



## Hydraulic Stimulation and Well Testing EP Summary

CDN/ID NT-2050-35-PH-0018

# Beetaloo JV

## 2016 HYDRAULIC STIMULATION AND WELL TESTING EP SUMMARY (AMUNGEE NW-1H)

### Review record

Rev	Date	Reason for issue	Reviewer/s	Consolidator	Approver
1.0	17/08/2016	Issued for Use	S Dale	A Greenwood	D Schneider

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## 1. Introduction

Origin Energy Resources Limited (Origin), as operator for Exploration Permits 98, 117 and 76 intends to undertake stimulation and well testing at its Amungee NW-1H well site in calendar year 2016. The 2016 stimulation and well testing program involves:

- Diagnostic fracture injection tests (DFITs)
- Hydraulic fracture stimulation (HFS)
- Well testing.

### 1.1 Contact Details

The nominated liaison person for this program is:

Name: Darryn Schneider

Position: Project Manager

Contact e-mail: [Origin\\_nt\\_beetaloo@originenergy.com.au](mailto:Origin_nt_beetaloo@originenergy.com.au)

### 1.2 Location

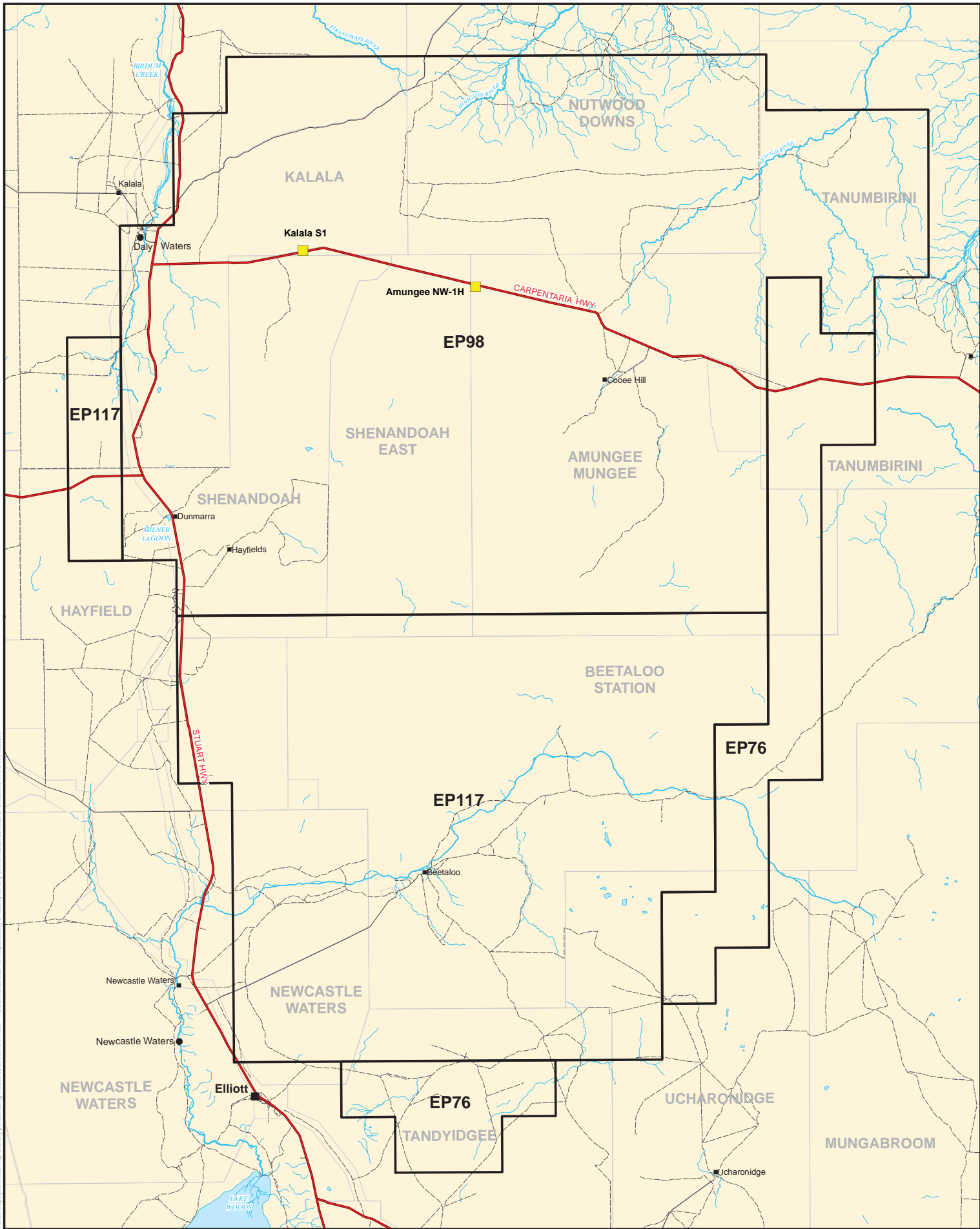
The Beetaloo Basin is located in the central north of the NT, approximately 180km south-east of Katherine. The nearest townships are Daly Waters and Dunmarra.

The exploration permits cover 18,512 square kilometres (km<sup>2</sup>) of pastoral lease on the Sturt Plain, part of the Barkly Tableland, Northern Territory.

Table 1 lists the central co-ordinates of the Amungee NW-1H well site whilst Figure 1 shows the location of the regional location of the well site.

Table 1 Central co-ordinates of well site

Exploration Permit	Well Name	Zone	Easting	Northing
EP98	Amungee NW-1H (wellhead)	53	391676	8190013



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**LEGEND**

- Homestead
- Place Name
- Populated Place
- Existing Wells
- Highway
- Minor Road
- Tracks
- River
- Creek
- Cadastre
- Permit Areas

**LOCATION**

Scale: 0 5 10 20 Kilometers  
GEOCENTRIC DATUM OF AUSTRALIA 94  
1:570,000 (when printed at A3)

**ORIGIN ENERGY RESOURCES LIMITED**  
**2016 DRILLING ENVIRONMENTAL PLAN**

Location

PROJECT ID: 60480548  
CREATED BY: justin.dwyer  
LAST MODIFIED: 26-Feb-2016  
VERSION: 1

Data sources:  
Permit Area, Cadastre - NT Gov 2014  
Places - Aust Gov 2014  
Highways, Roads, Drainage - StreetPro 2014

Location

**Figure 1**

## 2.0 Description of Program

### 2.1 Proposed Stimulation and Testing Activities

The stimulation and testing activities for the 2016 program consist of:

- Conducting a DFIT. The DFIT is a leak off test designed to understand key reservoir and HFS parameters including stresses, pore pressure, and permeability. The DFIT consists of injecting a small volume of fluid (1-5 m<sup>3</sup>) without proppant into the formation. The pressure falloff is then monitored to estimate the reservoir and HFS parameters.
- The fluid used in the DFIT will either be the drilling suspension fluid if the DFIT is executed prior to the first HFS stage or the HFS fluid if the DFIT is executed after the first HFS stage.
- Hydraulic Fracture operations of the nominated well sites including:
  - construction of water storage facilities on existing well leases
  - stimulation of up to 12 stages in Amungee NW-1H horizontal well in the Velkerri Shale formation
  - coiled tubing intervention
  - wireline intervention
  - construction of an on-site office and living accommodation for 24 hour operations and activities.
- Completion operations of nominated well sites including:
  - Service rig intervention to install production tubing
- Well testing operations of nominated well sites including:
  - 30 to 90 day production test at Amungee NW-1H

Upon completion of the stimulation and well test program, the wells will be suspended.

#### 2.1.1 Proposed Stimulation Fluid Additives

HFS fluid mixtures typically comprise 99% water, sand and guar gum (if required) by volume with the remaining 1% made up of salts and fluid additives. Fluid additives used in HFS are commonly found in food and other household domestic products.

All chemicals used in Australia must be approved for use by the Federal Government, Department of Health and listed on the Australian Inventory of Chemical Substances (AICS) which is maintained under the National Industrial Chemicals Notification and Assessment Scheme (NICNAS). No HFS fluids or additives that are used in the process contain BTEX (benzene, toluene, ethylbenzene and xylene).

Origin is currently investigating two fluid systems that may be utilised during the 2016 program. The likely chemical compositions of the two fluid systems (Slickwater and Crosslinked Gel) are outlined in Table 2 and Table 3 respectively. Fluid and proppant volumes will vary dependent on stimulation fluid type. For a slickwater application the preliminary design is for 1000-1500 m<sup>3</sup> of fluid and 75-150 tonnes of sand (proppant) per stage. A crosslinked gelled system would comprise 500-1000 m<sup>3</sup> of fluid and 75-150 tonnes of sand per stage. Prior to commencing HFS activities, Origin will provide the final composition of fluids and additives to the DME, including chemical abstracts service (CAS) number and material safety data sheet (MSDS) information.

Table 2 Slickwater Stimulation Fluid

Contains: Water, Surfactant, Hydrochloric Acid, Friction Reducer, Iron Control Agent, Scale Inhibitor, Clay Control Agent, Bactericide, Propping Agent Sand, Chelating Agent					
CAS #	Chemical Name	Mass Fraction (%)	Mass (Kg)	Volume (L)	Volume Fraction (%)
-	Water	~ 95	~ 14,500,000	~ 14,500,000	~ 97
57-13-6	Urea	< 0.001	< 1,000	< 1,000	< 0.01
64-02-8	Tetrasodium ethylenediaminetetraacetate	< 0.001	< 1,000	< 1,000	< 0.01
67-48-1	2-hydroxy-N,N,N-trimethylethanaminium	< 1	~ 160,000	~ 160,000	< 1
67-63-0	Propan-2-ol	< 0.001	< 1,000	< 1,000	< 0.01
79-06-1	2-Propenamid (impurity)	< 0.0001	< 100	< 100	< 0.001
107-21-1	Ethylene glycol	< 0.1	~ 16,000	~ 16,000	< 1

Contains: Water, Surfactant, Hydrochloric Acid, Friction Reducer, Iron Control Agent, Scale Inhibitor, Clay Control Agent, Bactericide, Propping Agent Sand, Chelating Agent

CAS #	Chemical Name	Mass Fraction (%)	Mass (Kg)	Volume (L)	Volume Fraction (%)
111-46-6	2,2"-oxydiethanol (impurity)	< 0.001	< 1,000	< 1,000	< 0.001
139-33-3	Disodium Ethylene Diamine Tetra Acetate (impurity)	< 0.0001	< 100	< 100	< 0.001
150-38-9	Trisodium Ethylenediaminetetraacetate (impurity)	< 0.0001	< 100	< 100	< 0.001
540-97-6	Dodecamethylcyclohexasiloxane	< 0.00001	< 10	< 10	< 0.00001
541-02-6	Decamethyl cyclopentasiloxane	< 0.00001	< 10	< 10	< 0.00001
556-67-2	Octamethylcyclotetrasiloxane	< 0.00001	< 10	< 10	< 0.00001
1310-73-2	Sodium hydroxide (impurity)	< 0.0001	< 100	< 100	< 0.0001
2682-20-4	2-methyl-2h-isothiazol-3-one	< 0.001	< 1,000	< 1,000	< 0.01
2836-32-0	Sodium Glycolate (impurity)	< 0.0001	< 100	< 100	< 0.001
5064-31-3	Trisodium nitrilotriacetate (impurity)	< 0.00001	< 10	< 10	< 0.0001
6381-77-7	Sodium erythorbate	< 0.0001	< 100	< 100	< 0.001
7447-40-7	Potassium chloride (impurity)	< 0.0001	< 100	< 100	< 0.0001
7631-86-9	Silicon Dioxide	< 0.0001	< 100	< 100	< 0.0001
7647-01-0	Hydrochloric acid	< 0.1	~ 16,000	~ 16,000	< 0.1
7647-14-5	Sodium chloride	< 0.01	< 10,000	< 10,000	< 0.01
7757-82-6	Sodium sulfate	< 0.0001	< 100	< 100	< 0.0001
7758-98-7	Copper(II) sulfate	< 0.00001	< 10	< 10	< 0.00001
7783-20-2	Ammonium sulfate	< 0.01	< 10,000	< 10,000	< 0.1
7786-30-3	Magnesium chloride	< 0.001	< 1,000	< 1,000	< 0.001
10043-52-4	Calcium Chloride	< 0.01	< 10,000	< 10,000	< 0.1
10377-60-3	Magnesium nitrate	< 0.001	< 1,000	< 1,000	< 0.01
14464-46-1	Cristobalite	< 0.0001	< 100	< 100	< 0.0001
14808-60-7	Quartz, Crystalline silica	< 5	~ 670,000	~ 260,000	< 2
26172-55-4	5-chloro-2-methyl-2h-isothiazolol-3-one	< 0.001	< 1,000	< 1,000	< 0.01
31726-34-8	Polyethylene glycol monohexyl ether	< 0.1	~ 16,000	~ 16,000	< 0.1
38193-60-1	Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium salt polymer	< 0.01	< 10,000	< 10,000	< 0.1
61789-77-3	Dicoco dimethyl quaternary ammonium chloride	< 0.001	< 1,000	< 1,000	< 0.01
63148-62-9	Dimethyl siloxanes and silicones	< 0.00001	< 10	< 10	< 0.0001
67762-90-7	Siloxanes and silicones, dimethyl, reaction products with silica	< 0.00001	< 10	< 10	< 0.0001
91053-39-3	Diatomaceous earth, calcined	< 0.01	< 10,000	< 10,000	< 0.1
129898-01-7	2-Propenoic acid, polymer with sodium phosphinate	< 0.1	~ 16,000	~ 16,000	< 0.1
136793-29-8	Polymer of 2-acrylamido-2-ethylpropanesulfonic acid sodium salt and methyl acrylate	< 0.001	< 1,000	< 1,000	< 0.001

Table 3 Crosslinked Gel Stimulation Fluid

Contains: Water, Surfactant, Hydrochloric Acid, Breakers, Gelling Agent, Crosslinker, Iron Control Agent, Scale Inhibitor, Clay Control Agent, Bactericide, Propping Agent Sand, Activator, Chelating Agent					
CAS #	Chemical Name	Mass Fraction (%)	Mass (Kg)	Volume (L)	Volume Fraction (%)
-	Water	~ 85	~ 4,450,000	~ 4,450,000	~ 89
64-02-8	Tetrasodium ethylenediaminetetraacetate	< 0.001	< 100	< 100	< 0.01
67-48-1	2-hydroxy-N,N,N-trimethylethanaminium chloride	< 1	~ 56,000	~ 51,000	< 1
67-63-0	Propan-2-ol	< 0.001	< 100	< 100	< 0.01
107-21-1	Ethylene Glycol	< 0.1	< 10,000	< 10,000	< 1
110-17-8	Fumaric acid	< 0.01	< 1,000	< 1,000	< 0.1
111-46-6	2,2"-oxydiethanol (impurity)	< 0.001	< 100	< 100	< 0.01
139-33-3	Disodium Ethylene Diamine Tetra Acetate (impurity)	< 0.0001	< 10	< 10	< 0.001
150-38-9	Trisodium Ethylenediaminetetraacetate (impurity)	< 0.0001	< 10	< 10	< 0.001
1310-73-2	Sodium hydroxide (impurity)	< 0.1	< 10,000	< 10,000	< 1
1319-33-1	Boronatocalcite	< 0.1	< 10,000	< 10,000	< 1
1330-43-4	Sodium tetraborate	< 0.01	< 1,000	< 1,000	< 0.1
2682-20-4	2-methyl-2h-isothiazol-3-one	< 0.001	< 100	< 100	< 0.01
2836-32-0	Sodium Glycolate (impurity)	< 0.0001	< 10	< 10	< 0.001
5064-31-3	Trisodium nitritotriacetate (impurity)	< 0.0001	< 10	< 10	< 0.001
6381-77-7	Sodium erythorbate	< 0.001	< 100	< 100	< 0.01
7447-40-7	Potassium chloride (impurity)	< 0.0001	< 10	< 10	< 0.001
7631-86-9	Non-crystalline silica (impurity)	< 0.01	< 1,000	< 1,000	< 0.1
7647-01-0	Hydrochloric acid	< 0.1	< 10,000	< 10,000	< 1
7647-14-5	Sodium chloride	< 0.01	< 1,000	< 1,000	< 0.1
7704-73-6	Monosodium fumarate	< 0.01	< 1,000	< 1,000	< 0.1
7727-54-0	Diammonium peroxodisulphate	< 0.1	< 10,000	< 10,000	< 1
7786-30-3	Magnesium chloride	< 0.001	< 100	< 100	< 0.01
7789-38-0	Sodium bromate	< 0.1	< 10,000	< 10,000	< 1
9000-30-0	Guar gum	< 3	~ 170,000	~ 240,000	< 5
10043-35-3	Boric acid	< 0.01	< 1,000	< 1,000	< 0.1
10043-52-4	Calcium Chloride	< 0.01	< 1,000	< 1,000	< 0.1
10377-60-3	Magnesium nitrate	< 0.001	< 100	< 100	< 0.01
14464-46-1	Cristobalite	< 0.0001	< 10	< 10	< 0.001
14807-96-6	Magnesium silicate hydrate (talc)	< 0.0001	< 10	< 10	< 0.001
14808-60-7	Quartz, Crystalline silica	< 12	~ 670,000	~ 260,000	< 5
25038-72-6	Vinylidene chloride/methylacrylate copolymer	< 0.01	< 1,000	< 1,000	< 0.1
26172-55-4	5-chloro-2-methyl-2h-isothiazolol-3-one	< 0.001	< 100	< 100	< 0.01
31726-34-8	Polyethylene glycol monohexyl ether	< 0.1	< 10,000	< 10,000	< 1
61789-77-3	Dicoco dimethyl quaternary ammonium chloride	< 0.001	< 100	< 100	< 0.01
91053-39-3	Diatomaceous earth, calcined	< 0.01	< 1,000	< 10,000	< 1
125005-87-0	Diutan gum	< 0.001	< 100	< 100	< 0.01
129898-01-7	2-Propenoic acid, polymer with sodium phosphinate	< 0.01	< 1,000	< 1,000	< 0.1

### 2.1.2 Water and Flowback Management

All HFS flowback will be stored on location in lined, above ground ponds to allow Origin to assess the quality and chemistry of the flowback fluid to accurately determine the appropriate management of that fluid. Above ground contained storage also prevents access to the fluid by livestock and other ground dwelling fauna.

For this campaign, water will be sourced from aquifers within the Gum Ridge Formation utilising nearby water



bores that were drilled under Origin’s 2015 Exploration Drilling EP with an additional water bore drilled at the Amungee camp site (Easting: 380863, Northing: 8192820, zone 53K).

Each modular above ground storage pond will have both geotextile and polyethylene linings (i.e. multiple barriers) in addition to monitoring to detect any leakage through the primary barrier. The flexiponds provide a storage capacity of 17,300m<sup>3</sup>, which will all be available at Amungee NW-1H where four ponds will be installed. However, as per Table 4 the total storage capacity for flowback fluid post HFS is 12,975m<sup>3</sup>, which assumes a 0.5m freeboard is maintained (this allows for a 72 hour, 1 in 100 year average recurrence intensity rainfall event of 370.8mm, which is calculated from BOM Daly Waters historical rainfall Intensity-Frequency-Duration data). All flowback water will be evaporated or removed from site(s) prior to the wet season.

Table 4. Water and flowback fluid storage summary.

Site	# of Flexiponds	Additional Storage Infrastructure	Total Storage Capacity (potable water)	Total Storage Capacity with 0.5m freeboard (flowback fluid)
Amungee NW-1H	4	1x 21m diameter ring tank	17,300m <sup>3</sup>	12,975m <sup>3</sup>

The initial flowback will predominantly be HFS fluid and sand utilised in the stimulation process. As observed in other shale reservoirs around the world, Origin anticipates 20-60% of injected stimulation fluid volume to be recovered during the flowback process. For the 10-12 stage horizontal application at Amungee NW-1H, this would equate to approximately 2-9 ML of fluid to be stored in the above ground flexiponds (noting that prior to storage, sand/proppant will be filtered out and stored in the mud sumps). During initial flowback, fluid will be directed to the water storage ponds and as the well begins to produce gas, the flow will be diverted through the test equipment to separate and measure water, sand and gas volumes. It is anticipated that the well will produce a dry gas (i.e. methane with limited ethane and other hydrocarbons) which will be flared (burned) as part of the well testing process. Origin will collect fluid samples regularly during the flowback and production test to analyse and report fluid composition. The proposed water storage configuration for Amungee NW-1H provides approximately 10,472m<sup>2</sup> of surface area. For a 10-12 stage horizontal application, based on a 50% HFS fluid recovery and the above surface area, evaporation and rainfall rates in Table 5 and flowback commencing on 1 September 2016, approximately 1ML of fluid will remain as at 30 November 2016.

Table 5 Average rainfall and evaporation at Daly Waters

Month	Mean Monthly Rainfall (mm)			Mean Daily Evaporation (mm)		
	DW	NW	E	DW	NW	E
January	165.4	125.5	133.1	7.1	8.2	7.9
February	165.4	130.9	164.0	6.0	7.0	7.3
March	120.1	93.7	85.9	5.9	6.3	7.3
April	23.6	24.6	23.0	6.2	6.4	7.5
May	5.0	9.3	7.2	5.9	5.1	6.5
June	5.6	5.3	4.6	5.5	4.4	5.6
July	1.5	3.4	2.8	5.6	4.6	5.7
August	1.7	1.0	1.1	6.6	6.2	6.7
September	4.9	5.4	5.9	8.4	8.2	8.4
October	22.5	20.9	22.4	8.8	9.1	9.4
November	59.4	35.7	49.0	8.5	9.2	9.5
December	110.0	77.3	95.7	8.1	9.1	8.7
Annual	680.5	535.4	608.2			
Minimum	1.5	1.0	1.1	5.5	4.4	5.6
Maximum	165.4	130.9	164.0	8.8	9.2	9.5
Average	57.1	44.4	49.56	6.9	7.0	7.5

When the ponds are decommissioned the associated residual solids, brines and liners are removed and

disposed of at an appropriately licensed waste disposal facility. Any remaining flowback fluid will be transported, by road, to a disposal facility within Queensland that is licensed to accept such waste under Queensland legislation. The material will be transported by an NT EPA approved contractor and in accordance with the NT's Waste Management and Pollution Control Act (whilst in the NT), the subsequent transport through Queensland and disposal in Queensland will be completed in accordance with Queensland's Environmental Protection Act. The transportation of wastes fluids across state/territory borders will be done in accordance to the National Environmental Protection Measure (NEPM) guidelines.

### 3.0 Existing Environment

#### 3.1 Land Use

The current land use in the project area is pastoral with varying stocking rates and varying management practices. Within the permit area there are nine pastoral properties with all of these properties Leasehold Land.

#### 3.2 Climate

The climate of the permit areas can be described as arid to semi-arid, with rainfall decreasing in frequency and quantity from north to south. The climate is monsoonal, with a distinctive wet and dry season experienced through the year. The area experiences a wet season during the summer months between October and March, which is dominated by hot and wet conditions. During the winter months, dry season, from May to August, mild days and cool nights are experienced. September and April are transitional months, with occasional rainfall. The average annual rainfall in the north of the permit area is listed at 680 mm at Daly Waters. The southern portion of the permit area records an average annual rainfall of 535 mm at Newcastle Waters and 608 mm listed at Elliott. Approximately 90% of the rainfall occurs during the wet season.

#### 3.3 Topography and Land Systems

The permit area is located within three main topographic zones. These are primarily made up of black soil plains in the south, laterite plains in the north and small sections of bedrock hills in the south west and north east of the permit areas. The elevation of the of the Amungee NW-1H site is approximately 263mAHD.

The Amungee NW-1H site occurs in the Beetaloo Land System which is characterised by:

- gently undulating lateritic plains and rises
- lateritic red earths and lateritic podzolic soils
- *Acacia shirleyi* (Lancewood) forest.

#### 3.4 Natural Environment

Of the 85 bioregions mapped nationally, 20 occur within the Northern Territory and only two within the Beetaloo JV permit area, the Sturt Plateau bioregion and the Mitchell Grass Downs bioregion. A description of the bioregions within the permit area is described below:

- Sturt Plateau Bioregion - comprises undulating plains on sandstone, with predominantly neutral sandy red and yellow earth soils. Dominant vegetation associations included extensive areas of Lancewood (*Acacia shirleyi*) - Bullwaddy (*Macropteranthes kekwickii*) vegetation and associated fauna, including the Spectacled Hare-Wallaby (*Lagorchestes conspicillatus*). Land condition in the bioregion is moderate to good but is threatened by impacts from weeds, feral animals, pastoralism and changed fire regimes.
- Mitchell Grass Downs Bioregion - consists of clear, undulating country with predominantly calcareous grey or brown clays (Black Soil Plains). Vegetation largely comprises of Mitchell Grass (*Astrelba* spp.) with emergent *Acacia* spp. and *Eucalyptus* spp. The bioregion faces a high risk of weed invasion, particularly along drainage lines and in areas where over-grazing has occurred.

The Amungee NW-1H well site is located in the Sturt Plateau Bioregion.

#### 3.5 Soils

The Sturt Plateau bioregion covers an area of 103,857 km and comprises undulating plains on sandstones, with mostly neutral sandy red and yellow earth soils. The soils within the Sturt Plateau have been derived from ancient rock formations and ancestral soils that were formed during earlier weathering cycles. The soils have been deeply weathered, leached and are relatively infertile because they have not been enriched by any recent geological events. The distribution and diversity of soils in the plateau have been influenced by:

- the past wetter conditions of the region that formed relict Tertiary plains which comprise of highly leached and generally lateritic soils
- extensive areas of Post-Tertiary Alluvia on which a variety of mature soils formed
- the dissected hilly country which is dominated by skeletal soils or rocky outcrops

- the range of parent materials of residual soils, ranging from basic volcanic and highly calcareous rocks to granitoid rocks and sandstones.

Soil erosion susceptibility varies throughout the permit area, dependent upon the soil types, slope and extent of ground disturbance. Apart from the erosive impact of climatic conditions, soil erosion is influenced mainly by the inherent properties of the soils and the processes which occurred during the formation of landscapes. The Amungee NW-1H site is considered to have a none/slight.

### 3.6 Surface Water and Drainage

The permit area is located within three main river basins. These include the Barkly, Roper and Wiso Basins. Inland drainage occurs in the Barkly Basin and parts of the Wiso Basin. The proposed exploration activities are located within the Wiso Basin. The Wiso Basin is drained by the Georgina River and its major tributaries.

### 3.7 Groundwater

The Beetaloo Basin comprises a thick sequence of flat-lying mudstone and sandstone formations (Roper Group) that were deposited between 1,500 and 1,430 million years ago (Ma). 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 Beds, 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.

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 suggest 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.

### 3.8 Flora / Fauna

The main vegetation communities within the exploration permit areas are woodlands, typically dominated by bloodwoods (*Corymbia spp.*) and tall shrublands and woodlands of Bullwaddy and Lancewood with open grassland understorey. Other less common vegetation communities within the area include Acacia shrubland over spinifex and Bullwaddy-dominated woodland. The Amungee Nw-1H site consists of Eucalypt woodland.

No Commonwealth threatened plant species were identified as occurring by the Department of the Environment's Protected Matters Search.

The region supports a diverse array of fauna. Searches of the Department of the Environment's Protected Matters Search, NT Fauna database and Atlas of Living Australia indicated the potential presence of 35 threatened species. These included 19 birds, 10 mammals, five reptiles and one fish listed.

### 3.9 Cultural Heritage

Sacred sites in the study area are primarily associated with drainage lines; natural landform features and stock routes, but there are also concentrations of sites nearby to old homesteads. The distribution of these sites may reflect historical patterns of Indigenous movements along drainage lines and subsequent development of stock routes on old Indigenous walking trails, or they may merely be indicative of the site clearance work undertaken along roads and tracks in the area. It is suspected that there will be a range of other sites also within the area, either not yet recorded, or known but not reported for cultural reasons.

APPA clearance certificate - AAPA 2014/1022 (C2014/184) – has been obtained for the Amungee NW-1H site.

#### 4.0 Stakeholder Consultation

Origin's local and directly impacted/affected stakeholders have been, and continue to be, consulted in a respectful, open and consistent manner. This has been the case since 2014, when Origin assumed operatorship of EP98, EP117 and EP76.

It is accurate, fair and reasonable to both acknowledge and accept that localised social license has been achieved given that the informed consent of Traditional Owners and pastoralists has been given where activity has occurred or is proposed. Land Access Agreements have been entered into with all pastoralists where Origin has undertaken activity, and no future activity will be considered without agreement with the relevant pastoralist.

Traditional Owners have also provided supplementary endorsement of the 2016 activities post the completion of a number of cultural heritage clearance surveys. A number of restricted work areas have been identified and Origin has employed the acceptable practice of ensuring buffer zones are in place around known and identified areas of importance and significance.

With specific regard to the pastoralist whose property Origin will conduct the 2016 HFS on, in-principle consent is conditional on confirmation from their independent consulting hydrogeologists of the methodology and results of an extensive baseline water monitoring program. Origin worked closely with the landholder to ensure that a robust data set was in place, prior to seeking the pastoralist's consent. Baseline data is of importance and relevance to both pastoralists and Origin. For the pastoralists - it provides them with the ability to assess impacts given a data set will exist for before, during and after the HFS activity. For Origin, it is equally important to be able to demonstrate to the landholder, Traditional Owners and regulators that our extraction processes are robust and measurable and environmentally sound.

Other primary stakeholders that have been consulted include:

- Neighbouring traditional owners and indigenous custodians
- Neighbouring pastoralists and landholders/leaseholders
- Local businesses in and around the permit areas
- Northern Territory Government
- Local Government and Shire Councils
- NT Cattlemen's Association and other primary producer groups
- NGOs and Environmental groups
- Industry Associations and Agencies
- Community members and businesses in the townships of Katherine and Tennant Creek

Origin has committed resources and time to allow competent and experienced personnel to participate in educational and community information sessions from Darwin in the North, to Alice Springs in the South and across to Borroloola in the East.

Additional stakeholder groups and events include, though are not limited to:

- Regional Economic Development Committee(s)
- Rotary Club(s)
- Chamber of Commerce and Industry (Darwin and regional offices)
- Darwin and Regional Shows
- Department of Tourism
- Department of Transport
- Regional Shire and Town Council Mayors and Alderman
- Darwin, Fred's Pass and regional shows
- Media (regional and Darwin)
- Attendance at APPEA events
- Environmental interest groups including Arids Land Council, Don't Frack Katherine, Don't Frack the Territory, Environmental Defenders Office, the Environment Centre
- Charles Darwin University
- International Association of Hydrogeologists
- NT Members of Parliament and nominated candidates for the August 2016 election
- Community members

### 5.0 Environmental Risks, Potential Impacts and Management Measures

The assessment of environmental risks and development of management measures aims to avoid and or minimise environmental impacts during the stimulation and well testing program. The Australian Petroleum Production and Exploration Association Limited (APPEA) *Code of Environmental Practice* (APPEA, 2008) and a range of State/Territory Government Exploration Guidelines have been used to develop the management strategies for each of the identified potential impacts.

Environmental risks associated with the 2016 program of works have been identified through a thorough hazard identification and risk assessment process. The identified risks have been assessed using the Origin corporate risk assessment criteria set out in the Origin risk management directive (ORG-RMS-DIR-001) using the Origin Risk Tool (ORG-RSK-TOOL-001). The purpose of the analysis was to identify risks and develop risk-reducing measures for preventing and mitigating impacts from the planned activities.

The assessed environmental risks are recorded in the detailed risk register. The detailed risk assessment presents the range of potentially impact-causing activities, corresponding mitigation measures and pre- and post-mitigation risks based on their assessed worst-case consequence and likelihood of occurrence.

Table 6 provides a count of the environmental risks associated with the 2016 stimulation and well testing program.

**Table 6** Count of Mitigated Environmental Risks from the Stimulation and Well Test Program

	Risk Level				
	Low	Medium	High	Severe	Extreme
Count	24	3	-	-	-

Table 7 outlines the potential impacts of the stimulation and well test program and the management measures to be implemented to minimise these impacts.

**Table 7** Potential Impacts and Management Measures for the Stimulation and Well Test Program

Aspect	Potential Impacts	Management Measures
Soil and erosion	Soil disturbance and degradation of soil profile resulting in: <ul style="list-style-type: none"> <li>- Soil instability or movement</li> <li>- Soil erosion</li> <li>- Soil compaction</li> <li>- Loss of topsoil and land suitability/capability</li> <li>- Soil contamination</li> <li>- Dust impacts on built-up areas, vegetation and amenity</li> </ul>	<ul style="list-style-type: none"> <li>- Ensure site environmental inductions for all site personnel and contractors include the requirement to use only approved access tracks created under Origin’s 2015 and 2016 Exploration Drilling EPs.</li> <li>- Monitor and maintain sediment fences around lease pad, in accordance with ESCP installed under Origin’s 2015 and 2016 Exploration Drilling EPs.</li> <li>- Monitor lease pad and road conditions and implement management measures where required.</li> <li>- Use only approved access tracks and established designated parking and vehicle movement areas.</li> <li>- Ensure site environmental inductions for all site personnel and contractors include the requirement to use only approved access tracks created under Origin’s 2015 and 2016 Exploration Drilling EPs.</li> <li>- Monitor and maintain sediment fences around camp, in accordance with ESCP installed under Origin’s 2015 and 2016 Exploration Drilling EPs.</li> </ul>
Surface water	<ul style="list-style-type: none"> <li>- Contamination or pollution of surface waters through hydrocarbon or chemical spill or leak</li> <li>- Contamination or pollution of surface waters through waste or waste water impact</li> <li>- Impacts associated with soil erosion such as increased water turbidity</li> <li>- Pollution of potable and stock water supply.</li> </ul>	<ul style="list-style-type: none"> <li>- Monitoring local weather and climate information to make informed decision regarding site operations.</li> <li>- Ensure site environmental inductions for all site personnel and contractors includes protective measures to prevent avoidable discharge into, or contamination of, waterways or established drainage systems.</li> <li>- Ensure appropriate storage of fuel and other flammable and combustible liquids in accordance with AS1940:2004 The storage and handling of flammable and combustible liquids.</li> <li>- Maintain stormwater containment system as required.</li> <li>- Have a procedure in place to manage large quantities of</li> </ul>

Aspect	Potential Impacts	Management Measures
		<p>water. This may include pumping to an existing dam or watering point.</p> <ul style="list-style-type: none"> <li>- Regular inspection and integrity checks of flowback tanks. Test tank integrity during commissioning and prior to use.</li> <li>- All access roads, culverts and creek crossings will be maintained in proper working order.</li> <li>- Ensure adequate freeboard is maintained in and ponds. A minimum of 0.5 metre freeboard is to be maintained to allow for a 72 hour, 1 in 100 year average recurrence intensity rainfall event (370.8mm – based on BOM Daly Waters historical rainfall Intensity-Frequency-Duration data)</li> <li>- Ensure all pipes and hoses are in good condition and fit for purpose to minimise risk of leaks from pipe.</li> <li>- Ensure site environmental inductions for all site personnel and contractors includes the issue of water pollution and protective measures to prevent avoidable discharge into, or contamination of, waterways or established drainage systems.</li> <li>- Ensure appropriate storage of fuel and other flammable and combustible liquids in accordance with AS1940:2004 The storage and handling of flammable and combustible liquids. Establish appropriate wastewater containment system as required.</li> <li>- Maintenance of all water using utilities, such as toilets, showers to ensure in working order.</li> <li>- Visual inspections of the sites stormwater and waste water containment systems should be undertaken weekly.</li> <li>- Refuel and transfer chemicals away from drainage lines.</li> </ul>
Groundwater	<ul style="list-style-type: none"> <li>- Exploration drilling enables cross formational flow between shallow aquifers in contravention of Water Act regulations.</li> <li>- Cross formational flow of formation water/hydrocarbons from deeper formations to a utilised aquifer causes groundwater contamination and impacts existing groundwater users.</li> <li>- Spill of fuel/additives/produced water causes groundwater contamination.</li> <li>- Leakage from mud/flare pits causes groundwater contamination.</li> <li>- Groundwater extraction causes declining water levels in utilised aquifers which impacts on existing groundwater users/environmental values.</li> <li>- Loss of drilling fluids into an aquifer impairs capacity in existing bores.</li> <li>- Cross flow of water from a utilised aquifer to another formation causes declining water levels.</li> </ul>	<ul style="list-style-type: none"> <li>- Ensure site environmental inductions for all site personnel and contractors include protective measures to prevent avoidable discharge into, or contamination of, groundwater.</li> <li>- Ensure appropriate storage of diesel fuel and other combustible and flammable liquids in accordance with AS1940:2004 The storage and handling of flammable and combustible liquids.</li> <li>- Ensure site is equipped with spill clean-up equipment.</li> <li>- Have a procedure in place to manage large quantities of water. This may include pumping to an existing dam or watering point.</li> <li>- Regular inspection and integrity checks of flowback tanks. Test tank integrity during commissioning and prior to use.</li> <li>- Ensure well control critical equipment and systems on stimulation equipment are fit for purpose, certified, maintained in good working order and tested as required.</li> <li>- Ensure appropriate well control training/certification for rig personnel.</li> <li>- Pressure test verifying integrity of the string.</li> <li>- Ensure sufficient distance between HFS target and aquifers commensurate with HFS design. Presence of natural frac barriers and high perm zones to contain fracture height growth.</li> <li>- Continuous real-time pressure, rate and volume monitoring during HFS to stop pumping as soon as potential loss of containment identified.</li> <li>- Ensure site environmental inductions for all site personnel and contractors includes the issue of groundwater pollution and protective measures to prevent avoidable</li> </ul>



Aspect	Potential Impacts	Management Measures
	<ul style="list-style-type: none"> <li>- The loss of a radioactive source during geophysical logging results in groundwater contamination.</li> <li>- Hydraulic fracturing induces seismicity increasing connection between formations and enhancing the potential for cross formational flow.</li> </ul>	<ul style="list-style-type: none"> <li>- discharge into, or contamination of, groundwater.</li> <li>- Maintain all waste water systems in working order to minimise impact on groundwater</li> <li>- Ensure appropriate storage of fuel and other flammable and combustible liquids in accordance with AS1940:2004 The storage and handling of flammable and combustible liquids.</li> </ul>
Noise and vibration	<ul style="list-style-type: none"> <li>- occupational health and safety issues such as physical damage to humans through short-term exposure to loud noise and/or long term exposure to noise sources through use of mechanical equipment</li> <li>- nuisance noise impacts on surrounding communities or exploration workers through use of mechanical equipment</li> <li>- disrupting or altering fauna feeding, breeding or other activities through noise, vibration and lighting from use of mechanical equipment</li> <li>- interference with pastoral activities if noise, vibration and lighting affects behaviour of stock.</li> </ul>	<ul style="list-style-type: none"> <li>- Ensure site environmental inductions for all site personnel and contractors include the issue of noise, vibration and light and protective measures to prevent disturbance.</li> <li>- Existing noise attenuation devices fitted to drill rig and other machinery used on site will be maintained in good working order.</li> <li>- Lighting used on drill site to minimise offsite disturbance, while maintaining safety standards.</li> <li>- Existing noise attenuating devices fitted to camp equipment, such as generators used on site will be maintained in good working order.</li> <li>- Lighting used on camp site to minimise offsite disturbance, while maintaining safety standards.</li> </ul>
Waste management	<ul style="list-style-type: none"> <li>- Contamination of soil or water through generation of or use of hazardous materials, domestic and industrial wastes and wastewater.</li> <li>- Encouragement of pest species to sites.</li> </ul>	<ul style="list-style-type: none"> <li>- Ensure site environmental inductions for all site personnel and contractors include the safe storage and segregation of wastes; and disposal of wastes in appropriate containers.</li> <li>- Segregate and safely store and label chemical packaging, lube oils, batteries, tyres, maintenance and other industrial wastes for proper disposal to recycling and approved landfill facilities.</li> <li>- Carry Material Safety Data Sheets and handling procedures for hazardous chemicals stored on site.</li> <li>- Ensure site is equipped with spill clean-up equipment.</li> <li>- Have a procedure in place to manage large quantities of water. This will include storage, evaporation and/or transportation to an approved disposal site. If waste fluids are transported between states and territories it will be undertaken as per the NEPM guidelines.</li> <li>- Regular inspection and integrity checks of flowback tanks. Test tank integrity during commissioning and prior to use.</li> <li>- All waste material introduced to site will be removed from the lease area and disposed of</li> <li>- All sample bags, waste materials and contaminants must be removed from site and disposed of in an appropriate manner, following the completion of the program.</li> <li>- Solid returns from completion operations should be diverted to the existing sump on site.</li> <li>- Undertake inspection of waste storage areas regularly, or after significant rainfall event (greater than 20 mm in 24 hour period).</li> </ul>



Aspect	Potential Impacts	Management Measures
		<ul style="list-style-type: none"> <li>- Grey water from kitchen and showering facilities will be managed in accordance with Part 6 of the DoH Code of Practice for Small On-site Sewage and Sullage Treatment Systems and the Disposal or Reuse of Sewage Effluent, 2014.</li> <li>- Toilet facilities should consist of pit or chemical systems, as described in Part 4 of the DoH Code of Practice for Small On-site Sewage and Sullage Treatment Systems and the Disposal or Reuse of Sewage Effluent, 2014. For chemical systems, the contents should be disposed of off-site. If pit toilets are necessary, the pit should be covered with at least a metre of fill.</li> <li>- Domestic refuse to be disposed of in accordance with NT waste guidelines. No incineration of wastes on site.</li> <li>- Mini-camps at well sites will accommodate 8 people and have their own sewage treatment. Treated water will be dispersed via drainage away from the mini-camp to the edge of the lease, but inside the lease area in accordance with the Code of Practice for Small On-site Sewage and Sullage Treatment Systems and the Disposal or Reuse of Sewage Effluent, issued by the NT Department of Health.</li> </ul>
Air quality	<ul style="list-style-type: none"> <li>- Increase in dust during from vehicular traffic resulting in decreased functioning of the surrounding vegetation</li> <li>- Increase in exhaust emissions from contractors' vehicles and generators.</li> <li>- Potential for increase in air emissions as a result of exploration activities.</li> </ul>	<ul style="list-style-type: none"> <li>- Ensure site environmental inductions for all site personnel and contractors include protective measures to control or report air emissions and fire prevention, including smoking and hot work in designated areas.</li> <li>- All vehicles and equipment used on site will be well maintained with mufflers fitted, in accordance with NT Work Safe requirements and/or Motor Vehicle Registration requirements.</li> <li>- All access roads, culverts and creek crossings will be maintained in proper working order.</li> <li>- Use water truck where applicable to manage dust emissions from vehicle movement or drilling operations on the site.</li> <li>- Keep flaring to a minimum length of time necessary to determine resource and production parameters.</li> <li>- Monitor gas volumes and report to the DME.</li> <li>- Pressure test all surface equipment during commissioning to minimise the potential of fugitive emissions at surface.</li> <li>- Potential fugitive emissions, as a result of migration along the well bore, are mitigated by constructing the well to Origin standards and industry best practices. These require the presence of cemented casing strings, assessment of the cement quality with logging tools and monitoring the well during flowback.</li> <li>- Minimise vehicle movement to that necessary in the camp area.</li> <li>- Use water truck where applicable to manage dust emissions from vehicle movement.</li> </ul>
Vegetation and Flora	<ul style="list-style-type: none"> <li>- Spread of introduced plants and plant diseases</li> <li>- Increased incident and intensity of fire</li> <li>- Dust generation</li> </ul>	<ul style="list-style-type: none"> <li>- Ensure site environmental inductions for all site personnel and contractors include the management of onsite vegetation and flora, including personnel to only use access tracks and vehicle weed hygiene requirements.</li> <li>- Stay within designated access roads and work areas.</li> </ul>
Fauna Habitat	<ul style="list-style-type: none"> <li>- Spread of introduced plants and plant diseases which competes with native fauna food source</li> <li>- Increased pest fauna</li> <li>- Increased incident and intensity of fire</li> </ul>	<ul style="list-style-type: none"> <li>- Site inductions are to ensure that all personnel are aware their obligations and the correct procedures for fauna encounters.</li> <li>- Minimise vehicle movements during dawn and dusk.</li> <li>- Restrict vehicle movement to existing or specifically designated access roads and impose suitable speed limits.</li> <li>- Lease pad to be stock fenced.</li> </ul>

Aspect	Potential Impacts	Management Measures
	<ul style="list-style-type: none"> <li>- Dust generation</li> <li>- Light, noise and vibration disturbance.</li> </ul>	<ul style="list-style-type: none"> <li>- Ensure waste is managed correctly so as not to attract fauna.</li> <li>- Site inductions are to ensure that all personnel are aware their obligations and the correct procedures for fauna encounters.</li> <li>- Employees will be prohibited from bringing firearms, traps and domestic animals into lease area.</li> <li>- Avoid interactions with fauna where practicable.</li> <li>- Ensure waste is managed correctly so as not to attract fauna.</li> <li>- The workforce will be prohibited from bringing domestic animals into the lease area (recognising that pastoralists don't need to comply with this instruction).</li> <li>- Restrict vehicle movement to existing or specifically designated access roads and impose suitable speed limits.</li> <li>- Although there is no specific volunteer organisation contact in the Barkly Region, Wildcare NT may be able to assist in getting the sick, injured or orphaned animals to the right Wildlife Carer's. Contact Wildcare NT with one of the following numbers:               <ul style="list-style-type: none"> <li>▪ Darwin: 89 886 121 or 0408 885 341</li> <li>▪ Alice Springs: 0419 221 128</li> <li>▪ Katherine: 0412 955 336</li> </ul> </li> </ul>
Weeds	<ul style="list-style-type: none"> <li>- Degradation of the existing environment as a result of altering existing landscapes and enhancing opportunities for weeds species to become established and/or spread</li> <li>- Nuisance effects of some weed species on livestock or native fauna</li> <li>- Nuisance effects of some weed species on humans.</li> </ul>	<ul style="list-style-type: none"> <li>- Site inductions are to ensure that all personnel are aware of vehicle weed hygiene requirements and staying on designated access tracks.</li> <li>- Ensure vehicles, machinery and equipment entering the permit areas have been cleaned and are free of vegetative matter, or have a valid weed hygiene certificate in accordance with Origin's <i>Vehicle and Mobile Plant Weed Hygiene Procedure</i> (OEUP-1000-PRO-ENV-025).</li> <li>- All vehicle, equipment and rig movements to stay on formed access tracks, well leases and camp areas.</li> </ul>
Feral animals and other pest species	<ul style="list-style-type: none"> <li>- Introduction of feral animals and pest species may compromise existing habitats, vegetation or native fauna through predatory behaviour or competition.</li> <li>- Introduction of feral and pest species may impact upon livestock.</li> <li>- Introduction of diseases associated with feral and pest species may impact upon existing habitats, vegetation, native fauna and livestock.</li> <li>- Damage of vegetation or natural habitat through feral animal activity.</li> <li>- Feral animal nuisance around campsites and domestic waste material.</li> <li>- Damage to equipment or creation of safety risks through burrowing.</li> </ul>	<ul style="list-style-type: none"> <li>- No rubbish (<i>i.e.</i> food packaging) to be left on sites.</li> <li>- Domestic refuse will be disposed of in accordance with NT waste guidelines.</li> <li>- Ensure waste is managed correctly so as not to attract fauna.</li> <li>- Wastes will be stored in dedicated waste storage areas.</li> </ul>
Bush Fires	<ul style="list-style-type: none"> <li>- Reduction in fauna and habitat.</li> <li>- Increased erosion and impacts upon soil and surface water as a result of vegetation loss.</li> <li>- Damage to or loss of culturally</li> </ul>	<ul style="list-style-type: none"> <li>- Site inductions are to ensure that all personnel are aware of designated smoking areas and hot work permit requirements.</li> <li>- Fire or unprotected flame must be kept at least 45 m from unprotected sources of flammable vapour.</li> </ul>

Aspect	Potential Impacts	Management Measures
	<ul style="list-style-type: none"> <li>- significant sites.</li> <li>- Damage to or loss of public infrastructure, private infrastructure and equipment or community lands.</li> <li>- Possible safety risk to humans (i.e. personnel on site).</li> <li>- Creation of greenhouse gases.</li> </ul>	<ul style="list-style-type: none"> <li>- Ensure appropriate storage of fuel and other flammable and combustible liquids in accordance with AS1940:2004 The storage and handling of flammable and combustible liquids.</li> <li>- Smoking only allowed in designated areas.</li> <li>- Any hotwork activity requires a work permit before proceeding.</li> <li>- Whenever hotwork activities are undertaken, the area surrounding the work site should be cleared combustible materials and appropriate firefighting equipment kept on hand during such operations.</li> <li>- Hazardous area diagram for drilling rig is to be developed and implemented.</li> <li>- Diesel engines must not be used within 15 metres of a well or other source of flammable vapour unless fitted out appropriately.</li> <li>- Where safe to do so attempt to put out natural fires in the vicinity of operational areas.</li> <li>- Fit all fixed engines operating at drilling site with adequate spark arrestor and emergency shut-down devices.</li> <li>- A flare pit shall be sited and constructed so as not to create a hazard to property of natural vegetation.</li> <li>- Firefighting equipment should be signposted, accessible and ready for operations.</li> <li>- Any rubbish, debris or oil refuse that could constitute a fire hazard shall be removed to a safe distance away from all buildings and installations, wells and production facilities.</li> <li>- Fire breaks to be maintained around the camp (minimum of 4 m wide).</li> </ul>
Cultural Heritage	<ul style="list-style-type: none"> <li>- Misunderstandings arising as a result of non-Indigenous workers being unfamiliar with the Aboriginal traditions, life-style, customs and cultural values.</li> <li>- Damage to or loss of culturally significant artefacts, areas or species.</li> <li>- Disruption of activities of Indigenous stakeholders in culturally significant areas.</li> <li>- Cultural and environmental awareness issues may lead to a lack of protection of sacred sites or culturally significant places and artefacts.</li> <li>- Lack of cultural and environmental awareness may lead to intrusion on Aboriginal land of special significance to the local people.</li> </ul>	<ul style="list-style-type: none"> <li>- Site inductions are to ensure that all personnel are aware of cultural awareness obligations, such as:</li> <li>- Regulations applying to the area, including specific conditions on the exploration permits and agreements with the NLC.</li> <li>- Awareness of the conditions outlined in the Aboriginal Areas Protection Authority (AAPA) Authority Certificate.</li> <li>- Ensure all site personnel and contractors are aware of any potential Restricted Work Areas (RWAs) and conditions outlined in the AAPA Certificates.</li> <li>- Brief personnel on the rules and regulations and disciplinary measures for breaches of the RWAs.</li> <li>- Considerations and special procedures to be used for protection of archaeological and cultural sites in the define work areas.</li> <li>- Work practices that avoid or minimise impacts – particularly for operators of machinery such as graders and dozers</li> <li>- Landowner or manager sensitivities, including Aboriginal communities and their specific cultural requirements</li> <li>- Ensure that site personnel and contractors report all new discoveries of archaeological or cultural artefacts, as per <i>Origin's Unexpected Aboriginal Cultural Heritage Find Procedure</i> (OEUP-Q1000-PRO-BUS-001). Cease work and effect practical protection measures until the area can be assessed by DLRM personnel.</li> </ul>
Land Access	<ul style="list-style-type: none"> <li>- Inadequate consultation regarding access to the site may lead to misunderstandings and have an impact on the drilling program.</li> <li>- Access to properties affects land use and use of resources by other stakeholders (e.g. farmers, community and Indigenous groups).</li> </ul>	<ul style="list-style-type: none"> <li>- A TMP to be prepared to provide mitigations to minimise the risk related to the general public, site visitors, and site based workers, whilst providing a method to minimise traffic flow disruption during operation works.</li> <li>- Register should be kept of all incidences relating to access issues, unauthorised access and requirements of pastoralists, recognising that these requirements may change seasonally.</li> </ul>

Aspect	Potential Impacts	Management Measures
	<ul style="list-style-type: none"> <li>- Access may contribute to disturbance of natural resources and vegetation.</li> <li>- Access routes may require import of external materials for construction.</li> <li>- Access routes may increase public access to infrastructure or unauthorised use of land.</li> </ul>	
Visual amenity	<ul style="list-style-type: none"> <li>- Creation of scars on the landscape.</li> <li>- Encouragement of unauthorised access along tracks and roads, because they are visible.</li> </ul>	<ul style="list-style-type: none"> <li>- Locate in area that minimises visual impact as far as practicable</li> <li>- The degree of light spread and potential impacts on landowners should be considered</li> <li>- Minimise visual impact, by deviations around topographical features or stands of vegetation, doglegs at road crossings, where feasible.</li> <li>- Position major infrastructure so that it is offset back from roads and highways.</li> </ul>
Communication	<ul style="list-style-type: none"> <li>- Impedance to the stimulation and testing program through inappropriate consultation and communication.</li> <li>- Loss of good relations with leaseholders and other stakeholders.</li> </ul>	<ul style="list-style-type: none"> <li>- Consult with land users and public interest groups, such as landholders, Aboriginal communities, natural resource managers, conservation groups, tourism operators and other affected parties, early in the planning phase to exchange information and facilitate good working relationships.</li> <li>- Provide a Work Program for each year's proposed activities to the NLC and other regulatory bodies, which includes site-specific environmental and cultural issues, likely impacts and their mitigation.</li> <li>- Prior to commencement onsite, communicate with leaseholders for access permission. Provide detail of the time and dates proposed to be on site, and the location, at least one month in advance of works commencing.</li> </ul>

In addition to the management measures outlined in the table above, other measures to manage potential impacts on the environment include:

- Developing an environmental monitoring program
- Conducting audits and Environmental Plan reviews
- Identifying relevant training and ensure all employees and contractors complete a site specific induction
- Reporting (routine and non-routine) provisions included in the Environmental Plan.

## 6.0 Rehabilitation Strategy

The stimulation and testing program will be conducted on land that was disturbed in accordance with Origin's 2015 Exploration Drilling EP. At the conclusion of the stimulation and testing program rehabilitation of the land will be conducted in accordance with the requirements of that EP. The following is a summary of the rehabilitation strategy outlined in that EP.

The proposed rehabilitation strategy for this program is based on assisted natural regeneration. This approach allows natural regeneration in disturbed areas, combined with monitoring to determine the success of this approach, and then, if necessary, use of locally collected native seed and soil preparation, to enhance germination success. However, regeneration is also dependent on rainfall and so recovery may take several years. The monitoring program proposed for the rehabilitation activities will take into consideration factors that affect rate of recovery, such as rainfall.

Areas of greater disturbance consisting of drill pads and sumps will require more intensive rehabilitation requiring:

- Stockpiling of topsoil and vegetation during clearing.
- Reshaping the site to as close to natural form as possible and filling in sumps at the completion of the program.
- Ripping or scarifying the surface and covering with the stored topsoil and vegetative material.
- Spreading seed of suitable local native species.

If these steps are undertaken prior to the next wet season the area should be non-erosive and will rehabilitate when the rains come in the wet season.