated finds (three sites; 4.6%). Three other site types are registered to be within the search area including an artefact site (unspecified quantity), a site with both a burial and a stone arrangement, and a site recorded as a resource and gathering site. Each of these site types account for 1 of the 65 returned results (each accounting for 1.5% of sites).

Figure 2-1 shows all previously recorded sites in relation to the study area and **Table 2-2** shows the types of sites that are close to the study area.

While there are no previously recorded sites registered on the AHIMS database that are located directly within either of the study areas, there are six sites close to the seismic study area to warrant ground-truthing to ensure that they are not going to be at risk of harm from the proposal (AHIMS sites 29-1-0119, 29-1-0122, 29-1-0117, 29-1-0116, 29-1-0114, and 29-1-0113).

Table 2-2: Site types and frequencies of AHIMS sites near the study area.

Site Type	Number	% Frequency
Artefact site (unspecified quantity)	1	1.5
Artefact scatter	29	44.6
Artefacts scatter & culturally modified tree	1	1.5
Burial & stone arrangement	1	1.5
Grinding grooves	4	6.2
Isolated find	3	4.6
Culturally modified tree	25	38.5
Resource & gathering	1	1.5
Total	**65**	**100**

Based on the available data, the most likely site type for previously unrecorded Aboriginal sites and objects would be artefact scatters or culturally modified trees. Due to the nature of isolated finds, these are also a likely site type despite their low frequency in the AHIMS search results. If present, isolated finds and artefact scatters are likely to be located on flat or plains landforms, while modified trees may be present where mature native remnant vegetation is located. The likelihood of finding unrecorded culturally modified trees is higher within the study area for the seismic assessment as it is occurring near a conservation area with a high density of native mature vegetation.

Figure 2-1: Previously recorded sites in relation to the study areas.

2.3.3 Step 2b

Are there any other sources of information of which a person is already aware?

No, there are no other sources of information that would indicate the presence of Aboriginal objects in the study areas.

Ethno-Historic Information

According to Tindale (1974), the proposal falls within the limits of the lands occupied by the Gamilaraay (Kamilaroi) language group and the Namoi River landscape provided plentiful resources for the traditional owners.

The name Gunnedah is derived from an Aboriginal word, meaning 'place of many white stones' and in the past the town had a sizeable outcrop of white stone where the public school now stands in Bloomfield Street. At the end of the 18th century, the Gunn-e-darr people of the Kamilaroi tribe were led by a legendary warrior named Cumbo Gunnerah (Idriess 1953). He was also known as the 'Red Chief', who eventually became immortalised through being the subject of a 1953 novel by Ion Idriess.

Following Oxley's British 'discovery' of the Liverpool Plains in 1817, a runaway convict George Clarke ("The Barber") began the first European settlement of the Boggabri area. According to historical reports, Clarke made first contact with local Aboriginal people and was adopted into the Aboriginal community (Dunlop et al 1957 as cited in Hamm 2005).

In 1831 Mitchell's exploring party, following Clarke's route, came across the Leard Forest. Their native guide "Mr Brown" noticed axe markings called "Mogo" on a number of trees which he described as a sign 'to keep away' (O'Rourke 1995). For further information Michael O'Rourke details an account of Mitchell's crossing in *Raw Possum and Salted Port: Major Mitchell and the Kamilaroi* (O'Rourke 2005).

Previous archaeological assessments

The study areas have not been specifically previously assessed for the proposal, however the AHIMS search detailed in **Section 2.3.2** demonstrates that there has been previous heritage assessment work undertaken in the area of the proposed seismic lines. A selection of studies carried out in the region near to the study areas can provide a general understanding of the archaeological landscape and information on the previously recorded Aboriginal sites close to the seismic lines.

In 1981 the area known as 'Authorisation 138' at 'Springfield' was surveyed by Gorecki (1981). This study recorded three sites located approximately 6.2 km northeast of the north-eastern point of the seismic line study area. The number of artefacts at each site varied, with some locations containing single stone artefacts and others containing clusters of artefacts. All were recorded adjacent to Springfield Knob and relatively close to minor drainage features not unlike the one at the study area. It is important to note that no artefacts were found either upslope in the surrounding hills or downslope on the plains. Gorecki argued that these artefacts were in secondary contexts as agriculture / pastoralism, erosion and construction of contour banks had disturbed their original locations (Gorecki 1981).

Haglund (1984a and 1984b) undertook two studies during 1984 in the vicinity of Gunnedah. The first study (Haglund 1984) consisted of a survey of the proposed Red Hill – Top Rocks – Trunk Road 72 coal haulage route. In this study, Haglund refers to sites previously located at Greenwood Creek (Thompson 1981) and Top Rocks (Haglund 1982), with particular emphasis on 20 axe grinding grooves and an extensive archaeological deposit at Top Rocks. The grinding grooves were situated in the vicinity of sandstone outcrops at the water's edge. The archaeological deposit consisted of stone tools and evidence of manufacturing. Haglund (1984) also examined the proposed location for a coal loader, situated between the north-western railway and Trunk Road 72, 3 km west of Gunnedah. This study, covering 87 ha of cultivated / cleared land, recorded no Aboriginal objects.

In 1985, Haglund conducted a survey of all previous studies relating to the area immediately north of Gunnedah and the Namoi River. This survey concluded that the archaeology of the area is concentrated along rivers and other permanent waterways. This concentration is a result of both prehistoric land use patterns, in which such locations arguably constituted more permanent camps, and historical land use patterns, such as agriculture, which may have disturbed and/or destroyed the archaeology present in areas away from these waterways (Haglund 1985).

Haglund returned to Gunnedah in 1986 to conduct two test excavations of sites requiring ground truthing (Haglund 1987). These sites were located on opposite sides of the Namoi River, and one was a portion of the extensive Namoi River site. Artefacts were recovered at these sites, however, Haglund noted that the artefacts were largely too dispersed to be considered archaeologically significant and were situated in secondary contexts created by vehicle movement and water flows (Haglund 1987).

The AHIMS database search summarised in **Section 2.3.2** and the associated site cards suggests a number of local studies have been conducted within the Wondoba State Conservation Area, which is located in the centre of the northern half of the seismic line study area, north of Goscombe Road. However, no reports are available for these assessments.

Among the studies in the Wondoba State Conservation Area, Red Chief Local Aboriginal Land Council (LALC) has recorded multiple sites, including an artefact scatter, grinding grooves and several culturally modified trees in the conservation area, as well as approximately 6 km south of the conservation area where a further two scarred trees and an artefact scatter were also recorded. Of these recordings, six are in proximity of the seismic line and are discussed further in **Section 3**.

The Walhallow LALC conducted a survey that recorded three culturally modified trees west of the seismic line, on the western side of Wandobah Road, approximately 4.8 km north of the southern extent of the study area.

Tom Griffiths has recorded a further two scarred trees in the same vicinity as part of his archaeological investigation for a Telecom easement (Griffiths 1993), with another survey by Peter Greenwood recorded two artefact scatters and a grinding groove site. These sites are well outside the seismic line easement.

The collective archaeological / scientific evidence from the region suggests that occupation during the late Holocene was centred on small family groups (10 to 15 people) making use of terraces, paleochannels and floodplains as temporary camps as they moved throughout the territory (Purcell 2000; Appleton 2008).

2.3.4 Step 2c

<u>Are there any landscape features that are likely to indicate presence of Aboriginal objects?</u>

Yes, portions of the study areas contain archaeologically sensitive landforms.

The Due Diligence Code (DECCW 2010) specifies a number of landscape features which are most associated with the likely presence of Aboriginal objects, and which therefore require further assessment if present. These are areas that are: within 200 m of waters; located within a sand dune system; located on a ridge top, ridge line or headland; located within 200 m below or above a cliff face; within 20 m of or in a cave, rock shelter, or a cave mouth.

<u>Kahlua Wells study area</u>

The Kahlua Wells study area is located entirely within a flat plain landform. The elevation of this study area is between 300 m and 350 m. The closest major watercourse to the Kahlua Wells study area is Coxs Creek, approximately 9.5 to 10 km west of the study area. There is a minor, unnamed, non-perennial watercourse along the western edge of the study area. Portions of this ephemeral watercourse are located within 100 m of the study area. However, this is a seasonal waterway and does not qualify as 'waters' as set out in the due diligence guidelines. As such, there are no landforms with identified archaeological sensitivity within the study area.

<u>Seismic line assessment study area</u>

Due to the size and expanse of the study area for the seismic line assessment, the proposal is within multiple landform ty[es. From a desktop level, it appears that the two main landforms are flat plains landforms, where the elevation change is more gradual or remains relatively the same over large areas, and slope landforms where there are rolling or undulating slopes and steeper elevation changes.

The seismic line assessment area is in an area of land between two major watercourses, Coxs Creek and Mooki River that are located approximately 14 and 13 km respectively from the study area at their closest points. Most of this study area is also within 100 to 200 m of watercourses of varying nature and permanence. The visual inspection will confirm if these are ephemeral or perennial in nature. As such, portions of this study area are within archaeologically sensitive landforms.

Figure 2-2: Watercourses associated with the study area of Kahlua Wells.

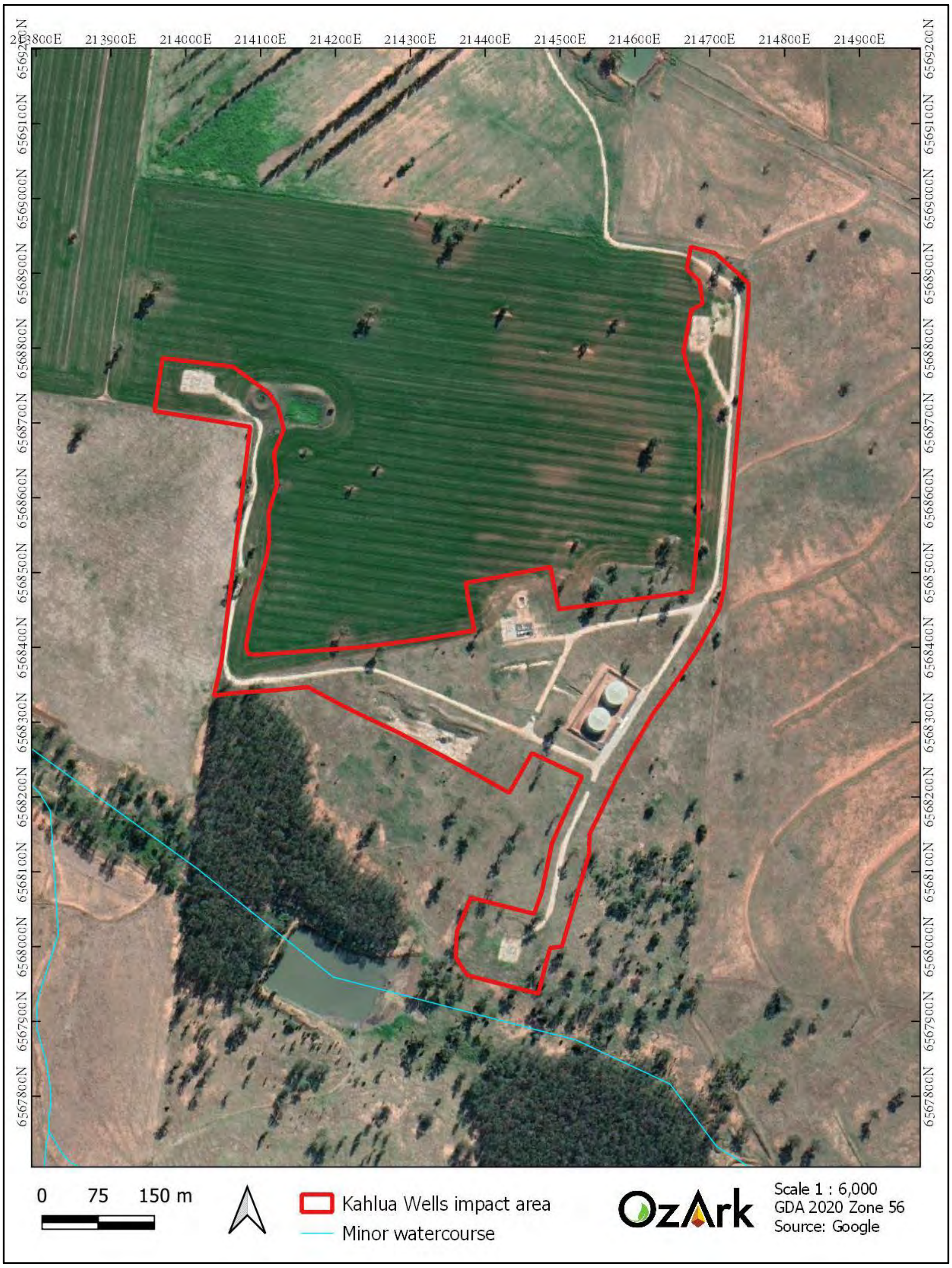
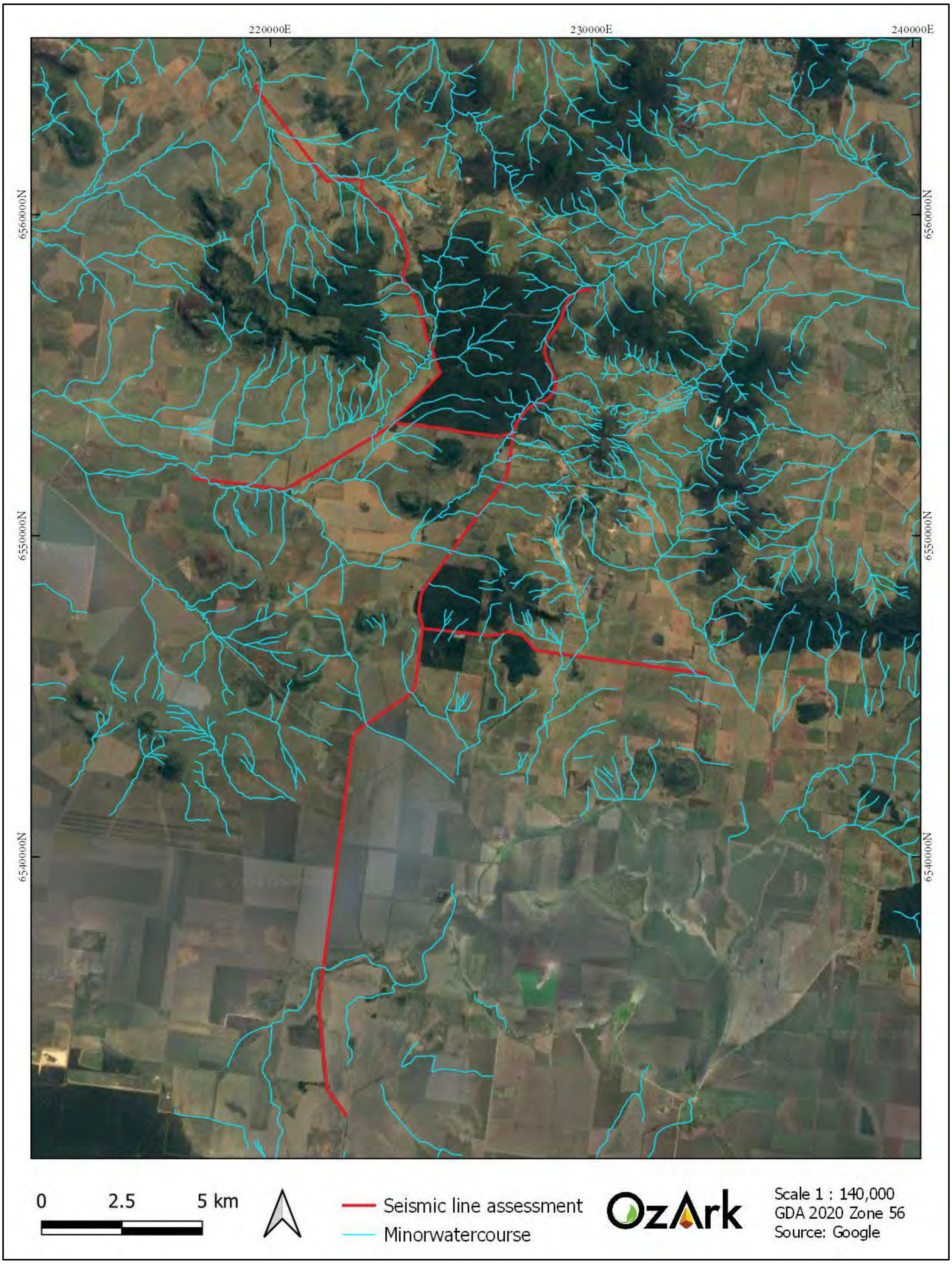


Figure 2-3: Watercourses associated with the study area of the seismic line assessment.



2.3.5 Step 3

Can harm to Aboriginal objects or disturbance of archaeologically sensitive landscape features be avoided?

No. Landforms with identified archaeological sensitivity may be impacted by the proposal.

Grading and the use of heavy machinery along the road corridors is likely to be part of the seismic survey and the ground surface of previously undisturbed portions of sensitive landforms may be impacted by the proposal.

2.3.6 Step 4

Does a desktop assessment and visual inspection confirm that there are Aboriginal objects or that they are likely?

Yes, there are Aboriginal sites or objects in close proximity of the seismic line study area.

The visual inspection of the study areas was undertaken by OzArk Director, Dr Jodie Benton, on 29 and 30 March 2022. No members of the local Aboriginal community were present during the visual inspection. The results for the visual inspection are provided below.

Kahlua Wells impact area

The Kahlua Wells area was assessed via pedestrian transects (**Figure 2-4**). The wells and access tracks are already extant, as is a large quarry area likely used to win the material used for access track establishment. Beyond these areas of high disturbance, the land was either ploughed or covered in chest high weeds / vegetation. It is also relevant that there was a lot of standing water at the time of the assessment, which precluded walking through some areas such as the ploughed paddocks.

This assessment revealed no Aboriginal sites/objects and a high level of prior land use disturbance.

Seismic line assessment area

Due to the relatively low ground impact anticipated for the seismic line survey and as the easement was comprised of formed roads (from formal bitumen roads to dirt tracks), an approach to the visual assessment was devised that included:

- Driving all seismic routes
- Stopping for visual inspections at all locations where previously recorded sites were located or where the road or track crossed a waterway.

In terms of limitations, it is noted that Goscombe Road (which runs along the southern edge of the Wandoba State Conservation Area), was unpassable due to wet conditions, so assessment was made via pedestrian means from each end of the road, leaving the central portion unassessed (**Figure 2-5**).

Figure 2-4: Survey coverage within Kahlua Wells impact area study area.

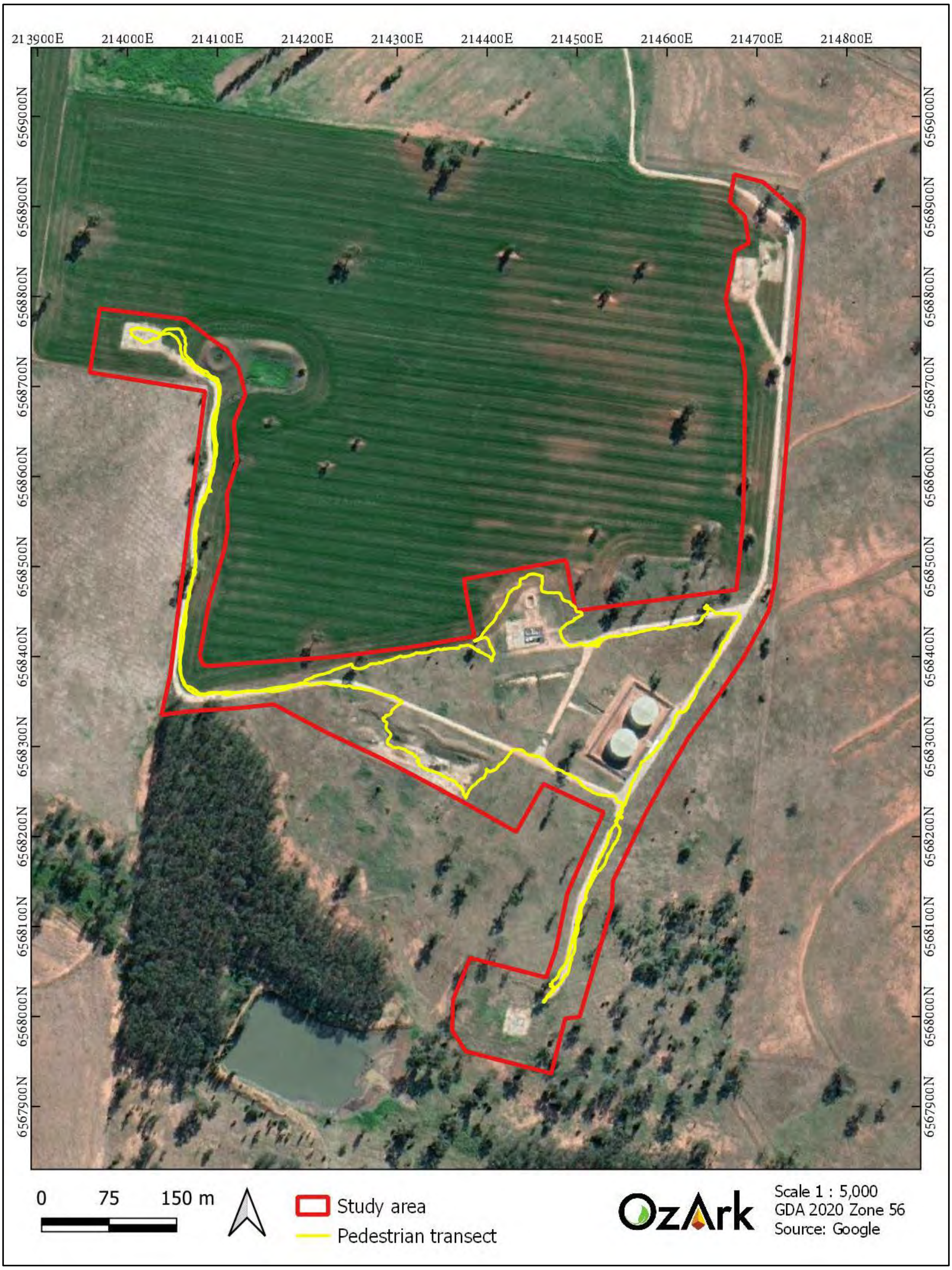


Figure 2-5: Survey coverage of the seismic line assessment study area.

Discussion

No Aboriginal objects were recorded during the assessment. Previously recorded Aboriginal sites along the seismic line can be protected from potential impacts through the implementation of management measures, specifically fencing and inductions as detailed in **Section 4**.

A 'no' answer for Step 4, results in the following outcome (DECCW 2010):

> *AHIP (Aboriginal Heritage Impact Permit) application not necessary. Proceed with caution. If any Aboriginal objects are found, stop work, and notify Heritage NSW (02) 9873 8500 (heritagemailbox@environment.nsw.gov.au). If human remains are found, stop work, secure the site, and notify NSW Police and Heritage NSW.*

2.4 Conclusion

The due diligence process has resulted in the outcome that an Aboriginal Heritage Impact Permit (AHIP) is not required. The reasoning behind this determination is set out in **Table 2-3**.

Table 2-3: Due Diligence Code application.

Step	Reasoning	Answer
Step 1 Will the activity disturb the ground surface or any culturally modified trees?	The proposed works will disturb the ground surface through potential earthworks at the Kahlua Well site The proposal may impact mature, native vegetation and therefore has the potential to harm culturally modified trees.	Yes
If the answer to Step 1 is 'yes', proceed to Step 2		
Step 2a Are there any relevant records of Aboriginal heritage on AHIMS to indicate presence of Aboriginal objects?	AHIMS indicated that there are no Aboriginal sites within the Kahlua Wells study area, although there are some previously recorded Aboriginal sites nearby the seismic line easement. The previously recorded sites are modified trees and impact can be avoided through fencing and inductions and hence they will not be harmed by the proposal.	No
Step 2b Are there other sources of information to indicate presence of Aboriginal objects?	There are no other sources of information to indicate that Aboriginal objects are likely in the study area, although it is noted that there is a general likelihood for landforms in the region to contain Aboriginal objects.	No
Step 2c Will the activity impact landforms with archaeological sensitivity as defined by the Due Diligence Code?	Landforms with identified archaeological sensitivity are present as some seismic line sections are within 200 m of 'waters'.	Yes
If the answer to any stage of Step 2 is 'yes', proceed to Step 3		
Step 3 Can harm to Aboriginal objects listed on AHIMS or identified by other sources of information and/or can the carrying out of the activity at the relevant landscape features be avoided?	The proposal may impact landforms with archaeological sensitivity as identified in the Due Diligence Code: landforms within 200 m of 'waters'; and there are AHIMS sites nearby the seismic line.	No
If the answer to Step 3 is 'no', a visual inspection is required. Proceed to Step 4.		
Step 4 Does the visual inspection confirm that there are Aboriginal objects or that they are likely?	The visual inspection recorded no Aboriginal objects in the study area. Landforms that were identified at a desk-top level as having archaeological sensitivity were found during the inspection to not contain archaeological sites. Modified trees located adjacent to the seismic line can be protected from the proposed works through management measures such as fencing and inductions.	No
Conclusion		
AHIP not necessary. Proceed with caution.		

3 ABORIGINAL HERITAGE SITES RECORDED

No Aboriginal objects were recorded as a result of the visual assessment.

Attempts were made to locate any previously recorded Aboriginal site within 10 m of the seismic line. Six previously recorded Aboriginal sites were in this category, as shown on **Figure 3-1** and listed in **Table 3-1**. Of these, four were located and their coordinates checked, while two were unable to be located and are thought to have the wrong coordinates on AHIMS.

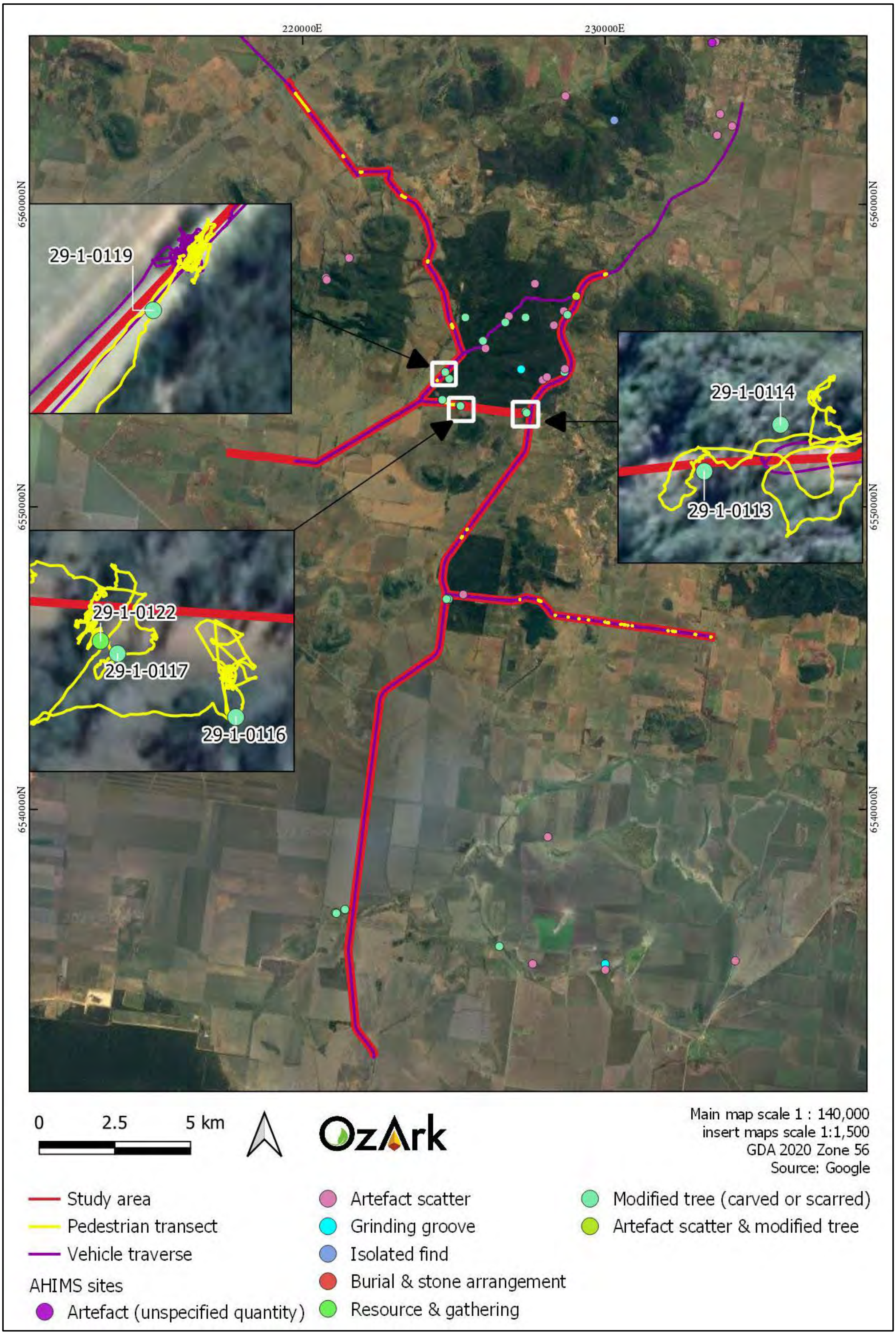
Table 3-1 lists these sites and provides updated coordinates for those that were located, as well as providing management measures to ensure the conservation of these sites in relation to the proposed works.

Table 3-1: AHIMS listed sites near the seismic line, assessment results, and management recommendations.

AHIMS No.	Site Name	Site type	Coordinates (AGD) From site card	New Coordinates (GDA) From 2022 field visit	Image	Management recommendations
29-1-0119	Wandoba Scar Tree 9	Modified Tree	224609E 6554266N	Could not be located at the AHIMS location. From the site card location sketch it is likely that this site is located far to the north of the study area, although this could not be verified.	Site not located	As this tree could not be located, there are no management recommendations. Unlikely that it is at risk from the proposal.
29-1-0117	Wandoba Scar Tree 7	Modified Tree	225084E 6553162N	225187E 6553367N		This tree is approximately 2 m south of Goscombe Rd. The tree should be temporarily fenced prior to seismic activity and crews inducted to ensure no inadvertant impacts occur.
29-1-0122	Wandoba Resource 1	Grass trees	225080E 6553165N	Could not be located at this location. From the site card location sketch it is likely that this site is located north of Goscombe Road within the Wondoba Conservation Area, although this could not be verified.	Site not located	As this tree could not be located, there are no management recommendations.. Unlikely that it is at risk from the proposal.
29-1-0116	Wandoba Scar Tree 6	Modified Tree	225112E 6553147N	225218E 6553350N		This tree is approximately 10 m south of Goscombe Rd. No management required.

AHIMS No.	Site Name	Site type	Coordinates (AGD) From site card	New Coordinates (GDA) From 2022 field visit	Image	Management recommendations
29-1-0113	Wandoba Scar Tree 3	Modified Tree	227261E 6552958N	227368E 6553151N		This tree is approximately 3 m south of Goscombe Rd. The tree should be temporarily fenced prior to seismic activity and crews inducted to ensure no inadvertant impacts occur.
29-1-0114	Wandoba Scar Tree 4	Modified Tree	227279E 6552969N	227397E 6553166N		This tree is approximately 10 m north of Goscombe Rd. No management required.

Figure 3-1: Previously recorded sites within 10 m of seismic line



3.1 Likely impacts to Aboriginal heritage from the proposal

Table 3-2 presents a summary of potential impacts to Aboriginal cultural heritage associated with the proposal. These are based on the understanding that the two previously recorded modified trees within 5 m of the proposed seismic line will be fenced to ensure no inadvertent impacts and that work crew inductions will be undertaken as per the recommendations of this report.

Table 3-2: Aboriginal cultural heritage: impact assessment.

Site Name	Type of Harm (Direct/Indirect / None)	Degree of Harm (Total/Partial / None)	Consequence of Harm (Total/Partial/No Loss of Value)
29-1-0117	None	None	No Loss of value if appropriate management is undertaken
29-1-0116	None	None	No Loss of value
29-1-0113	None	None	No Loss of value if appropriate management is undertaken
29-1-0114	None	None	No Loss of value
29-1-0119 29-1-0122	Sites unable to be located during the survey but unlikely to be harmed by the proposal.		

4 MANAGEMENT RECOMMENDATIONS

The undertaking of the due diligence process resulted in the conclusion that the proposed works will have an impact on the ground surface, however, no Aboriginal objects or intact archaeological deposits will be harmed by the proposal. This moves the proposal to the following outcome:

> *AHIP application not necessary. Proceed with caution. If any Aboriginal objects are found, stop work, and notify Heritage NSW (02) 9873 8500 (heritagemailbox @environment.nsw.gov.au). If human remains are found, stop work, secure the site, and notify NSW Police and Heritage NSW.*

To ensure the greatest possible protection to the area's Aboriginal cultural heritage values, the following recommendations are made:

1) The proposed work may proceed at the Gunnedah Works Programs project without further archaeological investigation under the following conditions:
   a) All land and ground disturbance activities must be confined to within the study areas, as this will eliminate the risk of harm to Aboriginal objects in adjacent landforms. Should the parameters of the proposal extend beyond the assessed areas, then further archaeological assessment may be required.
   b) All staff and contractors involved in the proposed work should be made aware of the legislative protection requirements for all Aboriginal sites and objects.
2) This assessment has concluded that there is a low likelihood that the proposed work will adversely harm Aboriginal cultural heritage items or sites. If during works, however, Aboriginal artefacts or skeletal material are noted, all work should cease and the procedures in the *Unanticipated Finds Protocol* (**Appendix 2**) should be followed.
3) AHIMS sites 29-1-0113 and 29-1-0117, both modified trees, are within 5 m of the proposed seismic line (coordinates provided in **Table 3-2**). These modified trees should be temporarily fenced off with appropriate signage to indicate a no access area during the seismic work.
4) The work crew should be provided with the location of these AHIMS sites, and the sites must be avoided.
5) Inductions for work crews should include a cultural heritage awareness procedure to ensure they recognise Aboriginal artefacts (see **Appendix 3**) and are aware of the legislative protection of Aboriginal objects under the NPW Act and the contents of the *Unanticipated Finds Protocol.*
6) The information presented here meets the requirements of the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales*. It should be retained

as shelf documentation for five years as it may be used to support a defence against prosecution in the event of unanticipated harm to Aboriginal objects.

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APPENDIX 1: AHIMS SEARCH RESULTS

AHIMS Web Services (AWS)
Extensive search - Site list report

Your Ref/PO Number : Gunnedah Santos
Client Service ID : 670321

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status **	SiteFeatures	SiteTypes	Reports
29-2-0272	Wondoba Grinding Grooves 1 - Duplicate of 29-1-0092	AGD	56	227119	6554359	Open site	Valid	Grinding Groove : 3		
	Contact	Recorders	Ms.Dapline Cubby					Permits		
29-1-0129	Wondoba Artefact 7	AGD	56	228200	6555816	Open site	Valid	Artefact : 11		
	Contact Searle	Recorders	Mr.Peter Beale					Permits		
17-1-0049	Sunnyside AS2	GDA	56	224497	6567811	Open site	Valid	Artefact : 2		
	Contact	Recorders	Mr.John Appleton,Doctor.Matthew Whincop,Doctor.Matthew Whincop,Whincop Ar					Permits		
29-1-0122	Wondoba Resource 1	AGD	56	225080	6553165	Open site	Valid	Aboriginal Resource and Gathering : 10		
	Contact Searle	Recorders	Mr.Peter Beale					Permits		
29-1-0290	Goran Lake Scarred tree	GDA	56	226505	6535471	Closed site	Valid	Modified Tree (Carved or Scarred) : -		
	Contact	Recorders	Mr.Wade Natty,Yawiriawiri Murri Ganuur Descendant Aboriginal Corporation					Permits		
29-1-0131	Wondoba Artefact 9	AGD	56	225938	6555052	Open site	Valid	Artefact : 22		
	Contact Searle	Recorders	Mr.Peter Beale					Permits		
20-4-0815	Sunnyside IA2	GDA	56	224223	6567558	Open site	Valid	Artefact : -		
	Contact	Recorders	Doctor.Matthew Whincop,Whincop Archaeology Pty Ltd					Permits		
29-1-0124	Wondoba Artefact 2	AGD	56	227829	6554009	Open site	Valid	Artefact : 7		
	Contact Searle	Recorders	Mr.Trent Colley					Permits		
29-1-0114	Wondoba Scar tree 4	AGD	56	227279	6552969	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact Searle	Recorders	Mr.Leonard Talbott					Permits		
29-2-0274	Wondoba North Scar Tree 2	AGD	56	227263	6556075	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact	Recorders	Ms.Daphne Cubby					Permits		
29-1-0080	BBS; Walhallow LALC; Red Bobs 2	AGD	56	220989	6536401	Open site	Valid	Modified Tree (Carved or Scarred) : 1		98931
	Contact	Recorders	Archaeological Surveys & Salvage ,Walhallow LALC - BBS survey team					Permits		
29-1-0009	Howes Hill;	AGD	56	227500	6534700	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	P.W Greenwood					Permits		
29-1-0139	GDRF-OS1 with PAD	AGD	56	228583	6563399	Open site	Valid	Artefact : 2		101309
	Contact	Recorders	Mr.Phillip Cameron					Permits		
29-1-0015	King Jack Mountain Springfield;	AGD	56	233700	6562800	Open site	Destroyed	Artefact : -	Open Camp Site	342
	Contact	Recorders	Paul Gorecki					Permits		
20-4-0813	Sunnyside GG1	GDA	56	224458	6568219	Open site	Valid	Grinding Groove : -		
	Contact	Recorders	Doctor.Matthew Whincop,Whincop Archaeology Pty Ltd					Permits		

Report generated by AHIMS Web Service on 24/03/2022 for Jodie Benton for the following area at Datum :GDA, Zone : 56, Eastings : 206000.0 - 235000.0, Northings : 6529600.0 - 6571600.0 with a Buffer of 0 meters.. Number of Aboriginal sites and Aboriginal objects found is 65

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Page 1 of 5

AHIMS Web Services (AWS)
Extensive search - Site list report

Your Ref/PO Number : Gunnedah Santos
Client Service ID : 670321

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status **	SiteFeatures	SiteTypes	Reports
29-1-0256	Marshmead3	AGD	56	233547	6565389	Open site	Valid	Artefact : -		
	Contact Ms.Tammy Bush	Recorders	Mr.Patrick Gaynor					Permits		
29-1-0113	Wondoba Scar Tree 3	AGD	56	227261	6552958	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact Searle	Recorders	Mr.Trent Colley					Permits		
29-1-0026	Red Bob's Scarred Tree 3;RB 3;	AGD	56	221290	6536490	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	2734
	Contact	Recorders	Tom Griffiths					Permits		
29-1-0011	Goran Hokey Pokey	AGD	56	229900	6534700	Open site	Valid	Grinding Groove : -	Axe Grinding Groove	344
	Contact	Recorders	P.W Greenwood					Permits		
29-1-0016	King Jack Mountain;	AGD	56	234100	6562400	Open site	Destroyed	Artefact : -	Open Camp Site	342
	Contact	Recorders	Paul Gorecki					Permits		
29-1-0127	Wondoba Artefact 5	AGD	56	226712	6556115	Open site	Valid	Artefact : 14		
	Contact Searle	Recorders	Mr.Peter Beale					Permits		
29-1-0255	Marshmead2	AGD	56	233550	6565188	Open site	Valid	Artefact : -		
	Contact Ms.Tammy Bush	Recorders	Mr.Patrick Gaynor					Permits		
29-1-0088	BBS; Red Chief LALC; Goran SF 2	AGD	56	224716	6546763	Open site	Valid	Modified Tree (Carved or Scarred) : 1		99031
	Contact	Recorders	Archaeological Surveys & Salvage ,Red Cheif LALC - BBS Survey Team					Permits		
20-4-0814	Sunnyside IA1	GDA	56	224311	6567683	Open site	Valid	Artefact : -		
	Contact	Recorders	Doctor.Matthew Whincop,Doctor.Matthew Whincop,Whincop Archaeology Pty Ltd,					Permits		
29-1-0123	Wondoba Artefact 1	AGD	56	227975	6554102	Open site	Valid	Artefact : 23		
	Contact Searle	Recorders	Mr.Leonard Talbott					Permits		
29-1-0128	Wondoba Artefact 6	AGD	56	228528	6556286	Open site	Valid	Artefact : 15		
	Contact Searle	Recorders	Mr.Peter Beale					Permits		
29-1-0089	BBS; Red Chief LALC; Goran SF ST 1	AGD	56	224650	6546763	Open site	Valid	Modified Tree (Carved or Scarred) : 1		99031
	Contact	Recorders	Archaeological Surveys & Salvage ,Red Cheif LALC - BBS Survey Team					Permits		
28-3-0030	Argyle;Kurinyar	AGD	55	778000	6533000	Open site	Valid	Stone Arrangement : -, Burial : -	Burial/s,Stone Arrangement	
	Contact	Recorders	Paul Gorecki					Permits		
29-1-0259	Mt Somner AS2	GDA	56	220769	6357577	Open site	Valid	Artefact : -		
	Contact	Recorders	Doctor.Matthew Whincop,Whincop Archaeology Pty Ltd					Permits		
29-1-0010	Goran Lake;	AGD	56	234200	6534800	Open site	Valid	Artefact : -	Open Camp Site	

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Page 2 of 5

AHIMS Web Services (AWS)
Extensive search - Site list report

Your Ref/PO Number : Gunnedah Santos
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SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status **	SiteFeatures	SiteTypes	Reports
	Contact	Recorders	Mr.Peter Greenwood					Permits		
29-1-0090	BBS; Red Chief LALC; Goran SF 1	AGD	56	225202	6546912	Open site	Valid	Artefact : 3		99031
	Contact	Recorders	Archaeological Surveys & Salvage ,Red Cheif LALC - BBS Survey Team					Permits		
29-1-0081	BBS; Walhallow LALC; Red Bobs 1	AGD	56	220976	6536387	Open site	Valid	Modified Tree (Carved or Scarred) : 1		98931
	Contact	Recorders	Archaeological Surveys & Salvage ,Walhallow LALC - BBS survey team					Permits		
29-1-0003	Goran Lake;	AGD	56	228000	6538900	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Quirindi District Historical Society					Permits		
29-1-0130	Wondoba Artefact 8	AGD	56	228200	6555816	Open site	Valid	Artefact : 8		
	Contact Searle	Recorders	Mr.Peter Beale					Permits		
29-1-0093	BBS; Red Chief LALC; Wondoba SF 3	AGD	56	228938	6556779	Open site	Valid	Artefact : -, Modified Tree (Carved or Scarred) : -		99031
	Contact	Recorders	Archaeological Surveys & Salvage ,Red Cheif LALC - BBS Survey Team					Permits		
29-1-0208	Marshmead 4	GDA	56	233540	6565352	Open site	Valid	Artefact : -		
	Contact	Recorders	PJ Gaynor (consultant),Mr.Patrick Gaynor					Permits		
29-1-0111	Wondoba Scar Tree 1	AGD	56	224737	6554048	Open site	Valid	Modified Tree (Carved or Scarred) : 2		
	Contact Searle	Recorders	Mr.Peter Beale					Permits		
28-3-0096	BBS; Walhallow LALC; Trinky Forest 3	AGD	55	782139	6529933	Open site	Valid	Artefact : 20		98931
	Contact	Recorders	Archaeological Surveys & Salvage ,Walhallow LALC - BBS survey team					Permits		
29-1-0289	Sunnyside AS3	GDA	56	223976	6566869	Open site	Valid	Artefact : -		
	Contact	Recorders	Doctor.Matthew Whincop,Whincop Archaeology Pty Ltd					Permits		
29-1-0138	GDRF-IF1	AGD	56	230196	6562591	Open site	Valid	Artefact : 1		101309
	Contact	Recorders	Mr.Phillip Cameron					Permits		
29-1-0027	Red Bob's Scarred tree 4;RB 4;	AGD	56	221290	6536500	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	2734
	Contact	Recorders	Tom Griffiths					Permits		
29-1-0260	Mt Sommer AS3	GDA	56	221533	6558230	Open site	Valid	Artefact : -		
	Contact	Recorders	Doctor.Matthew Whincop,Whincop Archaeology Pty Ltd					Permits		
29-1-0126	Wondoba Artefact 4	AGD	56	228533	6554287	Open site	Valid	Artefact : 14		
	Contact Searle	Recorders	Mr.Leonard Talbott					Permits		
29-1-0121	Wondoba Scar tree 11	AGD	56	228550	6554268	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact Searle	Recorders	Mr.Trent Colley					Permits		

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Page 3 of 5

AHIMS Web Services (AWS)
Extensive search - Site list report

Your Ref/PO Number : Gunnedah Santos
Client Service ID : 670321

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status **	SiteFeatures	SiteTypes	Reports
29-1-0125	Wondoba Artefact 3	AGD	56	228565	6554374	Open site	Valid	Artefact : 14		
	Contact Searle	Recorders	Mr.Leonard Talbott					Permits		
29-1-0091	BBS; Red Chief LALC; Wondaba SF 1	AGD	56	228649	6556162	Open site	Valid	Modified Tree (Carved or Scarred) : 1		99031
	Contact	Recorders	Archaeological Surveys & Salvage ,Red Cheif LALC - BBS Survey Team					Permits		
29-1-0119	Wondoba Scar tree 9	AGD	56	224609	6554266	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact Searle	Recorders	Mr.Peter Beale					Permits		
20-4-0977	Sunnyside OS1	GDA	56	221649	6567125	Open site	Valid	Artefact : -		
	Contact	Recorders	Doctor.Matthew Whincop,Whincop Archaeology Pty Ltd					Permits		
29-1-0117	Wondoba Scar tree 7	AGD	56	225084	6553162	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact Searle	Recorders	Mr.Peter Beale					Permits		
29-1-0120	Wondoba Scar tree 10	AGD	56	226593	6555911	Open site	Valid	Modified Tree (Carved or Scarred) : 2		
	Contact Searle	Recorders	Mr.Peter Beale					Permits		
28-3-0151	Melville Hill ST1	GDA	55	783043	6562929	Open site	Valid	Modified Tree (Carved or Scarred) : -		
	Contact	Recorders	Mr.Patrick Gaynor					Permits		
29-1-0116	Wondoba Scar tree 6	AGD	56	225112	6553147	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact Searle	Recorders	Mr.Leonard Talbott,Mr.Peter Beale					Permits		
29-2-0273	Wondoba North Scar Tree 1	AGD	56	225272	6556075	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact	Recorders	Ms.Daphne Cubby					Permits		
29-2-0271	Wondoba North Artefact 1	GDA	56	227682	6557379	Open site	Valid	Artefact : 14		
	Contact	Recorders	Ms.Daphne Cubby,Miss.Lucy Blackam					Permits		
29-1-0083	BBS; Walhallow LALC; Trinky Forest 13	AGD	56	216474	6529920	Open site	Valid	Modified Tree (Carved or Scarred) : 1		98931
	Contact	Recorders	Archaeological Surveys & Salvage ,Walhallow LALC - BBS survey team					Permits		
29-1-0079	BBS; Walhallow LALC; Red Bobs 3	AGD	56	221006	6536373	Open site	Valid	Modified Tree (Carved or Scarred) : 1		98931

Report generated by AHIMS Web Service on 24/03/2022 for Jodie Benton for the following area at Datum :GDA, Zone : 56, Eastings : 206000.0 - 235000.0, Northings : 6529600.0 - 6571600.0 with a Buffer of 0 meters.. Number of Aboriginal sites and Aboriginal objects found is 65

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Page 4 of 5

NSW GOVERNMENT

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : Gunnedah Santos

Client Service ID : 670321

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status **	SiteFeatures	SiteTypes	Reports
	Contact	Recorders	Archaeological Surveys & Salvage ,Walhallow LALC - BBS survey team					Permits		
29-1-0258	Mt Sommer AS1	GDA	56	220795	6557509	Open site	Valid	Artefact : -		
	Contact	Recorders	Doctor.Matthew Whincop,Whincop Archaeology Pty Ltd					Permits		
29-1-0092	BBS; Red Chief LALC: Wondaba SI 2, duplicate of 29-02-0272	AGD	56	227119	6554359	Open site	Valid	Grinding Groove : 10		99031
	Contact	Recorders	Archaeological Surveys & Salvage ,Red Cheif LALC - BBS Survey Team					Permits		
29-1-0012	Hokey Pokey Lake Goran	AGD	56	229900	6334500	Open site	Valid	Artefact : -	Open Camp Site	344
	Contact	Recorders	Van Hoen					Permits		
29-1-0118	Wondoba Scar tree 8	AGD	56	225854	6555301	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact Searle	Recorders	Mr.Peter Beale					Permits		
20-4-0538	Torrens Road ST2	GDA	56	234731	6571520	Open site	Valid	Modified Tree (Carved or Scarred) : -		
	Contact Ms.Tammy Bush	Recorders	Mr.Patrick Gaynor					Permits		
29-1-0017	King Jack Mountain Springfield	AGD	56	233600	6362100	Open site	Destroyed	Artefact : -	Open Camp Site	342
	Contact	Recorders	Paul Gorecki					Permits		
28-3-0029	Quinella Dam	AGD	55	783000	6334000	Open site	Valid	Artefact : -	Open Camp Site	344
	Contact	Recorders	Paul Gorecki					Permits		
29-1-0115	Wondoba Scar tree 5	AGD	56	224510	6553350	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact Searle	Recorders	Mr.Trent Colley					Permits		
29-1-0112	Wondoba Scar Tree 2	AGD	56	227298	6352922	Open site	Valid	Modified Tree (Carved or Scarred) : 1		
	Contact Searle	Recorders	Mr.Peter Beale					Permits		

** **Site Status**

Valid - The site has been recorded and accepted onto the system as valid

Destroyed - The site has been completely impacted or harmed usually as consequence of permit activity but sometimes also after natural events. There is nothing left of the site on the ground but proponents should proceed with caution.

Partially Destroyed The site has been only partially impacted or harmed usually as consequence of permit activity but sometimes also after natural events. There might be parts or sections of the original site still present on the ground

Not a site - The site has been originally entered and accepted onto AHIMS as a valid site but after further investigations it was decided it is NOT an aboriginal site. Impact of this type of site does not require permit but Heritage NSW should be notified

Report generated by AHIMS Web Service on 24/03/2022 for Jodie Benton for the following area at Datum :GDA, Zone : 56, Eastings : 206000.0 - 235000.0, Northings : 6529600.0 - 6571600.0 with a Buffer of 0 meters.. Number of Aboriginal sites and Aboriginal objects found is 65

Page 5 of 5

APPENDIX 2: ABORIGINAL HERITAGE: UNANTICIPATED FINDS PROTOCOL

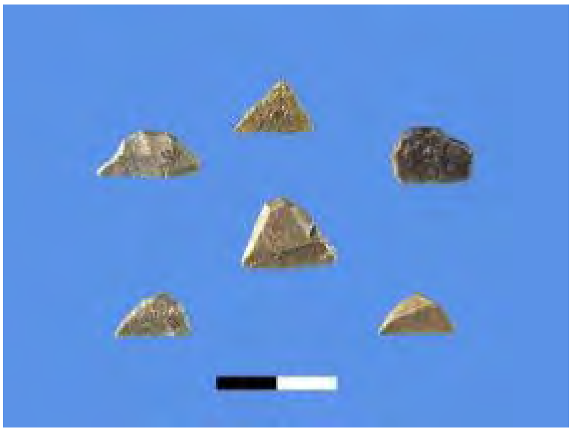
An Aboriginal artefact is anything which is the result of past Aboriginal activity. This includes stone (artefacts, rock engravings etc.), plant (culturally scarred trees) and animal (if showing signs of modification; i.e. smoothing, use). Human bone (skeletal) remains may also be uncovered while onsite.

Cultural heritage significance is assessed by the Aboriginal community and is typically based on traditional and contemporary lore, spiritual values, and oral history, and may also consider scientific and educational value.

Protocol to be followed if previously unrecorded or unanticipated Aboriginal object(s) are encountered:

1. If any Aboriginal object is discovered and/or harmed in, or under the land, while undertaking the proposed development activities, the proponent must:
   a. Not further harm the object
   b. Immediately cease all work at the particular location
   c. Secure the area to avoid further harm to the Aboriginal object
   d. Notify Heritage NSW as soon as practical on (02) 9873 8500 (heritagemailbox @environment.nsw.gov.au), providing any details of the Aboriginal object and its location; and
   e. Not recommence any work at the particular location unless authorised in writing by Heritage NSW.
2. If Aboriginal burials are unexpectedly encountered during the activity, work must stop immediately, the area secured to prevent unauthorised access and NSW Police and Heritage NSW contacted.
3. Cooperate with the appropriate authorities and relevant Aboriginal community representatives to facilitate:
   a. The recording and assessment of the find(s)
   b. The fulfilment of any legal constraints arising from the find(s), including complying with Heritage NSW directions
   c. The development and implementation of appropriate management strategies, including consultation with stakeholders and the assessment of the significance of the find(s).
4. Where the find(s) are determined to be Aboriginal object(s), recommencement of work in the area of the find(s) can only occur in accordance with any consequential legal requirements and after gaining written approval from Heritage NSW (normally an Aboriginal Heritage Impact Permit).

APPENDIX 3: ABORIGINAL HERITAGE: ARTEFACT IDENTIFICATION

	
A retouched silcrete flake	A quartz flake
	
Microliths (scale = 1 cm)	Volcanic flakes
	
Flake characteristics (scale = 1 cm)	A mudstone/tuff core from which flakes have been removed

Appendix I

Statement of commitments

Statement of commitments

Item	Commitment
Activity type	Onshore gas exploration and appraisal
Activity location	Mary's Mount, approximately 20 kms west of Gunnedah, NSW
Activity scope	The proposed activity is gas exploration and appraisal at the site utilising the existing coal seam gas exploration infrastructure. It includes some minor additional civil and construction works including installation of buried gas and water gathering and power cables, upgrade of the gas flare, establishment of central power generation infrastructure and 65 kilolitre diesel storage, followed by workovers and completions, and appraisal activities.
Hours of operation	Unless otherwise specified by any other condition all construction activities are: a) restricted to between the hours of 7:00am and 6:00pm Monday to Friday; b) restricted to between the hours of 8:00am and 1:00pm Saturday; and c) not to be undertaken on Sundays or Public Holidays.
Activity duration	The civil and construction works, and workovers and completions, would occur collectively over about three months. The appraisal activities would then continue for up to two years following the commencement of production through to late 2024/early 2025.
Proposed commencement date	The proposed activity is planned be carried out from early 2023.
Proposed completion date	Late 2025
Maximum area of disturbance	As the site is largely cleared, it is not expected that additional clearing or other disturbance would be needed.
Air quality	A1 Carry out water-based dust suppression as required. A2 Implement on site speed limits to minimise dust generation. A3 Water, cover or otherwise stabilise stockpiled excavated material. A4 Maintain plant and equipment A5 Turn off plant and equipment when not in use
Greenhouse gas	G1 Consider energy efficiency in the procurement of goods and services. G2 Implement a Gas Leak Detection and Repair (LDAR) program for all gas process plant and equipment on the premises.
Water resources	W1 Implement a groundwater monitoring program including: - Daily monitoring of extraction rates/groundwater levels in pilot wells - Review of groundwater level data from all available NSW state monitoring points within 10 km of the Kahlua site at 12 months and at completion - Reporting of results of review findings to NSW Office of Water as required W2 Carry out the activity in accordance with relevant standards including the Code of Practice for Coal Seam Gas Well Integrity (NSW Government 2012a). W3 Implement erosion and sediment controls in place where appropriate accordance with Managing Urban Stormwater: Soils and construction — Volume 1 (the Blue Book) (Landcom 2004). W4 Vehicles and machinery would be properly maintained and routinely inspected to minimise the risk of fuel/oil leaks W5 Spill kits appropriate to products used in the machinery and vehicles would be available during the proposed activity W6 Spills of fuel, oil, chemicals or the like would be cleaned immediately, and the environmental manager for the activity would be notified of the location of the incident, extent of the incident and type of material spilled. W7 Light vehicles would be refuelled off-site
Soils and land use	S1 Carry out the proposed activity in consultation with the landholder and through the development of a land access and compensation agreement. S2 Stockpile topsoil separately so that the soil profile is maintained when backfilled. S3 Manage stockpiled material in accordance with standard sediment and erosion control management measures in Managing Urban Stormwater: Soils and construction — Volume 1 (the Blue Book) (Landcom 2004).

Item	Commitment
	S4 Carry out decommissioning and rehabilitation in consultation with the landholder and in accordance with the relevant guidelines including the Exploration Code of Practice: Rehabilitation (NSW Government 2012c). S5 Vehicles and machinery would be properly maintained and routinely inspected to minimise the risk of fuel/oil leaks S6 Spill kits appropriate to products used in the machinery and vehicles would be available during the proposed activity S7 Spills of fuel, oil, chemicals or the like would be cleaned immediately, and the environmental manager for the activity would be notified of the location of the incident, extent of the incident and type of material spilled. S8 Light vehicles would be refuelled off-site
Noise and vibration	N1 Prior to carrying out the proposed activity all reasonable efforts would be made to provide notice to landholders of activities with the potential to cause disturbance and accommodate reasonable requests in relation to the scheduling of activities. N2 Maintain vehicles and equipment in good working condition. N3 As far as practicable, avoid scheduling noisy activities out of standard hours. N4 Promptly respond to noise complaints and carry out monitoring if necessary. N5 Plant or machinery would not be permitted to warm-up near residential dwellings before the nominated working hours. N6 Appropriate plant would be selected for each task, to minimise the noise impact (e.g. all stationary and mobile plant would be fitted with residential type silencers). N7 Plant, vehicles and machinery would be regularly inspected and maintained in good working order.
Waste and resources	WA1 All waste generated by the proposed activity must be classified in accordance with the Waste Classification Guidelines (EPA 2014) and transported and reused, recycled or disposed of by suitably licensed waste contractors and facilities. WA2 General construction waste and other general solid waste stored on site must be held in suitable containers and regularly collected for disposal. WA3 Produced water would be stored in accordance with relevant Australian standards
Hazardous materials	H1 The diesel fuel storage would be designed and operated in accordance with all relevant Australian standards. The diesel fuel storage would be situated within an appropriately bunded area to contain spills. Appropriate signage, fencing/bollards and speed limits would also be put in place to further mitigate risks of spills. H2 All chemicals and dangerous goods would be transported, stored and handled in line with all relevant Australian standards including AS1940:2017 The storage and handling of flammable and combustible liquids and the Australian Code for the Transport of Dangerous Goods by Road & Rail Edition 7.6, 2018. H3 If a spill is identified on site, it would be immediately acted upon including stopping the spill at its source and carrying out measures to contain and remediate the spill affected area. All statutory notifications would be carried out in accordance with the requirements of the Protection of the Environment Operations Act 1997. A trigger action response plan would be included in the environmental management plan. H4 An emergency response procedure is to be developed for the event of a spill.
Biodiversity and biosecurity	B1 Provide all workers with a site induction on the biodiversity values of the site. B2 Have a suitably qualified ecologist undertake a pre-clearance site survey of paddock trees that may be impacted by the proposed works and inspect fallen timber for fauna as required. B3 Implement measures to avoid impacts to mature native trees including marking out tree protection zones and preventing any disturbance or compaction of those zones. B4 If any habitat features such as hollow logs are present in the disturbance area relocate them to a nearby area that would not be disturbed prior to the disturbance. B5 Backfill or cover any open trenches at the completion of each work period to prevent injury to fauna. Check any covered trenches at the start of each work period. B6 If any threatened fauna or flora are identified within the area of the works notify the environmental representative and do not carry out works in that area until approved. B7 Implement weed hygiene protocols to prevent introduction and/or spread of weeds.

Item	Commitment
	B8 Manage weeds in accordance with the requirements of the Biosecurity Act 2015 and additional requirements for any Weeds of National Significance.
Community impacts	C1 Carry out stakeholder consultation as described in section 2.10. C2 Carry out the proposed activity in consultation with the landholder. C3 Implement policies for local hiring and procurement of goods and services to maximise the potential for regional economic benefits.
Cultural heritage	CH1 Work crews will receive site inductions that include the contents of the Unanticipated Finds Protocol and a cultural heritage awareness component to assist them in recognising Aboriginal artefacts and make them aware of legislative protections of Aboriginal objects under the National Parks and Wildlife Act 1974. The Unexpected Finds Protocol is provided as Appendix 2 to Appendix H. Guidance on Aboriginal artefact identification is in Appendix 3 to Appendix H. CH2 If during works, however, Aboriginal artefacts or skeletal material are noted, all work should cease and the procedures in the Unanticipated Finds Protocol should be followed. The Unexpected Finds Protocol is provided as Appendix 2 to Appendix H.
Traffic and transport	T1 Develop and implement a traffic management plan for the proposed activity.
Cumulative impacts	CU1 Consult with Gunnedah Shire Council during the development of the traffic management plan to ensure the proposed routes are suitable and that the content of the plan is appropriate and complete.
Other (as applicable)	NA

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