18 APPENDICES

APPENDIX 1
HEALTH, SAFETY AND ENVIRONMENT

1. **HSE Management Plan Summary**
2. **Summary of all HSE incidents during the 2015-2016 Beetaloo Drilling Campaigns**

1. BEETALOO HSEMP

The primary document governing the safe operation of the Beetaloo project in 2016 was the Health, Safety and Environmental Management Plan. The document details the Health, Safety and Environmental Management strategy and planned actions specific to Exploration Drilling activities for the Beetaloo Exploration Project 'Execute Phase' for 2016.

The Beetaloo project aimed to conduct the following works in calendar year 2016:

- Re-complete one horizontal well.
- Drill and complete one or two vertical exploration wells.
- Stimulate and test one horizontal well.
- Conduct well intervention works in support of stimulation and well suspension and similar operations, including DFIT operations.
- Conduct a series of supporting civil works including drill pad construction, road/track construction, site remediation works.

The permits areas are located in the Northern Territory, Australia, approximately 600km south-east of Darwin. Land use in the area is primarily pastoral leases used to run cattle.

The region experiences a distinct Wet/Dry season annual weather pattern; this sets a practical weather window for operations which are intended to occur as soon as the dry season commences in approximately May/June with works completion occurring prior to the recommencement of the wet season, nominally in November/December.

This document is supported by:

DOCUMENT NAME	NUMBER
Origin/SLR Bridging Plan (HSE Bridging Interface Origin Conventional - Drilling & Completions and SLR Rig 185	*NT-2050-95-RP-0008*
Bridging Emergency Response Plan [Drilling]	*NT-2050-15-MP-0003*
Oil Pollution Emergency Plan	*NT-2050-15-MP-0004*
Beetaloo Well Control Bridging and Air Drilling Report	*NT-2050-35-RP-0001*
Beetaloo Project HSEMP (Develop phase)	*NT-2050-15-MP-00001*
Beetaloo Project Environmental Plan	*NT-2050-15-MP-0005*
Beetaloo 2016 Campaign Aviation Management Plan	*NT-2050-95-AP-0004*
Beetaloo Basin Project Groundwater Monitoring Plan	*NT-2050-15-NP-0011*

2. SCOPE

The Health Safety and Environment Management Plan (HSEMP) applies to the Execute phase of the 2016 Beetaloo exploration drilling campaign and covers all operational activities involved with the exploration Drilling, operations.

The Execute Phase HSEMP includes Origin requirements (as distinct from the Primary contractor *Schlumberger Land Rigs* (SLR) or third parties) for planning operations and managing risks on behalf of the Beetaloo Project.

Origin managed activities include:

- Project & Contractor Management (Primary and direct contractors, other than level 1 management as noted below)
- Travel expected to consist of field visits by project personnel utilising chartered aircraft and light vehicles.
- Engineering/Design support
- Low impact **field work** including but not limited to:
  - Travel expected to consist of field visits by project personnel utilising light vehicles, primarily on formed roads - for stakeholder engagement, familiarisation, contractor visits, ground-scouting and limited scope studies.
  - Supervising drilling activities to monitor contractor safety compliance, equipment maintenance and direct subsurface construction requirements.
  - Environmental and/or other sampling conducted as part of the ESIA or otherwise.
  - Landholder and community engagement activities.
- In-field professional geological oversight
  - Including supporting persons with handling and marking the cores on-site.
  - Sidewall Coring photography, preservation and packaging. Standard professional geologist work covered by professional training & competencies.
- Field Logistics operations
  - Front End Loader operation performed by site logistic coordinators under SLR site rules & Origin requirements.

SLR (Level 1 Contractor) managed activities include:

- Drilling and associated operations
  - overall drill site management,
  - drilling service contractor management (on lease),
  - drilling camp and associated operations,
  - Rig move (mobilisation/demobilisation and inter lease well moves)
  - Light vehicle operations to/from well site whilst in custody of drill lease(s),

Aviation Managed Activities

- Aviation services – including crew change, aerodrome interaction and aviation transport services to field airstrip as detailed in the Project Aviation Management plan; aviation operations managed by (level 1 contractor).

2.1 Objectives

The objectives of the HSEMP plan are:

- To prescribe distinct Health and Safety Management actions as required to meet company HSEMS requirements for the management of the Drilling Execute phase of the project.
- The project schedule forms the basis of routine and one-off actions for the Project Manager, technical leads and support teams.
- To provide a concise and communicable summary of HS&E requirements and guidance information specific to the activities undertaken as required under the OE Health and Safety Management System (HSEMS) and supplementary OE HSE requirements.

3. STRATEGY OVERVIEW - RULES, REQUIREMENTS AND MANAGEMENT ACTIONS

The HSEMP has been developed in line with the Origin HSE Management System (ORG-HSE-SYS-001). It builds on from the Beetaloo HSEMP (Develop phase) and is paired with the other Execute phase HSEMP (Civil Works) and the HSE Bridging Interface document (NT-2050-95-RP-0008) which supports and bridges HSE systems with SLR equivalents.

All Origin Health, Safety and Environmental Policies and Standards will apply to work conducted under this project; unless a valid dispensation is in place.

The project will apply a 'best practice' or 'highest standard' where ever a choice as to which practice or standard should be complied with, as allowable under law.

The Origin HSE Management System (ORG-HSE-SYS-001) is comprised of 20 HSE Standards.

3.1 Leadership and Commitment

Origin is committed to managing the impact of its business on the health and safety of its employees and contractors, and on the environment through the implementation of its HSE Policy (ORG-HSE-POL-001).

The Origin HSE Policy defines the HSE aspirations for our HSE actions that will be applied for the duration of the project. Origin's Life Saving Rules shall apply at all times for all activities.

The policy, its requirements and the Origin Life Saving Rules will be communicated to all project personnel through mandatory completion of Origin HSE General Awareness training – or approved equivalents.

The Life Saving Rules relate to the highest risk activities — those tasks where the smallest deviation from the procedure could result in serious injury or death in our business. They set out clear and simple 'dos' and 'don'ts' to help ensure you are protected.

To demonstrate visible leadership in accordance with the HSE standard and to ensure plans are being effectively implemented, the project team schedule management visits throughout the execution phase. Visits are tracked on the project action tracker.

INCIDENT SUMMARY BEETALOO 2015-16

INCIDENT NUMBER	INCIDENT DATE	SUMMARY OF INCIDENT	CONSEQUENCE
INC-142276	31/05/2015	Small diesel/water spill from bund of compressor during lift. Less than 1L. Disposed in contaminates bin. All bunds checked.	Minor
INC-142298	1/06/2015	Small leak of hydraulic oil from a weeping hydraulic line on a water bore rig - approx 50ml onto ground. Disposed in contaminates bin.	Minor
INC-142319	2/06/2015	Transmission oil spill (15L) resultant from oil filter seal failure on grader. Disposed in contaminates bin.	Minor
INC-142358	4/06/2015	During Morning Pre start a sub-contractor returned a non-negative breath alcohol test result.	Minor
INC-142379	4/06/2015	Hole in tank liner. No spill.	Minor
INC-142431	5/06/2015	Damage to bore pump	Minor
INC-142419	7/06/2015	Driller rolled his ankle whilst checking drill pipe and continued working	Minor
INC-142662	7/06/2015	Personnel stumbled on uneven pavers at accommodation resulting in ankle injury	Minor
INC-142496	9/06/2015	Conducting work associated with removal of rig breakout at a height above 1.8m without fall protection. Stopped the job. Reviewed SWMS with worker.	Minor
INC-143445	14/07/2015	Small leaks on SPU Discharge lines observed. Lines repaired.	Minor
INC-143355	17/07/2015	Aircraft propeller damage at Newcastle Waters	Minor
INC-143427	20/07/2015	Personal gas detector alarmed during confined space entry in well cellar - apparent CO dissolved in liquid on cellar floor released by worker walking in cellar.	Minor
INC-143333	29/07/2015	Non-compliance with Zero Alcohol Policy	Minor
INC-143269	31/07/2015	During air drilling operations for top-hole apparent overpressure event causing shearing of diverter from wellhead. No injuries. Incident investigation undertaken.	Minor
INC-144274	2/09/2015	People on airstrip resulting in delayed landing of charter aircraft	Minor
INC-143931	18/09/2015	Charter flight return to base due cockpit indication	Minor
INC-143974	21/09/2015	Pierced aerosol can causing minor eye injury. PPE was being worn. Focus on improved housekeeping.	Minor
INC-144051	25/09/2015	Chemical spray impacted worker's face when dosing potable water tank. Assessed by medic. PPE being worn. Emphasise care while handling chemicals.	Minor
INC-144085	29/09/2015	Worker observed inside an exclusion zone during a pressure test. Stopped the job. Reviewed SWMS with worker.	Minor
INC-144197	30/09/2015	Non-compliance with Zero Alcohol Policy	Minor
INC-144198	8/10/2015	Damaged aerosol can in the kitchen facilities. Keep aerosol cans away from stove.	Minor
INC-144665	7/11/2015	Insect Bite on ear. Assessed by medic. Monitored. No action taken.	Minor
INC-147667	3/06/2016	While walking around grader to complete pre-use inspection, the operator hit his leg against the machine causing small cut/bruising to left shin.	Minor
INC-147751	19/07/2016	After filling a 4WD vehicle approximately 300ml of diesel was spilt to grade. Disposed in contaminates bin.	Minor

INCIDENT NUMBER	INCIDENT DATE	SUMMARY OF INCIDENT	CONSEQUENCE
INC-147746	20/07/2016	Water spilled from ring tank due to liner coming loose. Pure bore water so no action taken.	Minor
INC-147773	21/07/2016	Small stain on the ground below a hydraulic ram due to hydraulic ram leaking. Disposed in contaminates bin.	Minor
INC-147783	21/07/2016	Small stain on the ground below a hydraulic ram due to hydraulic ram leaking. Disposed in contaminates bin. Ram removed for repair.	Minor
INC-147784	21/07/2016	Water bore rig top head drive came out of track. Stopped the job. JSA done for repair.	Minor
INC-147806	22/07/2016	Dust Devil Rips Canopy off Caravan	Minor
INC-147825	27/07/2016	Flare pit containment breached. Transferred fluid to sumps. Incident investigation undertaken. Fluid comprised bore water + 2.2 kg of foaming agent + <0.5 kg of encapsulating agent (both products are classified as non-dangerous under criteria of the Australia Dangerous Goods Code).	Minor
INC-148321	1/08/2016	Driving without seatbelt >5km/h for >5 sec	Minor
INC-147899	2/08/2016	Catwalk hydraulic return hose burst. 20 litres released on rig matts and side of day tank. No spill to ground. Disposed in contaminates bin.	Minor
INC-147931	5/08/2016	Annular open after leak off test, uncontrolled release of pressure. Stopped the job. Incident investigation undertaken.	Minor
INC-147948	6/08/2016	30 gram pin dropped 3m and service loop damage. Stopped the job. Incident investigation undertaken.	Minor
INC-147993	8/08/2016	During checks small leak found at storage pond. 10L of clean bore water spilled. Pond liner repaired.	Minor
INC-147991	10/08/2016	4" Hose split and slipped of camlock fitting resulting in spill of drilling fluid. Cleaned up with vac truck.	Minor
INC-148324	15/08/2016	Driving without seatbelt >5km/h for > 5 sec	Minor
INC-148133	18/08/2016	Oil leaked from wheel bearing causing minor spill < 2L. Disposed in contaminates bin.	Minor
INC-148126	23/08/2016	Spill 750L water contained on lease. Cleaned up with vac truck.	Minor
INC-148152	25/08/2016	Crew member non work related health issue	Minor
INC-148155	26/08/2016	3L Diesel spill camp generator. Contained with spill pads.	Minor
INC-148173	28/08/2016	1L Hydraulic Oil - nil to grade. Disposed in contaminates bin.	Minor
INC-148322	31/08/2016	Driving without seatbelt >5km/h for > 5 sec	Minor
INC-148248	3/09/2016	Non-compliance with Zero Alcohol Policy	Minor
INC-148313	5/09/2016	Truck driver not wearing PPE. Stopped the job. Reviewed SWMS with worker.	Minor
INC-148295	6/09/2016	Seized starter solenoid smoked. Cooled and inspected before resuming operations.	Minor
INC-148346	6/09/2016	First aid case. Non work related.	Minor
INC-148292	7/09/2016	Diesel spill while fueling equipment. Disposed in contaminates bin. Spill mats to be used during fueling ops.	Minor
INC-148473	12/09/2016	Crew member reported irritation (non-work related) to medic	Minor
INC-148474	13/09/2016	Crew member reported not feeling well. Assessed by medic. Resumed work.	Minor

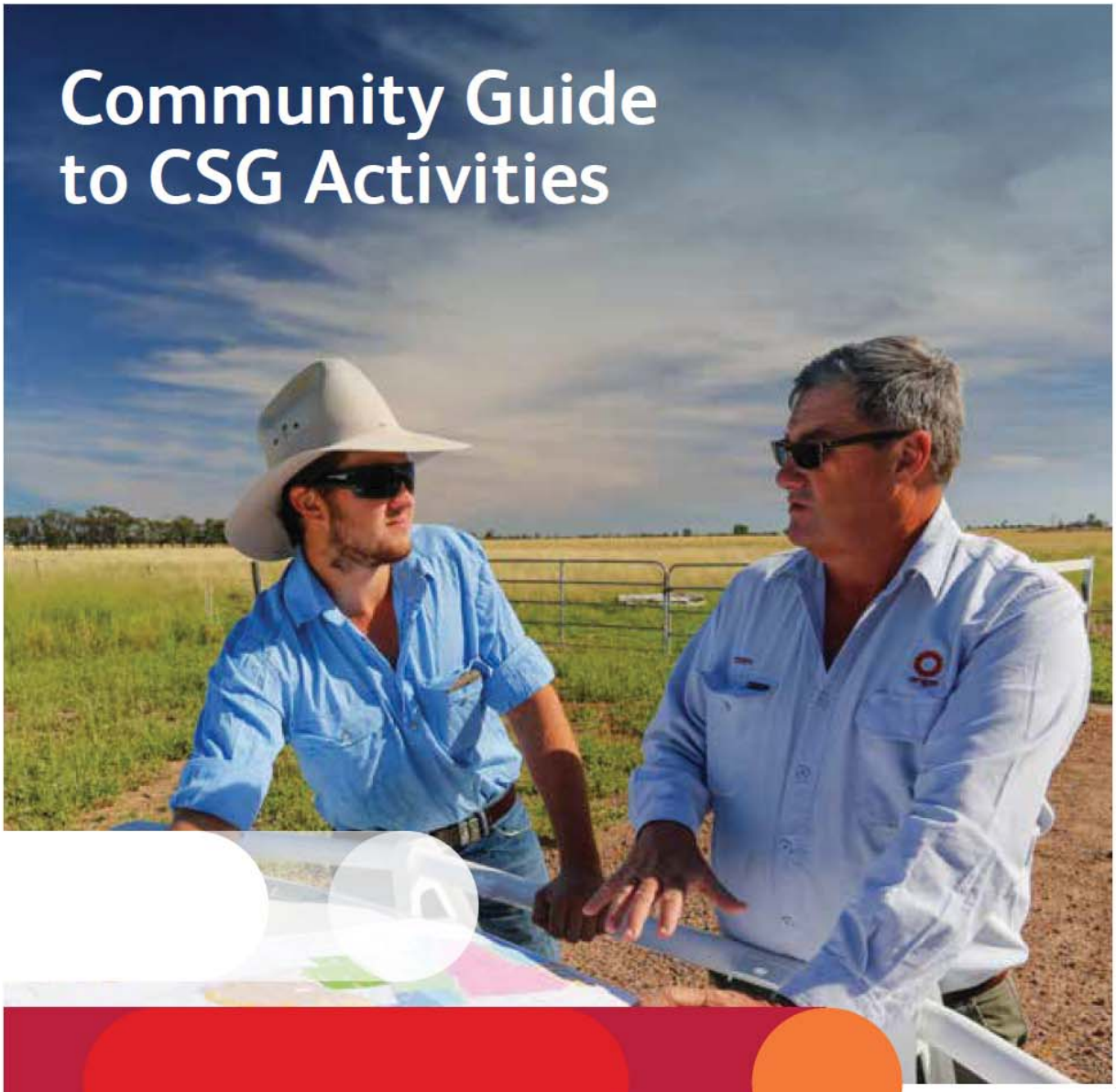
INCIDENT NUMBER	INCIDENT DATE	SUMMARY OF INCIDENT	CONSEQUENCE
INC-148529	16/09/2016	Rig contact with wellhead during move. Job stopped. Gauge damaged by contact. Gauge replaced and wellhead inspect. Contact very minor.	Minor
INC-149089	20/10/2016	Salt stain above backfilled sump - full rehabilitation to be completed after well abandonment	Minor
INC-149042	10/11/2016	Reoccurring health issue	Minor
INC-149061	15/11/2016	Small (1/4L) spill on location - during water transfer by vac truck. Flange replaced.	Minor
INC-149328	9/12/2016	Sleep shack tipped over side of trailer during demobilisation operations damaging portable building. Stopped the job. Reviewed SWMS with worker.	Near Miss
INC-149967	31/01/2017	Elevated Salinity detected in groundwater table adjacent to drilling sump. Incident investigation underway. Monitoring and planning mitigation.	Moderate

APPENDIX 2
CSG COMMUNITY GUIDE

Origin guide to CSG activity for communities

origin

Community Guide to CSG Activities



AUSTRALIA PACIFIC LNG

Operated by origin

COMMUNITIES CHARTER

We strive to be an integral, trusted and valued partner in community.
We will achieve this by sharing value with our communities, engaging transparently, and honoring our commitments

Relationships are Everything	• We build strength in our relationships through respect and trust. • We say what we'll do, and we do what we've said, and we'll fix any mistakes. • We always operate with honesty, integrity and an underlying sense of fairness.
Everyone knows how they connect	• We are honest and accountable in our communication. • Always with a view to gaining mutual clarity and understanding.
Value is Shared	• We understand the value of long term relationships and invest in them. • We want our partners and the communities in which we operate to be strong, vibrant and healthy.
We Involve	• We engage landholders and the community early and with an open mind to listen and learn what is important to the community. • We plan collaboratively and include key stakeholders in decision making.

OUR CHARTER HELPS GUIDE OUR ACTIONS. WE HAVE THE SUPPORT AND AUTHORITY TO STOP THE JOB WHEN WE FEEL OUR COMMITMENTS UNDER THE CHARTER COULD BE IMPACTED.

About this guide

Community Guide to CSG Activities provides you with an overview of coal seam gas (CSG) exploration, production, and field development activities Origin undertakes on behalf of Australia Pacific LNG.

We have developed this guide with you in mind as a landholder who will be involved in some way with our activities. As such you will have plenty of questions for us, as well as information that will help us understand your business and your needs. This guide is intended as a starting point for conversations.

Designed to help you understand the CSG industry, this guide provides detailed information about our CSG exploration, production, and field development activities.

Please note: all activities, types of equipment, number of people required and so on as described in this booklet are intended as a guide only. The actual type and duration of activities, number of people and machinery involved will vary from activity to activity and property to property. Not all activities contained in this guide will occur on your property. Information specific to proposed activities on your property will be provided during our conversations with you.

As technology changes our activities and the way they are carried out may change as well. We will always work in accordance with agreements we have in place with you as well as current regulations. We will work through any changes with you.

We will always seek to assist with any enquiries you may have. If you have any questions or you would like to talk to an Origin representative, please contact your Landholder Liaison (LL).

Meeting with your Landholder Liason

Contents

Disclaimer

Origin has prepared this information guide to provide an overview of its CSG activities for landholders and other stakeholders.

The information presented here is of a general nature and is subject to change without notice. There is a possibility that changes in circumstances after the date of publication may impact on the accuracy of the information.

Origin will not be liable for any errors or omissions in the information provided or the adequacy of that information. Users should make their own inquiries and decisions as to the relevance, accuracy and reliability of the information in relation to their individual circumstances.

This information does not constitute legal or financial advice. Origin strongly advises you to seek independent professional advice before making any decisions of a legal or financial nature in relation to the information provided.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1.1 Australia Pacific LNG

LNG Facility on Curtis Island

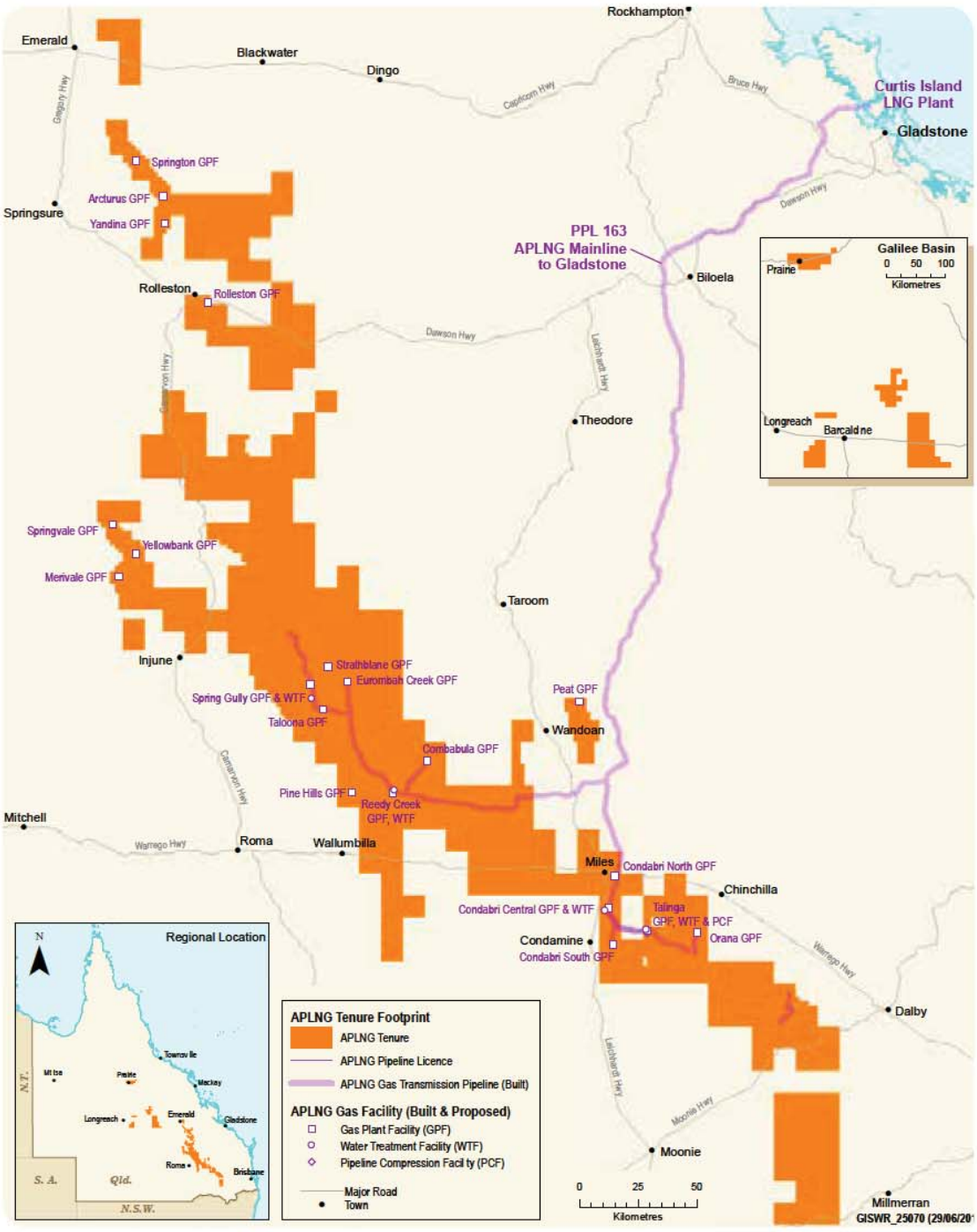
Origin is Australia's leading integrated energy company, focused on gas and oil exploration and production, power generation, and energy retailing.

Through Australia Pacific LNG, in partnership with Conoco Phillips and Sinopec, Origin is developing one of Australia's leading CSG to LNG businesses, based on Australia's largest CSG reserves base.

Established in October 2008, Australia Pacific LNG is developing CSG fields in the Surat and Bowen basins, supported by a 530km high pressure gas transmission pipeline and a new LNG Facility on Curtis Island, offshore from Gladstone.

Australia Pacific LNG is now supplying to international markets, and continues to supply to local markets.

1.2 Where we operate



1.3 CSG is natural gas

CSG is natural gas, mostly methane, trapped within the coal seams formed by the long-term decay of plant materials.

This plant material was compressed and progressively covered by sedimentary processes. The compression of the plant material (over geological periods of time) results in the formation of coal. Gas produced by the decay of this compressed plant material is trapped within the coal seams.

Natural gas is a cleaner alternative to many current fossil fuels, such as coal and petroleum. Power stations fired by natural gas emit approximately half the greenhouse gases of coal-fired electricity generation and use only a fraction of the water.

Gas is viewed as a preferred transitional energy source as the world develops its renewable energy capacity.

1.4 Natural gas as a partner for renewable energy

Origin has been preparing for a carbon constrained world for a long time and will continue to play an active role in developing low carbon and renewable energy solutions to meet the world's growing demand for energy.

Origin supports Australia's announced 2030 Climate Change target as a minimum goal for the nation and looks forward to working with government and industry on meeting or exceeding that target. We support Australia progressively de-carbonising its electricity mix with the aim of becoming net carbon neutral by 2050.

Origin aspires to be the number one renewable and low carbon energy company in Australia and was the first energy company in the world to adopt all seven of the 'We Mean Business' coalition commitments on climate change. Origin plans to increase its investment in renewable energy sources (including rooftop and utility-scale solar) and sees natural gas as playing a key role, in tandem with renewable energy, in reducing emissions from the electricity sector.

1.5 Uses for natural gas

Domestic use

CSG is natural gas. Natural gas is used for cooking and heating. It is also used by industries including refineries and in electricity generation. It is distributed via pipelines to residential and industrial customers or to power stations to generate electricity.

International use

Converting natural gas to its liquid form, LNG, involves cooling the gas to minus 161 degrees Celsius. In its liquid state LNG takes up just 1/600th of the space of its gaseous form, making it safer and easier to store and transport in specially designed ships. Once LNG reaches its overseas destination, it is converted back to gas in controlled processing facilities.

The gas is then ready to be distributed via pipelines to customers, as it is in Australia.

LNG is transported in specially designed ships

2 Landholder engagement

2.1 Overview

Australia Pacific LNG and Origin respect the rights and interests of people, organisations, and communities.

As a landholder, you are a vital part of our business, and we want to work with you through each of the CSG development steps. As a result, we have designed a landholder engagement process that seeks to build a mutually beneficial and long-lasting relationship with you.

A Landholder Liaison (LL) will be appointed to work with you. This representative will be your primary contact point and will establish a working relationship with you to address any questions or concerns. Your LL will learn about your individual property, including future business plans and current land use, so that we can avoid and or minimise any impacts of our operations on your land, lifestyle and business. Your LL will connect you into Origin and facilitate access to relevant subject matter experts for activities that will occur on your property.

We will communicate in whichever way works best for you. This may be face to face, email, phone, text or a combination of these. We can provide detailed information on specific queries you may have and show examples. It is important that we understand your needs or concerns so that we can keep you informed and establish a strong relationship with you.

2.2 Gate Mate

Gate Mate is a campaign to raise awareness among Origin staff and contractors around the importance of ensuring gates are left in the correct position and how this impacts Origin's relationships with you, our landholders and the greater community in which we operate.

At Origin, we're working towards being a better neighbour. We respect every property that we open the gate to. We understand that entering your property, is like entering your home. This means taking the time to understand the needs and requirements of each landholder before we open the gate. If we're unsure, we stop the job and find out first. Doing the right thing is what counts.

To help us, we've come up with the Gate Mate - it's a tool that helps us know how to treat each gate that we go through. And it's also our commitment to doing the right thing.

Gate Mate

2.3 Land Access Code

The Land Access Code is a set of guidelines and conditions that form the foundation of CSG land access laws in Queensland.

The code was developed in 2010 by the Queensland Government, in consultation with landholders and the resource and agricultural sectors, to help achieve a balanced approach to private land access and compensation. It was then updated in September 2016.

The code provides general principles around how parties can communicate effectively when undertaking discussions and negotiation about land access and compensation. It also outlines mandatory conditions that we must observe when conducting authorised activities on your land.

You will receive a copy of the Land Access Code with your initial Entry Notice but your LL will also be able to provide you with a copy at any time.

A copy of the Land Access Code is also located on the Department of Natural Resources and Mines website: www.dnrm.qld.gov.au

Your LL will discuss the Land Access Code with you

2.4 Our Privacy Policy

The *Privacy Act 1988 (Qld)* governs how personal information including sensitive information is managed. We respect your rights under the Privacy Act and are committed to complying with the requirements for collection and management of your personal information.

We will manage your personal information in order to have a working relationship with you.

We may collect information such as your name, address and contact details, banking details and tax details (including your ABN if applicable) and the name, address and contact details of any third party that you have authorised to negotiate on your behalf (including any attorneys appointed by you under a power of attorney). In some circumstances, we may also collect sensitive information about you (such as health information) where it is relevant to our business activities.

For further information on how we collect, hold, use and disclose personal information, refer to our Privacy Policy and Landholder Collection Statement at www.originenergy.com.au/privacy or email us at privacy@originenergy.com.au.

Environmental scout

2.5 Engagement process

Engagement Process with landholders for future CSG production activities

STEP	Collaborative Planning	Negotiating agreements
KEY ACTIVITIES	**Meetings with you** • Individual meetings • Discuss the CSG development process from exploration to production • Discuss compensation principles • Answer questions. **Property mapping*** • Property infrastructure mapping and planning conversations held in conjunction with landholders • Landholder constraints • Information sharing • Discuss rules of conduct on your property. **Keeping in contact** • LL • Technical and subject matter experts • Australia Pacific LNG project updates.	**Preliminary discussions** • Obtain landholder information • Issue Entry Notice for preliminary activities • Property access requests as necessary • Discuss proposed future advanced activities • Discuss Land Access Code. **Preliminary activities** • Independent valuation* • Ecology survey. **Scout** • Cultural heritage surveys • Environmental scouts. **Interim discussions** • Property infrastructure map • Compensation • General terms of access that Origin and any contractors will follow while on your property. **Possible re-scout** • This may be necessary to confirm locations of infrastructure or to address any changes in liaison with you. **Deliver and negotiate CCA** • Discuss any queries with you • Meetings with you and your solicitor • Construction start date. **Keeping in contact** • Follow-up phone calls.

This diagram provides an overview of when we will engage with you and the types of activities we will be discussing with you at each step of CSG development.

As each landholder's involvement and any potential property impacts will differ, this diagram is not a linear sequence of events, but provides a broad overview of what you can expect. The sequence of engagement activities may also vary depending on the type of CSG activities planned on your property. In addition, some activities may occur concurrently.

* Not always required for lower impact activities (e.g. seismic and EIS surveys).

Construction

Arrange access

- Property Access Coordinator will contact you.

Compensation payments

- As outlined in the CCA.

Pre-start kick-off meeting

- Prior to construction commencement
- May include separate meetings for gathering and drilling.

Tool box meetings

Site monitoring and compliance

- Authorised construction activities conducted in accordance with CCA conditions
- General terms of access
- End of construction review with landholder
- Opportunity for landholders to visit construction sites.

Keeping in contact

- Ongoing support throughout construction activities.

Operations: Maintaining our ongoing relationship

Ongoing compensation

- Compensation is paid on time in accordance with CCA.

Maintenance activities

- Including well interventions (p48), workovers (p50), well servicing activities (p47) and general activities (p46).

Additional activities

- Discuss any changes or additions to activities if applicable with you.

Continued access

- Property Access Coordinator will contact you
- Compliance with Property Access process.

Keeping in contact

- Regular support
- Australia Pacific LNG Project updates.

Your LL will stay in touch

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3 CSG

3.1 CSG overview

How is CSG produced?

Step 1: CSG production

Underground water pressure bonds the gas to the natural cracks and cleats found in coal. This is called adsorption. CSG is produced by removing some water from the coal seam, reducing the pressure and allowing the gas to flow into the well. Surface infrastructure at the well separates the gas from the water.

Step 2: Transportation

Both gas and water are then transferred via separate pipelines to either the Gas Processing Facility (GPF) or Water Treatment Facility (WTF). They can also be transported by truck during the completions and workover process, which involves work to complete the well, and any subsequent maintenance work.

The GPF removes any remaining water from the gas stream and compresses the gas in preparation for transport to customers via pipeline.

The associated water produced during CSG production is a valuable resource that is treated to an appropriate standard for various beneficial uses.

Step 3: Water storage and treatment

The Queensland Government's Coal Seam Gas Water Management Policy 2012 encourages the beneficial use of CSG production water in a way that protects the environment and maximises its productive use as a valuable resource.

Water extracted from the coal seams via CSG wells is generally brackish - slightly to moderately salty - and may need to be treated in order to be suitable for beneficial use. In some cases the untreated CSG water may be used for dust suppression or drilling uses where salt levels are low.

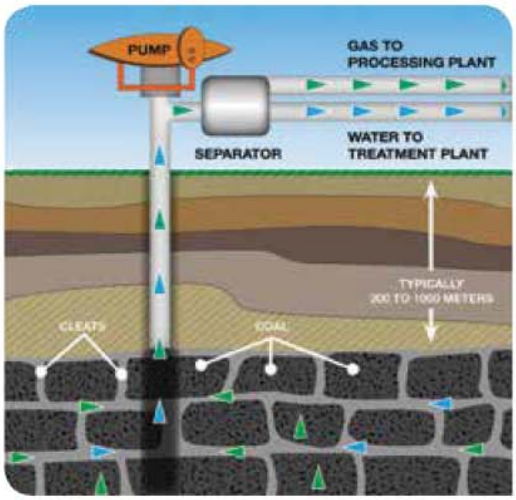
Water from the gas fields is gathered and temporarily stored in ponds prior to treatment. Origin uses reverse osmosis technology to treat the water. This process pushes water at high pressure through very fine membranes which capture salt and impurities, while allowing clean water to pass through.

The resulting pure, clean water is drinkable and is appropriate for many uses.

The remainder of the water is a highly concentrated brine solution (very salty water). The brine is contained in fully lined brine ponds. Evaporation helps to crystallise the brine before being completely enclosed and disposed of in landfill.

The clean water that has been treated can be used in many ways. Australia Pacific LNG is currently implementing the following water management options:

- Injection of treated water into aquifers
- Providing water to landholders for existing agricultural and industrial uses, potentially reducing demands on other ground water and surface water resources
- Reusing water in Australia Pacific LNG construction and operations activities
- Releasing treated water to local water courses.



How is CSG converted to LNG?

Step 1: Liquefaction

The process of turning CSG into LNG starts with piping the CSG to the LNG facility.

On arrival at the plant, the gas is chilled to approximately minus 161 degrees Celsius using the ConocoPhillips Optimised Cascade® Process, which involves three refrigeration circuits using propane, ethylene, and methane.

Each step progressively lowers the temperature of the gas until it reaches the desired temperature and is transformed into the product known as LNG.

In liquid form the gas takes up just one-six-hundredth of the volume of its gaseous form, allowing LNG to be safely and efficiently stored and transported.

Step 2: Storage

The LNG is then pumped into large, insulated storage tanks. The outer wall is more than one metre thick, with an inner tank to keep the LNG cold.

As it warms, some LNG will begin to vaporise. These vapours are captured and then returned to the chilling plant, where they are re-liquefied.

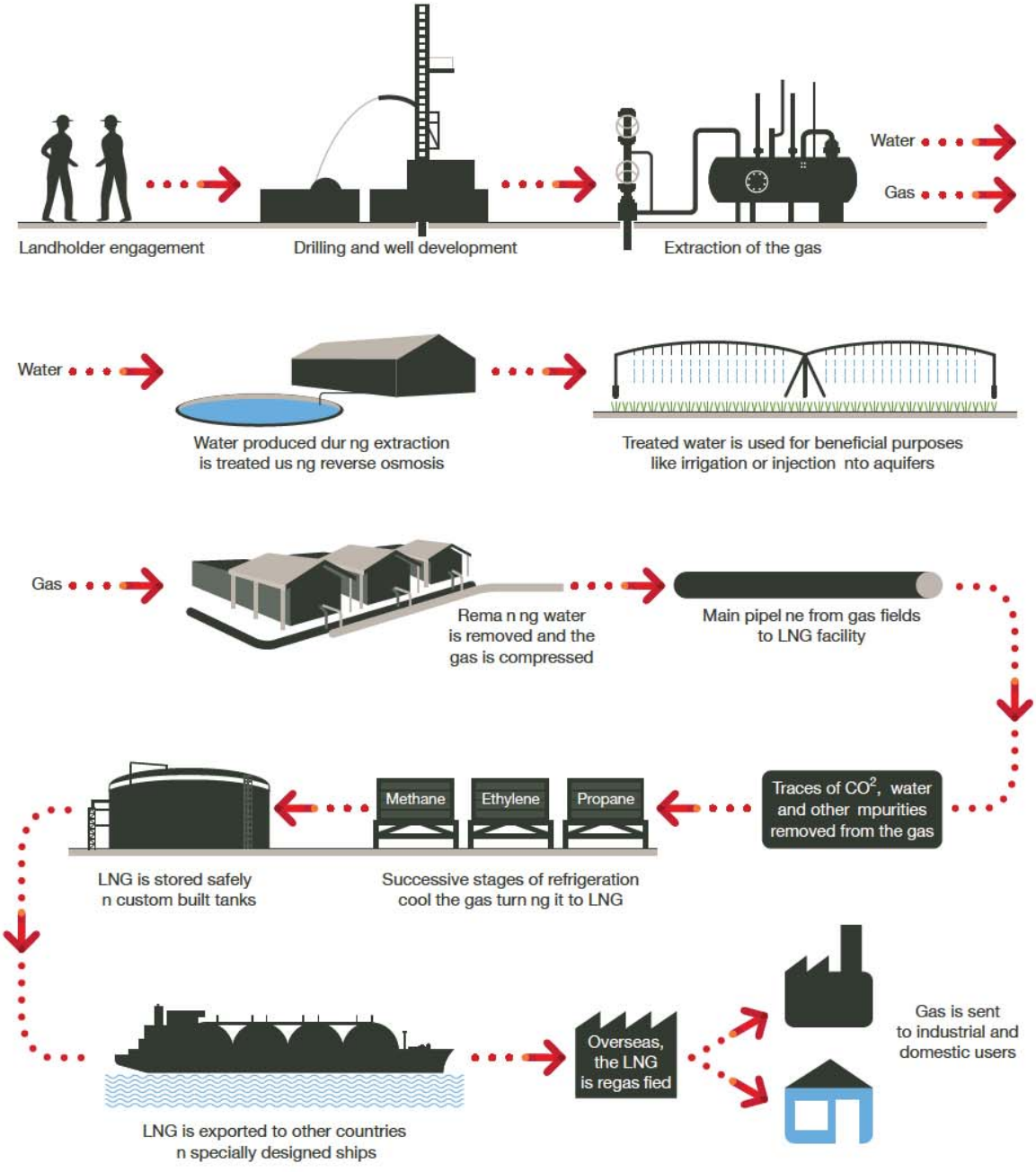
The LNG remains in these tanks prior to shipment.

Step 3: Transport

Australia's LNG will be exported around the world, primarily to Southeast Asia. Australia Pacific LNG has long-term contract agreements for supply to China and Japan. LNG is transported safely in large, purpose-built, double-hulled ships.

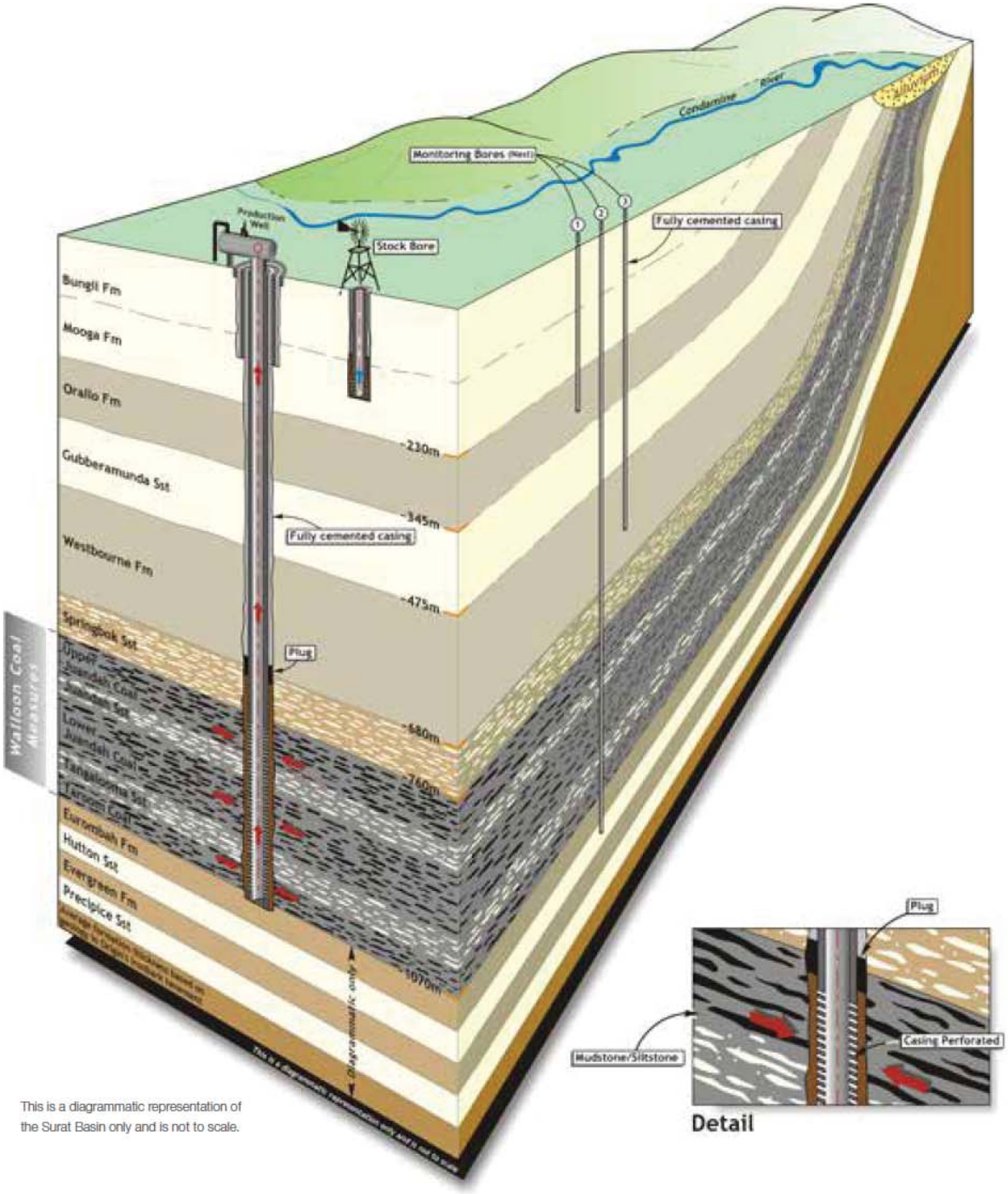
LNG storage tanks on Curtis Island

The CSG to LNG Process



origin

Below the surface



This is a diagrammatic representation of the Surat Basin only and is not to scale.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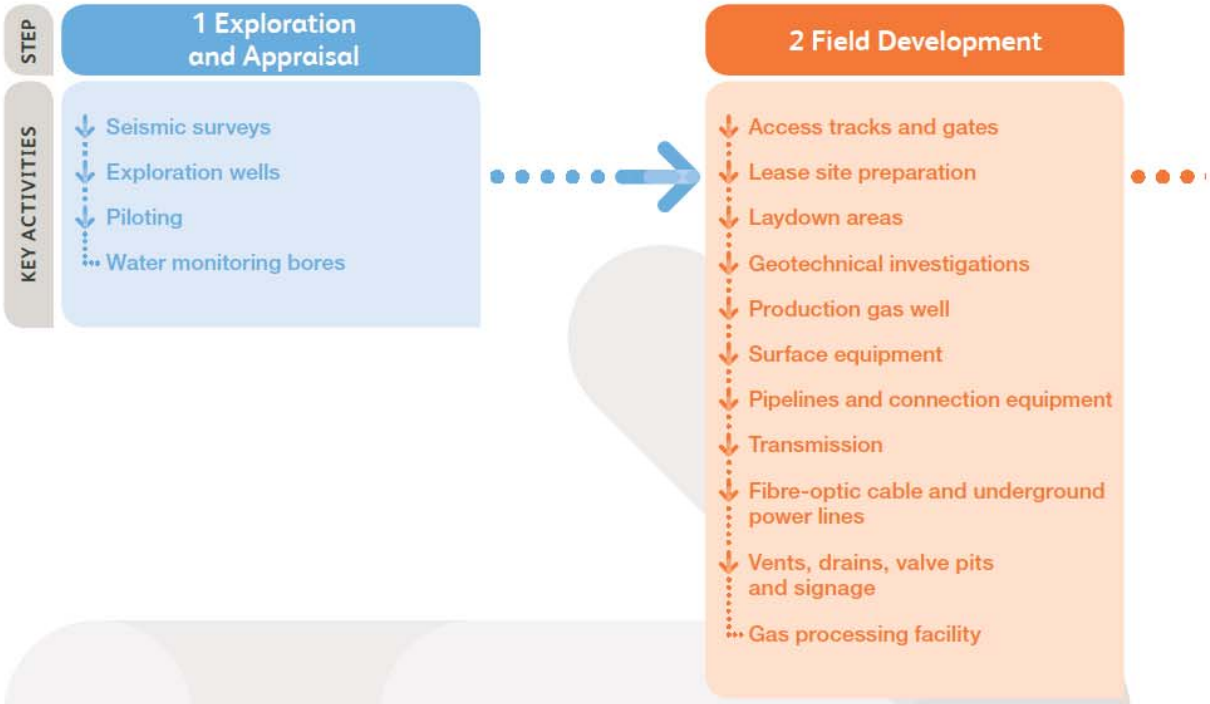
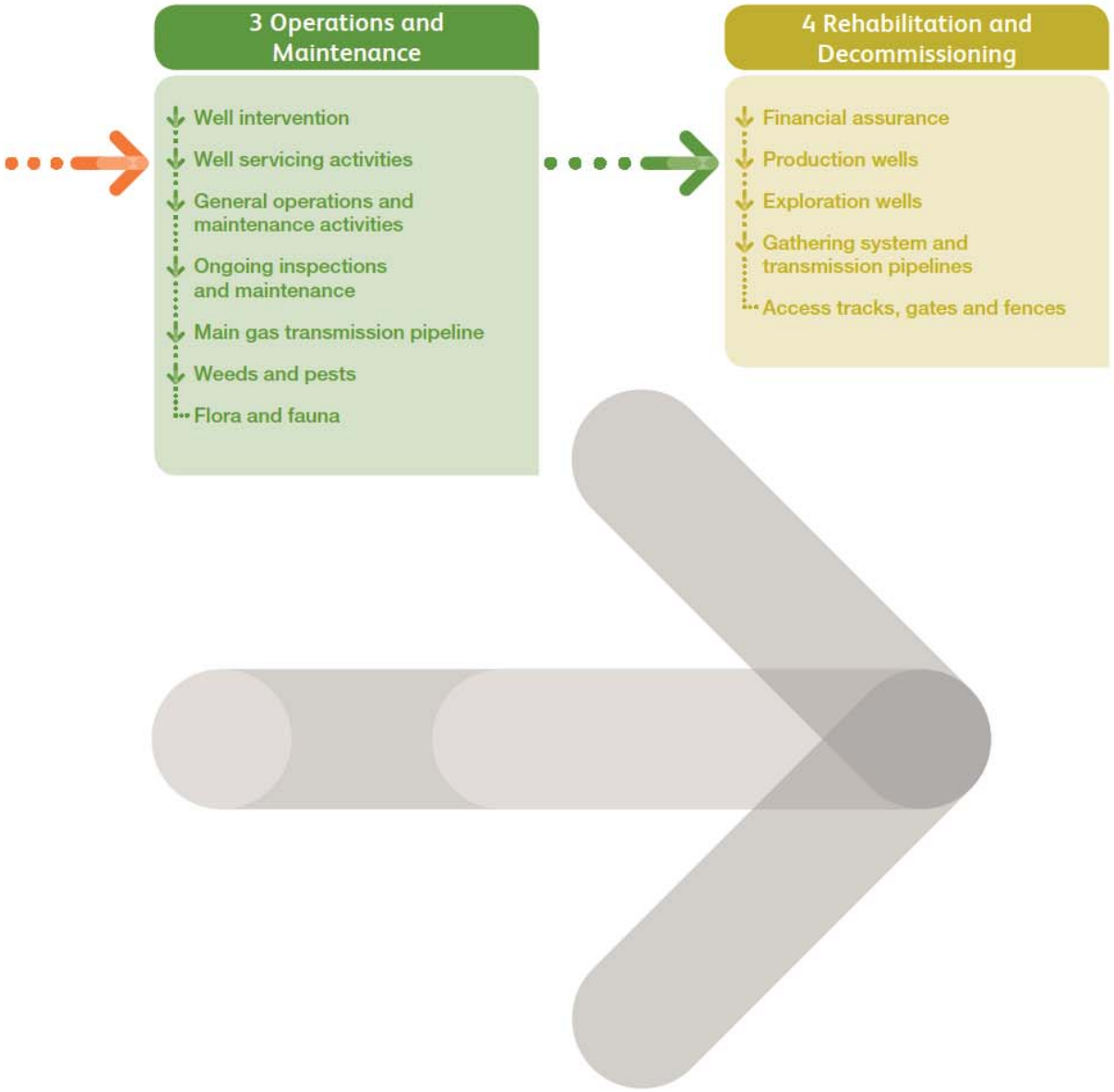
3.2 CSG development

The following diagram provides an overview of how CSG is developed.



Pipeline Right of Way


3 Operations and Maintenance
Well intervention
Well servicing activities
General operations and maintenance activities
Ongoing inspections and maintenance
Main gas transmission pipeline
Weeds and pests
Flora and fauna
4 Rehabilitation and Decommissioning
Financial assurance
Production wells
Exploration wells
Gathering system and transmission pipelines
Access tracks, gates and fences

3.3 Step one – Exploration and Appraisal

Seismic surveys

Seismic surveys are an essential part of natural gas exploration in Australia.

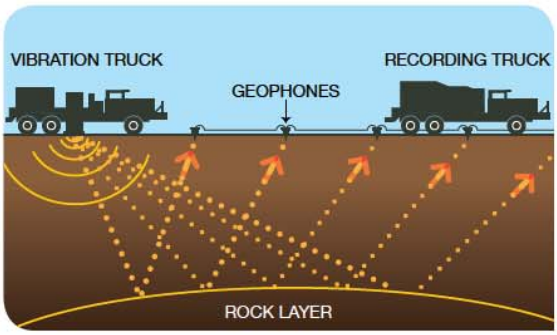
Seismic surveys are undertaken to gather images of the underground geology. This information is used to help guide field development activities in a manner that minimises the overall development footprint.

How they work

Seismic surveys map rock formations and subterranean geological structures.

Specialised seismic source vehicles generate a seismic sound wave that travels underground and bounces off rock formations. The reflected sound wave is recorded by hundreds of geophone sensors placed on the ground.

The data is then analysed by geoscientists who produce computer models of the different structures below the earth's surface.



Ground disturbance

Modern seismic surveys are very low impact operations.

As technology is constantly changing, you may see changes in our activities or procedures. Innovation gives us opportunities to make changes that are potentially more efficient or less intrusive. At all times we will keep landholders and interested community members informed on the types of activities proposed.

Where possible, seismic survey line paths are planned to take advantage of existing roads or tracks, however, when survey line paths traverse scrubland or long grass, the use of mulching or slashing equipment may be necessary.

In these circumstances, the exact path of the seismic line and the mulching or slashing path can be moved to preserve and protect any areas of ecological importance. For example, mulching operations usually avoid mature trees.

Careful survey design, along with the use of low impact seismic vehicles, and mulching or slashing only where necessary results in minimal ground disturbance, leaving the roots intact to regenerate quickly.

Associated noise

Surface noise can be generated when a seismic survey is undertaken. The surface noise is mainly generated by the source vehicle engine, and these sound levels are equivalent to those produced by standard agricultural vehicles. Studies have confirmed that seismic sound waves pose no threat to livestock.

Geophone sensors with cables

Activities involved may include:

- Scouting the area for technical, safety, environmental, and cultural heritage planning purposes
- Seismic line preparation, which may include the use of slashing and mulching equipment
- Installation of temporary or permanent gates
- Survey marking and pegging
- Placing seismic receiver equipment at intervals on the seismic lines
- Operating seismic source vehicles on the seismic lines to record data
- Recovering geophones and cables from the seismic lines
- Rehabilitation (if required).

Due to multiple and evolving technologies within the seismic industry, the activities from one seismic survey to another will vary significantly depending on the nature of the terrain and the particular technologies used.

Personnel on-site (generally)

The number of people required to undertake a seismic survey will vary depending on the scope of works.

A small refraction type two-dimensional survey crew may start at around ten to 12 people, while a large regional three-dimensional survey could require more across a wider area. Other factors influencing the number of people involved may include terrain, type of equipment used, and equipment deployment methodology.

Origin will discuss specifics of any survey program with you before and during survey activities.

Equipment and machinery may include:

- Tractors with slashing units
- Mulching machines
- 4WD vehicles
- All-terrain vehicles
- Medium to heavy vehicles (water trucks, data recording truck, equipment transportation, service trucks etc.)
- Seismic source vehicles (generally similar to agricultural vehicles)
- Drill rigs
- Helicopters
- Planes
- Earthmoving equipment.

Duration of activity

The time required for seismic surveys varies greatly. Surveys can take anywhere from a couple of weeks to more than a year to complete for large regional surveys.

As there are many variables to consider (beginning with the design parameters of the survey through to field data acquisition methodologies), the time spent on each property cannot be generalised.

Instead, the time taken to conduct seismic surveys will be determined and discussed on a project-by-project basis with you.

Seismic Vibroseis trucks

Exploration wells

Exploration wells help us to understand the nature and extent of gas reserves. These wells use a number of techniques including coring (removal of coal samples for off-site analysis), drill stem testing (very short duration pressure testing) or a combination of sampling/testing. These tests provide information about the presence of coal and gas, the volume of gas, and how readily the gas will flow.

In some circumstances the existing data and gas reservoir characteristics constrain the location where the well can be drilled to be able to obtain the required data.

After we have completed testing, exploration wells will be either plugged and abandoned or cased and suspended at the time of drilling.

Plugged and abandoned wells are cemented back to just below the surface with no equipment remaining on the surface following rehabilitation.

Exploration wells will generally be plugged and abandoned at the time of drilling. However a small number may be cased and suspended (lined with steel casing and cemented in) for future conversion to a production well.

Area disturbed

Leases for exploration wells are typically one hectare in size and also involve the use of existing access roads or newly constructed access roads to allow for the transportation of drilling rigs.

Core hole

Activities involved may include:

- Lease preparation
- Drilling
- Access tracks and laydowns.

Duration of activity

Lease preparation usually takes approximately ten days. Drilling activities may vary from between 15 to 35 days.

Equipment and machinery may include:

- Low loader
- Excavator
- Roller
- Grader
- 4WD vehicle
- Water truck
- Drilling rig
- Cement truck.

Further information about machinery and equipment is available on page 69.

Personnel on-site (generally)

15 to 30 people.

Piloting (pilot wells)

In determining reservoir conditions we also carry out pilot testing – a 'trial run' to test the productivity of the well.

Piloting involves drilling either single or multiple wells that are operated for a pre-determined period – usually 12 months – to gather information, including the permeability of the coal seam and the volume of water in the formation.

Gas obtained from pilot wells is flared as this is the safest method for managing the gas. Flaring is kept to the minimum time required to assess gas flows.

Once the necessary information about sub-surface conditions has been obtained, a pilot well may be cased and suspended which seals the pilot well pending long-term decisions on its use.

In certain circumstances, suspended pilot wells may later be converted to production wells.

Area disturbed

Single pilot test wells are constructed within a fenced area of approximately one hectare, with a single gas flare site of approximately 0.16 hectares. Associated water tanks require upwards of an additional hectare.

Multi-well pilots generally comprise four to five wells in a diamond formation, each separated by approximately 750m. These differ from single well pilots in that the gas and water from these wells are gatherered to a central point for gas flaring and water storage.

Should the location allow, both water and gas may be gathered for off-site collection and storage.

If the pilot well is to be fracture stimulated, or fracced (see page 56), the lease size is increased to approximately 1.2 hectares, with fraccing generally timed to take place as close as possible to drilling and completion of the well.

Pilot well

Multi-well pilot pond

Duration of activity

Pilots are typically operated for 12 months to allow adequate data to be collected.

Activities involved may include:

- Clearing and grading the well site area
- Fencing the site
- Drilling wells
- Installing a pump, surface facilities, and a gas flare
- Constructing water storage facilities (primarily ponds)
- Installing underground gas and water pipelines to central point for multi-well pilots.

Equipment and machinery may include:

- Drill rig
- Completion rig
- Fracture stimulation equipment (if required)
- Mud pump and mud tank
- Water storage tank or pond
- Casing racks
- Grader
- Loader
- Roller
- Storage tanks
- 4WD vehicles.

Further information about machinery and equipment is available on page 69.

Personnel on-site (generally)

- Lease preparation – ten people
- Drilling – 20 people
- Water storage – 30 people
- Fraccing – 20 people
- Rehabilitation – ten people.

Multi-well pilot flare

Water monitoring bores (including telemetry)

Ground water monitoring bores are strategically positioned across the petroleum tenements to monitor water levels and pressures of specific aquifers in accordance with Government requirements.

Ground water monitoring bores are either drilled as a single well, paired wells on a single lease or multiple wells.

Area disturbed

Typically a standard one hectare lease is required for single and paired wells, with multiple well sites comprising of up to four wells over two standard leases. Ground water monitoring bores may be drilled using a drilling rig, a drilling rig and a completions rig or a completions rig only. Shallow ground water monitoring bores may also be drilled by water rigs (the same as engaged by landholders). The lease size required is generally 40m by 40m.

The rehabilitated area is sometimes reduced to an area of approximately 10m by 5m which includes the surface equipment for monitoring of the wells. Leases drilled by water rigs may be rehabilitated back to an area of approximately 2m by 2m.

Duration of activity

The time required for lease preparation, drilling and rehabilitation for ground water monitoring bores is similar to that required for exploration wells (see page 24).

The bores typically have monitoring equipment installed downhole and usually telemetry on the surface to transmit or record data. The use of telemetry minimises the need for ongoing access.

Ongoing monitoring of groundwater bores is undertaken for the term of the gas development activities in the local area (typically twenty-five years).

Water bore sampling

3.4 Step two – Field Development

Access tracks and gates

A site access track is required for light and heavy vehicles (i.e. the drilling rig and associated equipment) to access the area where works will be undertaken, for example lease sites.

Depending on current access track conditions, earthworks may be required to upgrade existing tracks, or for the construction of new tracks.

All road works are completed to a standard to minimise wash-outs and erosion, so we can safely enter and exit your property. Sometimes minimal disturbance access tracks may be used to achieve this and lessen the environmental footprint, depending on soil types and terrain. Minimal disturbance access tracks vary but usually consist of a mowed strip and a light grade and roll to an existing track (to even out surface). Most tracks created for drilling and construction use have topsoil stripped to 100mm which is then replaced following construction.

If required, suitable grids and gates may be installed on fence lines.

We will consult with you about the proposed construction and upgrades of access tracks as part of our discussions regarding proposed CSG activities on your land.

Area disturbed

The size of the disturbance area for access tracks varies, as each site will require a different length of access track.

The approximate width of the access track construction corridor is 6m to 8m.

Duration of activity

The duration of time required to construct access tracks and gates will depend on the length of access tracks required in the construction phase and the number of lease sites on the property. Construction of access tracks and gates is incorporated in the lease preparation timeframes, which averages three to four days per lease site.

Access tracks and gates will continue to be used by 4WD vehicles and other machinery (e.g. workover rigs) throughout the life of the well to carry out maintenance activities during operations.

Rip rock may be used for significant or major creek crossings

Activities involved may include:

- Creating temporary stockpile areas during the construction of the access tracks
- Clearing, grading, and preparing access tracks according to the type of machinery that will travel on the track, to ensure there is no damage to the track surface:
  - Rip rock may be installed for significant or major creek crossings and water courses
  - Access tracks will only be gravelled where necessary to allow for rig access, or to ensure all-weather access to facilities.
- Installing gate and/or grid assemblies where tracks cross fence lines
- Installing double gates with turn-in access tracks in areas where rigs and heavy vehicles will be using the track as access through an internal fence or property boundary
- Installing a sliding 'open-closed' sign on some gates, allowing landholders to choose whether they want the gates left open or closed (refer p9 Gate Mate).

Equipment and machinery may include:

- Graders
- Loaders
- Rollers
- Tippers
- Water trucks
- 4WD vehicles
- Mulchers.

Further information about machinery and equipment is available on page 69.

Personnel on-site (generally)

Access tracks and gates are completed during lease site preparation and use existing personnel.

Double gate assembly

origin

Lease site preparation

The lease site is the name given to the pad on which the drilling rig (and other equipment used for well drilling) sits.

Identifying the location of wells is undertaken during the planning stages and will generally be shown on maps that are included in your CCA. Once the site has been identified for the well(s) and construction works commence, the lease site may be cleared, graded, and fenced (if required), and all drilling activities will take place within the confines of the lease site.

Several factors are taken into consideration when deciding on the preferred location of the lease site, including:

- Proximity to creeks or rivers
- Whether the location is part of an environmentally sensitive area
- The presence of cultural heritage and/or native title
- Proximity to any planned or current landholder infrastructure.

If the slope of the lease site area is relatively level at the critical area where the drilling rig will be located, a Minimal Disturbance Lease (MDL) will be constructed.

An MDL is a lease site where the topsoil is not removed and re-spread. Generally the lease area is slashed only.

If an MDL can be constructed, the physical disturbance to land is significantly reduced and the rehabilitation process is simplified. When constructing an MDL, we use a self-levelling drill rig that reduces the impacts of noise and vegetation disturbance.

Area disturbed

The size of the lease site is approximately 1.2 hectares, depending on the number of proposed wells for the pad. The size of this area will generally be reduced once the well is in production.

Duration of activity

Leases are constructed in a number of steps to support the drilling program. The overall process for Steps 1 and 2 of CSG development can take approximately three to six months.

An overview of the time required to develop a lease site includes:

- Step 1 – Construction
  - Approximately one week to construct a standard lease
  - Approximately three days to construct an MDL.

Minimal Disturbance Lease

- Step 2 – Interim rehabilitation
  - Approximately two to three days per lease to back-fill drilling sumps and flare pits, reduce fence area, and seed the lease area.

Activities involved may include:

- Clearing and grading the area to remove any grass and combustible items
- Creating access tracks (refer page 28)
- Fencing the lease site if required
- Mulching timber.

Equipment and machinery may include:

- Bulldozers
- Fence panels
- Forklifts
- Graders
- Rollers
- Mulchers
- Waste trucks
- 4WD vehicles.

Further information about equipment and machinery is available on page 69.

Personnel on-site (generally)

The number of personnel required on-site for lease building activities will vary depending on the number of CSG wells to be constructed on the property.

A standard crew usually comprises:

- One supervisor
- Five operators
- One environmental advisor (as required)
- One fauna spotter (during clearing).

In addition, Origin supervisors visit the site every few days to ensure compliance with your agreements and environmental management procedures.

Civil lease

Laydown yard

Laydown areas

A laydown area is a cleared area where we store materials such as pipes, equipment, and machinery.

This temporary area is generally only used during construction, and is rehabilitated once construction is complete.

Area disturbed

A laydown area requires approximately one hectare. The size of the laydown area can vary depending on the size and type of construction activities being undertaken.

Duration of activity

The duration of time the laydown area is required depends on the type of construction activities being undertaken.

Activities involved may include:

- Clearing and grading the area to remove grass and/or timber
- Topsoil stripping
- Fencing the area
- Constructing access tracks
- Delivering materials to be stockpiled
- Movements of delivery trucks and machinery, to load and unload materials.

Equipment and machinery may include:

- Bulldozers
- Cranes
- Forklifts
- Graders
- Rollers
- Trucks
- 4WD vehicles.

Further information about equipment and machinery can be found on page 69.

Personnel on-site (generally)

Four to six people. All work will be undertaken concurrently with the preparation of the lease site (refer to page 31), to minimise impacts on your business or farming activities.

Geotechnical investigations

Geotechnical investigations are undertaken to obtain specific information about the soil and/or rock where construction is proposed. The information gained in geotechnical investigations assists in the engineering design of CSG infrastructure, such as the well lease area, pipelines, flowlines, roads, water management ponds, camps, and laydown areas.

Soil samples are an important part of geotechnical investigations and are taken either by excavating test pits or drilling core holes (i.e. solid coal and rock cores). The samples are sent to a laboratory for analysis, to determine the type of soil and rock we are likely to encounter once construction begins.

Area disturbed

Core holes are generally 50mm in diameter and vary in depth from 6m to 20m.

The number of core holes required depends on the proposed site.

Duration of activity

Depending on the structure of the ground and location typically three to four core holes per day can be achieved.

Activities involved may include:

- A site survey to work out access and water source for the drilling process
- Drilling commences with core samples placed in trays to be taken back to the lab for testing
- Lab testing of core samples
- Detailed engineers report with recommendations to assist with the detailed design.

Equipment and machinery may include:

- Ten-tonne flat-bed truck with mounted drill rig.

Personnel on-site (generally)

- Driller
- One to two man drill crew.

Geotech rig

Completed CSG well; prior to installation of of surface equipment

Production gas well

A production gas well is constructed within the lease site to extract gas from the coal seams, by removing water which reduces the water pressure and releases gas from the coals.

If the coal seams have low permeability (i.e. it is difficult for the water and gas to flow from them) the seams may be stimulated (fracced) to improve the water and gas production rate. This is not required for all wells. Refer to page 46 for detail on well intervention.

In most cases a downhole pump is installed to bring water to the surface but sometimes this occurs naturally due to underground pressure.

There are typically two cemented casing strings (surface casing and production casing). These casings are cylindrical steel pipes with a diameter of 244.5mm for surface casing and 178mm for production casing.

Surface casing is cemented back to the surface.

Production casing is set across the coal seams and runs from the bottom of the well back to surface. In wells that are not fracced, the production casing is cemented from above the top coal back to the surface. In wells that are fracced the production casing is cemented across the entire casing length.

All wells are constructed to the Code of Practice for constructing and abandoning CSG wells and associated bores in Queensland.

The code prescribes the minimum standard for both CSG wells and CSG water bores to ensure they are constructed and abandoned correctly to maintain long-term well integrity, containment of gas, and the protection of groundwater resources.

As technology is constantly changing, you may see changes in our activities or procedures. Innovation gives us opportunities to make changes that are potentially more efficient or less intrusive for you. At all times we will keep you informed on the types of activities proposed.

Area disturbed

A site area of approximately one hectare is required to drill and complete each production gas well with approximately 1.2 hectares required if fracing is to occur.

Duration of activity

It generally takes up to fourteen days to drill and complete a standard development production gas well.

Typically a well will involve the following process:

- Drilling rig – three days
- Completions rig - one to two days
- Flushby rig – one day

Activities involved may include:

- A hole of approximately 220mm diameter is drilled with a drilling rig, which rotates a drill string with a drill bit on the end of it. The hole is generally drilled to a depth of between 200m and 1,200m, depending on the target seam depth
- Steel casing is installed and cement is pumped in the space between the casing and the outer walls of the well bore. This protects shallow aquifers and ensures well containment.

Equipment and machinery may include:

- Drilling rigs
- Completion and workover rigs
- Mud pumps and mud tanks
- Water storage tanks or ponds
- Drilling and completions auxiliary equipment
- Fuel tanks and settling tanks with mounted centrifuge
- Shale bins (cuttings skip) for cuttings storage
- Air compressors and boosters
- Hydraulic pipe handlers
- Pipe tubs
- Casing racks
- Forklifts
- Road trains
- Cement trucks and pumping units
- Wireline logging trucks
- Water tankers and vacuum trucks.

Personnel on-site (generally)

The establishment of production gas wells is a fairly labour intensive activity, which involves:

- Up to approximately 25 people working on the drilling rig (usually ten people on-site)
- Up to approximately 30 people working on the completions rig (usually ten people on-site).

Drilling work site

Precision GPS controls assist in assuring proper application rates, and proper application set back distances to environmentally sensitive areas and hazards.

Landspraying while drilling (LWD)

Landspraying While Drilling (LWD) is a less intrusive and more environmentally friendly way of disposing of water-based drilling muds – which are a mix of water (approximately 70%), rock fragments/solids (approximately 30%) and a small percentage of additives or compounds (approximately 0.1%).

LWD manages drilling by-products in a manner that preserves the biological, chemical and physical properties of soils, does not harm vegetation, and protects the quality of the surface groundwater.

Landspraying while drilling will not be used for all drilling activities and landholders will be involved in discussions on whether this activity meets the strict guidelines under the Environmental Authority (EA) or is appropriate for their property.

Key safeguards are in place to ensure only approved fluids are applied on flat land near the drilling site but away from natural water sources like creeks.

Fluids and drill solids created from drilling a well are stored in rig tanks and then sprayed on agricultural land by a fit-for-purpose truck.

It will further minimise land disturbance incurred by Australia Pacific LNG drilling activities because it removes or reduces the need to construct disposal sumps.

LWD is regarded as industry best practice in countries such as Canada where the technique has been used on more than 100,000 wells for over twenty-one years.

Area disturbed

Fluids and drill solids per well will cover between 3.5 ha - 8 ha (average is 5ha)

Duration of activity

- 2 - 3 days per well on a 24 hours basis involving up to 17 truckloads
- Each truckload will take up to 30 mins set up and spraying at site

Activities involved may include:

- Pre-testing of LWD site soil
- Pre-testing of fluid and drill solids
- Collecting fluids and drill solids from rig tanks
- Drive to LWD site and set up spray
- Spraying of mud (truck travels on average 6.5km per hour whilst spraying).

Equipment and machinery may include:

- One LWD truck per rig.

Personnel on-site (generally)

- One person (in addition to existing drilling personnel).

Purpose-built spray trucks have the ability to deflate their tyres to 18 psi (similar to pressures of tractor tyres) to reduce soil compaction. The truck then re-inflates the tyres on leaving the spray site so it can travel normally on public roads.

Surface equipment

After a well has been drilled and completed, wellsite equipment will be installed.

Typical surface equipment includes an electrical control box, a well-head separator, which separates any water from the gas, and the pipes connecting the gas and water to separate gathering system pipelines.

Since the wellsite equipment contains gas, each component will be tested and certified to ensure it is performing at the required standard. This helps ensure the safety of operators, landholders and the environment.

The well-head is installed during completion activities.

Area disturbed

No additional area is required to install or operate surface equipment, as all activity occurs within the lease site area.

Duration of activity

Installation of wellsite facilities may take up to two weeks, while final testing and initiation typically takes less than half a day.

Once the surface equipment is installed, the equipment is usually monitored weekly.

Activities involved may include:

- Moving equipment to the lease site, after the drilling rig has moved off-site
- Installing the electrical control box, separator, and the plumbing connecting the gas and water to the gathering system pipelines
- Testing the equipment to ensure it is operating at the required standard
- Ongoing inspections and maintenance, as required.

In the event of an emergency, access to the equipment may be required immediately. In these circumstances, the usual access requests are unlikely to be completed prior to entry. We will make all reasonable attempts to contact you before entry. If we are unable to contact you before entry, we will speak to you after the event.

Equipment and machinery may include:

- Trucks
- 4WD vehicles.

Personnel on-site (generally)

This work coincides with work on the production gas well and may include:

- Up to 25 people working on the drilling rig
- Up to 30 people working on the completions rig
- Up to 30 people working on the low permeability fracture stimulation wells.

Well installation

Pipelines and connection equipment

Gathering

Production gas wells are connected by separate underground water and gas pipelines called 'gathering systems'. Separation of the gas and water occurs at the well-head, and these systems connect via trunk lines to either a gas or water processing facility.

Gathering pipelines are buried below the ground so as not to disrupt any farming activities.

The underground gathering pipelines are made from high density polyethylene pipe, and have different diameters depending on their use and required pressure capacity. For the connection of wells, the pipelines vary from 125mm diameter pipelines leading to a trunk pipeline of approximately 560mm diameter.

During construction, pipes will be laid (strung) above ground and welded together prior to trenching and back-filling.

Once pipes are installed, they will undergo testing to ensure functionality and integrity before the trench is back-filled.

Back-filled trenches will be periodically checked for potential subsidence and erosion.

Area disturbed

A corridor called a Right of Way (RoW) is used during construction to carry out activities associated with the installation of the gathering system pipelines, vents, drains and valve pits, electrical infrastructure and the construction and use of access tracks for drilling rigs and other vehicular access. The width of the RoW is determined by the amount of infrastructure required and is usually between 12m and 42m wide.

Pipes are buried to a depth so that they will not interfere with your day-to-day activities. Origin will discuss this with you when discussing your current and proposed land use activities. This information is used to determine pipe depth. The minimum depth as per the Australian Pipeline Industry Association's Code of Practice is 750mm.

Duration of activity

Depending on ground and soil conditions, it can take up to approximately six days for every 500m of pipeline to be laid.

Activities involved may include:

- Moving earthmoving equipment to site
- Clearing and grading trees and shrubs
- Stripping topsoil and seed stock
- Excavating trenches to bury the pipes and electrical and fibre-optic cables
- Stringing and welding the pipes together
- Laying the pipe in the trench
- Checking the pipeline is undamaged and free of obstructions
- Laying tracing wire in the trench with the pipe to ensure the pipeline can be located with a detection device
- Pneumatic and hydrostatic testing
- Back-filling the trenches
- Installing above-ground signage at intervals along the pipeline corridor
- Rehabilitation.

Trenching

Equipment and machinery may include:

- Bulldozers
- Cranes
- Excavators
- Graders
- Welding machines
- Trenching machines
- Trucks
- Water trucks
- Test van
- 4WD vehicles.

Personnel on-site (generally)

Between 15 and 20 people.

Additional information

Once the pipelines are constructed, you will be required to contact Origin if you plan to undertake any future activities over the pipeline.

This may include excavating, drilling or erecting roadways, pavements, fences, cables or other improvements on or under the underground infrastructure.

Once notified, an operator may use a pipeline locating device to correctly identify the location of the pipes and any high voltage power cables. This will help ensure your safety and protect the pipes from any damage.

For any emergencies contact the Origin Operations Emergency Reponse line on 1800 076 251.

In addition you can call Dial Before You Dig on 1100 or visit www.1100.com.au.

DIAL BEFORE YOU DIG
www.1100.com.au
The Essential First Step

Pipeline

Pipeline – under rehabilitation

Cable laying

Open trench

Transmission

Australia Pacific LNG has a main high pressure gas transmission (or export) pipeline to transport gas from our CSG Gas Processing Facilities to our LNG Facility on Curtis Island, offshore from Gladstone. We also have smaller transmission pipelines to transport CSG and water from the gas fields to the gas and water treatment facilities distributed throughout the gas fields.

The main high pressure gas transmission pipeline is constructed from high-grade steel pipe (up to 1,050mm in diameter), and will deliver up to 1,560 terajoules of gas to the LNG Facility every day.

The smaller pipelines range in size from 450mm to 900mm in diameter.

The pipelines are typically buried to a depth of 750mm, going deeper on good quality agricultural land (900mm), under creeks and other water courses (2,000mm), and under railway crossings and road crossings (1,200mm).

The main gas transmission line is inspected by Origin's pipeline operations team on a regular basis. Inspection activities may include:

- Monitoring progress of rehabilitation
- Looking for soil subsidence or erosion
- Checking the condition of pipeline marker posts
- Identifying regrowth and weeds.

Area disturbed

High pressure steel gas pipelines require a construction width area of up to 40m wide along the entire pipeline length. This is also called a Right of Way corridor (see page 38).
Once construction is completed, the disturbed area is rehabilitated and returned to its previous land use.

In order to protect the integrity of the buried high pressure steel pipeline from external interference, an easement is established over the entire pipeline route occupying an area up to 30m wide and 720km long for the high pressure gas transmission pipeline, including the 530km main export pipeline and 190km of high pressure laterals.

If you need to work near or on these pipelines (i.e. pasture improvements, seeding, fencing etc) please call Origin before commencing work.

For any emergencies contact the Origin Operations Emergency Response line on 1800 076 251.

In addition you can call Dial Before You Dig on 1100 or visit www.1100.com.au.

Fibre-optic cable and underground power lines

Fibre-optic cable is used to transmit operational and safety data from each well to Origin's operations control centre in Brisbane. This information transfer process reduces the amount of traffic and the number of maintenance visits required to the well-heads.

In most cases, the fibre-optic cable will share the same trench as the high voltage electrical cables and gathering lines.

The fibre-optic cable will be inspected during construction prior to back-fill of the trench. The cable will then undergo testing to ensure functionality and integrity. Back-filled trenches will be periodically checked for integrity, potential subsidence, and erosion.

Area disturbed

- A Right of Way corridor of between 12m to 42m is required for fibre-optic cable (along with electrical cables and pipes).

Duration of activity

It takes up to approximately five to six days for every 500m of cable to be installed.

Tractor and cable trailer

Activities involved may include:

- Clearing and grading the area
- Laying the cable along the corridor zone
- Trenching
- Laying the cable into the trench
- Back-filling the trench with soil
- Installing the surface electrical infrastructure in the general vicinity of the gathering system pipeline corridor
- Compacting the soil to minimise subsidence post-construction
- Installing signs at intervals along the corridor
- Rehabilitating the land over the cables.

Equipment and machinery may include:

- Bulldozers
- Excavators
- Graders
- Tractors and cable trailers
- Trenching machines
- Water carts
- 4WD vehicles
- Cable drum trailers.

Further information about equipment and machinery is available on page 69.

Personnel on-site (generally)

Up to 15 people.

High point vent

Vents, drains, valve pits and signage

The gas and water produced from the well travels through the well-head separator at the well site, and are transported by separate gas and water gathering pipeline networks. After separation, there may still be some gas dissolved in the water, and the gas lines may also have water condensate inside the gathering pipeline.

High point vents (HPVs) are installed in water lines to allow any gas that may be dissolved in the water to vent to the atmosphere.

HPVs are installed at localised high points in the gathering network, such as the top of land undulations. They contain a pressure valve inside the unit, which operates automatically and can be manually overridden, if required. The HPV is similar to systems found in many irrigation lines to remove trapped air.

Low point drains (LPDs) are installed at the bottom of topographic undulations, and valves are installed in the gas lines to allow condensation collecting at the bottom of the gas line to be collected or released, where permitted.

In some cases, where permitted under an EA, water may be released to the surface of surrounding land.

Valve pits are sometimes installed outside a well site on the pipeline. This allows easy access to isolate well sites from the pipeline. If there is no valve pit above ground, there is most likely a valve buried underground.

HPVs and LPDs will mitigate any potential future pipeline blockages and ensure the system operates safely and efficiently.

Above ground signage used along gathering and transmission pipelines

Low point drain

Area disturbed

Each above-ground vent, drain, and valve pit requires an area no larger than approximately ten square meters.

Duration of activity

Installation of vents and drains is generally undertaken in conjunction with other construction activities. The below-ground components are usually installed with the pipeline, and the above-ground components are installed during final construction.

Activities involved may include:

- Installing above-ground components
- Fencing the area if required
- Installing a tank beside the LPD valve to collect the water.

Equipment and machinery may include:

- Graders
- 4WD vehicles
- Welding machines
- Vents, drains, and valve pits.

Further information about equipment and machinery is available on page 69.

Personnel on-site (generally)

Up to six people.

Condabri Central gas processing facility

Gas Processing Facility

A Gas Processing Facility (GPF) is a large, fenced site consisting of compressors, gas processing equipment, electricity generation, water storage and treatment, equipment storage, offices, and staff accommodation camp.

At a GPF, the gas is compressed and then dehydrated to remove any remaining water from the gas.

The associated water is pumped to a Water Treatment Facility (WTF), where it is treated via reverse osmosis to remove any dissolved salts and impurities. The treated water is then suitable for uses such as irrigation and aquifer reinjection.

Duration of activity

Construction of a GPF, including installation of all equipment and machinery, can take up to two years, depending on the infrastructure required on site.

Activities involved may include:

A wide variety of activities are undertaken to construct a GPF as each piece of infrastructure needs to be constructed separately. Infrastructure can include:

- Compressors
- Electricity generation equipment
- Water storage and treatment facilities
- Site offices
- Staff accommodation camps
- Associated pipelines that are connected to the gas processing and water treatment facilities.

Personnel on-site (generally)

A large number of people are involved in the construction of a GPF, however, the number of people on-site at any time will depend on the staging of construction activities.

GPF ongoing operation

The GPFs are designed to be highly automated and are remotely operated from our Brisbane Central Control Room with attendance from an operator at the gas plant during daylight hours to monitor equipment performance and perform operations and maintenance activities.

GPFs are designed to run for extended periods and typically only require shutdowns for major maintenance activities every four years. During shutdowns major maintenance crews travel to site and carry out work to minimise plant down time.

GPF Flares

Each GPF compression train is equipped with a dedicated enclosed ground flare. The flare is designed to safely combust gas and is part of the overall GPF pressure safety relief system.

In normal operation there is only a small pilot flame alight in the flare. In other situations where the GPF safety systems shut the GPF down, the gas inventory in the plant and any gas being produced in the field is directed to the flare and safely combusted. During these times there is generally an increased noise level generated from the combustion of the gas and there may be flames visible and an increase in light emissions.

3.5 Step three – Operations and maintenance

After field development activity is complete, wells and gathering pipelines are commissioned for ongoing operations. During the operating phase, ongoing inspections and maintenance will ensure the appropriate integrity of production infrastructure. From time to time, wells may also require some form of intervention to improve productivity or change equipment installed at surface or downhole.

Origin undertakes ongoing and progressive rehabilitation and monitoring throughout operations and at the completion of activities.

After construction is completed, regular inspections will continue for approximately six months. This may require vehicles to return for further work as required. Further details about rehabilitation can be found on page 55.

Ongoing inspections and maintenance

Infrastructure and land will require ongoing monitoring with regular follow-up inspections.

Area disturbed

No area will be disturbed in an inspection process, however if repairs are required further disturbance may be necessary.

Duration of activity

Inspections will take approximately fifteen – thirty minutes for each piece of infrastructure. Duration of maintenance will depend on each individual activity required.

Activities involved may include:

- Inspections
- Maintenance by Origin work crews and contractors.

Equipment and machinery may include:

- Excavator
- Roller
- Tractor with implements
- Truck and bobcat
- 4WD vehicles
- Truck and trailer
- Grader.

Personnel on-site (generally)

Up to 12 people.

Low point drain maintenance

Low point drains are drained as required.

Duration of activity

Usually up to one hour.

Activities involved may include:

- Collect water samples for analysis
- Release condensed water from gas line to grade from pipe outlet and/or a spray
- Drain condensed water from gas lines to water truck
- Transport water to WTF.

General maintenance around well

Equipment and machinery may include:

Truck.

Personnel on-site (generally):

One person.

High point vent maintenance

High point vents are checked approximately every three months or as required.

Duration of activity

Usually up to thirty minutes.

Activities involved may include:

Check and repair high point vents on water lines.

Equipment and machinery may include:

4WD vehicle.

Personnel on-site (generally):

One person.

Well servicing activities

Well-head inspections and reads:

Inspections are carried out on well-heads as required.

Duration of activity

Approximately one hour.

Equipment and machinery may include:

- 4WD vehicle.

Activities involved may include:

- Check well pressures
- Measure well fluid level
- Inspect for abnormal conditions
- Manage weeds.

Personnel on-site (generally)

One person.

Well-head maintenance:

Maintenance checks are carried out on each well every six months or as required.

Duration of activity

Approximately one day.

Equipment and machinery may include:

- Two 4WD vehicles.

Activities involved may include:

- Troubleshoot, diagnose and repair equipment fault.

Personnel on-site (generally)

Two people.

Well-head preventative maintenance

Preventative maintenance is carried out on each well approximately every four years. This involves a thorough inspection of the equipment.

Well-head

Duration of activity

Approximately one day.

Equipment and machinery may include:

- 4WD vehicles
- Light truck.

Activities involved may include:

- Isolate well-head production equipment
- Open up pipework and pressure vessel
- Inspect, remove and service well-head safety equipment
- Conduct thorough inspections on electrical equipment.

Personnel on-site (generally)

Four to six people.

Production Logging

Wireline activity where electric logging tools are deployed into the wellbore to evaluate the production characteristic and to capture well production data.

Duration of activity

Up to one day.

Equipment and machinery may include:

- 4WD vehicles
- Light truck.

Activities involved may include:

- Rigging up pressure control equipment to the wellhead to facilitate deployment of electric wireline tools into the wellbore.
- Flowing the well through the existing wellsite production equipment so that production characteristics can be measured by the tools.

Personnel on-site (generally)

One to three people

Well intervention

Well intervention refers to any works or activities that are carried out to restore or improve the production of a well, or to modify surface equipment and downhole equipment.

These activities may include workovers, well servicing activities, hydraulic fracturing and pump services.

Hydraulic Fracture Stimulation

Hydraulic fracture stimulation (also known as hydraulic fracturing, or fraccing) is a process commonly used in low permeability coal areas to increase the gas flow rates of wells and can significantly reduce the number of wells required to be drilled in an area.

It is the process by which a coal seam is fractured by pumping a fluid into the seam under pressure, to increase the flow of gas from a reservoir.

The fluid, called hydraulic fracturing fluid (or frac fluid) made up mostly of water and sand (to keep the fracture open), together with a small percentage of chemical additives (1%).

After being pumped down the well the pressure is released, leaving the sand in place.

The aim of hydraulic fracture stimulation is to open, connect, and create fractures in the coal seams, as well as placing sand in existing and new fractures, which holds them open to provide a pathway for water and gas to flow more easily into the well for extraction.

Hydraulic fracturing work site

To prevent hydraulic fracture stimulation fluids and gas from entering surrounding aquifers, rigid design standards are followed and the integrity of the well is confirmed prior to the commencement of hydraulic fracturing. By way of example, all CSG wells have multiple steel casings with cement sheaths that isolate surrounding formations from each other and the well bore. The well-head and casing system used is designed specifically to manage the increased pressure during hydraulic fracturing.

As set out above, the hydraulic fracturing fluids used are water based. Many of the additives contained in frac fluids are also commonly used in agriculture, food products, households, and medical products. They may include:

- Guar (found in cosmetics, ice cream, baked goods, cheese, sauce, animal food, pharmaceutical products)
- Acetic acid (vinegar)
- Potassium chloride (used in fertiliser, medicines, food additives, table salt replacement
- Gelatin (found in cosmetics, personal care, medical, and food products)
- Sodium hydroxide (caustic soda, used in toothpaste)
- Bactericides (to inhibit bacteria growth in frac fluids).

The number of chemicals used in a particular frac can vary from 2 to 16. These additives are used to:

- Enable the fluid to form a gel to hold the sand in suspension, therefore allowing less water to be used and more sand to be spread throughout the fracture network
- Break down the gel once the process is complete
- Stabilise clays to prevent swelling
- Balance pH levels
- Prevent transfer of bacteria from surface water to the coal seams, and maintain gel quality while the fluid is pumped.

Area disturbed

The size of the area used for well intervention depends on the number of gas wells that require stimulation, however all activity will occur within the lease site. In some cases the lease site size may need to be increased.

Duration of activity

Well interventions generally take up to approximately five days on each well.

Activities involved may include:

- The expansion of lease to an area measuring approximately 1.2 hectares if required
- Transport fraccing equipment to the lease site
- Pumping the water and sand blend to treat reservoir coals
- Demobilise from location.

Equipment and machinery may include:

- High pressure pumps
- Water storage
- Sand storage
- Sand and chemical blending equipment
- Site offices
- Small cranes.

Further information about equipment and machinery is included on page 69.

Personnel on-site (generally)

Up to 30 people.

Workovers

A workover refers to any well intervention servicing or maintenance activity required for the ongoing operation and production of a gas well.

Workover activities may include pump maintenance or replacement, tubing and rod string replacement, and other activities required to optimise well production or maintain well integrity. The well downhole production pumps will require maintenance throughout the well's production life cycle. When this occurs, a workover rig is required to replace the pump and restore the well's production.

Although it is difficult to predict the number of well interventions, based on current production knowledge and technology, it is estimated that a well intervention (requiring the operation of a major rig) will be required approximately once every two - three years. In the first 18 months this may occur more frequently to bring well up to maximum capability. It is estimated that a well intervention, (which will not involve the operation of a major rig) will be required once every six months to two years.

Area disturbed

All workover activity is conducted within the existing lease area. In some cases the lease site size may need to be increased.

Duration of activity (per well)

The duration of time required to conduct a workover varies depending on the maintenance activities required, but generally takes between two to four days.

Activities involved may include:

- The expansion of lease to an area measuring approximately 1.2 hectares if required
- Flushing out well
- Replacing the pump, tubing, and/or rod string
- Performing well diagnostics and/or integrity remediation activities
- Plug and abandonment
- Acidisation.

Equipment and machinery may include:

- Completions/workover rig or smaller Flushby rig, depending on type of activities required
- Wireline trucks
- Coil tubing units
- Mud pumps
- Water storage tanks or ponds
- Skids
- Air compressors
- Boosters.

Further information about equipment and machinery is included on page 69.

Personnel on-site (generally)

Up to 25 people.

Acidisation

The formation of scale is a known occurrence during gas and water production and its presence is dependent on certain well conditions including natural fluid properties (i.e. water chemistry) and downhole well conditions (i.e. pressure & temperature).

When these conditions are present, the formation of scale within the well is possible throughout the well's production life. The scale is typically made up of calcium carbonate ($CaCO_3$) and its presence has the ability to impact well production and restrict well maintenance activities. If scale does accumulate, the technique of acidisation is used to dissolve and remove the scale. This entails using a small volume (approx 20 litres) of 15% hydrochloric acid (HCL) within the well to dissolve the scale and recover it back at surface. The volume of HCL required can vary based on the extent of the scale accumulation.

Workover rig

Roads/civil maintenance

Access tracks are repaired approximately every one to two years.

These repairs may be conducted by Origin or a third party contractor depending on arrangements in place. This will be discussed with you.

Duration of activity

Usually one to three days, dependant on property size and roads on the property.

Activities involved may include:

Grade/repair tracks as required.

Equipment and machinery may include:

- Grader
- Tipper
- 4WD vehicles.

Personnel on-site (generally):

One person.

Rehabilitated pipeline Right of Way

Rehabilitated main gas transmission pipeline Right of Way

Main gas transmission (or export) pipeline

Origin carries out routine operating activities and regular scheduled maintenance on the pipeline network over its operational life. Many variables can contribute to the frequency of activities conducted on the pipeline network and its easements, such as business operational requirements and weather. For example, an intense storm or flood may require an unscheduled inspection.

Area disturbed

Within existing easement boundary.

Duration of activity

This will vary depending on type of activity. Inspections generally occur on a monthly basis and take approximately half a day to complete.

Activities involved may include:

- Inspection of the pipeline easement
- Excavations
- Inspection of main line valve sites
- Integrity checks.

Vegetation management activities

Vegetation management in the easement is undertaken to ensure the safe operation of the pipeline network. The easement will generally be maintained with grasses and groundcovers which are consistent with the surrounding vegetation and land use.

Vegetation management can involve slashing, hand clearing and spraying of woody or weed vegetation, as well as revegetation in accordance with landholder agreements. The easement will generally be maintained with grasses and groundcovers which are consistent with the surrounding vegetation and land use.

In line with Government approval conditions, Origin does not burn vegetation on the easement.

Equipment and machinery may include:

This depends on the nature of work being carried out but may include:

- 4WD vehicles
- Heavy vehicles such as backhoes, graders, trucks and excavators
- Helicopters for aerial inspections.

Personnel on-site (generally)

- One operator for initial inspection
- Two or more contractors depending on required follow-up activity.

Declared pest plant – Harissia cactus

Weeds and pests

Regular inspections are undertaken to determine the effectiveness of rehabilitation, which includes checking for the presence of weeds and pest species. We carry our appropriate control measures in relation to declared weed species within our disturbance footprint and these can be controlled by chemical (herbicides) or physical removal (hand removal). We maintain herbicide application records and all chemical use complies with relevant legislation including the *Agricultural Chemical Distribution Control Act 1966* (Qld).

Flora and fauna

All injured fauna are reported to the Field Environmental Advisor on shift. If any injured or sick livestock are identified, we will contact you. Above-ground infrastructure (e.g. well-heads, low point drains, gas plants) are fenced, generally with cattle panels to keep out livestock and wildlife. In some cases, and in consultation with you, lease sites will not be fenced.

3.6 Step four – Rehabilitation and decommissioning

Rehabilitation

The type of rehabilitation activities carried out will depend on the type of infrastructure located on your property, and future use requirements of the site. Rehabilitation will be discussed with you during the negotiation process.

Origin is committed to rehabilitation of properties in accordance with environmental laws, including where appropriate, rehabilitating properties so that the original ecosystem is as similar as practicable to that which had existed previously. Vegetation mapping, soil samples and analysis are undertaken to determine soil type and characteristics prior to activities commencing.

Interim rehabilitation (or reinstatement) and final rehabilitation are two stages of the process.

Interim rehabilitation includes backfilling trenches and bell holes (dug as part of trenching), bringing the ground back to its original form, re-spreading topsoil and temporarily installing erosion and sediment controls. This usually occurs after pipe and cable has been laid and again once construction is completed.

Interim rehabilitation occurs progressively during construction to achieve a stable landform for the duration of the operations phase and minimises the duration that topsoil is in stockpiles and the land is exposed. Erosion and sediment controls remain in place until interim rehabilitated areas are stable.

Once construction and installation works are completed in a particular area, interim rehabilitation continues - open excavations are backfilled, compaction relief conducted where needed, topsoil is re-spread and seeding occurs where required for vegetation establishment. Seeding usually includes a sterile cover crop for quick vegetation establishment and erosion protection. Additionally a seed mix that can be agreed with the landowner (subject to Environmental agreements) for pasture or cropping areas, or native seed if in an area that was previously native vegetation. Where available, mulch is spread to provide an immediate barrier to erosion - this generally is where native vegetation or timber was the previous land use. At stream crossings the bed and banks of streams are stabilised; for small streams this is usually with seed and a soil binder, however for large streams, rock is used to prevent erosion of the bed and banks.

Final rehabilitation occurs once the petroleum infrastructure for the tenure have been decommissioned. At this stage, additional measures may occur including:

- Removal of surface infrastructure
- Removal of fencing and signage
- Compaction relief of tracks and other operational areas no longer required
- Seeding and vegetation planting.

Well Abandonment

Well abandonment is the process undertaken when a well is no longer productive. The life of a production well is generally 20 to 30 years.

At abandonment, the well is plugged with cement and sealed to ensure all geological formations are isolated from each other. The plug and abandonment procedure complies with all Australian regulations and industry Codes of Practice for constructing and abandoning CSG wells and associated bores in Queensland.

Financial Assurance

Australia Pacific LNG and Origin have lodged a significant amount (in excess of $300 million*) with the Queensland Government in Financial Assurance (FA) for tenures (Authorities to Prospect, Petroleum Leases, and Petroleum Pipeline Licences etc.) in Queensland.

FA is a type of financial security that is provided to the Queensland Government by the holder of an Environmental Authority (EA).

FA provides the Queensland Government with a financial security, in the unlikely event that parties in the future do not have the financial means to cover any costs or expenses to rehabilitate disturbances associated with their gas development activities to meet their environmental obligations in the EA.

Petroleum activities cannot commence until the appropriate FA has been provided to the Queensland Government.

Lease site with interim rehabilitation pending final rehabilitation and eventual decommissioning of well.

* as at 30th September, 2016.

Steel marker sign for a plugged and abandoned well

Production wells

The size of the lease site on which the well was constructed is likely to be reduced as production commences. The reduced well-head site will continue to be panel-fenced to exclude livestock.

The area outside the panel fence will undergo interim rehabilitation to a stable landform with suitable ground cover. Where cut and fill civil construction is required, particularly for leases on sloping land, the landform may not be returned to an original contour profile due to future production workover requirements.

In this circumstance the landform will be contoured to a stable slope with suitable ground cover to prevent erosion. Top soil that was previously excavated and stockpiled will be re-spread and ground cover restored. Civil leases are stablised as soon as possible to minimise the risk of embankments eroding. All rehabilitation works are monitored to ensure re-instatement of ground cover to a suitable condition.

Duration of activity

The commencement of final rehabilitation and the decommissioning of a well generally takes between one and seven days per lease.

Final rehabilitation will continue following decommissioning of the well.

Activities involved may include:

- Filling flare pits
- Filling sumps
- Re-profiling topography
- Ripping soil
- Reinstating topsoil
- Seeding
- Monitoring and remedial works
- Weed control
- Removing surplus or waste materials.

Equipment and machinery may include:

- Excavators
- Bulldozers
- Scrapers
- Backhoes
- Bobcats
- Water trucks
- Tractor and agricultural implements
- Dump trucks.

Personnel on-site (generally)

Eight to 12 people.

Exploration wells

The size of the lease site on which the well was constructed is likely to be reduced for cased and suspended wells during rehabilitation. The reduced well-head site will continue to be panel-fenced to exclude livestock.

The area outside the panel fence will be rehabilitated as a stable landform with suitable ground cover.

For plugged and abandoned wells the lease will be fully rehabilitated and the lease fence removed.

Area disturbed

Area will be reduced to approximately 4m x 4m.

Duration of activity

Approximately four days.

Equipment and machinery may include:

- 4WD vehicles
- Water truck
- Loader or excavator
- Roller
- Grader.

Personnel on-site (generally)

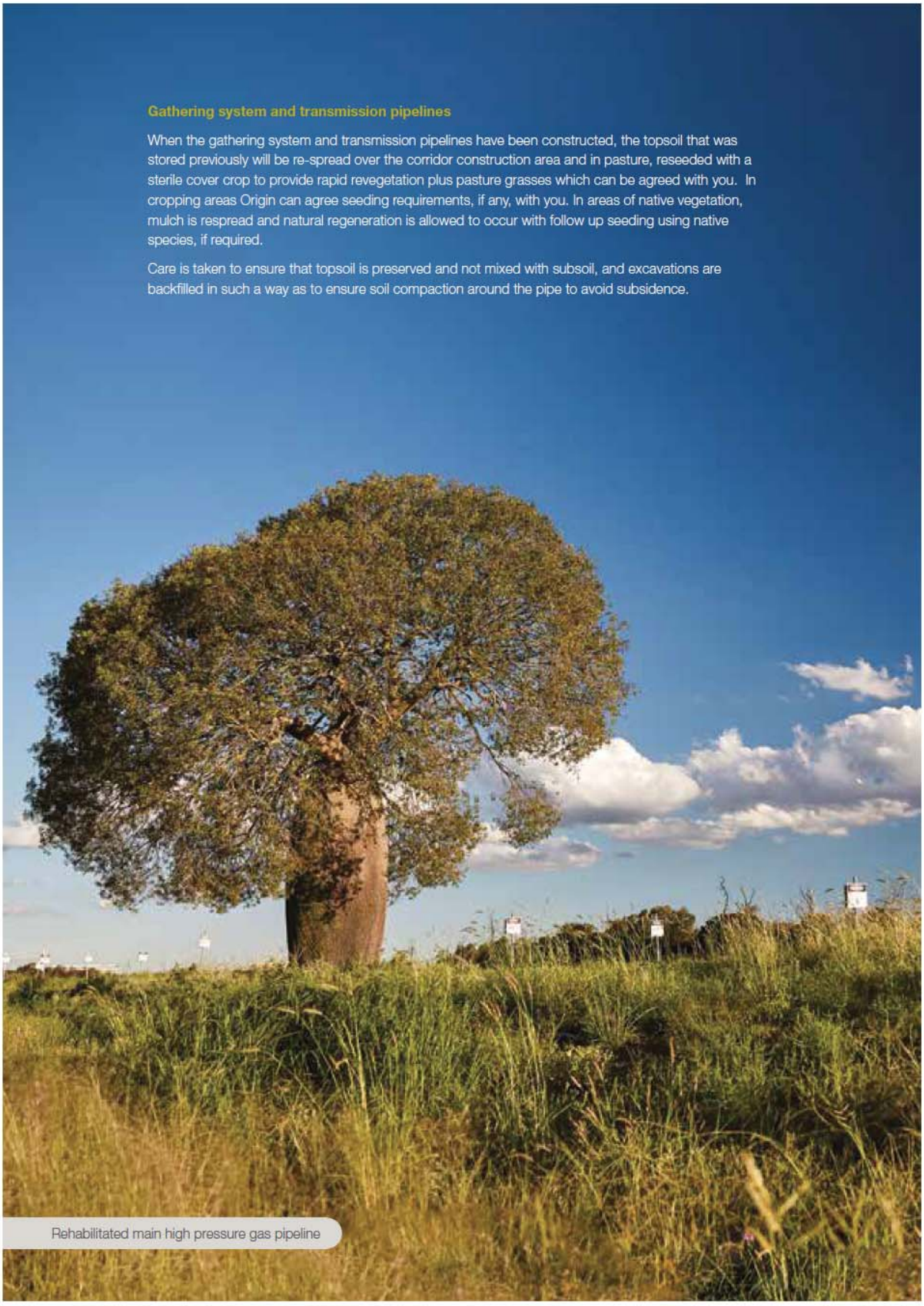
Eight to 12 people.

Exploration well cased and suspended prior to rehabilitation

Gathering system and transmission pipelines

When the gathering system and transmission pipelines have been constructed, the topsoil that was stored previously will be re-spread over the corridor construction area and in pasture, reseeded with a sterile cover crop to provide rapid revegetation plus pasture grasses which can be agreed with you. In cropping areas Origin can agree seeding requirements, if any, with you. In areas of native vegetation, mulch is respread and natural regeneration is allowed to occur with follow up seeding using native species, if required.

Care is taken to ensure that topsoil is preserved and not mixed with subsoil, and excavations are backfilled in such a way as to ensure soil compaction around the pipe to avoid subsidence.



Rehabilitated main high pressure gas pipeline

Right of Way rehabilitation at three to four weeks

Access tracks, gates and fences

When decommissioning, any gates and fences installed in the course of carrying out CSG activities may be removed, if they haven't been already. This will be discussed with you.

However, if permitted by law, we may leave behind the gates and fences that were installed following discussions with you and subject to your agreement.

In that case, the ownership and all rights and obligations in relation to the fences and gates, including responsibility for future maintenance, will transfer to you.

Grid and gates

origin

4 Environmental management

4.1 Overview

Origin is committed to responsible and sustainable environmental management practices across all its projects.

We understand the growth of our operations relies heavily on implementing sustainable environmental practices and initiatives, and we are committed to continuously refining and improving our procedures.

Our core environmental management focus remains on land use, soils, rehabilitation, waste and emissions management, weed control, erosion and sediment control, protection of flora and fauna and water management.

Before we start work on any property on behalf of Australia Pacific LNG, we undertake environmental assessments to identify any site-specific environmental management practices required.

We also work with landholders to ensure we avoid sensitive areas, adequately protect environmental and land values, and ensure minimal disruption to the existing environment and land use.

We design infrastructure to blend with the landscape, aim to ensure the efficient use of materials and energy, and we conduct interim rehabilitation (or reinstatement) following construction and final rehabilitation at the completion of activities.

Australia Pacific LNG has made a commitment across all of its projects to:

- Continue consultation and engagement programs with stakeholders to ensure their views are understood and considered throughout the life of the business
- Continue to participate with Government in local and regional planning processes, and provide timely information about CSG activities to inform discussion and decision making.

Environmental Impact Statement

An Environmental Impact Statement (EIS) is a document prepared to describe the potential impacts of a proposed activity on the environment and stakeholders. An EIS describes the impacts, and documents ways to avoid, minimise or mitigate potential impacts of a project.

In April 2009, the Queensland Coordinator-General declared the Australia Pacific LNG Project 'a significant project' requiring an EIS under the *State Development and Public Works Organisation Act 1971* (Qld) (SDPWO Act). The EIS process in Queensland is managed by the Department of State Development on behalf of the Coordinator-General.

In March 2010 the Australia Pacific LNG EIS was released for public and agency comment and approval was subsequently granted as set out in the Coordinator-General's report on the EIS dated November 2010.

Under Commonwealth legislation, the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) is also triggered by the Project, due to actions which are likely to have a significant impact on matters of national environmental significance.

The Project underwent formal assessment and approval under the EPBC Act. A number of EPBC Act approvals were granted for the Project, based on different Project components including separate approvals for the construction and operation of the gas fields, the high pressure gas transmission pipeline and the LNG Facility on Curtis Island.

Operating well surrounded by sorghum crop

4.2 Environmental impacts and management strategies

Origin focuses on ensuring the sustainability and co-existence of our landholders' businesses and our operations.

Prior to constructing any infrastructure, we will carry out ecological and environmental studies on your property to ensure that all environmentally sensitive areas are identified. We will also discuss and work with you to ensure our operations avoid any sensitive areas on your property, and cause minimal disruption to the existing environment and your property use.

We design our infrastructure to blend with the landscape. Reinstatement will occur following construction and final rehabilitation at the completion of all our activities.
This may include re-spreading of topsoil and restoring vegetation, and seeding and scarifying. We seek to use materials and energy as efficiently as possible in all our operations and are constantly implementing and upgrading initiatives to reduce our carbon emissions and waste. Any waste we do create on site is removed and disposed of appropriately. Some of these items may be reused or recycled.

We will work closely with you to ensure any concerns or questions you may have are listened to and acknowledged, before any work on your property.

We will seek your input on proposed activities in an effort to minimise impacts and disturbance, including the location of wells, access roads and other facilities.

The following information has been developed to provide you with clear information about our approach to environmental management, including the steps we will take to mitigate and manage any impacts.

Ground water

CSG production involves the extraction of water in coal seams to depressurise the coal measures, allowing natural gas to be extracted.

In the past, a number of stakeholders have raised concerns that the depressurisation of coal seams will affect groundwater levels or water quality in Great Artesian Basin (GAB) aquifers that are used for water supply.

A typical ground water bore is between 40m to 250m deep, while a CSG gas well is usually drilled to a depth of between 400m and 1,000m depending on the target seam depth.

Research and data collected over more than ten years, coupled with an in-depth knowledge of GAB aquifers and computer modelling, indicate that CSG production is likely to have negligible impacts on the most commonly used water supply aquifers.

We are committed to minimising the impacts of CSG production on the environment, and have formulated an extensive groundwater monitoring program that will operate throughout the life of the Australia Pacific LNG business. Our work in this area includes:

- Ongoing monitoring, including monitoring in some early development areas since 2007
- Modelling findings used to assist in the planning of future groundwater management
- Commissioning groundwater modelling and monitoring up to three years in advance.

In addition, Origin complies with the Queensland Government adaptive environmental management approach. This approach allows for best practice management techniques to be implemented as new technology becomes available, to ensure environmental values and groundwater resources are protected and managed into the future.

Landholder water bores that tap the same coals seams as CSG production may see reductions in groundwater levels within operational fields. Such bores normally fall under the "make-good" provisions of the *Water Act 2000 (Qld)*, and Origin enters into agreements to decommission these bores.

If you have any concerns about any of your registered water bores please contact us.

Water bore monitoring

Gas in water bores

The presence of natural gas has been recorded in some water bores for many years, and is noted in historical Queensland Government records of water bores in the Surat Basin. The gas is usually sourced from coal and other organic matter, which occur in most GAB aquifers. Methane is colourless, odourless and dissipates quickly if present at surface.

In a small number of cases, close to but outside of development, gas venting from water bores may also increase in response to CSG production, especially where the bore has had a history of gassiness. Where this is detected or assessed to be likely, Origin pursues agreements to decommission water bores whether they are subject to make good provisions or not.

If you have any concerns about any of your registered water bores please contact your LL.

Weeds and pests

Before we begin work on any property, we undertake environmental assessments of the area to identify any site-specific weed management requirements.

Our strict biosecurity management plans and procedures have been developed to minimise the chances of spreading declared pests, in accordance with relevant legislative requirements and the Land Access Code.

Thorough planning will take place, including an inventory of weeds where our activities will occur. Measures taken to control weeds, include:

- Engaging a licensed and experienced weed control subcontractor
- Implementing protocols to ensure that every vehicle has a valid weed hygiene report and remains within weed managed areas
- Restricting vehicle and personnel access in areas of known weed infestation
- Weed eradication measures, such as spraying with non-residual herbicides.

If chemicals are to be used, this activity will be undertaken in consultation with you. We also take into consideration sensitive farming practices (e.g. chemical free farming) and areas of heightened sensitivity.

Springs, creeks and waterways

We are committed to protecting the environmental values of springs and creeks. Prior to commencing construction, the disturbance footprint is scouted to ensure that all springs and creeks are identified. Infrastructure is then moved where possible to minimise the disturbance to creeks and springs. In situations where waterways cannot be avoided, such as waterway crossings, these are then maintained on a regular basis to ensure there is minimal impact on the aquatic environment.

Water truck for dust suppression

Dust

It is likely that dust will be generated as a result of some construction activities on your property.

We ensure that dust impacts are minimised and do not affect your health or your agricultural operations. Dust suppression is a condition of the EA and therefore, part of our compliance requirements.

The Queensland Government has permitted CSG companies to use CSG production water for dust suppression on site. However we will only use CSG production water for dust suppression during the construction activities if it is permitted in the EA or approved for beneficial re-use.

If CSG production water is used for dust suppression on local government-controlled roads, we will obtain written approval from the relevant local government authority, prior to use.

Where CSG production water is used for dust suppression on your property, we carry out dust suppression activities so that:

- Vegetation is not damaged
- Soil quality is not adversely affected
- There is no surface ponding or runoff of CSG production water from the application area
- The quality of shallow aquifers is not adversely affected
- There are no releases of CSG production water to any waters.

Noise logger

Noise

There are many complex factors that affect the noise levels which you may hear throughout the day as a result of CSG activities being conducted in the area. Noise levels may change depending on:

- Atmospheric conditions (e.g. wind speed/direction, temperature, humidity)
- The source of the noise profile (high or low frequency noise)
- Terrain and other barriers
- Dwelling design and facade reduction
- Background noise levels.

An example of the noise levels generated from typical noise sources is outlined in the table, right.

Typical noise level (dBA)	Typical source	Subjective evaluation
120 110	- Heavy rock concert - Grinding on steel	Intolerable Extremely noisy
100 90	- Loud car horn at 3am - Construction site with pneumatic hammering	Very noisy
80 70	- Kerb side of busy road - Loud radio or television	Loud
60 50	- Bird calls - Insects on a warm evening	Moderate to quiet
40 30	- Rural property during the day with light wind inside a bedroom	Quiet to very quiet
20	- Very rural location on a winter's night	Almost silent

An overview of potential noise sources associated with CSG construction activities is outlined in the table below.

Activity	Potential noise source
Well drilling and completion	Noise emitting equipment used for well drilling may include electricity generators, pumps, PA system, and truck and vehicle movements. Drilling noise may be generated on a continuous 24-hour basis but it will only continue for the temporary period while drilling activities are conducted on each lease site. This is generally two to three days for drilling and one to two days for completions.
General construction activities, including lease preparation, gathering line installation, and workovers	General construction activities may generate noise during excavation and trenching, earthmoving, pipe unloading, the lowering of pipe into trenches during trench filling, back-filling, and associated truck engine sounds. The equipment used during these activities creates a similar level of noise to regular farming activities.

The noise level you experience from construction activities will depend on a range of factors including:

- The distance from your house to the activity
- The nature of the activity
- Wind direction
- Temperature
- How well your house attenuates (blocks out) the noise.

Because noise impacts differ for each property, we will involve you to discuss the best approach to manage noise.

For most activities on your property, we will engage an acoustic specialist to determine whether the predicted noise is likely to meet the requirements under our EA.

We try to reduce noise emissions from our activities whenever possible. Examples of noise management practices can include:

- Limiting construction activities near residences to between 6.30am and 6.30pm whenever possible
- Undertaking 24-hour drilling activities in accordance with a noise management plan, as required by the Australia Pacific LNG EA
- Locating temporary accommodation facilities no closer than 500m to residences
- Locating gas pipelines no closer than 100m to nearby residences, commercial premises, or cultural heritage listed structures, to minimise the risk of cosmetic or structural damage
- Scheduling non-standard trenching operations, such as rock sawing, rock-hammering or directional drilling, during standard daytime working hours, and notifying residents and businesses within 200m before these activities occur
- Adhering to traffic management plans that identify suitable routes and travel times that minimise noise disturbance to residents and overall traffic conditions.

Before conducting any work on your property, we will contact you to discuss the nature of the activities and potential noise impacts.

Well intervention

Well intervention refers to activities carried out to improve the production of a gas well.

During well intervention activities, increases in noise and vibration can be expected. Noise and vibration is temporary but may be generated on a continuous 24-hour basis and will only continue for the period of the activity on each well.

Well intervention equipment that can generate noise includes:

- Electricity generators
- Compressors
- Pumps
- PA systems
- Cranes and forklifts
- Wireline operations (using wireline to record the physical properties of the well bores, to inform well intervention activities)
- Truck and vehicle movements.

To minimise noise and property impacts associated with well intervention activities, we will consult with you prior to undertaking any activity on your property. Mitigation and management strategies are undertaken as required.

Lifestyle

We understand CSG activities may result in some level of disturbance to your business operations and lifestyle.

Origin will work with you to develop plans which will deliver fair and mutually beneficial outcomes to both parties, wherever possible.

In addition, we are available to discuss any questions or concerns you may have regarding specific matters. For example, in consultation with you we may be able to:

- Manage construction activity times
- Identify suitable routes and travel times for heavy machinery
- Identify locations for infrastructure to minimise impacts on your operations.

By establishing an open and honest relationship based on trust and respect, we believe we can build and maintain a positive working relationship with you. Our aim is to ensure the co-existence of sustainable agriculture and gas production over the long-term.

Mud pump with noise curtains

4.3 Natural resource management

Water

Our CSG development, operations and maintenance activities use water from different sources, including:

- Overland flow (surface water)
- Groundwater – sourced from bores in different aquifers
- Production water – water that is treated and blended.

Water used for dust suppression is usually overland flow, groundwater, production water or treated water from a WTF.

Our first preference is to use overland flow water in close proximity to an activity occurring on site. Examples of overland flow water may include a landholder's dam water or an irrigator with the appropriate licenses.

We are generally not permitted to take water directly from creeks or rivers without a water licence or permit.

A rigorous series of environmental tests and conditions govern the use of water on site. Baseline assessments are carried out on groundwater sites, and measures are regularly undertaken to minimise any effects on aquifers.

Gravel

We prefer to source gravel used for our CSG activities from the local area where activities are occurring. The use of local gravel is governed by Queensland Government legislative requirements. These requirements cover all aspects of gravel use, including environmental management, and sediment control and access.

Gravel access and use is assessed on sound commercial principles.

As the requirements for gravel decline due to use of MDLs and new technology, new gravel pits are less likely to be established.

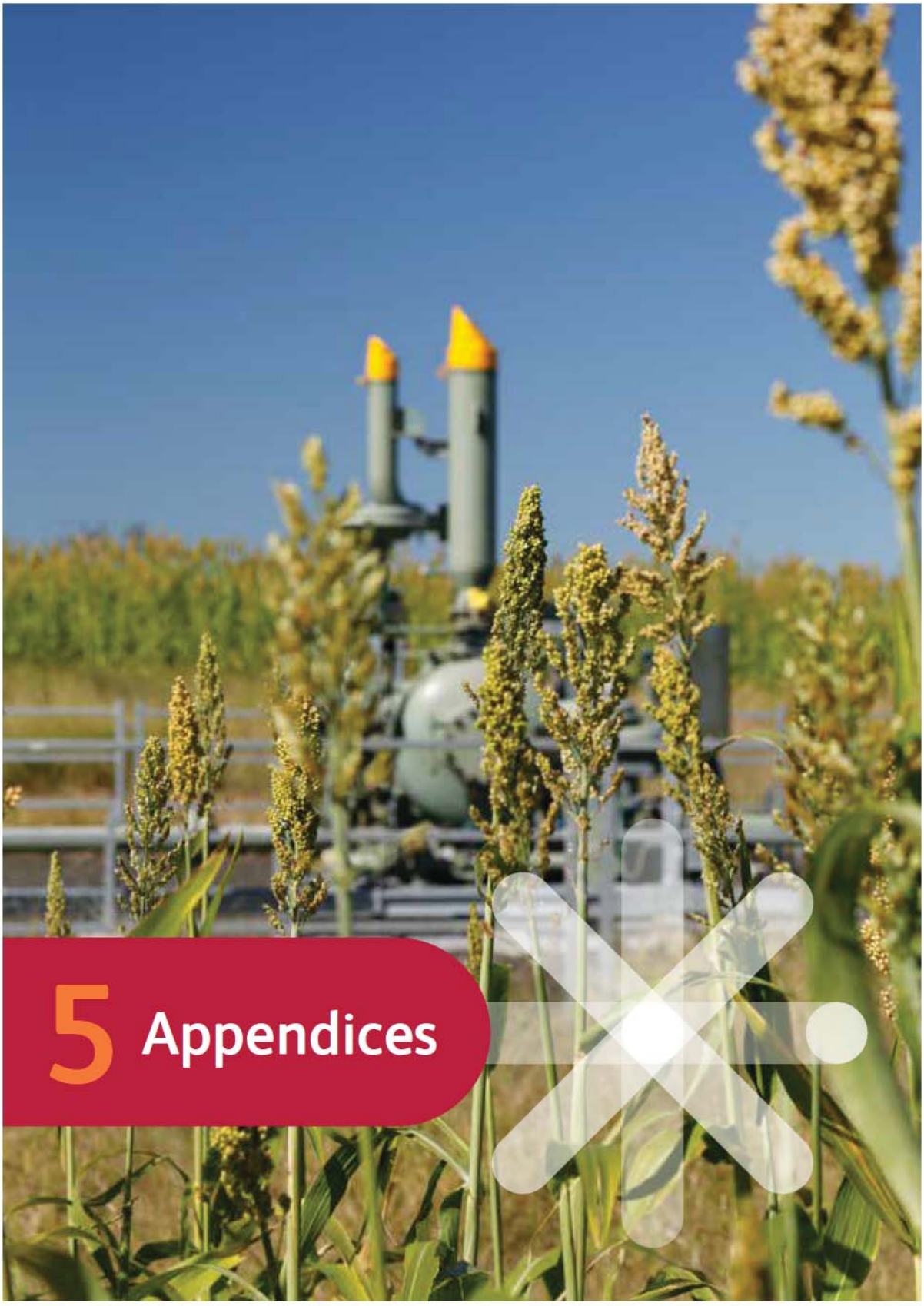
Consequently we are relying more on existing Petroleum Legislation pits and commercial gravel operators.

In addition to Queensland Government requirements, Australia Pacific LNG must also take into consideration local government issues that need to be addressed when sourcing and using gravel, including road use access entry points, and noise and dust.

Further information about the use of gravel is available at:

- Green Tape Reduction website www.ehp.qld.gov.au/management/greentape and www.ehp.qld.gov.au/factsheets/pdf/environment/greentape-reduction-act.pdf
- Department of Natural Resources and Mines website www.dnrm.qld.gov.au

Gravel pit



5 Appendices

5.1 Equipment and machinery

Equipment/machinery	Images
High point vent (HPV) HPVs are installed in water lines to allow any gas that may be dissolved in the water to vent to the atmosphere.	
Low point drain (LPD) LPDs are installed at low points to siphon remaining water from gas in the gathering pipeline.	
Mulcher Most mulching is vegetation already removed and roots disturbed and is followed by topsoil stripping. Cleared vegetation is mulched and may be used for sediment control berms and re-spread at reinstatement to protect topsoil from erosion.	
Open/Close gate sign Used to allow landholders to choose whether they want the gates left open or closed.	

Equipment/machinery	Images
Rigs – Drilling rig A drilling rig drills the hole in the ground for the CSG well. **Completions rig** A completions rig completes a well by putting the final lining in the casing that the drilling rig set. It installs the pumps and anything necessary to get gas flowing to surface. **Workover rig** A workover rig cleans out the well periodically, changing in-hole equipment like the pump. Completions and workover rigs are terms often used interchangably. **Flushby Rig** The flushby rig is small and faster than a conventional workover rig, capable of performing all types of well servicing, especially diagnostics. When a well goes offline, the unit troubleshoots and identifies problems such as tubing holes, failed or stuck pumps and parted rods, and then executes the required repair work.	
Seismic Vibroseis truck A seismic truck, which is fitted with a vibrating plate, is used to cause vibrations on the ground and creates a source of sound waves.	
Separator A separator is used to separate the CSG from the water that is extracted from the gas well.	

Equipment/machinery	Images
Telemetry Telemetry equipment records and stores digital data from sensors such as groundwater level probes, and transmits it via a radio, mobile phone, or satellite phone link to a programmed schedule or on-demand. Telemetry allows 'live' access to information, and reduces the need to visit the site for manual measurements or maintenance.	
Trenching machine A trenching machine is used to dig trenches suitable for pipeline and cable installation work. A trenching machine is efficient and can handle a variety of terrain.	
Valve pit Valve pits are installed in the gas lines to allow condensation collecting at the bottom to be collected or released where permitted.	
Welding machine The welding machine is used to weld pipe.	
Well sub-station Well sub-station (or kiosk) contains electrical and fibre-optic cables which enter from underground. Sub-stations are approximately 3m wide, 5m long and 2.5m high.	

Equipment/machinery	Images
Well main switch board Electrical control panel located on lease.	
Well-head A wellhead is the well component connecting the downhole equipment (steel casing and other tubulars) with surface facilities (valves, wellsite seperator etc).	

5.2 Glossary

The following common CSG terms may be used in discussions with you.

Term	Description
Clear and grade	An activity used to remove any trees, shrubs, and/or grass to prepare the area.
Codes of Practice	Codes of Practice set out industry standards of conduct. Most of these can be found on the Department of Natural Resources and Mines website www.dnrm.qld.gov.au
CSG production water	CSG production water refers to groundwater that is brought to the surface in the process of CSG exploration or production.
Cultural Heritage Officer	A Cultural Heritage Officer is a Traditional Owner of land or country that has a connection to the land through birth, family, relationship, or time spent on the country or land. Origin employs these Cultural Heritage Officers to identify, record, and advise on the finding and potential to find Indigenous artefacts that may be prevalent or located on properties that are engaged through our operations.
Dust suppression	An activity used to suppress the dust that is generated from CSG activities. CSG water may be used to suppress dust only if it is permitted to do so in the Beneficial Use Approval granted to Origin.
Environmental Advisor	Contributes to Project-related environmental assessment, approvals and environmental management, and provides advice on onsite environmental improvements, impact minimisation, and compliance with regulatory and Project approvals.
Environmental Authority (EA)	An EA is required to undertake environmentally relevant activities, including resource activities under the *Environmental Protection Act 1994* (Qld). Assessed by the Department of Environment and Heritage Protection, the EA includes strict operating conditions that must be complied with. These include conditions regardinging the management, treatment and disposal of waste water, ongoing assessment of fraccing activities and other environmental issues such as noise and land disturbance.
Fauna Spotter	Required to be present during vegetation clearing or disturbance of fauna habitat to minimise harm and manage potential impacts to native fauna in accordance with management plans and legislative requirements. Fauna Spotters conduct monitoring, capture, release, relocation and other activities required in association with fauna which may be affected by CSG development activities.
Final Rehabilitiation	The process of reshaping and revegetating land to restore it to a stable landform in accordance with acceptance criteria set out in relevant environmental approvals.
Gas flare	An activity used to dispose of unprocessed gas from gas processing facilities and gas wells in a safe, controlled and environmentally friendly manner.
Hydraulic Fracture Stimulation	A process used to inject (under pressure) a mixture of sand, water, and other additives into the coal seams in a well to liberate gas from the coal seams. Also known as Hydraulic fracturing or fraccing.
Interim Rehabilitation (or Reinstatement)	Refers to the restoration and stabilisation of land following project disturbance activities to establish a stable landform suitable for the operational phase of the project. Reinstatement will occur prior to final rehabilitation.

Term (cont.)	Description (cont.)
Landholder Liaison (LL)	Your appointed contact with Origin while we are conducting activities on your property.
Petroleum Legislation	Petroleum Legislation means the *Petroleum and Gas (Production and Safety) Act 2004* (Qld) (if the Tenement is granted pursuant to the 2004 Act) or the *Petroleum Act 1923* (Qld) (if the Tenement is granted pursuant to the 1923 Act)
Pigging	A process used to check that a pipeline is undamaged and free of obstructions after the pipeline is constructed and before it is put into use.
Privacy Act	*The Privacy Act 1988* (Cth) is an Australian law which regulates the handling of personal information about individuals. Personal information is information or an opinion about an identified individual, or an individual who is reasonably identifiable.
Property Access Coordinator	This person may contact you to advise details and timeframes of planned activities on your property.
Reverse osmosis	A process used to treat CSG production water that is produced from the gas well to remove the dissolved salts and impurities and resulting in water suitable for other uses such as agriculture.
Scarifying	A rehabilitation activity used to alleviate compaction, normally completed with tines on a grader or specific scarifying agricultural tools.
Stripping topsoil	An activity used to remove the top layer of topsoil and seed stock from the relevant area. Topsoil and seed stock are then stockpiled on the side of the work area which will be graded back over the area during rehabilitation.
Tenement	A license or lease over an area of land granted by the Queensland Government that gives Origin rights to undertake exploration or petroleum production activities within that area.
Turnarounds	Turnaround refers to the disturbances to land adjacent to access roads and infrastructure where trucks and other vehicles are required to turn around.
Wellbore	A wellbore is a hole that is drilled to aid in the exploration and recovery of natural resources including gas or water. A wellbore is the actual hole that forms the well and can be encased by materials such as steel and cement.
Well intervention	A process used to restore or improve the production of a gas well or to modify surface equipment and/or downhole equipment in the well.
Well completion	A process used to enable a drilled well to be converted into a gas producing well.
Workover	An activity used to service or maintain a well to ensure ongoing operation and production of a gas well.

5.3 Acronymns

Abbreviation	Meaning
ATP	Authorities to Prospect
ATV	All-terrain vehicle
CCA	Conduct and Compensation Agreement
CSG	Coal Seam Gas
dBA	Decibels
DEHP	Dept of Environment and Heritage Protection
DoE	Commonwealth Dept of the Environment
EA	Environmental Authority
E&A	Exploration and Appraisal
EIS	Environmental Impact Statement
EN	Entry Notice
EP Act	*Environmental Protection Act 1994* (Qld)
EPBC	*Environmental Protection and Biodiversity Conservation Act 1999* (Cth)
ESA	Environmentally Sensitive Area
FA	Financial Assurance
GAB	Great Artesian Basin
GPF	Gas Processing Facility
HPV	High point vents
IVMS	In-vehicle monitoring system
LNG	Liquefied Natural Gas
LPD	Low point drains
LL	Landholder Liaison
LWD	Landspraying while drilling
MDL	Minimal Disturbance Lease
PL	Petroleum Leases
PPL	Petroleum Pipeline Licences
RO	Reverse osmosis
UHF	Ultra-high frequency
WTF	Water Treatment Facility

5.4 Notes

Contact details

Your LL:

Land Access Hot Line:

Call **0429 019 177**

Dial Before You Dig:

Call **1100** or visit **1100.com.au** before undertaking any easement work.

Origin Operations Emergency Response:

Call **1800 076 251** to report the following:

- Any emergencies on or near the pipeline.
- Any unauthorised access to the easement or facilities.
- Any damage to the pipeline or the facilities.
- A fire hazard.
- Any erosion or subsidence.
- Other safety or environmental hazards.

Emergencies/natural disasters (e.g. flood or bushfire):

Call **000** or **112** from a mobile.

March 2017

AUSTRALIA PACIFIC LNG

Operated by origin

APPENDIX 3
GROUNDWATER

Origin Energy Groundwater Monitoring Program (GMP) and 2017 Groundwater Monitoring Report

(data submitted electronically)

Beetaloo Basin Exploration Program Groundwater Monitoring Plan

Annual Report - 2017

Groundwater Monitoring Plan

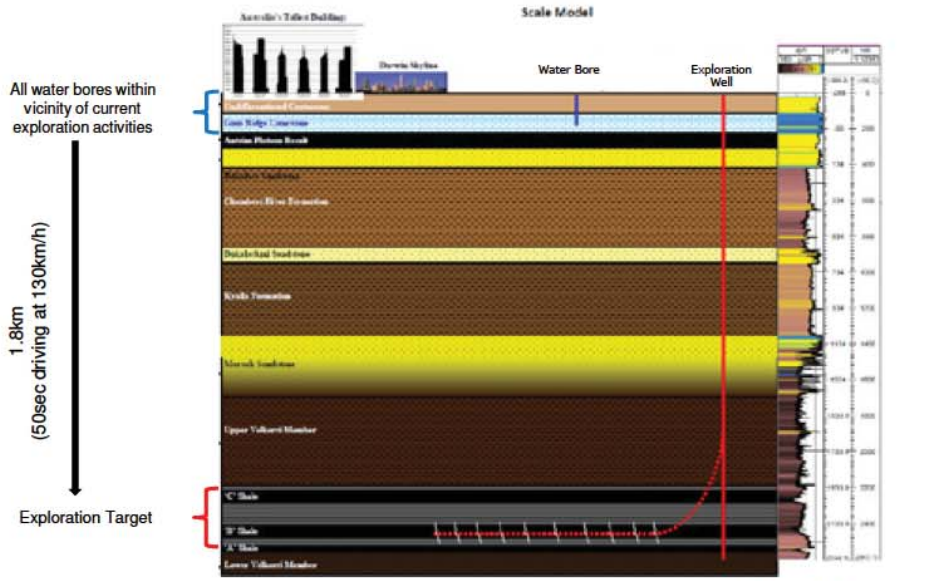
The objectives of this groundwater monitoring plan are to:

- Enable detection of potential groundwater impacts associated with exploration activities*;
- Enable improved understanding of the temporal water quantity and water quality trends (natural variability) prior to the preparation of groundwater assessments as part of potential Environment Impact Statements (EIS); and
- Support improved understanding of the hydrogeological system of the Beetaloo Basin

*regulatory requirement

Context for groundwater use and exploration Activities

- Monitoring focusses on the upper formations where the groundwater is used by landowners



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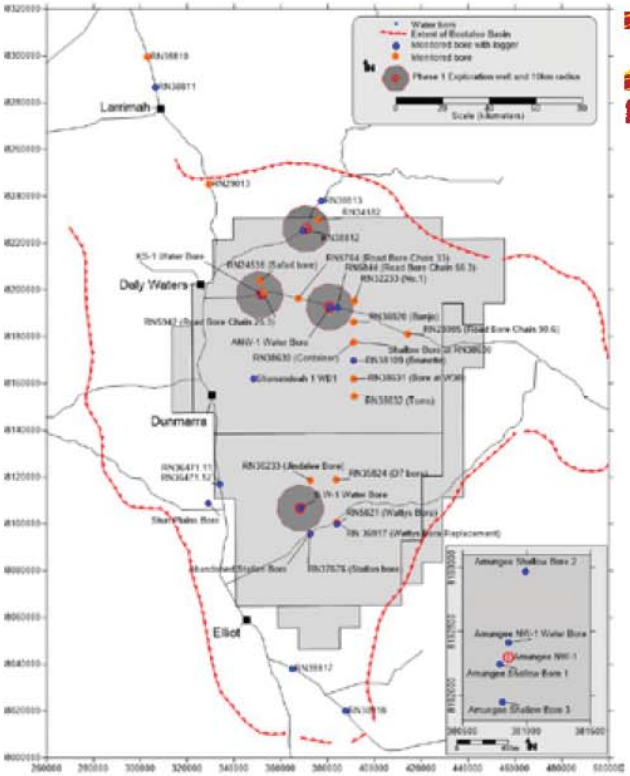
Monitoring Locations

- Current plan includes ongoing monitoring at 36 bores with opportunities for network expansion sought in 2017
  - Water supply bore at Nutwood Downs SE-1 to be installed in 2017
  - Two locations on Beetaloo Station not incorporated due to access constraints
- 20 pressure loggers currently monitored
- 3 barometric pressure loggers monitored
- Monitoring bores include:
  - Origin installed bores
  - Landholder stock and domestic bores
  - NTG groundwater monitoring bores
  - NTG Highways water supply bores
- Field visits completed:
  - November 2014 - baseline/scouting
  - June 2015 – 3rd party baseline of Amungee Mungee
  - August 2015 – Implementation of GMP
  - April 2016 – Continuation of GMP
  - September 2016 – Continuation of GMP



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Field Acitivities

- The presence of methane, carbon monoxide, hydrogen sulphide and for oxygen concentration measured at the bore headworks
- Water level measured with slimline electronic dipmeter
  - sonic water level meter used where WL >150m
  - Not always possible where pumps are installed
    - Airlines in some cases available in lieu of dip meter
- Sample collected for field and or laboratory analysis
  - If pump is installed and running, samples submitted for laboratory analysis
  - If no pump installed, a bailed grab sample collected for field assessment only
- Water level logger downloaded (where installed)
- Water level reference point measured with differential GPS (>0.5m vertical accuracy)

5

Water level results (refer to following pages)

- Logger installation occurred prior to the 2015/16 wet season. Additional loggers were installed in 2016.
- CLA water levels generally stable or marginally increasing over the monitoring period.
- Observations relating to specific bores include:
  - ANW-1 water bore was pumped almost continuously during August and September 2016 to provide water for the HFS programme of Amungee NW-1H. No pressure response was observed in nearby CLA bores
  - RN38109 (Brunette Bore) water level spike (~20m) following the 2016 wet season. In Mid-2015 the groundwater level was similar to other bores on Amungee Mungee and by September 2016 the level had recovered by >10m. The magnitude and rate of the change and the jagged profile of the spike suggests that the response is likely due to direct water input into the bore, rather than a response to aquifer recharge. Further works will be undertaken in 2017 to investigate.
  - RN32233 water level was measured 3m deeper between June 2015 and April 2016, most likely due to different measurement technique on each occasion (CCTV camera and dipmeter).
  - Initial level in RN28085 was 0.8m deeper but this is potentially due to the accuracy of measuring the water level with a sonic meter as the water level is approximately 157m below ground.
  - The Shallow Bore at RN38630 (buried by landholder in 2016), which taps a Cenozoic perched aquifer, shows a large and immediate recharge response corresponding with rainfall. This suggests a high infiltration rate for the surficial material at this site. Water levels start falling immediately following the end of the rainfall event, suggesting that the perched system is of limited extent. The barometric sensor at this site became submerged when the water level rose in the bore in which is was located and therefore no future data will be available.
  - The Amungee Mungee Shallow Bores, which also tap the perched aquifer, show a consistent, declining groundwater level trend from commencement of monitoring following the 2015/2016 wet season. The trend matches the tail of the declining trend from the Shallow Bore at RN38630.
  - There is a degree of isolation between the Anthony Lagoon Beds and the Gum Ridge Formation, as evidenced by the difference in water levels (~1m) in the nested bores at RN36471. A shallower groundwater level in the Gum Ridge Formation indicates an upward vertical hydraulic gradient between the 2 formations at this location.

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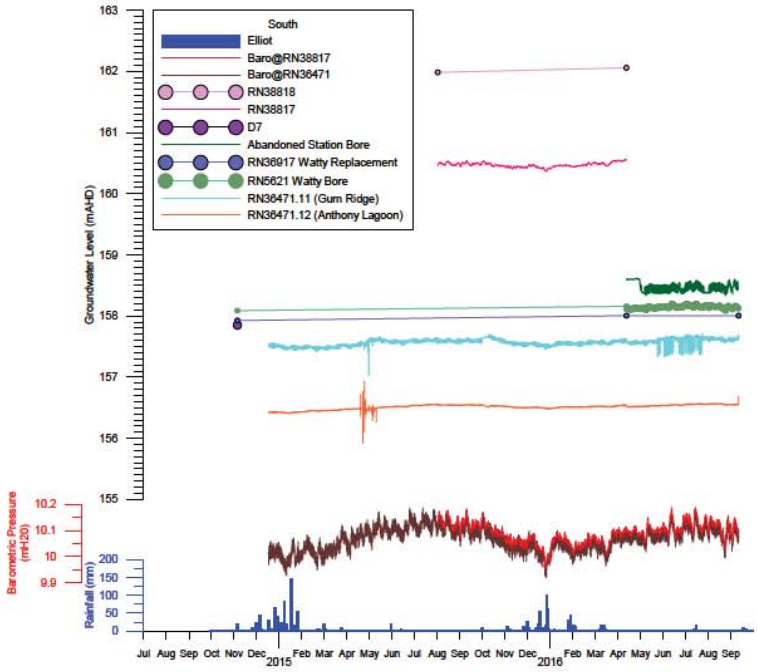
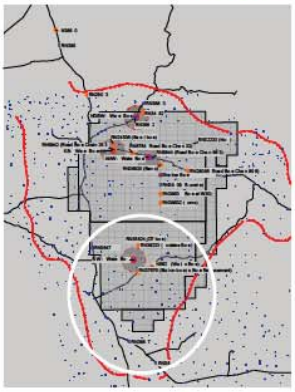
Hydrographs - Southern Area





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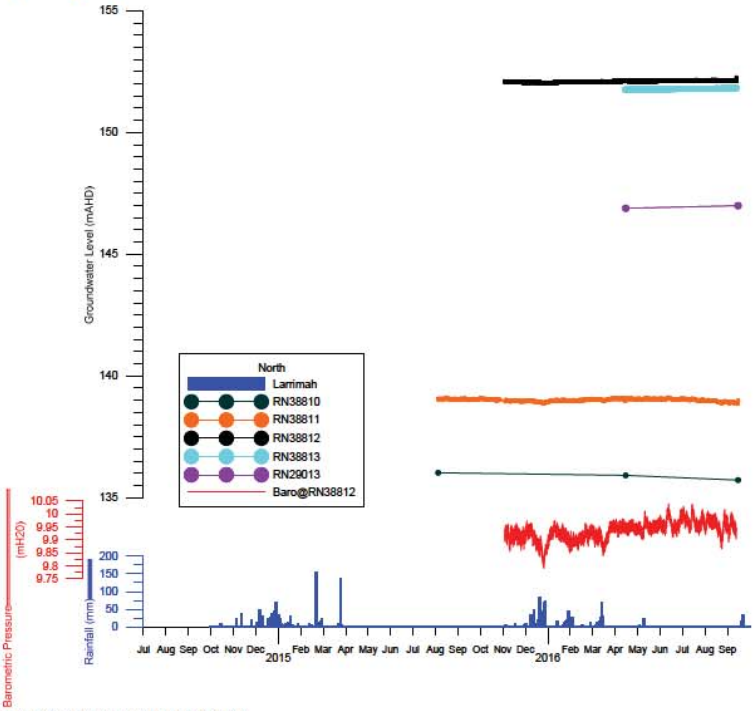
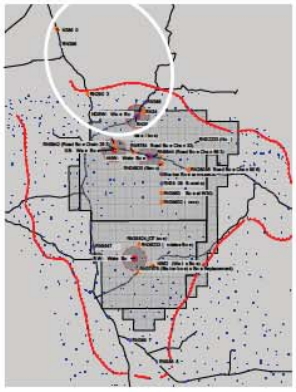
Hydrographs - Northern Area





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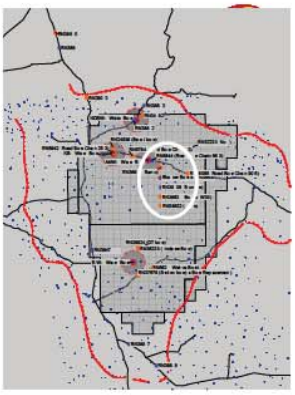
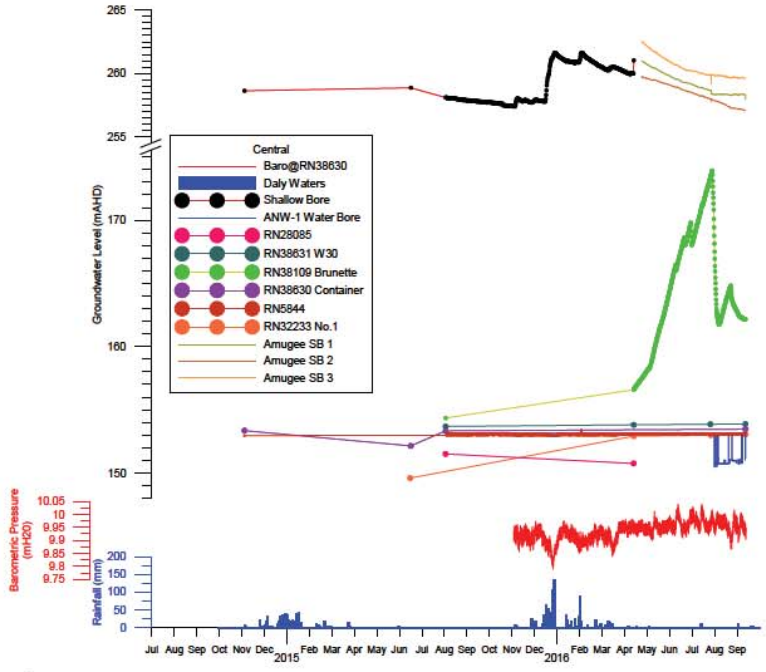
Hydrographs - Central North-South Transect





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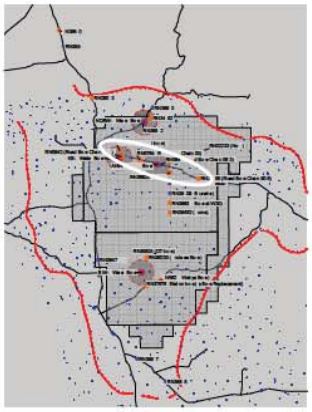
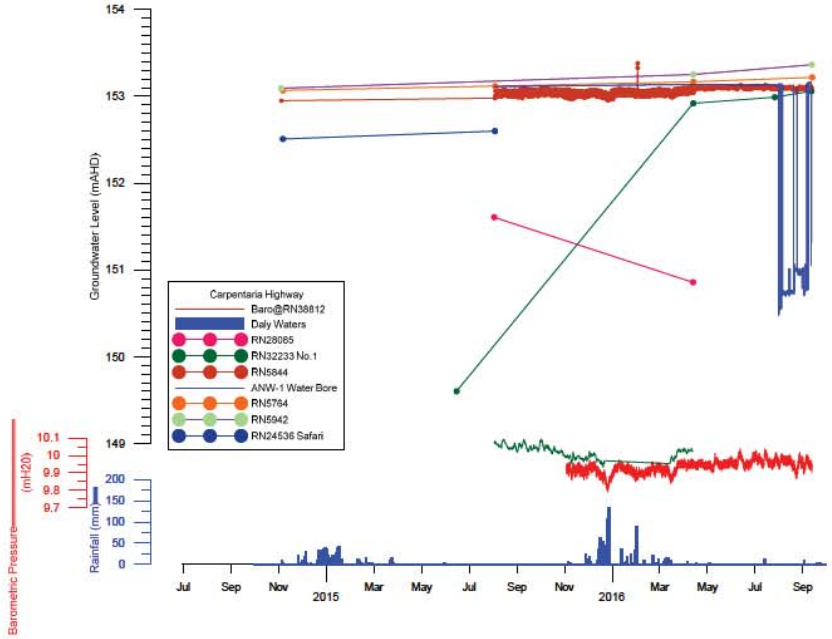
Hydrographs - Carpentaria Highway East-West Transect





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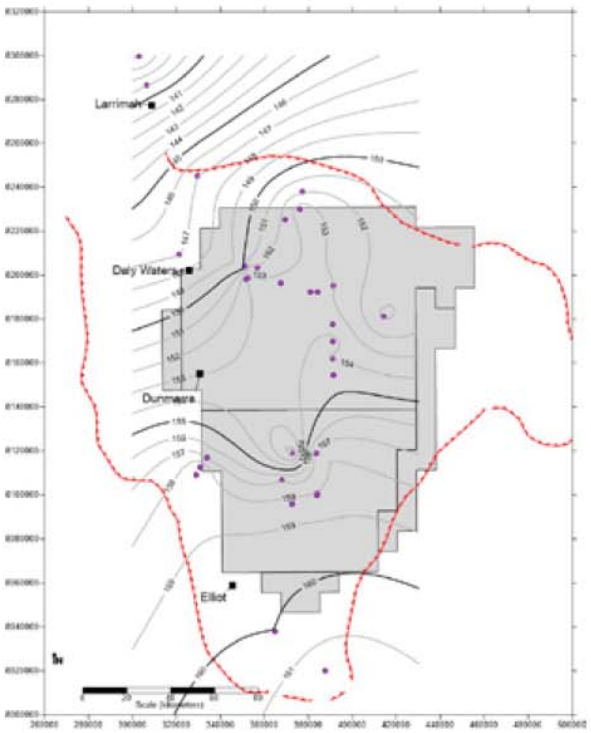
CLA Potentiometric Surface - mAHD

- North-westerly flow direction in CLA across the basin, which is consistent with previous studies
- Generally very flat hydraulic gradient of ~0.00008 (20m over 250km) across the length of the groundwater monitoring network

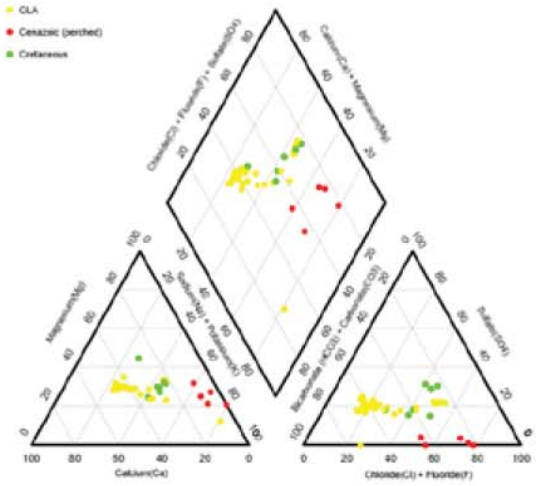


Chemistry results

Inorganic Analyses

- All samples analysed met stock water guidelines.
- pH, iron, sodium, chloride, sulphate, hardness, total dissolved solids, manganese and iron exceed the ADW Aesthetic guideline in multiple bores.
- Manganese (Amungee NW-1) and Nickel (Beetaloo W-1) were detected above ADW Health guideline on one occasion each, but for both bores concentrations were less than the guideline values on previous and subsequent occasions.
- The majority of metals were below detection limits in all samples analysed. The following metals were detected in most samples:
  - Barium
  - Boron
  - Copper
  - Iron
  - Lead
  - Manganese
  - Zinc
- Trace concentrations (0.002mg/L) of arsenic were detected in the Amungee NW-1 water bore on all occasions that it was analysed.
- With the exception of beryllium, chromium, mercury, selenium and vanadium, the commonly analysed trace elements have all been detected.
- No petroleum hydrocarbons or BTEX were reported in any of the samples analysed.
- Dissolved methane was generally not detected with the exception of trace concentrations reported on 4 (all sampling events) occasions from the RN36920 (Banjo Bore) with concentrations ranging from 0.01 to 0.03mg/l
- Methane was detected as free gas at the bore headworks in RN34671.11 on 2 occasions (500 and 340 ppm). There was an intermittent diesel odour emanating from the bore.
- 15ppm methane was detected in RN38109 on one occasion. No other gaseous methane has been detected.
- No hydrogen sulphide has been detected in either dissolved phase or as free gas.

Formation



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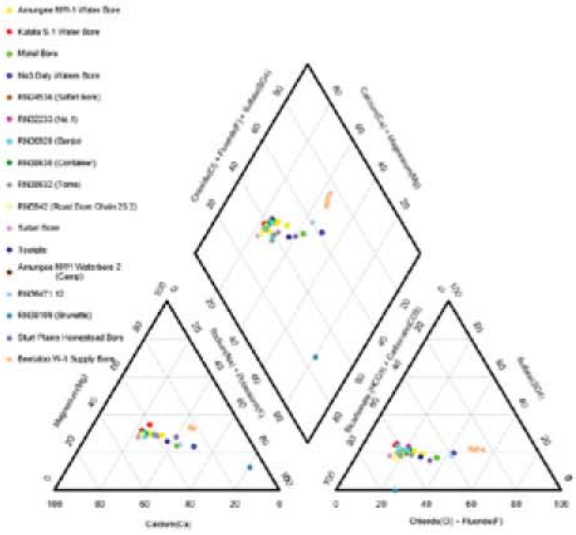
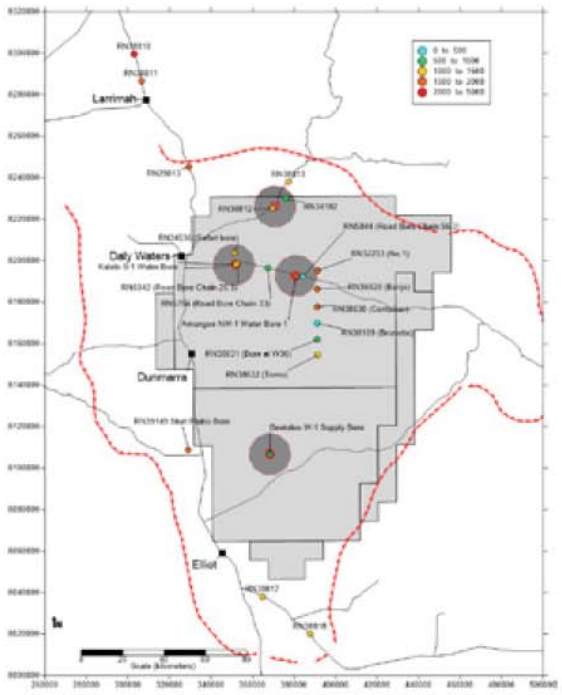
CLA Bores



CLA Electrical Conductivity - µS



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Chemistry Findings

- Generally, there appears to be some discrimination in major ion chemistry between the Cretaceous sediments and the underlying CLA, with the younger formation hosting a water richer in sodium chloride and possibly sulphate. However, at Beetaloo station where the CLA is overlain by saturated Cretaceous sediments, groundwater samples (Beetaloo W-1) show comparable water quality composition to samples collected from bores targeting the Cretaceous, indicating the distinction in major ion composition between the 2 formations is likely due to local recharge processes and the presence or absence of saturated Cretaceous sediments.

- The Cenozoic perched aquifer is free of sulphate and more bicarbonate rich.

- Bores in the central part of the basin, proximal to the perched Cenozoic aquifer at Amungee Mungee show comparatively low but also variable salinity and are relatively depleted in chloride, which is indicative of more immature water suggesting discrete recharge pathways may be present.

- RN38109 (Brunette Bore) major ion composition is unique from other samples analysed, being sodium/potassium – bicarbonate dominant. This indicates ion exchange processes in the subsurface and therefore, that perched aquifer water, rather than direct infiltration of surface water, is the likely source of water entering the bore.

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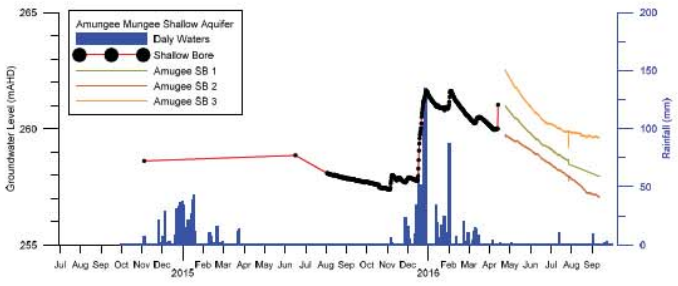
Amungee Mungee Summary

- Trace concentrations of methane detected in RN36920 (Banjo Bore) on all 4 occasions sampled
  - Concentrations ranging from 0.01 to 0.03mg/l
  - First sample in August 2015, prior to spudding ANW-1 at detection limit (0.01mg/L)
  - No higher chain hydrocarbons
- Shallow aquifer very dynamic. Responds almost immediately to rainfall but water level recedes quickly
- RN38109 ~20m water level fluctuations. Response characteristics and major ion chemistry indicates perched aquifer water directly entering bore
- Relatively stable water levels in other bores
- GISERA research project to investigate recharge processes



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Conclusions

- Groundwater monitoring commenced in 2014, pre-dating the commencement of current exploration activities
- A formalised Groundwater Monitoring Plan for the current exploration program was developed and commenced implementation in 2015.
  - 36 bores are currently included in the groundwater monitoring network
  - Monitoring focusses on the shallow, used aquifers, which are vertically offset from the exploration target by over 1.5km of intervening low permeability rocks
  - The plan has been progressively rolled out as access approvals have been gained and bores drilled
- Water level monitoring to date has found:
  - Groundwater flow is towards the NW with a hydraulic gradient of approximately 0.00008 across the groundwater monitoring network (NW-SE)
  - Groundwater levels have generally been stable over the period of monitoring in the Cretaceous and Cambrian Limestone aquifers, the most notable exception being:
    - RN38109 which has a dynamic water level likely due to perched aquifer water directly entering bore. Further work will be undertaken in 2017 to investigate the response.
  - The Cenozoic perched aquifer responds strongly to rainfall, but water levels recede quickly suggesting relatively limited volume in storage
- Water chemistry monitoring has found:
  - Limited presence of hydrocarbons in the bores sampled. Only one location has reported dissolved methane (trace concentration)
  - All waters sampled are suitable for stock use
  - The 3 aquifers have distinct major-ion compositions
  - Localised recharge from Cenozoic and Cretaceous sediments to the CLA is probable
- There is no evidence of any impact from the current exploration activities

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BEETALOO EXPLORATION DRILLING CAMPAIGN 1 – GROUND WATER MONITORING PLAN

NT-2050-15-MP-0011

This Groundwater Monitoring Plan pertains to activities during the exploration phase of the Beetaloo JV operated by Origin Energy Resources Limited. The primary purposes of the plan are to monitor potential impacts associated with the drilling, and potential stimulation, of up to six hydrocarbon exploration wells, and to gain insight into background groundwater conditions.

Version:	**Revision 4**
Released:	**7/8/2016**
Document Owner:	Ryan Morris
Review Date:	4/4/2017

Contents

1 Introduction

Origin Energy Resources Limited (Origin) as the operator for the Beetaloo JV (Origin 35%, Sasol 35% and Falcon 30%) is undertaking an exploration drilling campaign in its permits (EP 98, EP 117, EP 76) between 2015 and 2018.

The purpose of this document is to provide a framework and details of ongoing groundwater monitoring activities that will be undertaken as part of the Phase 1 exploration activities. It does not include bore baselining requirements for Environmental Management Plans. This plan will continue for the duration of the exploration program.

The groundwater monitoring framework adopted by Origin is based on the principle of adaptive management. Adaptive management is a structured, iterative process of decision making with a focus on reducing uncertainty over time via systems monitoring. Should monitoring results indicate an increased risk profile, the adequacy of monitoring can be reviewed to assist in the management of that risk.

The primary objective of this groundwater monitoring plan is to establish a monitoring regime that is considered appropriate to the intended scope of activities in both geographical spread and duration. Secondary objectives include:

- Establishing baseline groundwater conditions prior to potential future development in utilised aquifers;
- Enabling detection of potential groundwater impacts associated with exploration activities;
- Enabling improved understanding of the temporal water quantity and water quality trends (natural variability) prior to the preparation of groundwater assessments as part of potential Environment Impact Statements; and
- Supporting improved understanding of the hydrogeological system of the Beetaloo Basin.

Version 4 of this plan includes updates following the September 2016 field campaign and confirmation of the 2016 exploration program.

1.1 Exploration Activities

An outline of the intended exploration program is provided in Table 1.

Table 1 Beetaloo JV exploration program 2015-2018

Year	Exploration Phase	Activities	Firm/ Contingent
2015	1	• Kalala S-1 • Amungee NW-1 • Amungee NW-1H[1]	Completed
2016	1	• Beetaloo W-1[2] • HFS* Amungee NW-1H	Completed
2016	1	• HFS 1 Vertical Well	Contingent**
2017	2	Drill and HFS 2 Horizontal Well	Contingent
2018	3	Drill and HFS 2 Horizontal Well	Contingent

* HFS= Hydraulic Fracture Stimulation

** Contingent on lifting of the moratorium on hydraulic fracturing of unconventional gas reservoirs in the Northern Territory in place since 14 September 2016

[1] Kicked-off horizontally from Amungee NW-1

[2] Delayed from 2015 program

The outcomes and data from each phase of the exploration program testing and appraisal are critical in informing subsequent exploration phases. The need for additional monitoring, and hence update to this plan, will be reviewed with each phase of exploration.

The exploration program is to investigate the Kyalla Formation and the Velkerri Formation to total depths ranging from ~2,200 metre true vertical depth (mTVD) to ~2,600 mTVD. The wells will be drilled with a combination of air and KCl/Polymer water based mud and cased and cemented as required to ensure well integrity and aquifer isolation. The wells will either be suspended for repurposing as monitoring or testing wells or abandoned immediately following drilling in accordance with the DME requirements.

2 Conceptual Hydrogeological Model

A conceptual hydrogeological model is a succinct, simplified understanding of a groundwater system. It is essential component to the design of an appropriate monitoring program. The conceptual model described below is based on the *Beetaloo Basin Hydrogeological Assessment* by CloudGMS (2015a).

The Beetaloo Basin comprises a thick sequence of flat-lying mudstone and sandstone formations (Roper Group) that were deposited between 1,500 and 1,350 million years ago (Ma) – see Table 2. The Roper Group is estimated to reach of 5,000 m in thickness in the centre of the basin and with the exception of the north and eastern margins occurs at an average depth of about 500 m. The Roper Group is overlain by the Georgina Basin (630 – 497 Ma), which includes widespread basalts and a thick limestone sequence that forms the Cambrian Limestone Aquifer (CLA), a significant water supply aquifer. The Georgina Basin is capped by Cretaceous mudstone and sandstone (145 – 66 Ma) and recent alluvial and laterite deposits.

The CLA, comprising the Gum Ridge Formation and the Anthony Lagoon Formation, is an extensive regional aquifer system that forms the principal water resource in the Beetaloo Basin. Limestone in the CLA is commonly fractured and cavernous, regionally bore yields of up to 100 l/s have been recorded from this aquifer. Approximately 80% of groundwater bores drilled in the basin screen the CLA and the aquifer supplies water for the pastoral industry and local communities including Elliot, Daly Waters, Larrimah and Newcastle Waters. Where the CLA is absent, has limited saturated thickness or is deep, local scale aquifers are targeted in Proterozoic fractured rock, Georgina Basin formations and the base of the Cretaceous sequence. Groundwater resources in these aquifers are of limited extent and have a lower yield (< 5 l/s) relative to the CLA. Limited information exists on the hydrogeological characteristics of the Roper Group sequence as it occurs at depth within the Beetaloo Basin. Sandstone dominated formations may behave as aquifers, however, drilling results suggest these formations have limited permeability and will only form marginal, very local scale aquifers. Groundwater in the Roper Group is highly saline and contrasts with the shallower, utilised aquifers in which groundwater is generally of drinking water quality.

The CLA contains a significant but largely undeveloped groundwater resource with the sustainable yield from the Georgina Basin estimated to be in the order of 100,000 ML/year (NALWTF, 2009). Existing groundwater use in the Beetaloo Basin is estimated at 6,000 ML/year. Unconventional gas exploration in the basin is at a very early stage and the volume of water required to develop any potential resource is uncertain. However a first order estimate of the water required to develop potential gas resources on Origin tenements is 1,000 ML/year over the development phase. Combined, current groundwater extraction and projected demand for gas development represents 7% of the estimated water resource available from the CLA in the Georgina Basin.

The regional groundwater flow direction in the CLA is north-west toward Mataranka, where the aquifer discharges into the Roper River and supports significant groundwater dependent ecosystems including the Roper River at Elsey National Park and Red Lily/57 Mile Waterhole. These discharge features occur around 100 km north-west of the Beetaloo Basin. Dry season flow in the Roper River has been gauged at 95,000 – 126,000 ML/yr and provides an estimate of the magnitude groundwater discharge from the CLA. Large decadal changes in the discharge to the Roper River suggests that most recharge input

occurs close to the discharge zone (i.e. beyond the Beetaloo Basin region). Groundwater recharge mechanisms to the CLA are poorly characterised but are likely to be dominated by infiltration through sinkholes and preferential recharge through soil cavities.

The Velkerri Formation represents the primary unconventional gas target in the Beetaloo Basin, although other hydrocarbon intersections have been encountered in other formations within the Roper Group. Vertical pressure gradients between the Roper Group and the CLA are not well characterised, however, previous exploration well formation tests indicate there is an upward pressure gradient from the Roper Group to the CLA. Over much of the basin the CLA is separated from these formations by multiple aquitards including the Antrim Plateau Volcanics and Hayfield Mudstone. Thick, unweathered and undeformed basalt sequences in the Antrim Plateau Volcanics and tight claystone beds within the Chambers River Formation form a barrier that restricts the mixing of hydrocarbons and brines in the Roper Group with high quality groundwater in the CLA and other utilised aquifers. Where these formations are absent or thinner, along the eastern margin and in the south of the Beetaloo Basin, there is greater potential for interconnection between the Roper Group and the CLA. Potential for interconnection also exists along the major faults and structures that bound the Beetaloo Basin. The potential for fluid migration through faults between formations is limited because most faults don't extend to the shallow formations.

Two shallow, perched aquifers exists in the vicinity of Amungee Mungee, one in the shallow soil profile (<6m) and one in the top of the Cretaceous sediments. The two aquifers can be differentiated by the difference in water chemistry. The aquifers are not documented in the literature and little is known about its extent and temporal dynamism, although data to date has shown strong seasonal water level fluctuation of in excess of 3m. The aquifer appears to be directly recharged through rainfall infiltration and discharges via evapotranspiration, however there may be overspill at the edges of the perching layer resulting in recharge to the CLA. The perched aquifers are not directly utilised by the pastoralists, however consideration is being given to deep rooted grasses and fodder species to enhance the cattle carrying capacity of the land.

2.1 GISERA Research Programme

Commencing 2017, a GISERA (Gas Industry and Environmental Research Alliance) coordinated research programme will investigate groundwater age and recharge patterns on Origin permits with the aim of enhancing the understanding of the regional recharge mechanisms for the CLA.

The programme will initially consist of a single sampling campaign to collect environmental tracers from selected bores along groundwater flow paths. The study will focus on north central permit area where localised recharge has been interpreted from data collected thus far.

Table 2 Summary Beetaloo Basin Hydrostratigraphy

PROVINCE	PERIOD / AGE	FORMATION		AQUIFER STATUS	THICKNESS (m)	YIELD (l/s)	AVE. EC (µs/cm)
CARPENTARIA BASIN	Recent	Undifferentiated		*Local Aquifer*	0-20	NA	200
	CRETACEOUS 145 – 66 Ma	Undifferentiated (formerly Mullamen Beds)		*Local Aquifer*	0 - 130	0.3 - 4	1800
GEORGINA BASIN	CAMBRIAN 497-630 Ma	Cambrian Limestone Aquifer (CLA)	Anthony Lagoon Formation	REGIONAL AQUIFER	0 – 200	1 - 10	1600
			Gum Ridge Formation	REGIONAL AQUIFER	0 – 300	0.3 - >20	1400
		Antrim Plateau Volcanics		REGIONAL AQUITARD *Local Aquifer*	0 – 440	0.3 - 5	900
		Bukalara Sandstone		*Local Aquifer*	0 – 75	0.3 - 5	1000
BEETALOO BASIN (ROPER GROUP)	NOT KNOWN	Chambers River Formation (formerly Hayfield Mudstone)		REGIONAL AQUITARD *Local Aquifer*	0 – 450	-	32000
		Bukalorkmi Sandstone (formerly Jamison Sandstone)		*Local Aquifer*	0 – 150	-	138000
	MESO-PROTEROZOIC 1350-1500 Ma	Kyalla Formation		REGIONAL AQUITARD	0 – 800	-	-
		Moroak Sandstone		*Local Aquifer*	0 – 500	0.5 - 5	131000
		Velkerri Formation		REGIONAL AQUITARD	700 – 900	-	-
		Bessie Creek Sandstone		*Local Aquifer*	450	0.5 - 5	-

3 Groundwater Monitoring

The primary purpose of the groundwater monitoring program is to detect potential impacts associated with exploration activities, with the secondary purpose to improve understanding of the hydrogeological regime in the Beetaloo Basin.

3.1 Monitoring Locations

Table 3 summarises the proposed monitoring bores and the parameters that will be measured at each. The locations are shown on Figure 1.

The bores were selected to provide:

- Monitoring at each of the exploration sites;
- Background monitoring in the vicinity of the exploration activities but distant from any potential impact from exploration activities;
- Coverage of the regional aquifers and the local aquifers that are utilised in the vicinity of the exploration activities;
- Monitoring to improve understanding of the range in temporal variations in water levels.

The proposed monitoring network comprises a combination of water supply bore purpose drilled for the exploration drilling[3], pastoral bores, road construction water supply bores and DLRM monitoring bores.

Project water supply bores will be drilled and constructed in accordance with the Minimum Construction Requirements for Water Bores in Australia, Edition 3 (NUDLC, 2012) by an appropriately licensed driller. They will be located at approximately 100m north of the exploration well so that potential spillages or annular cross-flow could be detected. The flow direction in the CLA is generally observed to be to the north.

The closest used pastoral bores to the exploration well locations were selected for ongoing monitoring. Monitoring of pastoral bores is subject to agreement with the landholder(s).

The locations and elevations of bores monitoring under this plan will be surveyed with a differential GPS.

Table 3 Groundwater monitoring locations and parameters

Bore ID / RN	Owner/Property	Aquifer	Water level	Water quality	Gas at headworks
Kalala S-1 Water Bore	Origin	CLA	Logger	Laboratory	•
Amungee NW-1 Water Bore	Origin	CLA	Logger	Laboratory	•
Beetaloo W-1 Water Bore	Origin	CLA	Logger	Laboratory	•
Nutwood Downs SW-1 Water Bore*	Origin	CLA	Logger	Laboratory	•
RN5621	Beetaloo Station	Cretaceous Sandstone	Logger	Grab	•
RN 36917 (Wattys Bore)	Beetaloo Station	Cretaceous Sandstone	Dip	Laboratory	•

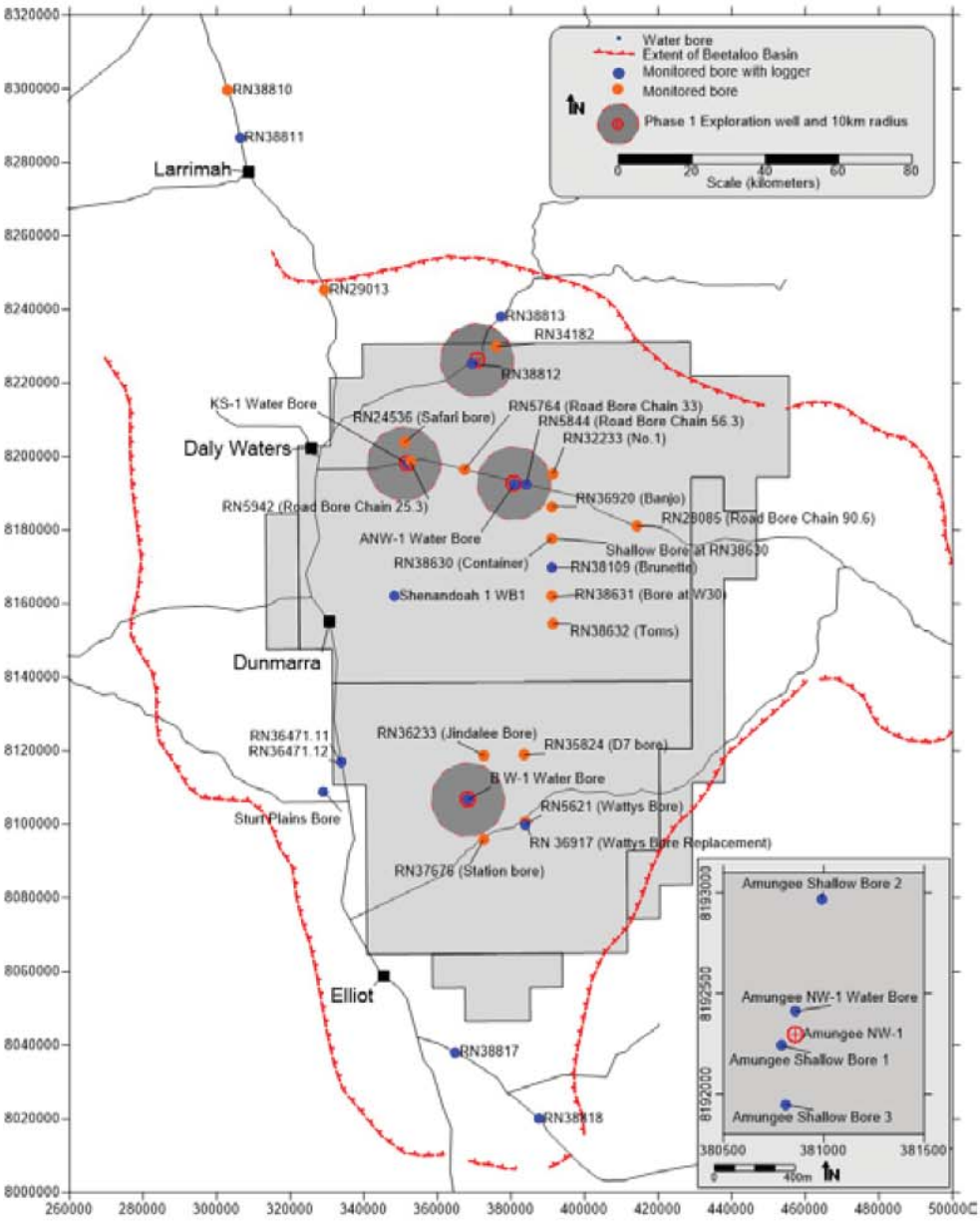
[3] These bores will be ceded to the properties under the terms of access following completion of exploration activities.
* Not yet installed

Bore ID / RN	Owner/Property	Aquifer	Water level	Water quality	Gas at headworks
RN37676 (Station bore)	Beetaloo Station	Cretaceous Sandstone	Dip (if accessible)	Laboratory	•
Abandoned Station Bore	Beetaloo Station	Cretaceous Sandstone	Logger	(Station Bore)	•
RN35824 (D7 bore)	Beetaloo Station	Cretaceous Sandstone	Dip	Laboratory	•
RN36233 (Jindalee Bore)	Beetaloo Station	Cretaceous Sandstone	Dip	Laboratory	•
RN36920 (Banjo)	Amungee Mungee	CLA	Dip	Laboratory	•
RN38630 (Container)	Amungee Mungee	CLA	Dip (if accessible)*	Grab	•
Shallow Bore at RN38630[1]	Amungee Mungee	Cenozoic (perched aquifer)	Logger	Grab	•
RN38109 (Brunette)	Amungee Mungee	CLA	Logger*	Grab	•
RN38631 (Bore at W30)	Amungee Mungee	CLA	Dip (if accessible)	Grab	•
RN38632 (Toms)	Amungee Mungee	CLA	Dip (if accessible)	Grab	•
RN32233 (No.1)	Amungee Mungee	CLA	Dip (if accessible)	Grab	•
RN24536 (Safari bore)	Kalala	CLA	Dip (if accessible)	Laboratory	•
RN36471	DLRM	Anthony Lagoon Beds	Logger (plus baro)	Grab	•
		Gum Ridge Formation	Logger	Grab	•
RN38817	DLRM	CLA	Logger (plus baro)	Grab	•
RN38818	DLRM	CLA	Logger	Grab	•
RN38811	DLRM	CLA	Logger	Grab	•
RN38810	DLRM	CLA	Dip	Grab	•
RN38812	DLRM	CLA	Logger (plus baro)	Grab	•
RN38813	DLRM	CLA	Logger	Grab	•
RN34182	Nutwood Downs	CLA	Dip	Grab	•
RN29013	Department of Transport	CLA	Dip	Grab	•
RN5844	Department of Transport	CLA	Logger	Grab	•
RN5764	Department of Transport	CLA	Dip	Grab	•
RN5942	Department of Transport	CLA	Dip	Grab	•
RN28085	Department of Transport	CLA	Dip	Grab	•
RN39149 (Sturt Plains Bore)	Sturt Plains	CLA	Logger	Laboratory	•

Bore ID / RN	Owner/Property	Aquifer	Water level	Water quality	Gas at headworks
Shenandoah 1 WB1	Hayfield	CLA	Logger	Grab	•
Amungee Shallow Bore 1	Origin	Cenozoic (perched)	Logger	Laboratory	•
Amungee Shallow Bore 2	Origin	Cenozoic (perched)	Logger	Laboratory	•
Amungee Shallow Bore 3	Origin	Cenozoic (perched)	Logger	Laboratory	•

*A logger was installed in RN38630 in August 2015, but was removed when the landholder installed a pump. A logger was installed in RN38109 in April 2016 in lieu of RN38630.
[!] Bore could not be located in July 2016 as it had been buried during earth moving by the landholder

Figure 1 Monitoring bore locations



3.2 Water Level Monitoring

Monitoring commenced close to the start of exploration drilling of Kalala S-1 in early August 2015.

For selected bores standalone pressure/temperature sensors (unvented) with on-board datalogging capability (InSitu© Rugged or Level Trolls) will be used for continuous (twice daily) water level monitoring. The sensors are suspended within the bore with a stainless steel cable. Barometric pressure sensors are monitored at 3 DLRM bores, including RN36471 (west of Beetaloo Station), RN38812 (proximal to Nutwood Downs) and RN38817 (south of tenements). Bores will be visited twice per year to download data from the sensors.

Water levels will be measured with an electronic water level meter (dipmeter) each time the bore is visited. Where water levels are greater than 150m, a sonic water level meter will be used, recognising that it is a less accurate instrument compared with a dipmeter. Water levels in those bores not equipped with loggers, will only be measured with a dipmeter during field visits.

It is recognised that it may not be possible to access the water level past pumping equipment, however pumps *will not* be removed to facilitate this.

Where airlines are installed and operational, airline pressure measurements will be collected.

3.3 Water Quality Monitoring

Water quality samples will be collected from bores with installed pumps for laboratory analysis. The shallow bores surrounding Amungee NW-1H will be sampled with a 12V submersible pump or a bailer. If landholder bore pumps are not running at the time of monitoring, or samples cannot be collected without modifying infrastructure, samples will not be collected.

Water quality samples will be collected from the bores identified in Table 3 for laboratory analysis. Samples will be routinely analysed for:

- Field parameters: electrical conductivity, pH, temperature;
- Total dissolved solids;
- Major cations and anions (Ca, Mg, Na, K, Cl, SO_4, CO_3, HCO_3);
- Trace elements (As, B, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, Se, V, Zn, Hg);
- Total petroleum hydrocarbons and BTEX;
- Dissolved methane; and
- Dissolved hydrogen sulphide.

Samples will be

- Collected in new, laboratory supplied sample containers, with appropriate preservatives;
- Stored in a chilled esky prior to delivery to the laboratory;
- Submitted under Chain-of-Custody protocols, and;
- Submitted to a laboratory accredited with the National Association of Testing Authorities (NATA) for the analyses to be conducted.

Field water quality will be measured at the time of sample collection using a calibrated handheld water quality meter. A bailer will be used to collected grab samples from unequipped bores which will be tested for field water quality parameters only.

At least three samples will be collected on non-consecutive days from the water supply bores installed at the exploration leases during early drilling activities. At least one sample will be collected following the exploration activities at each wellsite.

3.3.1 Hydraulic Fracture Stimulation Water Quality Monitoring

Additional water quality monitoring will be undertaken during hydraulic fracture stimulation. This will include:

- An additional round of monitoring no more than 6 weeks prior to the HFS, to include, at a minimum, the onsite water supply/monitoring bores;
- Collection of samples of the HFS fluids prior to pumping (1 per stage) and of samples of the flow back fluid during the well testing post-HFS (1 per 10% of total volume pumped in). Laboratory analysis of the samples will include the following in addition to the standard suite of analysis:
    - Polycyclic aromatic hydrocarbons
    - Phenols
    - Nutrients
    - Surfactants
    - Gross alpha and beta
- Continued monitoring of the bores in accordance with this plan following HFS for at least 3 samples.

3.4 Gas Monitoring

Methane gas concentrations will be measured at the bore headworks each time the bore is visited. Measurements will be made with a portable multi-parameter gas analyser with low level methane sensor upgrade (RKI Eagle 2 or similar). Measurements will be made above and inside the casing.

3.5 Relevant Procedures

The following Origin standard operating procedures are relevant for the field activities described herein:

- Purging and Sampling Groundwater Monitoring Bores CDN/ID 8212543
- Installing and Downloading Water Level Sensors CDN/ID 8227127
- Groundwater Bore Gas Measurements CDN/ID 3676218
- Measuring Standing Water Level CDN/ID 3676220

4 Data Management, Reporting and Data Dissemination

4.1 Data Management

Data collected and compiled as part of this groundwater monitoring program will be stored in the Origin Esdat environmental database.

4.2 Reporting

An annual report will be produced to present and assess the results of groundwater monitoring program. These reports will include:

- Changes to the proposed monitoring network from the previous report (for example, new monitoring bores coming online);
- Presentation and discussion of water level data;
- Presentation of water quality monitoring results, including:
    - Standard hydrochemical plots (e.g. Piper tri-linear, Durov, Schoeller, or Stiff) of major ion chemistry;
    - Tabulation of field and laboratory chemical data.
- Discussion of changes in water quality as a result of exploration activities

A brief report will be prepared comparing HFS fluid, pre-pumping and flowback, and with the groundwater bore data from before and after the HFS activities.

4.3 Data Dissemination

The monitoring reports will be provided to the Beetaloo Basin landholders, the Northern Territory Government Department of Mines and Energy (DME) and Department of Land and Resource Management Water Resources Division (DLRM WRD).

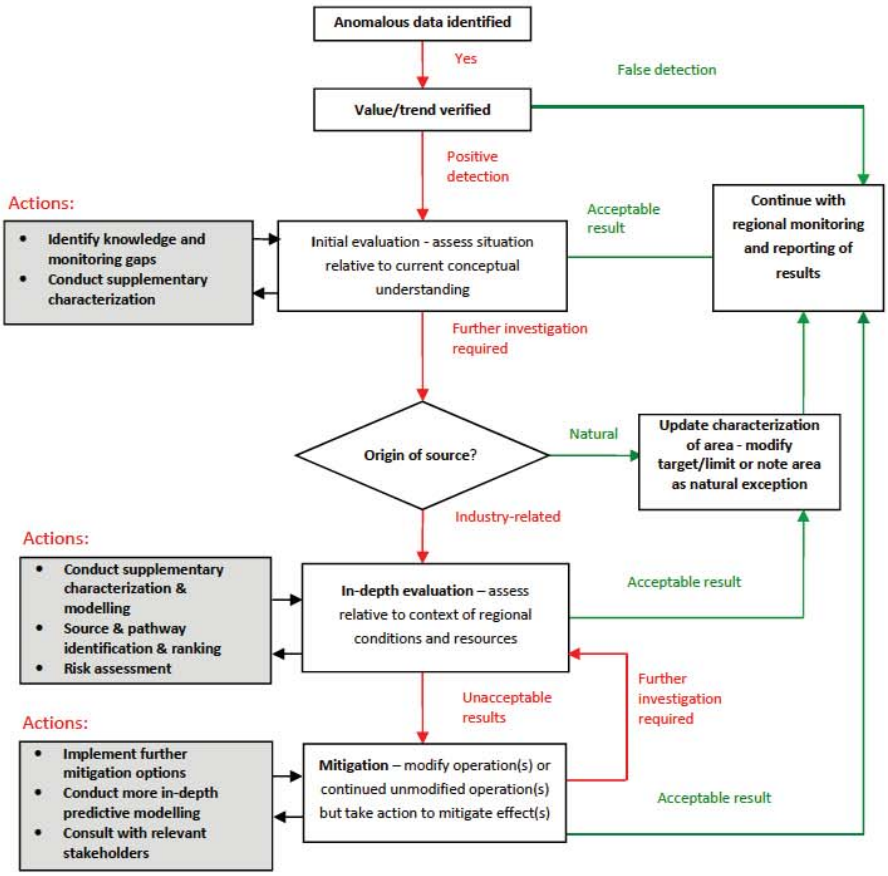
DLRM WRD will be provided with the raw data to upload to its groundwater bore database following the completion of the report.

DME will be provided with raw HFS data with the reporting thereon.

5 Investigation and Response

Should monitoring data fall outside of the expected range, response actions will follow the framework shown in Figure 2. DME and DLRM WRD will be notified of verified positive detections within seven days of Origin becoming aware of the anomaly.

Figure 2 Follow up response framework



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APPENDIX 4
WELL ACCEPTANCE CRITERIA

Origin Energy Well Acceptance Criteria (WAC)
Amungee NW-1, Amungee NW-1H

WELL ACCEPTANCE CRITERION #1	
Description	16" conductor successfully penetrates the top of the Gum Ridge formation and the conductor is cemented with returns to surface.
Reasoning	To avoid the unstable clays in the shallow section sloughing in while drilling the subsequent section. To comply with government regulations requiring cement to surface.
Tests	Cuttings will be visually identified at surface. Cement to surface on the cement job will be visually confirmed.
Verification	The daily report while drilling the 16" hole reports limestone cuttings seen at surface. The report for the cement jobs identifies that on the initial cement job, no cement returns to surface were seen. Subsequent top up jobs down the back of the annulus were conducted until cement at surface was seen.

WELL ACCEPTANCE CRITERION #2	
Description	Cement the 10-3/4" surface casing from the shoe back to surface..
Reasoning	To provide a positive isolation between the next section and the potable Gum Ridge aquifer. To provide a competent shoe to hold back any potential well influx seen. To comply with government regulations requiring cement to surface.
Tests	Cement will be visually confirmed at surface and hold as it sets.
Verification	Although some losses were taken while pumping the cement job, extra cement was pumped to assist with achieving the cement to surface requirement. Cement at surface was seen but slumped during setup so a top up job was performed. The daily drilling report confirms cement top up was successful and there is cement at surface.

WELL ACCEPTANCE CRITERION #3	
Description	Pressure test the 10-3/4" casing to 1000psi for 10 minutes...
Reasoning	This pressure test proves the integrity of the casing and cement for isolation of the aquifer and subsequent well operations.
Tests	The casing will be pressure tested to 1000psi for 10 minutes and cannot fall more than 2% during that period.
Verification	The pressure test undertaken achieved the success criteria outlined above and was recorded in the daily report, as well as having an associated pressure test chart on file.

WELL ACCEPTANCE CRITERION #4	
Description	A-Section and BOP Installation and Testing
Reasoning	This criterion notes the first installation and testing of the BOP. This is an important step in the program as beyond this point, secondary well control is a critical requirement. This criterion does not remove the requirement for subsequent BOP tests as required, although these are not tracked as individual WACs.
Tests	The wellhead provider created an installation report with all appropriate pressure tests and records of tie down engagement. Pressure tested BOP to 1000psi for 10 minutes.
Verification	The tests performed are noted in the relevant daily drilling reports and the drilling contractor is obliged to hold copies of the pressure tests for two years.

WELL ACCEPTANCE CRITERION #5	
Description	9-5/8" Casing Leak Off Test and Kick Tolerance
Reasoning	This criterion requires a test on the strength of the rock directly below where the surface casing was set. This test proves that the cement on the outside of the casing is isolating the new open hole from any permeable areas or surface. It also proves the integrity of the rock is sufficient to withstand the pressure of taking an influx of gas and circulating it from the bottom of the section and back up to surface. This is known as "kick tolerance".
Tests	A leak off test is a test in which a column of fluid of known weight is pressured up until the rock breaks down. This would be a linear build up of pressure (no leak off around shoe) and a distinct break down of the rock. Using the pressure applied and the known hydrostatic pressure, the strength of the rock can be back calculated. An assumed rock strength, based on offset data, is used to design the well. This is then tested by the LOT. The strength of the rock calculated from the test is used to confirm whether appropriate kick tolerance has been achieved.
Verification	The leak off test charts are reviewed by the engineer and filed. The kick tolerance is re-calculated with the new "actual" data and confirmed to meet minimum requirements. This activity is recorded in the daily drilling reports. This formation leaked off at 1,431psi with 8.4ppg mud, which gave a rock strength of 38.2ppg equivalent (i.e. it could hold a column of fluid of that weight). The targeted gradient was 11.8ppg, meaning the rock was more than 3 times as strong as it needed to be to meet minimum requirements.

WELL ACCEPTANCE CRITERION #6	
Description	Cement the 7-5/8" surface casing from the shoe back to surface.
Reasoning	To provide a second barrier between the targeted hydrocarbons and the potable Gum Ridge aquifer. To provide a competent shoe to hold back any potential well influx seen. To comply with government regulations requiring cement to surface.
Tests	Cement will be visually confirmed at surface and hold as it sets.
Verification	Cement was returned to surface with minimal losses. This was noted in the cement reports and daily drilling reports.

WELL ACCEPTANCE CRITERION #7	
Description	Pressure test the 7-5/8" casing to 5000psi for 10 minutes.
Reasoning	This pressure test proves the integrity of the casing and cement for isolation of formations and subsequent well operations..
Tests	The casing will be pressure tested to 5000psi for 10 minutes and cannot fall more than 2% during that period.
Verification	The pressure test undertaken achieved the success criteria outlined above and was recorded in the daily report, as well as having an associated pressure test chart on file.

WELL ACCEPTANCE CRITERION #8	
Description	Install and test the next casing spool.
Reasoning	The wellhead used on this well was a conventional wellhead and required the installation of another section to drill the production hole.
Tests	The wellhead will be pressure tested as per the installation procedures provided by the manufacturer.
Verification	The wellhead seals were tested and passed. The test charts were captured in a wellhead report and the daily drilling report also noted the test details.

WELL ACCEPTANCE CRITERION #9	
Description	7-5/8" Casing Leak Off Test and Kick Tolerance
Reasoning	This criterion is the same as that given in #5, it aims to prove the integrity of the previous casing string and provide kick tolerance.
Tests	A leak off test will be conducted to a minimum of 14.7ppg.
Verification	The leak off test was conducted to an equivalent of 26.2ppg, in excess of the minimum requirement. This was recorded in the daily drilling reports.

Note that at this point in the well construction, the well was suspended pending re-entry in 2016. The barriers put in place to achieve well suspension were also subject to verification testing but were subsequently removed during the re-entry. Those barriers no longer form part of the constructed well.

WELL ACCEPTANCE CRITERION #10	
Description	Cement the 4-1/2" casing back to surface.
Reasoning	To provide a casing string that can withstand the pressures required for placing fractures in the formation. To provide isolation back to surface for producing reservoir fluids. To comply with government regulations requiring cement to surface
Tests	Cement will be visually confirmed at surface and hold as it sets. Note that at a later date, a Cement Bond Log will also be conducted (part of the completions activity).
Verification	Cement was observed back to surface. Volumes indicate the hole was likely "over gauged" (enlarged down hole) and the extra volume pumped went to fill that larger bore. This detail was recorded in a cement report and the daily drilling reports.

WELL ACCEPTANCE CRITERION #11	
Description	Pressure test the 4-1/2" casing to 5000psi for 20 minutes.
Reasoning	This pressure test proves the integrity of the casing as a barrier for suspension. Further testing will be required prior to stimulating or producing the well. This is carried out as part of the fracture stimulation operation.
Tests	The casing will be pressure tested to 5000psi for 20 minutes and cannot fall more than 2% during that period.
Verification	The pressure test undertaken achieved the success criteria outlined above and was recorded in the daily report, as well as having an associated pressure test chart on file..

WELL ACCEPTANCE CRITERION #12	
Description	Install C-Section and Suspend Well.
Reasoning	The final piece of the wellhead is installed and tested to provide a secondary isolation for the well, the first being the casing tested in WAC #11. The well is also chained and padlocked to deter any outside interference, in line with regulatory requirements.
Tests	The wellhead will be tested in line with the manufacturer procedures and then chained, padlocked and photographed.
Verification	The wellhead seals were tested and passed. The test charts were captured in a wellhead report and the daily drilling report also noted the test details. The wellhead was photographed as it was left and shared with the regulator.

APPENDIX 5
HFS CHEMICAL DISCLOSURE

Full listing of fracture stimulation fluid additives as planned and pumped at Amungee NW-1H

5.1 PREJOB DISCLOSURE REPORT FOR SLICK WATER DESIGN AT AMUNGEE NW-1H

Client:	Origin
Well:	Amungee NW-1H (Treated Water)
Basin/Field:	Beetaloo
State:	Northern Territory
Disclosure Type:	Post-Job
Well Completed:	N/A
Date Prepared:	5/26/2016 7:20 PM
Report ID:	RPT-42764

		FLUID DESCRIPTION(S)
Slickwater	3,962,700 Gal	Contains: Water, Surfactant F112, Hydrochloric Acid, Friction Reducer J609W, Iron Control Agent L058, Scale Inhibitor L065, Clay Control Agent L071, Bactericide M275, Propping Agent S012 Sand, Chelating Agent U042

The total volume listed in the tables above represents the summation of water and additives. Water is supplied by client.

* Mix water is supplied by the client. Schlumberger has performed no analysis of the water and cannot provide a breakdown of components that may have been added to the water by third-parties.

CAS NUMBER	CHEMICAL NAME	MASS FRACTION	MASS (kg)	VOLUME (L)	VOLUME FRACTION
-	Water (Including Mix Water Supplied by Client)*	95.43713%	14,963,339	14,963,322	0.980648743%
57-13-6	Urea	0.00029%	45.47	52.87	3.46494E-06%
64-02-8	Tetrasodium ethylenediaminetetraacetate	0.00032%	50.17	38.01	2.49099E-06%
67-48-1	2-hydroxy-N,N,N-trimethylethanaminium chloride	0.15776%	24,734.78	22,486.14	0.00147367%
67-63-0	Propan-2-ol	0.00019%	29.79	37.90	2.48386E-06%
79-06-1	2-Propenamid (impurity)	0.00001%	1.57	1.43	9.34122E-08%
107-21-1	Ethylene glycol	0.01136%	1,781.10	2,003.49	0.000131302%
111-46-6	2,2"-oxydiethanol (impurity)	0.00011%	17.25	10.55	6.91307E-07%
139-33-3	Disodium Ethylene Diamine Tetra Acetate (impurity)	0.00001%	1.57	1.43	9.34122E-08%
150-38-9	Trisodium Ethylenediaminetetraacetate (impurity)	0.00001%	1.57	1.39	9.08518E-08%
540-97-6	Dodecamethylcyclohexasiloxane	< 0.00001%	1.57	0.74	4.84686E-08%
541-02-6	Decamethyl cyclopentasiloxane	< 0.00001%	1.57	0.74	4.84686E-08%
556-67-2	Octamethylcyclotetrasiloxane	< 0.00001%	1.57	0.74	4.84686E-08%
1310-73-2	Sodium hydroxide (impurity)	0.00007%	10.98	5.15	3.37687E-07%
2682-20-4	2-methyl-2h-isothiazol-3-one	0.00011%	17.25	13.80	9.0423E-07%
2836-32-0	Sodium Glycolate (impurity)	0.00003%	4.70	3.70	2.42725E-07%
5064-31-3	Trisodium nitrilotriacetate (impurity)	< 0.00001%	1.57	1.29	8.42241E-08%
6381-77-7	Sodium erythorbate	0.00006%	9.41	9.41	6.1652E-07%
7447-40-7	Potassium chloride (impurity)	0.00003%	4.70	2.38	1.55687E-07%

CAS NUMBER	CHEMICAL NAME	MASS FRACTION	MASS (kg)	VOLUME (L)	VOLUME FRACTION
7631-86-9	Silicon Dioxide	0.00006%	9.41	3.92	2.56883E-07%
7647-01-0	Hydrochloric acid	0.01276%	2,000.61	1,667.17	0.000109261%
7647-14-5	Sodium chloride	0.00215%	337.09	155.70	1.02041E-05%
7757-82-6	Sodium sulfate	0.00007%	10.98	5.54	3.6327E-07%
7758-98-7	Copper(II) sulfate	< 0.00001%	1.57	0.79	5.18956E-08%
7783-20-2	Ammonium sulfate	0.00593%	929.75	920.54	6.03295E-05%
7786-30-3	Magnesium chloride	0.00034%	53.31	22.98	1.50587E-06%
10043-52-4	Calcium Chloride	0.00108%	169.33	118.41	7.76039E-06%
10377-60-3	Magnesium nitrate	0.00069%	108.18	121.69	7.97523E-06%
14464-46-1	Cristobalite	0.00007%	10.98	4.22	2.76644E-07%
14808-60-7	Quartz, Crystalline silica	4.33676%	679,949.28	261,518.66	0.017139105%
26172-55-4	5-chloro-2-methyl-2h-isothiazolol-3-one	0.00037%	58.01	46.41	3.0415E-06%
31726-34-8	Polyethylene glycol monohexyl ether	0.02295%	3,598.27	3,520.81	0.000230743%
38193-60-1	Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer"	0.00438%	686.73	515.17	3.37629E-05%
61789-77-3	Dicoco dimethyl quaternary ammonium chloride	0.00096%	150.52	150.52	9.86432E-06%
63148-62-9	Dimethyl siloxanes and silicones	< 0.00001%	1.57	1.57	1.02753E-07%
67762-90-7	Siloxanes and silicones, dimethyl, reaction products with silica	< 0.00001%	1.57	1.99	1.30729E-07%
91053-39-3	Diatomaceous earth, calcined	0.00344%	539.35	1,147.55	7.52067E-05 %
129898-01-7	2-Propenoic acid, polymer with sodium phosphinate	0.01062%	1,665.08	640.42	4.19708E-05 %
136793-29-8	Polymer of 2-acrylamido-2-methylpropanesulfonic acid sodium salt and methyl acrylate"	0.00047%	73.69	37.79	2.47662E-06 %
		100%	**34,592,268 lb**	**4,032,229 gal**	**100%**

5.2 PREJOB DISCLOSURE REPORT FOR HYBRID DESIGN AT AMUNGEE NW-1H

Client:	Origin
Well:	Amungee NW-1H (Cross-linked)
Basin/Field:	Beetaloo Basin
State:	Northern Territory
Disclosure Type:	Prejob in Post Job Format
Well Completed:	N/A
Date Prepared:	5/26/2016 7:09 PM
Report ID:	RPT-42763

		FLUID DESCRIPTION(S)
Slickwater	1,323,000 Gal	Contains: Water, Surfactant F112, Hydrochloric Acid, Breakers J218, J479 and J481, Gelling Agent J580, Crosslinker J604, Iron Control Agent L058, Scale Inhibitor L065, Clay Control Agent L071, Bactericide M275, Propping Agent S012 Sand, Activator U028, Chelating Agent U042

The total volume listed in the tables above represents the summation of water and additives. Water is supplied by client.

* Mix water is supplied by the client. Schlumberger has performed no analysis of the water and cannot provide a breakdown of components that may have been added to the water by third-parties.

CAS NUMBER	CHEMICAL NAME	MASS FRACTION	MASS (kg)	VOLUME (L)	VOLUME FRACTION
-	Water (Including Mix Water Supplied by Client)*	84.91606%	4,828,426.88	4,828,421.4	0.906838875%
64-02-8	Tetrasodium ethylenediaminetetraacetate	0.00085%	48.33	36.62	6.87678E-06%
67-48-1	2-hydroxy-N,N,N-trimethylethanaminium chloride	0.14494%	8,241.46	7,492.23	0.001407135%
67-63-0	Propan-2-ol	0.00018%	10.24	13.02	2.44563E-06%
107-21-1	Ethylene Glycol	0.06145%	3,494.12	3,930.39	0.000738177%
110-17-8	Fumaric acid	0.00232%	131.92	80.68	1.51534E-05%
111-46-6	2,2"-oxydiethanol (impurity)	0.00011%	6.25	3.83	7.18481E-07%
139-33-3	Disodium Ethylene Diamine Tetra Acetate (impurity)	0.00002%	1.14	1.03	1.94168E-07%
150-38-9	Trisodium Ethylenediaminetetraacetate (impurity)	0.00002%	1.14	1.01	1.88846E-07%
1310-73-2	Sodium hydroxide (impurity)	0.03460%	1,967.40	923.66	0.000173475%
1319-33-1	Boronatrocalcite	0.08812%	5,010.61	2,352.39	0.00044181%
1330-43-4	Sodium tetraborate	0.00742%	421.91	178.25	3.3477E-05%
2682-20-4	2-methyl-2h-isothiazol-3-one	0.00010%	5.69	4.55	8.54339E-07%
2836-32-0	Sodium Glycolate (impurity)	0.00007%	3.98	3.13	5.88619E-07%
5064-31-3	Trisodium nitrilotriacetate (impurity)	0.00001%	0.57	0.47	8.75347E-08%
6381-77-7	Sodium erythorbate	0.00017%	9.67	9.67	1.81547E-06%
7447-40-7	Potassium chloride (impurity)	0.00003%	1.71	0.86	1.61807E-07%
7631-86-9	Non-crystalline silica (impurity)	0.00659%	374.72	156.13	2.93234E-05%

CAS NUMBER	CHEMICAL NAME	MASS FRACTION	MASS (kg)	VOLUME (L)	VOLUME FRACTION
7647-01-0	Hydrochloric acid	0.03510%	1,995.83	1,663.19	0.000312368%
7647-14-5	Sodium chloride	0.00197%	112.02	51.74	9.71737E-06%
7704-73-6	Monosodium fumarate	0.00232%	131.92	63.12	1.18545E-05%
7727-54-0	Diammonium peroxidisulphate	0.06012%	3,418.49	1,726.51	0.000324261%
7786-30-3	Magnesium chloride	0.00032%	18.20	7.84	1.473E-06%
7789-38-0	Sodium bromate	0.04210%	2,393.86	716.94	0.00013465%
9000-30-0	Guar gum	2.62860%	149,465.28	213,521.59	0.040102067%
10043-35-3	Boric acid	0.00232%	131.92	92.25	1.73258E-05%
10043-52-4	Calcium Chloride	0.00100%	56.86	39.76	7.468E-06%
10377-60-3	Magnesium nitrate	0.00063%	35.82	40.30	7.56796E-06%
14464-46-1	Cristobalite	0.00006%	3.41	1.31	2.46444E-07%
14807-96-6	Magnesium silicate hydrate (talc)	0.00008%	4.55	1.65	3.10669E-07%
14808-60-7	Quartz, Crystalline silica	11.93375%	678,567.04	260,987.03	0.049016679%
25038-72-6	Vinylidene chloride/methylacrylate copolymer	0.00295%	167.74	94.24	1.76987E-05%
26172-55-4	5-chloro-2-methyl-2h-isothiazolol-3-one	0.00034%	19.33	15.47	2.90475E-06%
31726-34-8	Polyethylene glycol monohexyl ether	0.02108%	1,198.63	1,172.83	0.000220272%
61789-77-3	Dicoco dimethyl quaternary ammonium chloride	0.00088%	50.04	50.04	9.39773E-06%
91053-39-3	Diatomaceous earth, calcined	0.00316%	179.68	382.30	7.18008E-05%
125005-87-0	Diutan gum	0.00012%	6.82	2.62	4.92888E-07%
129898-01-7	2-Propenoic acid, polymer with sodium phosphinate	0.00976%	554.97	213.45	4.00882E-05%
		100%	**12,536,946 lb**	**1,406,724 gal**	**100%**

5.3 AS PUMPED CHEMICAL DISCLOSURE AT AMUNGEE NW-1H

INDEPENDENT VERIFICATION OF ADDITIVES					
CAS NUMBER	CHEMICAL NAME	MASS (kg)	MASS (%)	VOLUME (L)	VOLUME (%)
-	Water (Including Mix Water Supplied by Client)*	10633215.45	89.33825%	10633203.53	95.26733%
14808-60-7	Quartz, Crystalline silica	1204412.67	10.11925%	463235.15	4.15032%
9000-30-0	Guar gum	20618.58	0.17323%	29455.06	0.26390%
67-48-1	2-hydroxy-N,N,N-trimethylethanaminium chloride	17736.45	0.14902%	16123.98	0.14446%
7647-01-0	Hydrochloric acid	5665.27	0.04760%	4721.15	0.04230%
107-21-1	Ethylene glycol	4106.85	0.03450%	4619.61	0.04139%
31726-34-8	Polyethylene glycol monohexyl ether	2436.20	0.02047%	2383.77	0.02136%
1319-33-1	Boronatrocalcite	5050.84	0.04244%	2371.33	0.02125%
1310-73-2	Sodium hydroxide (impurity)	2491.30	0.02093%	1169.65	0.01048%
7783-20-2	Ammonium sulfate	880.00	0.00739%	871.31	0.00781%
91053-39-3	Diatomaceous earth, calcined	388.60	0.00326%	826.75	0.00741%
7789-38-0	Sodium bromate	1764.05	0.01482%	528.32	0.00473%
38193-60-1	Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer	649.26	0.00545%	487.14	0.00436%
129898-01-7	2-Propenoic acid, polymer with sodium phosphinate	1106.20	0.00929%	425.51	0.00381%
1330-43-4	Sodium tetraborate	425.48	0.00357%	179.72	0.00161%
7647-14-5	Sodium chloride	223.25	0.00188%	103.14	0.00092%
61789-77-3	Dicoco dimethyl quaternary ammonium chloride	101.54	0.00085%	101.54	0.00091%
10043-35-3	Boric acid	132.87	0.00112%	92.88	0.00083%
10377-60-3	Magnesium nitrate	77.85	0.00065%	87.62	0.00079%
110-17-8	Fumaric acid	132.87	0.00112%	81.25	0.00073%
10043-52-4	Calcium Chloride	112.93	0.00095%	78.93	0.00071%
7704-73-6	Monosodium fumarate	132.87	0.00112%	63.50	0.00057%
57-13-6	Urea	42.74	0.00036%	49.71	0.00045%
136793-29-8	Polymer of 2-acrylamido-2-methylpropanesulfonic acid sodium salt and	69.57	0.00058%	35.70	0.00032%
26172-55-4	5-chloro-2-methyl-2h-isothiazolol-3-one	41.58	0.00035%	33.31	0.00030%
67-63-0	Propan-2-ol	20.35	0.00017%	25.83	0.00023%
7631-86-9	Non-crystalline silica (impurity)	60.59	0.00051%	25.21	0.00023%
7786-30-3	Magnesium chloride	38.98	0.00033%	16.85	0.00015%
2682-20-4	2-methyl-2h-isothiazol-3-one	12.55	0.00011%	10.06	0.00009%
111-46-6	2,2"-oxydiethanol (impurity)	11.96	0.00010%	7.35	0.00007%
7757-82-6	Sodium sulfate	9.90	0.00008%	4.99	0.00004%
595585-15-2	Diutan gum	6.57	0.00006%	4.48	0.00004%
14464-46-1	Cristobalite	7.58	0.00006%	2.98	0.00003%
79-06-1	2-Propenamid (impurity)	2.07	0.00002%	1.81	0.00002%

INDEPENDENT VERIFICATION OF ADDITIVES					
CAS NUMBER	CHEMICAL NAME	MASS (kg)	MASS (%)	VOLUME (L)	VOLUME (%)
7447-40-7	Potassium chloride (impurity)	3.59	0.00003%	1.77	0.00002%
67762-90-7	Siloxanes and silicones, dimethyl, reaction products with silica	1.24	0.00001%	1.51	0.00001%
63148-62-9	Dimethyl siloxanes and silicones	1.24	0.00001%	1.24	0.00001%
64-02-8	Tetrasodium ethylenediaminetetraacetate	1.40	0.00001%	0.99	0.00001%
7758-98-7	Copper(II) sulfate	1.24	0.00001%	0.63	0.00001%
540-97-6	Dodecamethylcyclohexasiloxane	1.24	0.00001%	0.59	0.00001%
541-02-6	Decamethyl cyclopentasiloxane	1.24	0.00001%	0.59	0.00001%
556-67-2	Octamethylcyclotetrasiloxane	1.24	0.00001%	0.59	0.00001%
	TOTAL	**11902198.25**	**100%**	**11161437.04**	**100%**

APPENDIX 6
OIL SPILL RESPONSE PLAN

Origin Energy Stimulation and Well Testing
Oil Pollution Emergency Plan

origin

Emergency Response Plan
[NT-2050-35-MP-0006]

Integrated Gas

OIL POLLUTION EMERGENCY RESPONSE PLAN ONSHORE
Beetaloo Stimulation and Well Testing 2016

Review record

Rev	Date	Reason for issue	Reviewer/s	Consolidator	Approver
0	05/07/2016	Issued for use.	J Carr	C Christoffersen	J Boorman

In the event of spill, refer to Section 6 on Page 11

THE THREE WHATS

What can go wrong?
What could cause it to go wrong?
What can I do to prevent it?

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1. Introduction

1.1 Background

This Oil Pollu ion Emergency Plan (OPEP) has been developed to detail Origin Energy's (Origin) response to on-shore oil pollution incidents associated with the Beetaloo Stimulation & Well Testing Activity in the permit areas EP98 and EP117.

Permits are approximately 18,512 square kilometres approximately 500km south west of Darwin and are held under a Joint Venture Agreement between Origin Energy Pty Ltd, Sasol and Falcon.

Origin is the operator of the permit area and Stimulation and Well Testing activities will be undertaken by Schlumberger Australia (SLB) with completion tubing running run by a Savanna Energy (SAV) completions rig.

1.2 Scope

Any release of oil/gas/hydrocarbon liquids (referred to as 'oil') into the environment that has the potential to cause harm to the surrounding environment from activities associated with the Stimulation and Well Testing campaign within permits EP98 and EP117 as shown in Figure 1.

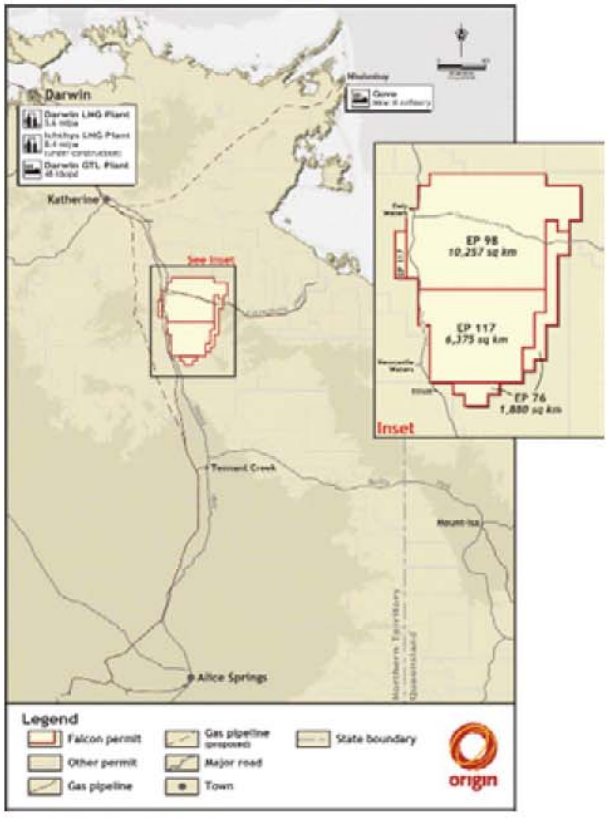


Figure 1: Location of proposed activity

1.3 Definitions/Acronyms

Acronym	Expansion
BoM	Bureau of Meteorology
CMT	Crisis Management Team
EP	Environment Plan
ER	Emergency Response
ERP	Emergency Response Plan
GEMT/P	Group Emergency Management Team/Plan
HSE	Health, Safety, and Environment
NEBA	Net Environmental Benefit Analysis
NOK	Next of Kin
OCIS	Origin Collective Intelligence System
OPEP	Oil Pollution Emergency Plan
SERT	Site Emergency Response Team
SME	Subject Matter Expert
ZPI	Zone of Potential Impact
PC	Primary Contractor
SLB	Schlumberger Australia
SAV	Savanna Energy Australia

1.4 Aim and objectives

The aim of this OPEP is to detail the activities and arrangements and provide a framework for site response actions to protect life, the environment and property.

The specific objectives of a response to any oil spill relating to the campaign are:

- Stop any further discharge of oil from the source;
- Contain any spilled oil;
- Limit the spread of oil;
- Recover spilled oil, as far as safely practicable within the capabilities of the site resources, to prevent oil reaching environmentally sensitive areas or impacting on commercial or other values of the area;
- Ensure rapid notifications of any spill or potential spill in accordance with regulatory requirements and to facilitate any escalation of the response.

The actions outlined within this document are integrated within Origin's overall emergency response framework. This plan is intended to support and supplement the Contractor's Emergency Pollu ion Plans or equivalent.

This OPEP defines:

- Priorities for protection in the event of a spill;
- The response incident management structure;
- Protocols for notifications to government agencies as appropriate;
- Response strategies and Response Action Plans based on feasible worst case scenario;
- Roles and responsibilities of personnel within the Response Action Plans;
- Spill equipment and resources, including responsibilities for audit and maintenance;
- Procedures and responsibilities for review and maintenance of the OPEP.

1.5 Overarching response priorities

In responding to an incident, the following protection priorities will be observed.

Priority 1 Protection of human life, health and personal safety

Priority 2 Containment of the pollution source on site

Priority 3 Prevention of oil reaching environmentally sensitive locations

Priority 4 Prevention of impacts to commercial/industrial resources, properties and assets

Priority 5 Protection of cultural, recreational and human amenity resources

1.6 Interface with Origin Plans

The following internal documents have been referred to as required and appropriate information extracted:

- Stimulation and Well Testing Environmental Plan NT-2050-35-PH-0018;
- Bridging Emergency Response Plan NT-2050-35-MP-0004;
- Group Emergency Response Plan INT-IGMS-SAF-PLN-00003;
- Crisis Management Plan ORG-CMP-PRO-001.

1.7 Interface with external plans

Information from the following external documents has been used or referred to:

- Schedule of Onshore Petroleum Exploration and Production Requirements 2012;
- SLB Emergency Management Plans (EMPs) APG-WPS-PL-ERP-001, APG-WI-PL-ERP-001 WI, APG-WL-PL-ERP-001, APG-TS-PL-ERP-001
- SAV Emergency Management Plan (EMP) SAV-HSE-PL-017

1.8 The Tiered Response Structure

Oil spills are divided into three categories depending on their size and the resources and capabilities required for an effec ive response.

For the purposes of this plan, the following summarises the different tiers:

Table 1: Tier Definitions

Tier	Definition
Tier 1	Spills that can be contained within the well site and can be cleaned up by the operator without involvement of external organisations.
Tier 2	Spills that cannot be completely contained within the site boundary and/or may require the involvement of external organisations for spill control and/or clean-up.
Tier 3	Severe spills that cannot be contained by the operator and requires substantial additional external resources to manage the spill.

1.9 Oil types/volumes & potential spill scenarios

The oil types that may be released as a result of an incident involving the contractors include:

Table 2: Oil Types/Volumes & Potential Spill Scenarios

Type	Source	Volume	Potential Scenario
Hydrocarbon gas (methane)	well	undefined	Loss of well control
Hydrocarbon liquids (condensate)	well	undefined	Loss of well control
Hydraulic oils	control system	205 litres (single drum, max)	Hydraulic hose/system failure

Type	Source	Volume	Potential Scenario
Diesel	Storage tanks	Dual walled, self bunded diesel tanks: • Well site 26.4m3	Loss of containment during transfer operations Loss of containment due to tank integrity issues

2. Response Operations

2.1 Origin's Crisis and Emergency Management Response Hierarchy

This plan falls under Standard 14 - Crisis and Emergency Management of Origin's HSE management System (HSEMS).

The hierarchy for managing and coordinating Origin's response to incidents is illustrated below in Figure 2.

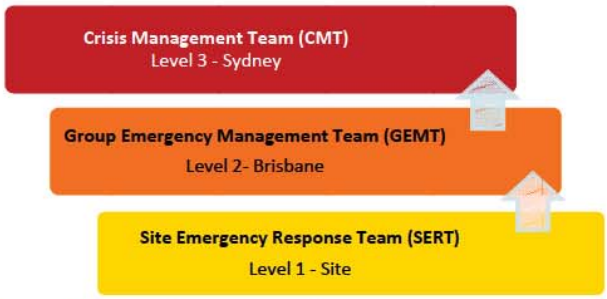


Figure 2: Origin's Emergency Response Team Hierarchy

Table 3 summarises the roles played by Origin's framework with respect to oil spills. The extent of the response structure will be dictated by the size of the incident and the required response.

Table 3: Spill Response Framework

Team	Respond to Tier #	Type of Response
SERT	1/2/3	Tactical response at the incident site
GEMT	2/3	Support of the tactical response, strategic support and external affairs
CMT	3	Implementation of Business Continuity Plans

2.2 Pollution Response Structure

Figure 3 demonstrates the response structure in the event of a spill at the 3 tiers.

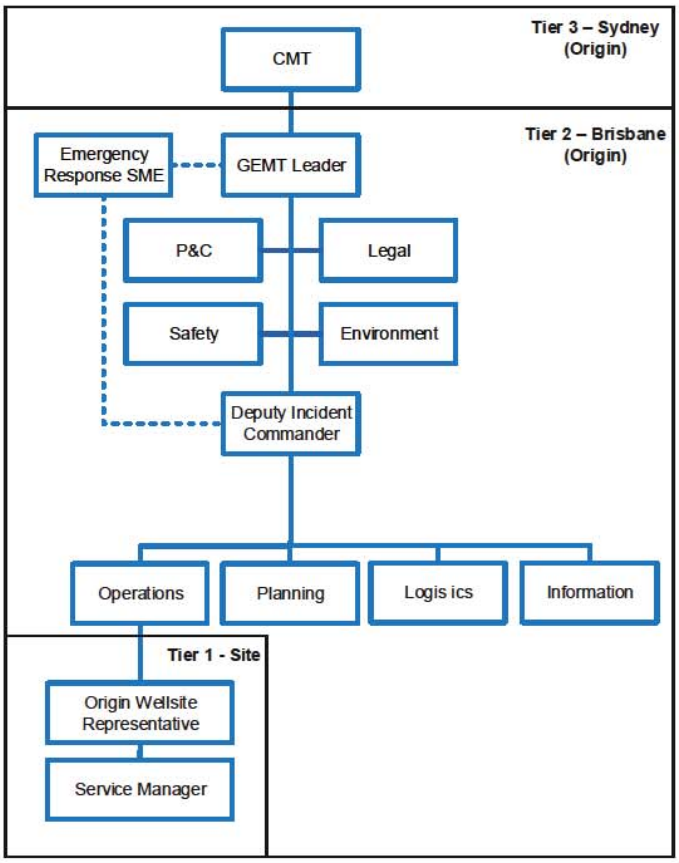


Figure 3: Response Structure

2.3 Response strategies

There are a number of response strategies that can be utilised in response to an oil spill including:

- Monitoring and evaluation;
- Containment and recovery;
- Protection and deflection;

3. Occupational health and safety

The health and safety of all personnel is the highest priority. Hazards associated with oil spills and spill response may include:

1. Flammability;
2. Toxicity - ingestion, inhalation and absorption;
3. Working conditions/environment - slips, trips and falls;
4. Improper manual handling techniques;
5. Fatigue.

The health and safety requirements listed in Table 4 shall be considered during a response to minimise exposure to hazards.

Table 4: Health and safety requirements

Training	Only crew who are trained in a particular role or task will be used for that role or task.
Safety Management Plan:	All actions will be conducted in accordance with the contractor safety management plan.
Material Safety Data Sheet:	MSDS's for all oil types shall be available and familiar to those personnel responding to the spill.
Personal Protective Equipment (PPE):	PPE shall be provided to personnel undertaking any spill response actions. PPE worn shall be appropriate to the clean-up activity being undertaken.
Monitoring:	All health and safety incidents will be reported and corrective actions addressed.
Decontamination:	All personnel partaking in clean-up exercises shall be provided with the appropriate decontamination equipment.
Fatigue Management	Adequate breaks; Healthy food and drink; Non-excessive work hours; Non-prolonged response operation; Non-stressful working environment; Adequate welfare facilities; Comfortable accommodation.
Equipment Handling	Check all equipment before use; Check services are up to date; Enough people to lift equipment or use lifting equipment.
Manual Handling	Enough people to lift; Use lifting equipment when possible; Ensure area is clear; Cover slippery areas to allow safe work; Bend knees and lift with legs not back.

4. Spill equipment and resources

4.1 Personnel

Contractor crew are to be familiar with the contractor ERP and their roles and responsibilities in assisting in a spill response. At no time should crew be asked to perform spill response tasks for which they are not adequately trained or equipped.

4.2 Spill equipment

Oil spill equipment will be supplied by the contractor for small (tier 1) type spills while additional equipment will be acquired as needed. Table 5 summarises the equipment available during a response which may be utilised.

Table 5: Oil spill equipment

Category	Equipment requirements	Intended use
Equipment to be kept at well site	• Shovels • Rakes • Buckets • Brushes • Heavy duty plastic bags • Absorbent pads • Absorbent granules • Skips • 45 gallon drums • Personal Protective Equipment	• All minor incidents
Heavy equipment available at nearby centre	• Bulldozer • Back hoe • Trucks	• Removal of contaminated top soil • Treatment of access road
Call out equipment	• Pumps • Vacuum recovery unit or tanker • Well intervention	• Treatment of contaminated top soil • Removal of oil on site • Stop flow of hydrocarbon for well control incident

5. Waste management

To provide context for the methodology Origin would utilise in the event of a waste management activity the following section is an example.

Table 6 summarises packing, storing and disposal of different types of waste and which may be encountered.

Table 6: Waste category, storage, disposal and treatment options

Waste category	Packing and temporary on-site storage	Disposal and treatment[5]
Oiled Liquids	Oil field tanks (fast tanks) IBC Tank trucks Sealed oil drums Lined skips/pits[1]	Recovery and recycling Bioremediation/land farming[3] Incineration/land filling[2]
Oiled man-made materials	Lined skips Lined earthen pits or berms[1] Industrial waste bags Plastic trash bags Sealed-top drums	Recovery and recycling Incineration/land filling[2]
Oiled naturally-occurring organic materials	Lined skips Lined earthen pits or berms[1] Industrial waste bags Plastic trash bags Sealed-Top drums	Recovery and recycling Bioremediation/land farming[3] Incineration/land filling[2]
Oiled dead wildlife/birds[4]	Industrial waste bags Plastic trash bags	Incineration/land filling[2]

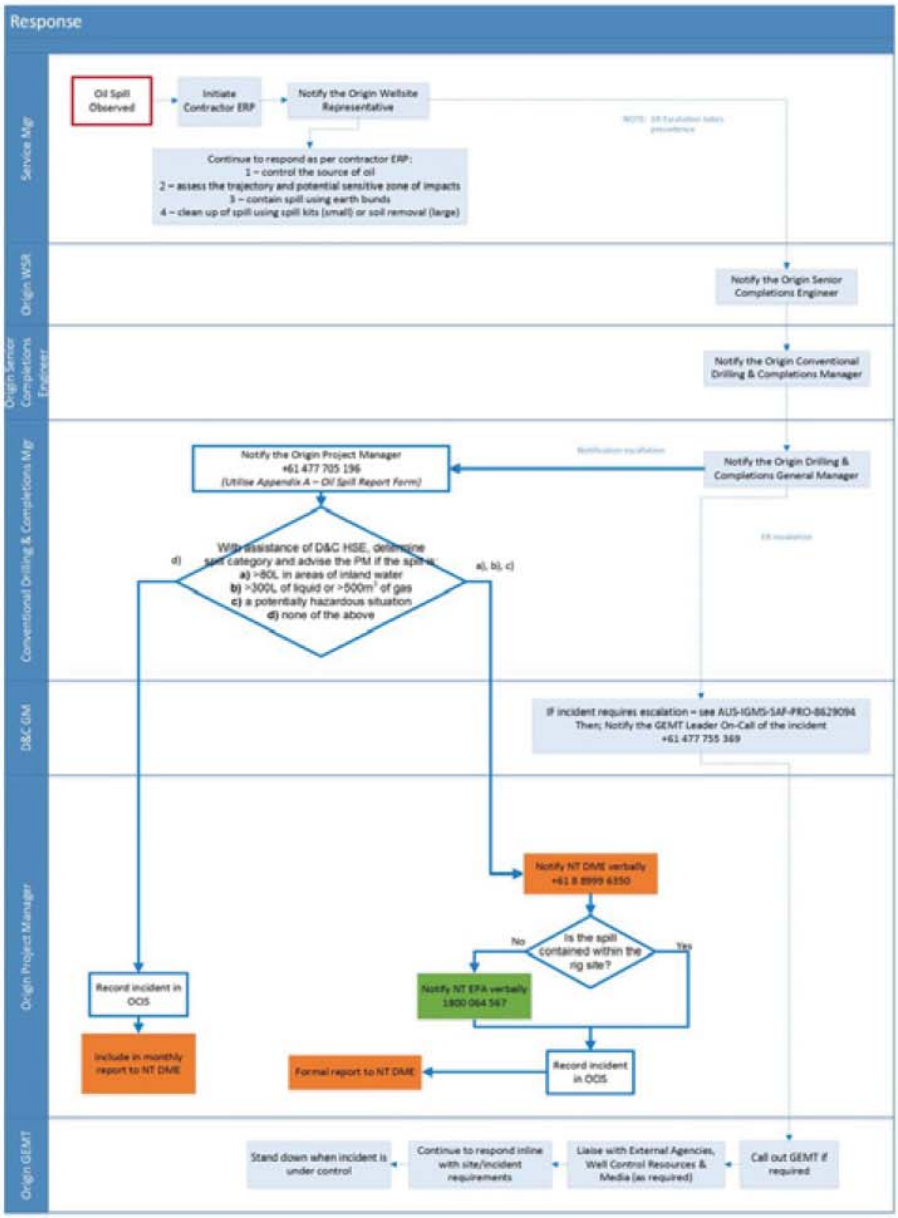
1 Lined pits for the storage of oiled wastes cannot be constructed within a National Park due to the sensitivity of the location. The potential impacts on subterranean fauna and aquifers must be considered at all other locations.
2 Incineration and land filling will only occur at appropriately rated waste disposal facilities
3 Suitable areas to be identified in consultation with local and state authorities.
4 Wildlife and birds are collected by those trained in wildlife recovery. All dead wildlife and birds must be segregated.
5 Sorted by most preferred to least preferred method

The transport of waste material on land can be conducted using liquid transport trucks, flatbed trucks, dump trucks and gully suckers. All waste will be as per legislative requirements through an authorised waste collection such as Veolia or Waste Solutions.

6. Response actions and notifications

6.1 Response flow chart

Response actions and notifications are as per the figure below:



6.2 Net Environmental Benefits Analysis

The Net Environmental Benefit Analysis (NEBA) process is used to compare the likely positive and negative outcomes of various oil spill response options with respect to environmental sensitivities at risk from the spill or response activities. NEBA recognises that certain cleanup options may cause a net negative environmental impact in comparison to the impact of leaving the spill to disperse and weather naturally, or alternative response options. The key objective is to identify the response options that will result in minimal impacts and maximum recovery of the environment, taking into account the specific sensitivities of the resources that have been prioritised for protection.

As part of the due diligence process, Origin may conduct a NEBA and would engage with the contractor regarding the results of that assessment and recommendations for response activities. Additionally, information from the NEBA may be used to help inform requirements for environmental monitoring relating to anticipated impacts from the spill and any response activities. Origin's NEBA assessment would be conducted by an environmental scientist with experience in oil spill planning and response.

The following steps allow for an effective NEBA to be conducted:

Step 1

Identify potential spill impact area based on incident specifics, trajectory modelling and observations. Within the predicted impact area, identify the key characteristics of the habitats. This can be based on field observation, aerial photos and local knowledge.

Step 2

Identify resources (human, ecological, economic etc) at risk at each of the different habitats within the impact area.

Step 3

Assess the potential impact from the spill on each of the resources at risk based on severity of impact and predicted recovery time. This is assuming no response to the spill.

A precautionary approach should be adopted, assuming that the entire site will be covered by oil and that this will persist at the site for at least 24 hours. However, in certain situations the behaviour of the spill may be more accurately predicted and this information can be used when assessing potential impacts. The second assumption that must be agreed is whether the percentage of a species or resource impacted relates to the local (site), regional or even global (in the case of endangered species) population. This does not necessarily need to be consistently applied to all resources at the site. For example, it may be considered that if a resource is very abundant regionally then it is not significant enough at a particular site to warrant a high level of concern, even though it may be seriously impacted at that site.

Step 4

Review the site-specific advantages and disadvantages of the different response options available, using natural recovery as a baseline. The predicted effect, likely impact and recovery time of the various response options on each of the resources must be assessed.

6.3 Response termination

Origin will continually assess the on-going requirement for response as new data is received, through the ongoing revision of the NEBA, until it is determined that the response will not provide any further environmental benefit and the source of the spill is controlled.

Termination of the response will be communicated to all parties by Origin and the Service Supervisor.

7. On-Going response preparedness and exercises

7.1 Review

The OPEP shall be reviewed and updated as necessary in response to one or more of the following:

1. Annually, at least once every 12 months;
2. Following any project changes that may affect the Oil Spill Response coordination or capabilities;
3. Following routine testing of the plan;
4. After any activation of the plan;

7.2 Training

1. All contractor personnel will be trained in the requirements of the contractor ERP and this OPEP in accordance with their roles and responsibilities under the plan;
2. All personnel directly involved in spill response will be trained specifically in the use of response equipment and waste management protocols as per the approved PC HSE Management Plan;

7.3 Exercises

At a minimum this OPEP will be tested:

1. Prior to the commencement of the project.
2. When a significant modification to the plan has occurred.
3. At a minimum frequency of 1 per year.

Exercises shall be undertaken in accordance with the Origin Emergency Response Exercise Planning and Reporting Procedure (OEUP-1000-PRO-SAF-158). This details responsibilities, accountabilities, types of exercises, scenarios and reporting.

8. Record keeping

The following records shall be kept by Origin in relation to spill preparedness and response:

1. The names and roles of personnel with nominated responsibilities and roles under the OPEP;
2. Any inductions or training conducted relevant to this OPEP, including the names of attendees, dates or training and the nature of the training;
3. Any exercises of the OPEP;
4. Any oil spill incidents including: Discharge Volumes, Investigation Report, Inductions and Toolbox Meeting (and attendees), and actions taken;
5. Wastes, including type and volume, generated during any oil spill incident, methods of storage and location and contact details of disposing contractor;
6. Investigation reports of any HSE incidents or near-misses occurring during the implementation of this OPEP;
7. Auditing and monitoring/maintenance of Spill Equipment;
8. Any updates or amendments to the OPEP.

9. Document information and history

DOCUMENT CUSTODIAN GROUP

Title	Name/s
Conventional Drilling & Completions Manager	James Boorman

DOCUMENT AUTHOR

Position	Name
Senior Emergency Response & Security Advisor	Jason Kuzmanovski

STAKEHOLDERS AND OTHER CONTRIBUTORS

Position	Name
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Project Manager	Darryn Schneider
Senior Completions Engineer	Edward Wong
Environmental Specialist	Scott Dale

DOCUMENT HISTORY

Rev	Date	Changes made in document	Reviewer/s	Consolidator	Approver
0		Issued for use.	E Wong J Carr	C Christoffersen	J Boorman

Appendix A Oil Spill Report Forms

SUBMIT TO ORIGIN Senior Completions Engineer FOR COMMUNICATION TO ORIGIN	
Date:	
Spill observer:	
Report time:	
Reported to:	
Location of the spill: **Location description:**	Latitude Longitude
Material spilled:	
Estimate of spill quantity and description of appearance:	
Particulars of damage caused:	
Apparent source/cause of the spill:	
Action taken to control spill:	
Has spill been contained?	(Tick ✓) ❑ Yes ❑ No

Comments		
Location	Reported by	Reported to
Time	Date	Phone No
Are additional resources required to contain spill: ❑ Yes ❑ No		

Appendix B Contact list

External agencies		
Role	**Name**	**Primary**
Local Emergency Services	Police, Fire, Ambulance	000 (or 112 from mobile)
Hospital	Katherine Hospital	+61 (0)8 8973 9211
Police (non-emergency)	Police Link	131 444
Poisons Information Centre	n/a	13 11 26
Bureau of Meteorology	Cyclone Warnings Forecasts & Warnings	1300 659 211 08 8920 3826
NT DME	Dominic Marozzi	08 8999 6350 0439 744 119
NT EPA	n/a	1800 064 567
NT WorkSafe	n/a	1800 019 115 ntworksafe@nt.gov.au

Origin		
Role	**Name**	**Primary**
GEMT Leader On-Call	[redacted]	
Project D&C HSE Advisor		
Conventional Drilling & Completions Manager		
Drilling and Completions General Manager		
External Affairs Manager – QLD or External Affairs Manager - LNG → direct media enquires		
Project Manager		
Senior Completions Engineer		
Well site Representative		
Logistics (@ SLR RIG 185)		

PC @ Well site		
Role	**Name**	**Primary**
SLB Rig Manager (equivalent)	[redacted]	
SLB Camp Manager		
SAV Rig Manager		
SAV Rig (reserved for WSR)		

Neighbouring Properties			
Property Name	**Contact Name**	**Phone**	**Direct Neighbouring Properties**
Amungee Mungee	[redacted]	[redacted]	Nutwood Downs –North Tanunbirini – East Hayfield – West Beetaloo – South
Beetaloo			Amungee Mungee – North Hayfield/Shenandoah – N/W NCW – West NCW – South (Tandi/Uchar)
Sturt Plains Hayfield/Shenandoah			Buchannan – West Kalala – North Amungee Mungee – East Beetaloo – East NCW – South
Hidden Valley			Sunday Creek – North Kalala – East Buchannan – South
Kalala			Sunday Creek – West Maryfield – North Nutwood Downs – East Hayfield/Shenan – South Hidden Valley - West
Newcastle Waters			Hayfield – North Beetaloo – North
Nutwood Downs			Kalala – West Amungee Mungee – South
Tanunbirini			Amungee Mungee - West

APPENDIX 7
RADIATION PROFESSIONALS REPORT

Radiation Professionals report on cuttings obtained from Beetaloo exploration wells

Radiation Professionals

TECHNICAL MEMORANDUM

Date: 3 August 2016 **Reference No.** ORG161109-TM1

To: Origin
Claus Christoffersen

From: Annelize van Rooyen **Email:** annelize@radsafe.com.au

NORM impact on drill cuttings from Origin wells in the Northern Territory Beetaloo-W1, Kalala-S-1, Amungee NW-1 & Amungee NW-1H

This Technical Memorandum summarises the outcomes of a review of three technical notes prepared by Origin with regards to the disposal options of drill cuttings from the Beetaloo, Kalala and Anungee wells in the Northern Territory of Australia.

1 Exemption Criteria

The applicable legislation and regulations that is referred to is summarised below:

Legislation/Regulation	Description
Radiation Protection Regulations, 2012 (NT) Regulation 7	Radioactive material, to which the act does not apply: a) The sum of the fractions obtained by dividing the activity of each material present by the appropriate activity value from the National Directory, Schedule 4, does not exceed 1; or (b) The sum of the fractions obtained by dividing the activity concentration of each material present by the appropriate activity concentration value from the National Directory, Schedule 4, does not exceed 1.
The National Directory for Radiation Protection, Part B, Section 3.2	The criteria to exempt radioactive material or practices from notification, registration and licensing are: (a) the radioactive material has an activity concentration less than that prescribed in Schedule 4 Table 1. Specifically: U-nat: 1 Bq/g Th-nat: 1 Bq/g K-40: 100 Bq/g

2 Summary of activity concentrations

For the determination of the activity concentration of the various elements, the specific activities of Uranium and Thorium (12 445 Bq/g and 4 090 Bq/g respectively) were used.

Substituting the original values with these specific activities, had a very slight effect on the outcome.

Specific Activities relevant to the Regulations			
Radionuclide	**Natural Abundance**	**Specific Activity (original)**	**Specific Activity (adjusted)**
(naturally occurring)	**(%)**	**Bq/g**	**Bq/g**
	Source	**IAEA**	**IEAE**
Potassium 40	0.012	258,900	258,900
Potassium (natural)	100	**30**	**30**
Thorium 232 (natural)	100	**4,066**	**4,090**
Uranium 238	99	12,460	12,445
Uranium (natural)	100	**12,370**	**12,355**

Applying the adjusted SA to the exemption calculations, is shown in the tables below:

Amungee NW-1

Activity Concentrations for Exemptions (original)					**Activity Concentrations for Exemptions (Adjusted)**				
Dividing the activity of each material present by the appropriate activity value from the National Directory (Schedule 4)					*Dividing the activity of each material present by the appropriate activity value from the National Directory (Schedule 4)*				
Activity values (Bq/g) (from ND schedule 4)		Calculated activity concentration			**Activity values (Bq/g) (from ND schedule 4)**		Calculated activity concentration		
		max	p95%	p50%			max	p95%	p50%
Uranium	1	0.286	0.192	0.044	**Uranium**	1	0.285	0.192	0.044
Thorium	1	0.183	0.118	0.071	**Thorium**	1	0.184	0.119	0.071
Potassium	100	0.015	0.012	0.008	**Potassium**	100	0.015	0.012	0.008
	SUM	**0.483**	**0.322**	**0.123**		**SUM**	**0.484**	**0.323**	**0.123**
Exemption threshold		1.0	1.0	1.0	**Exemption threshold**		1	1	1
Classification		Exempt	Exempt	Exempt	**Classification**		Exempt	Exempt	Exempt

Amungee NW-1H

Activity Concentrations for Exemptions (original)					**Activity Concentrations for Exemptions (Adjusted)**				
Dividing the activity of each material present by the appropriate activity value from the National Directory (Schedule 4)					*Dividing the activity of each material present by the appropriate activity value from the National Directory (Schedule 4)*				
Activity values (Bq/g) (from ND schedule 4)		Calculated activity concentration			**Activity values (Bq/g) (from ND schedule 4)**		Calculated activity concentration		
		max	p95%	p50%			max	p95%	p50%
Uranium	1	0.309	0.267	0.168	**Uranium**	1	0.309	0.266	0.168
Thorium	1	0.104	0.090	0.049	**Thorium**	1	0.104	0.091	0.049
Potassium	100	0.011	0.010	0.004	**Potassium**	100	0.011	0.010	0.004
	SUM	**0.424**	**0.367**	**0.221**		**SUM**	**0.424**	**0.367**	**0.222**
Exemption threshold		1.0	1.0	1.0	**Exemption threshold**		1	1	1
Classification		Exempt	Exempt	Exempt	**Classification**		Exempt	Exempt	Exempt

Beetaloo W-1

Activity Concentrations for Exemptions (original)					Activity Concentrations for Exemptions (Adjusted)				
Dividing the activity of each material present by the appropriate activity value from the National Directory (Schedule 4)					*Dividing the activity of each material present by the appropriate activity value from the National Directory (Schedule 4)*				
Activity values (Bq/g) (from ND schedule 4)		Calculated activity concentration			**Activity values (Bq/g) (from ND schedule 4)**		Calculated activity concentration		
		max	p95%	p50%			max	p95%	p50%
Uranium	1	0.229	0.081	0.024	**Uranium**	1	0.229	0.080	0.024
Thorium	1	0.133	0.094	0.055	**Thorium**	1	0.134	0.094	0.055
Potassium	100	0.015	0.012	0.007	**Potassium**	100	0.015	0.012	0.007
	SUM	0.378	0.186	0.086		**SUM**	0.378	0.187	0.086
Exemption threshold		1.0	1.0	1.0	**Exemption threshold**		1	1	1
Classification		Exempt	Exempt	Exempt	**Classification**		Exempt	Exempt	Exempt

Kalala S-1

Activity Concentrations for Exemptions (original)					Activity Concentrations for Exemptions (Adjusted)				
Dividing the activity of each material present by the appropriate activity value from the National Directory (Schedule 4)					*Dividing the activity of each material present by the appropriate activity value from the National Directory (Schedule 4)*				
Activity values (Bq/g) (from ND schedule 4)		Calculated activity concentration			**Activity values (Bq/g) (from ND schedule 4)**		Calculated activity concentration		
		max	p95%	p50%			max	p95%	p50%
Uranium	1	0.338	0.222	0.040	**Uranium**	1	0.337	0.221	0.040
Thorium	1	0.103	0.096	0.071	**Thorium**	1	0.104	0.096	0.071
Potassium	100	0.011	0.010	0.007	**Potassium**	100	0.011	0.010	0.007
	SUM	0.452	0.327	0.118		**SUM**	0.453	0.327	0.119
Exemption threshold		1.0	1.0	1.0	**Exemption threshold**		1	1	1
Classification		Exempt	Exempt	Exempt	**Classification**		Exempt	Exempt	Exempt

3 Conclusion

All drill cuttings from above mentioned wells, are exempt from regulation.

Changes to the activity concentrations of the actual material due to the adjustment of the specific activities were negligible.

APPENDIX 8
WELL FAILURE

Notice of Violation and wells drilled database
(data has been submitted electronically)