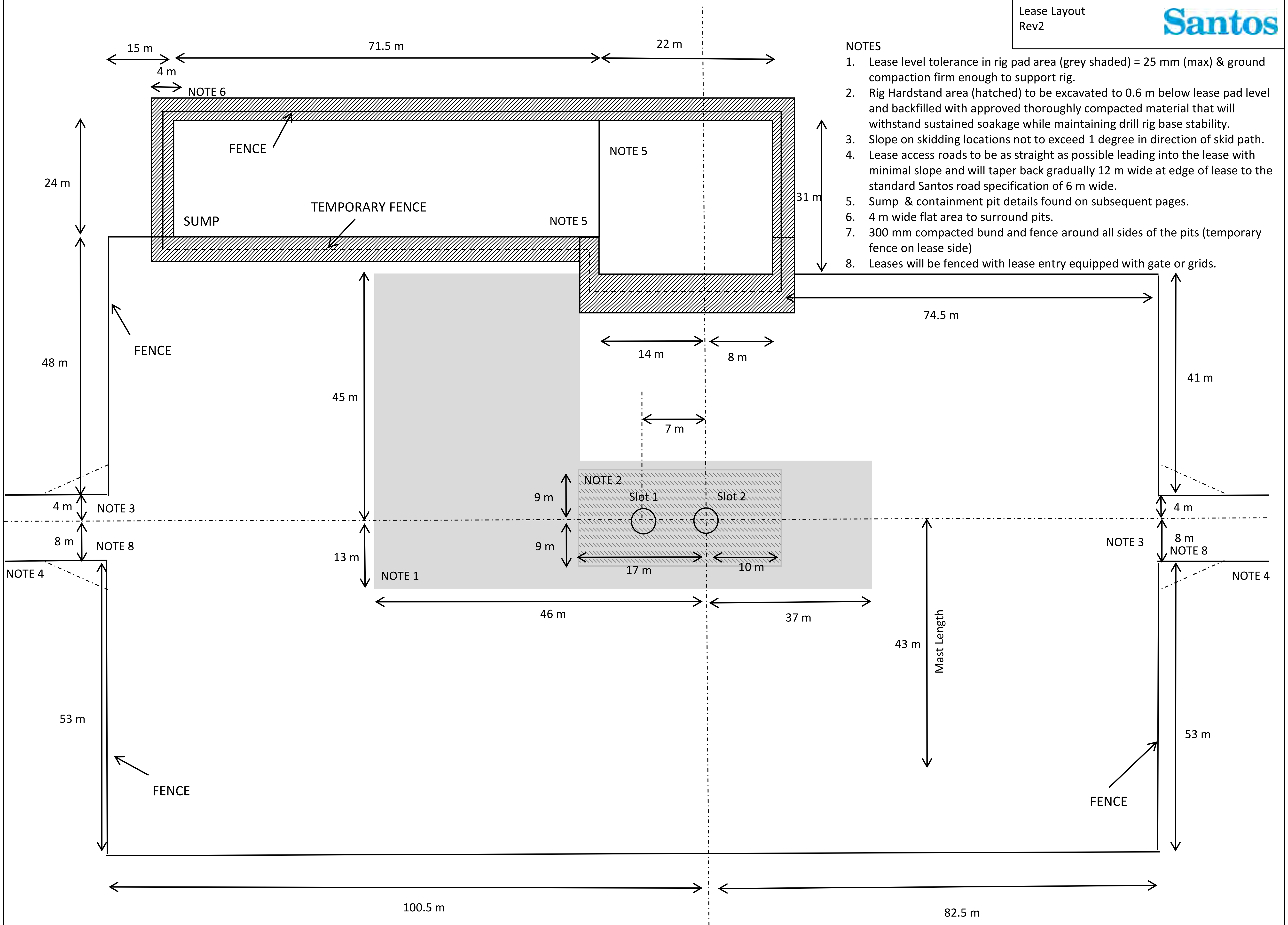
Appendices

Appendix A: Detailed Lease Layout Plan

Inacumba-1 & Tanumbirini-2
Lease Layout
Rev2

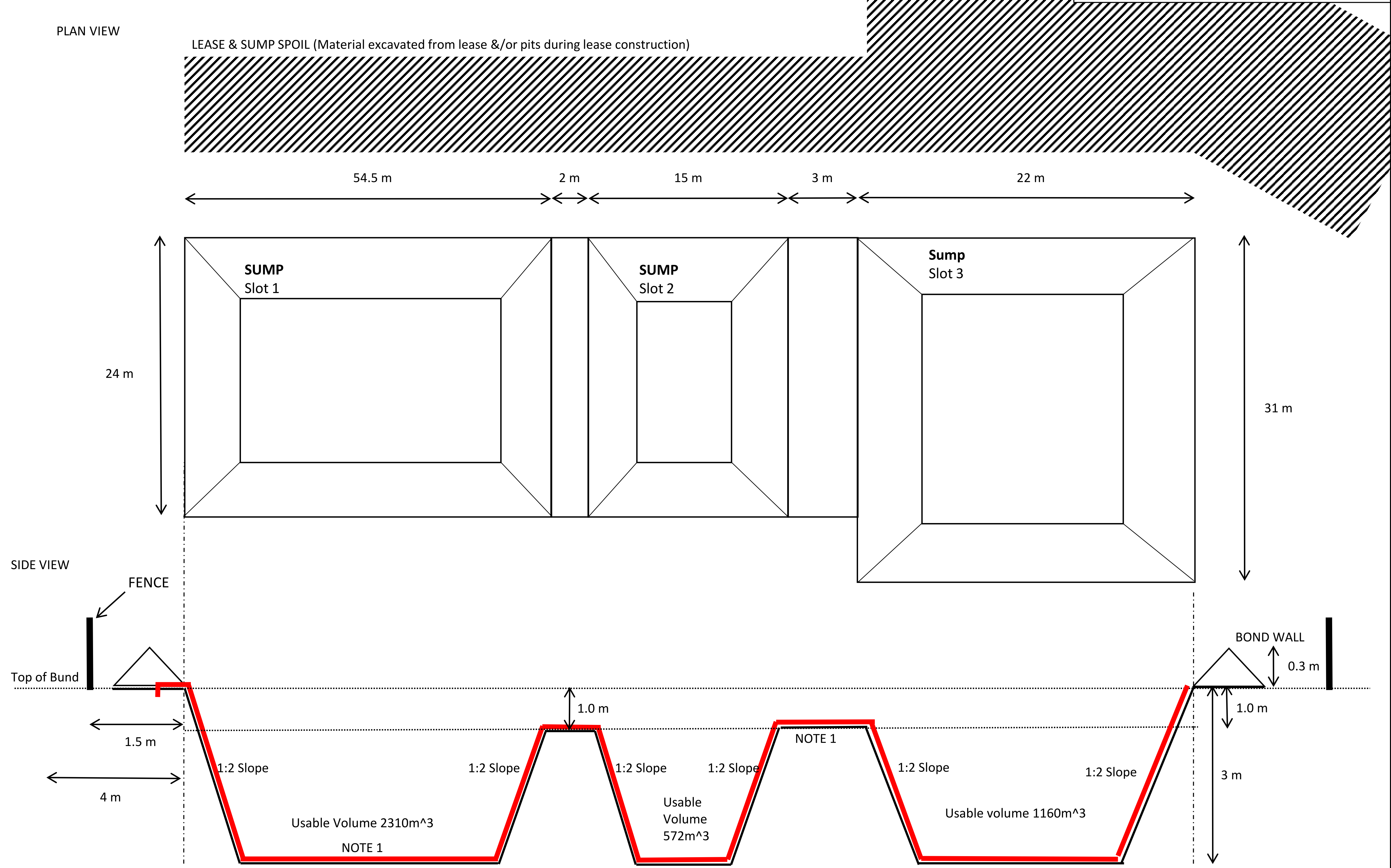


NOTES

1. Lease level tolerance in rig pad area (grey shaded) = 25 mm (max) & ground compaction firm enough to support rig.
2. Rig Hardstand area (hatched) to be excavated to 0.6 m below lease pad level and backfilled with approved thoroughly compacted material that will withstand sustained soakage while maintaining drill rig base stability.
3. Slope on skidding locations not to exceed 1 degree in direction of skid path.
4. Lease access roads to be as straight as possible leading into the lease with minimal slope and will taper back gradually 12 m wide at edge of lease to the standard Santos road specification of 6 m wide.
5. Sump & containment pit details found on subsequent pages.
6. 4 m wide flat area to surround pits.
7. 300 mm compacted bund and fence around all sides of the pits (temporary fence on lease side)
8. Leases will be fenced with lease entry equipped with gate or grids.

Inacumba-1 & Tanumbirini 2
Sump and Pit Design
Rev2

Santos



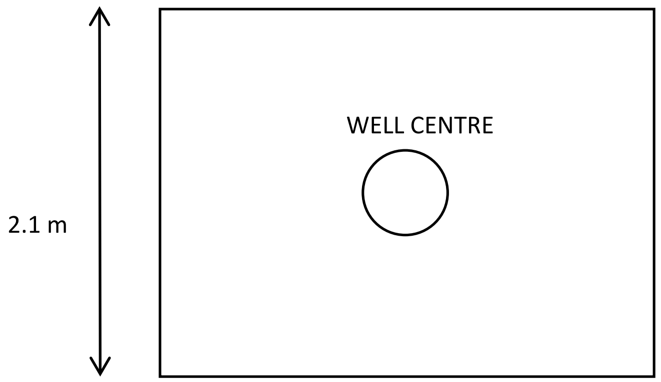
NOTES
1. Sump (Slot 1, 2 & 3) to be lined as per permeability requirements
2. Liner installed as per specification
3. Weir system used to recycle drilling fluids & meet 1m freeboard requirements.
4. Useable volume excludes 1m freeboard

Inacumba-1 & Tanumbirini-2
Cellar Design
Rev2

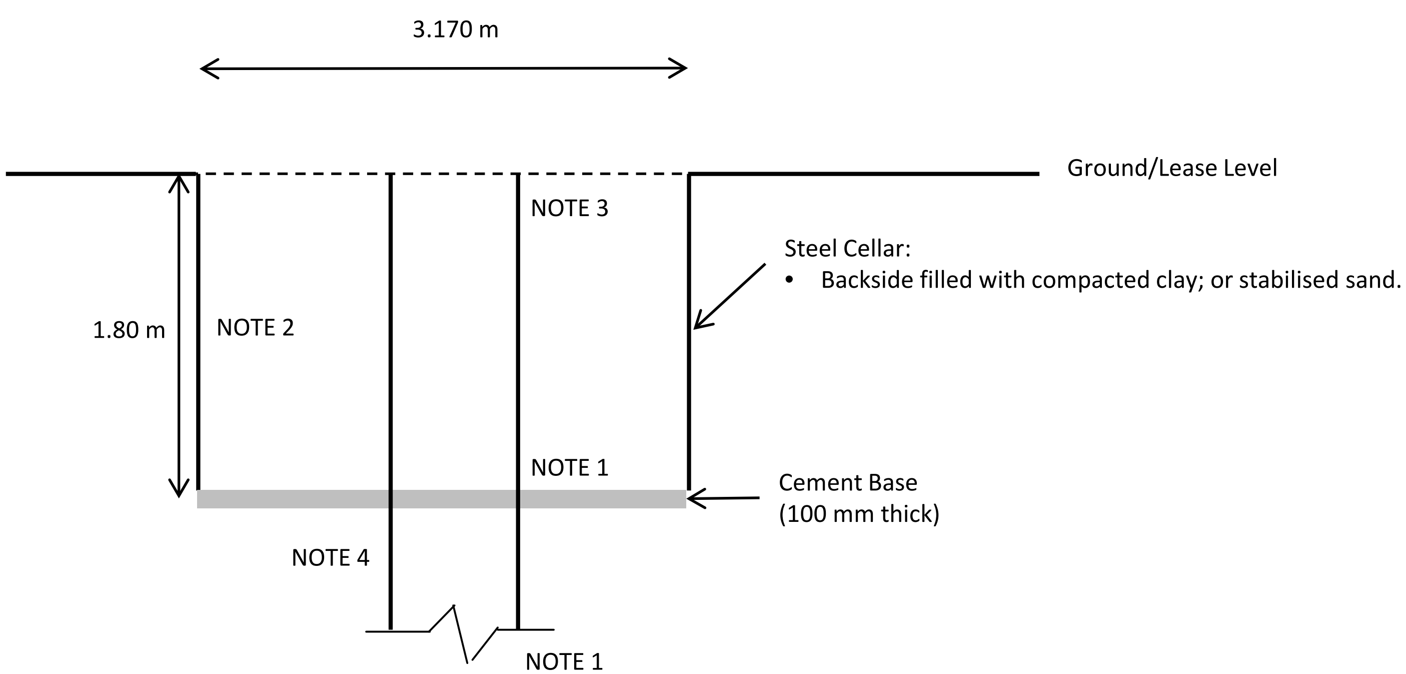
Santos

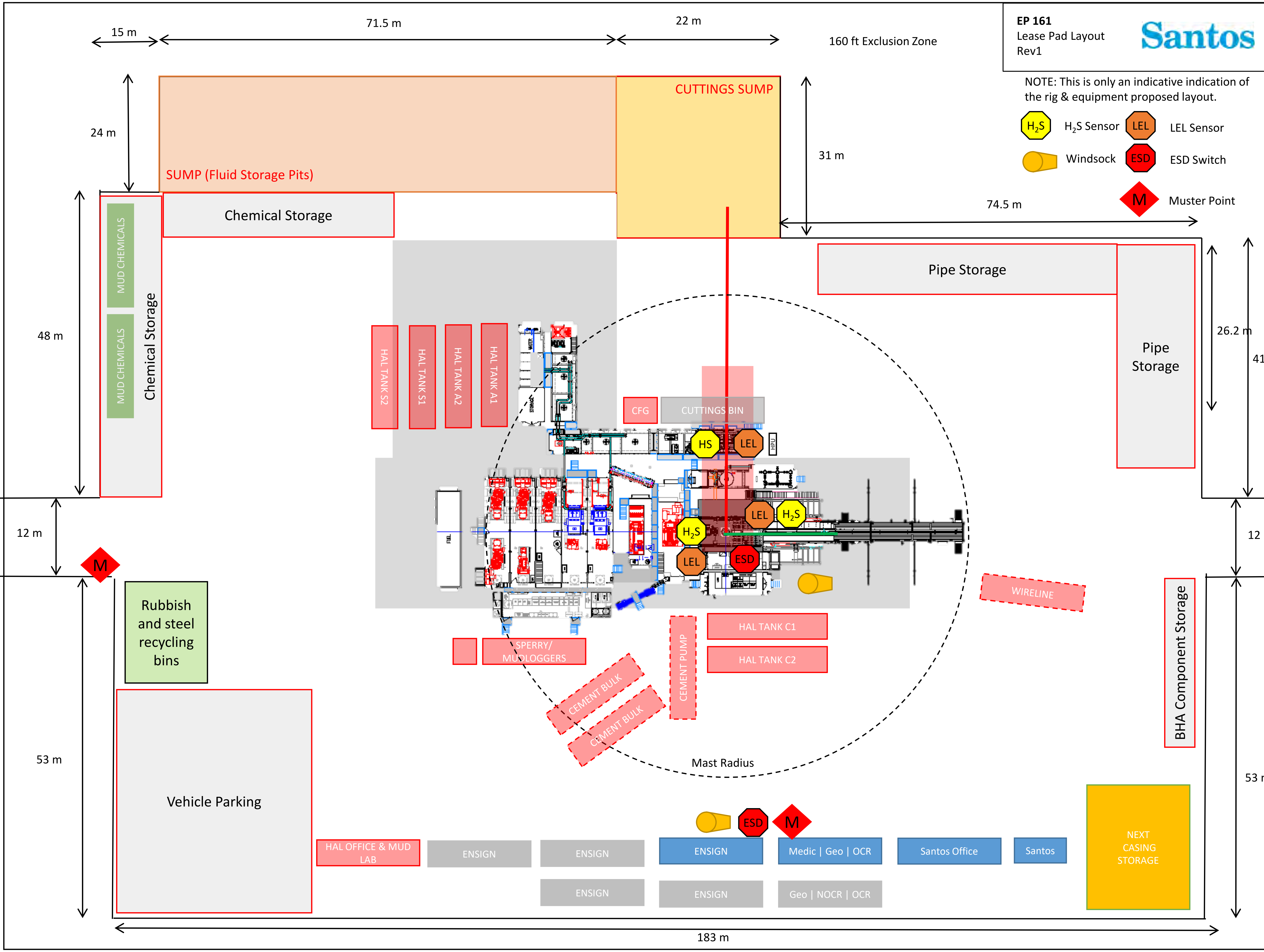
NOTES
1. 20” conductor to be set at ~16 – 24 m (two joints of conductor pipe)
2. Cellar depth GL to top of cement at bottom of the cellar **1.64m** (63.9”) to allow for emergency 13-3/8” hanger to be installed.
3. Conductor to be installed vertically
4. Conductor to be cemented via a backside stinger and agitated to improve cement job.

PLAN VIEW



SIDE VIEW

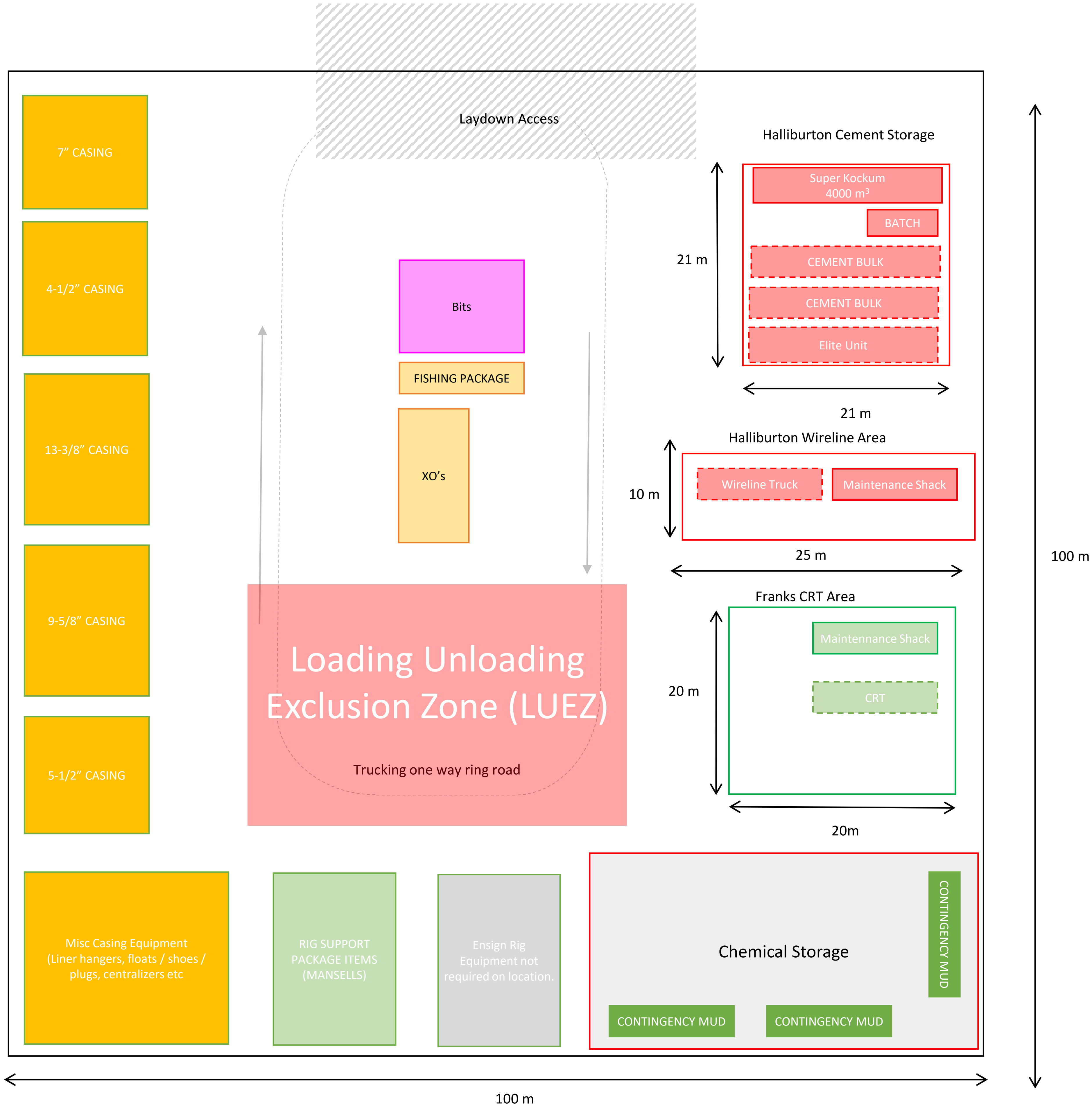




EP 161
Lease Pad Layout
Rev1
Santos
NOTE: This is only an indicative indication of the rig & equipment proposed layout.
H_2S Sensor
LEL Sensor
Windsock
ESD Switch
Muster Point
15 m
71.5 m
22 m
160 ft Exclusion Zone
24 m
31 m
74.5 m
48 m
26.2 m
41 m
12 m
12 m
53 m
53 m
183 m
SUMP (Fluid Storage Pits)
CUTTINGS SUMP
Chemical Storage
MUD CHEMICALS
MUD CHEMICALS
Chemical Storage
Pipe Storage
Pipe Storage
HAL TANK S2
HAL TANK S1
HAL TANK A2
HAL TANK A1
CFG
CUTTINGS BIN
HS
LEL
LEL
H_2S
H_2S
LEL
ESD
WIRELINE
Rubbish and steel recycling bins
HAL TANK C1
HAL TANK C2
SPERRY/ MUDLOGGERS
CEMENT PUMP
CEMENT BULK
CEMENT BULK
BHA Component Storage
Mast Radius
Vehicle Parking
ESD
M
M
HAL OFFICE & MUD LAB
ENSIGN
ENSIGN
ENSIGN
Medic | Geo | OCR
Santos Office
Santos
ENSIGN
ENSIGN
Geo | NOCR | OCR
NEXT CASING STORAGE

EP 161
Laydown Pad
Rev1

NOTE: This is only an indicative indication of the rig & equipment proposed layout.



Laydown pad is aimed at minimising truck movements of infrequently utilised items or contingency items.

- **Minimise unnecessary load movements between leases.**
- **Utilise as a staging area as required**
- **Lease will be fenced with grid access.**

Appendix B: Commonwealth Protected Matters Search Tool

Australian Government
Department of the Environment and Energy

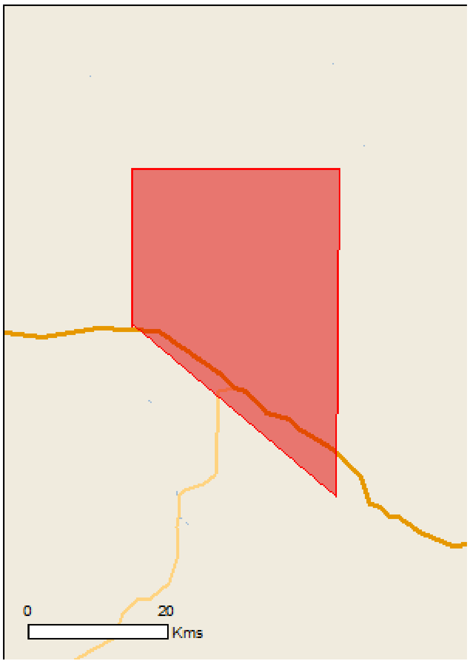
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

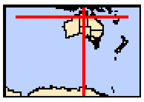
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 04/12/18 14:34:12



Coordinates
Buffer: 10.0Km



Summary

Matters of National Environmental Significance

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

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	12
Listed Migratory Species:	13

Other Matters Protected by the EPBC Act

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

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

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

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	20
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

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

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	11
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Falcunculus frontatus whitei Crested Shrike-tit (northern), Northern Shrike-tit [26013]	Vulnerable	Species or species habitat likely to occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat likely to occur within area
Mammals		
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat may occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat likely to occur within area
Pseudantechinus mimulus Carpentarian Antechinus [59283]	Vulnerable	Species or species habitat known to occur within area
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Elseya lavarackorum Gulf Snapping Turtle [67197]	Endangered	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cecropis daurica		
Red-rumped Swallow [80610]		Species or species habitat may occur within area
Cuculus optatus		
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Pandion haliaetus		
Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundo daurica Red-rumped Swallow [59480]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Reptiles		
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area

Extra Information

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Bubalus bubalis Water Buffalo, Swamp Buffalo [1]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Sus scrofa		
Pig [6]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica		
Prickly Acacia [6196]		Species or species habitat may occur within area
Cenchrus ciliaris		
Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

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

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

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

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

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

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

Coordinates

-16.477111 134.597816,-16.282944 134.597816,-16.282944 134.863795,-16.686305 134.859469,-16.475715 134.599258,-16.475715 134.599258,-16.477111 134.597816

Acknowledgements

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

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

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

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

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Appendix C: Natural Resources Management Report

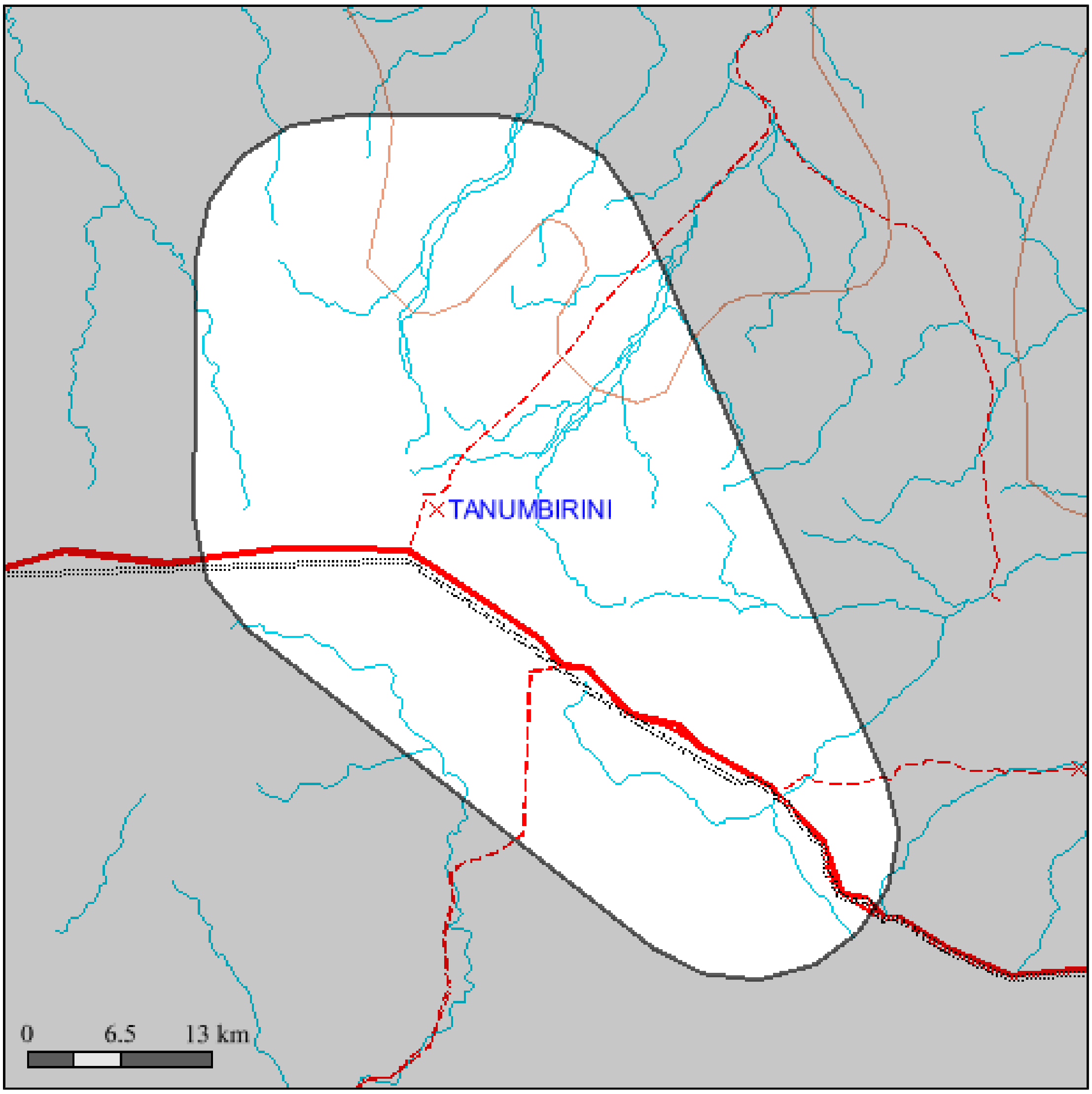
Custom area

NT NRM Report

Custom area

Custom area encompasses an area of 1807.39 sq km extending from 16 deg 12.0 min to 16 deg 45.0 min S and 134 deg 29.0 min to 134 deg 56.0 min E.
Custom area is located in the Gulf Fall and Uplands, Sturt Plateau, bioregion(s)

Location of Custom area

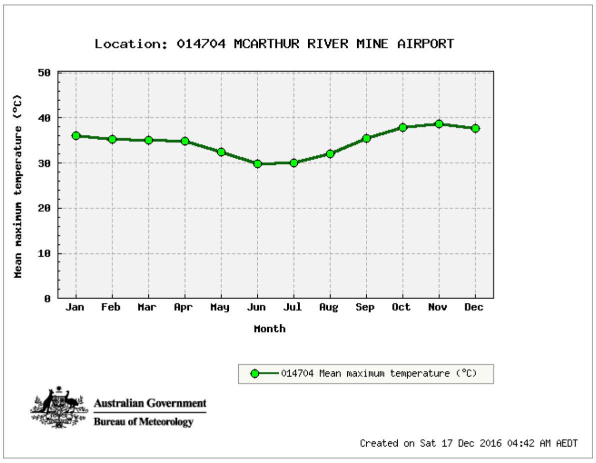


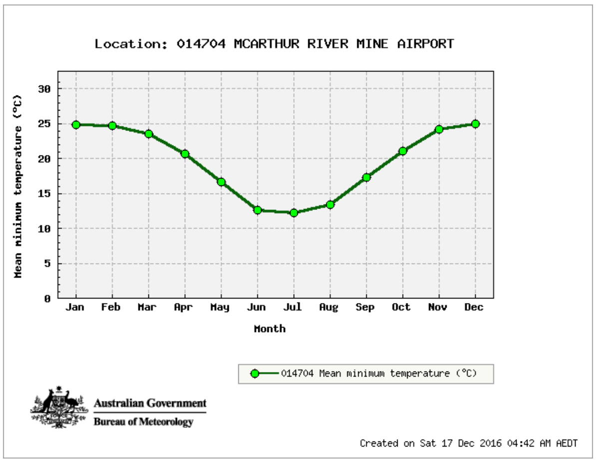
Custom area Climate

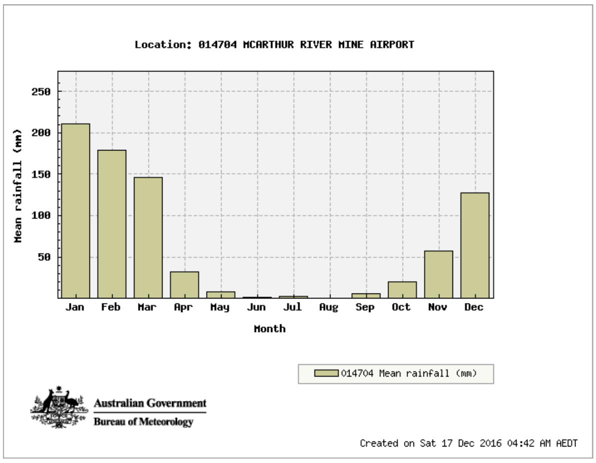
The closest long-term weather station is MCARTHUR RIVER MINE (16 deg 26.0 min S, 136.076E) 145 km E of the center of selected area

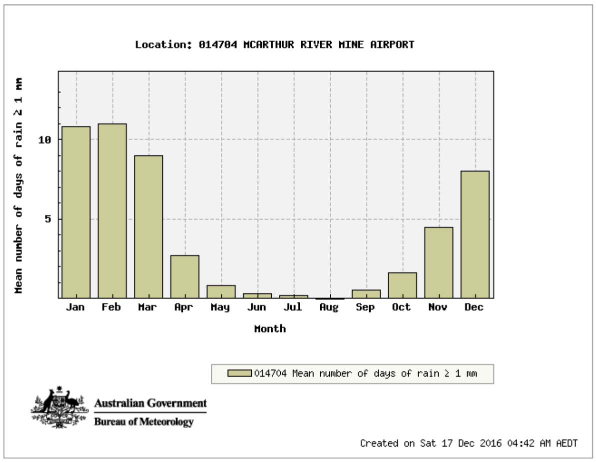
Statistics	Annual Values	Years of record
Mean max temp (deg C)	34.6	39
Mean min temp (deg C)	19.7	39
Average rainfall (mm)	766.1	38
Average days of rain	49.4	45

Climate summaries from Bureau of Meteorology (www.bom.gov.au)



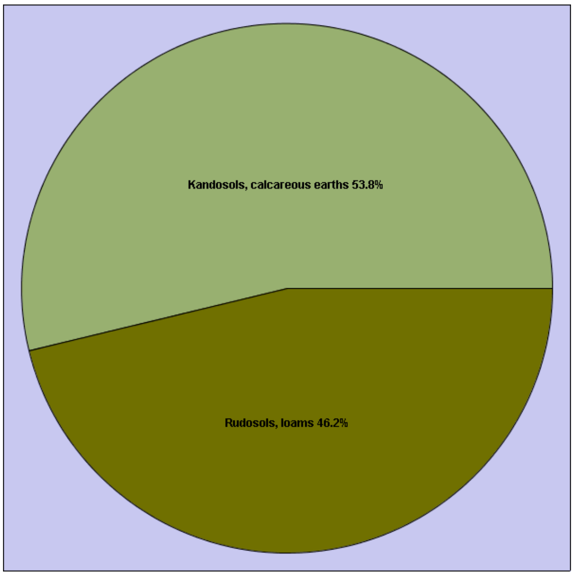






Custom area Soils

Soil Types



Area of soil types (Northcote Factual Key)

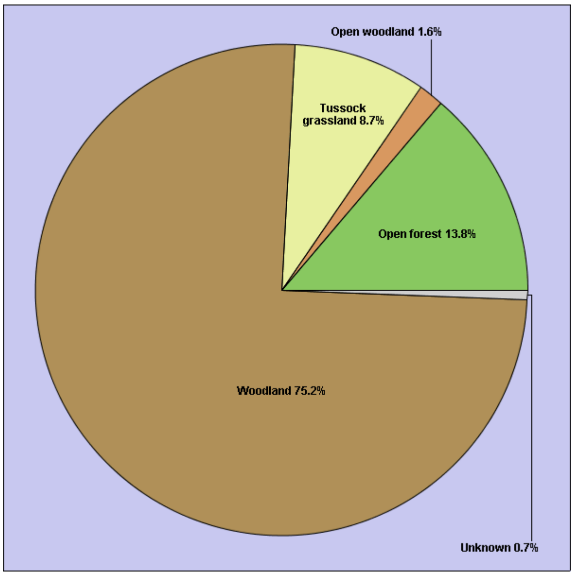
Category	Area sq km	Area%
Kandosols, calcareous earths	972.43	53.80
Rudosols, loams	834.96	46.20

Soil Types

Soils 1:2M Layer is a copy of the NT portion (1:2,000,000 scale dataset) of the CSIRO Atlas of Australian Soils - K.H. Northcote et al. Data scale: 1:2,000,000 ANZLIC Identifier: 2DBCB771205D06B6E040CD9B0F274EFE
More details: Go to www.lrm.nt.gov.au/nrmapsnt/ and enter the ANZLIC identifier in the Spatial Data Search

Custom area Vegetation

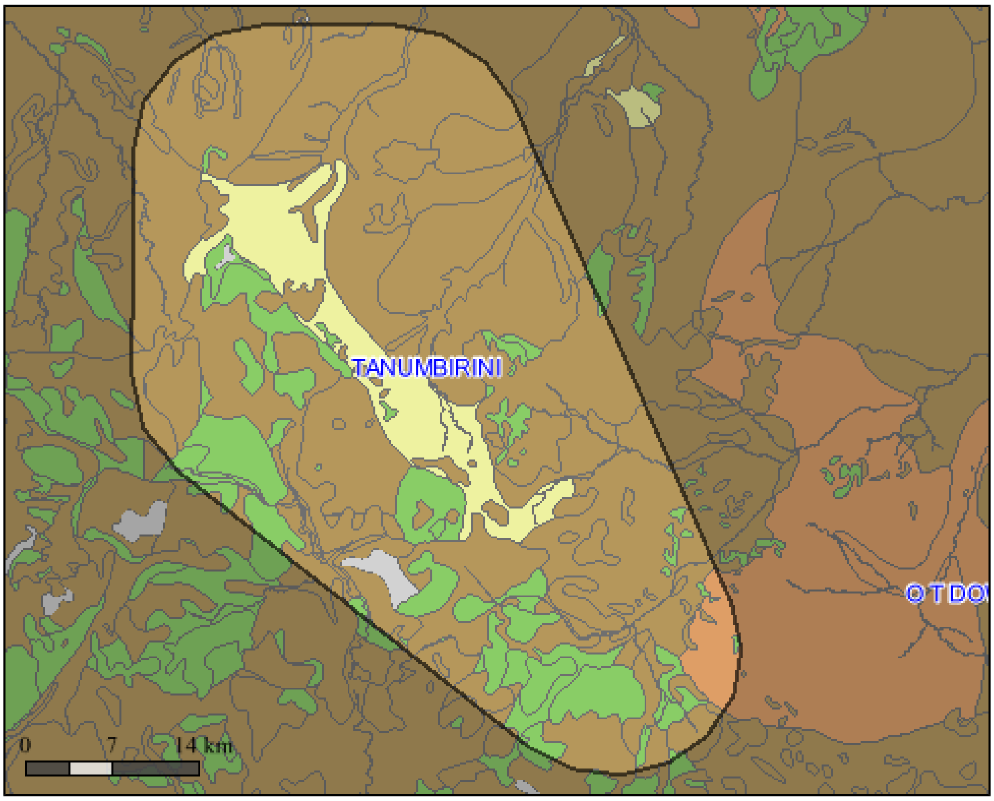
Vegetation Communities



Area of vegetation communities

Category	Area sq km	Area%
Woodland	1359.29	75.21
Open forest	248.56	13.75
Tussock grassland	158.11	8.75
Open woodland	29.57	1.64
Unknown	11.86	.66

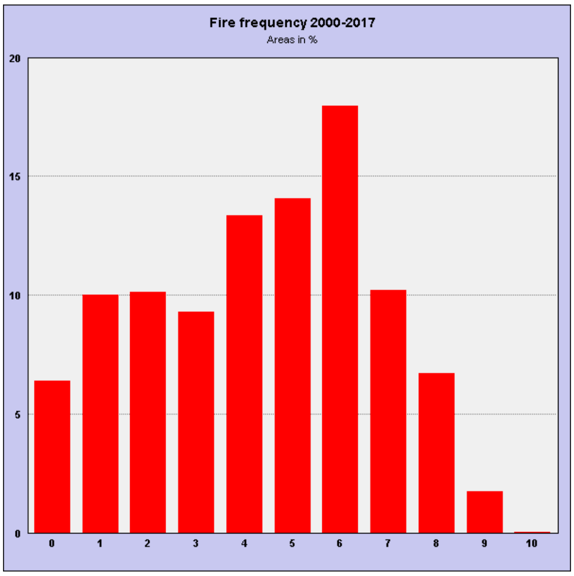
Vegetation Communities



The NVIS 2005 Layer is compiled from a number of vegetation and land unit survey maps that were recoded and re-attributed for the National Vegetation Information System (NVIS)
Data scale variable depending on location. ANZLIC Identifier:2DBCB771207006B6E040CD9B0F274EFE
More details:Go to www.lrm.nt.gov.au/nrmapsnt/ and enter the ANZLIC identifier in the Spatial Data Search

Custom area Fire History

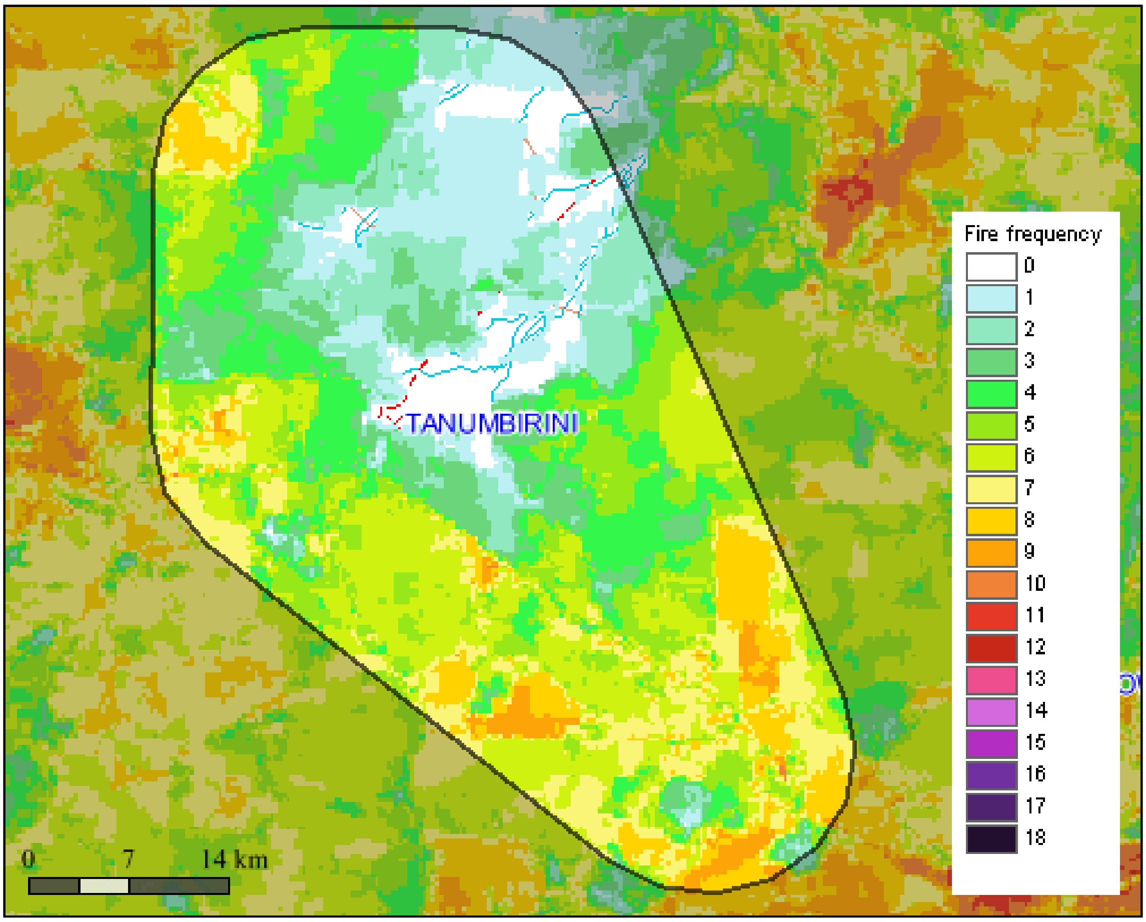
Fire frequency 2000-2017



area burnt for each fire frequency category 2000-2017

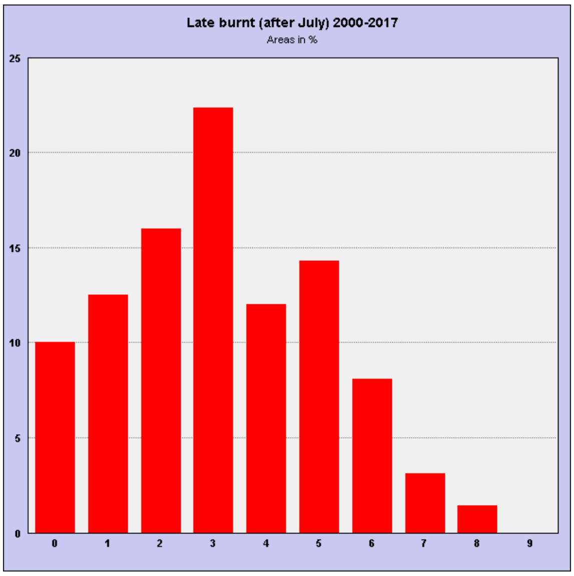
Category	Area sq km	Area%
0	115.48	6.39
1	181.34	10.03
2	183.18	10.13
3	168.48	9.32
4	241.17	13.34
5	254.24	14.07
6	324.74	17.97
7	184.99	10.24
8	121.51	6.72
9	31.52	1.74
10	.75	.04

Fire frequency 2000-2017



The fire frequency(250m) Layer is derived from satellite imagery sourced from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the NASA Terra satellite
Spatial Resolution: 250m x 250m pixels (at Nadir).

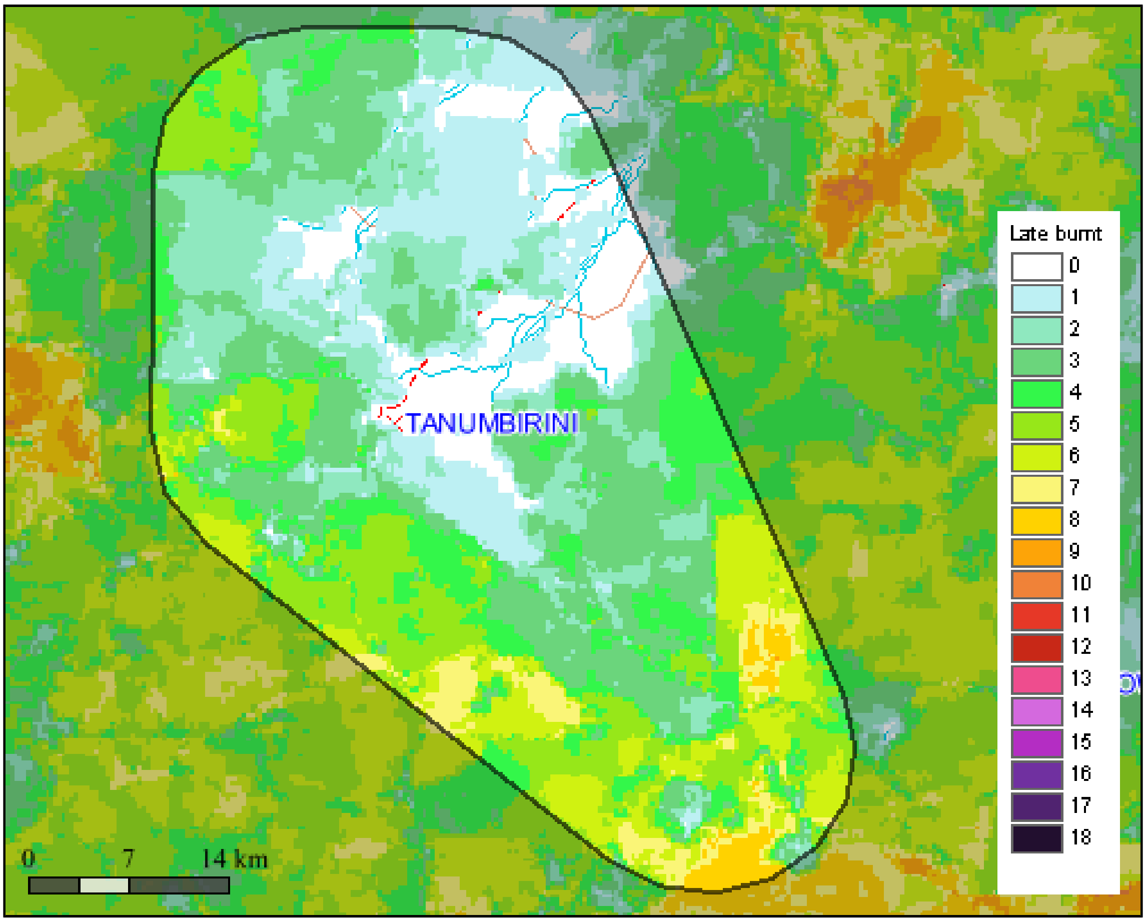
Late fire frequency(after July 31) 2000-2017



area burnt in each late fire frequency category 2000-2017

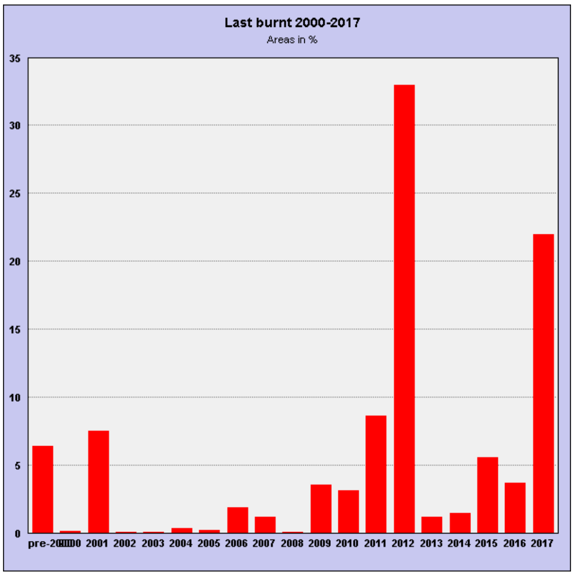
Category	Area sq km	Area%
0	181.75	10.06
1	226.39	12.53
2	289.26	16.00
3	403.91	22.35
4	217.82	12.05
5	259.01	14.33
6	146.42	8.10
7	56.96	3.15
8	25.71	1.42
9	.15	.01

Late fire frequency 2000-2017



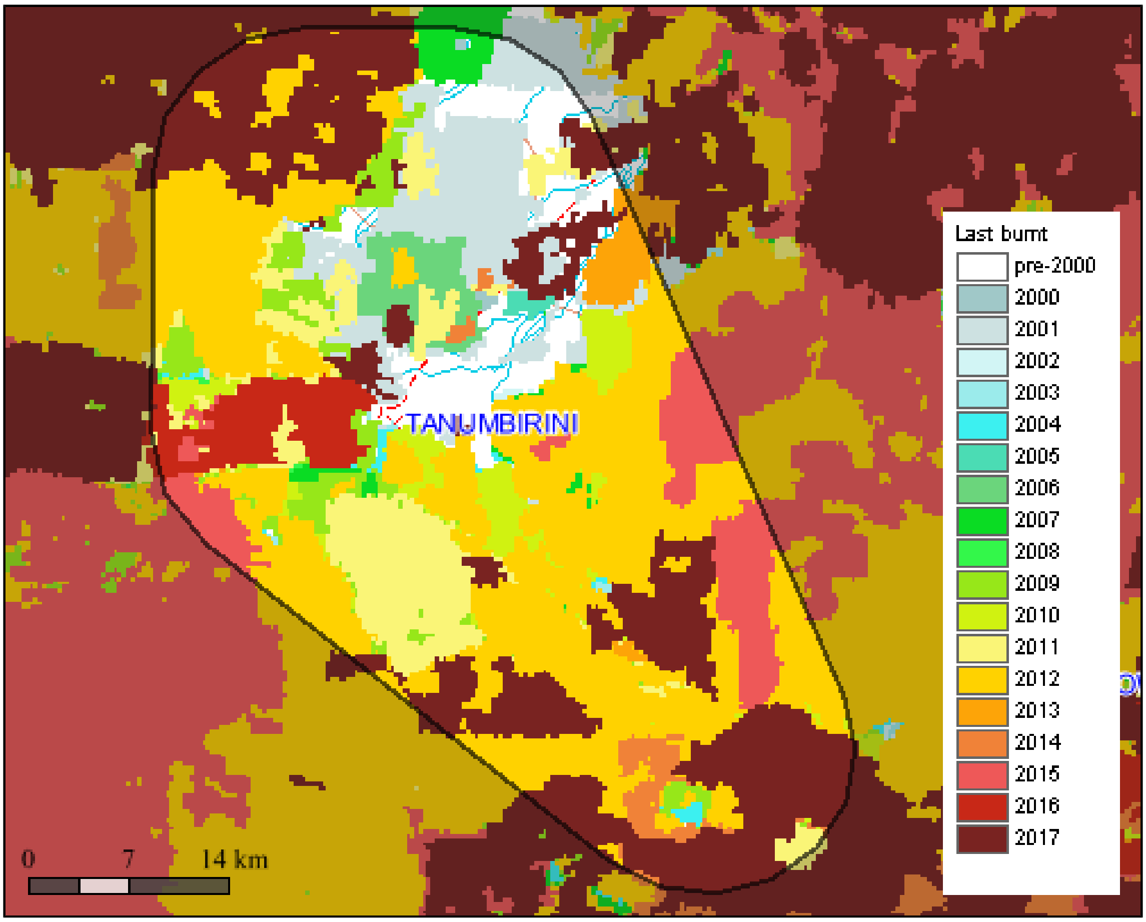
The fire frequency(250m) Layer is derived from satellite imagery sourced from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the NASA Terra satellite
Spatial Resolution: 250m x 250m pixels (at Nadir).

Year last burnt 2000-2017 and area of each year category



Category	Area sq km	Area%
pre-2000	115.48	6.39
2000	1.95	.11
2001	135.29	7.49
2002	1.42	.08
2003	1.42	.08
2004	6.29	.35
2005	4.12	.23
2006	34.31	1.90
2007	21.27	1.18
2008	.90	.05
2009	64.00	3.54
2010	56.25	3.11
2011	155.80	8.62
2012	596.58	33.01
2013	20.99	1.16
2014	26.46	1.46
2015	100.15	5.54
2016	67.19	3.72
2017	397.51	21.99

Year last burnt 2000-2017



The fire frequency(250m) Layer is derived from satellite imagery sourced from the Moderate Resolution Imaging Spectroradiometer (MODIS) on the NASA Terra satellite
Spatial Resolution: 250m x 250m pixels (at Nadir).

Custom area Threatened Species

Threatened species recorded in Custom area (Records Updated: Sept 2013)

Group	Common Name	Scientific Name	NT Status	National Status	ID	#Observations (Latest)	#Specimens (Latest)	#Surveys (Latest)
Reptiles	Mertens` Water Monitor	*Varanus mertensi*	VU	.	347295	2 (1993)	0 (Unknown)	1 (1993)
Mammals	Carpentarian Antechinus	*Pseudantechinus mimulus*	.	VU	176925	0 (Unknown)	1 (1987)	0 (Unknown)

EX = Extinct
EW = Extinct in the Wild
ER = Extinct in the NT
EN = Endangered
EN/VU = One Endangered subspecies/One Vulnerable subspecies
VU=Vulnerable
VU/- = One or more subspecies vulnerable EN/- = One or more subspecies endangered

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the ID number from the tables above for the species of interest.

Custom area Threatened Species Grid

Threatened species recorded in the grid cell(s) in which Custom area occurs (Records Updated: Sept 2013)

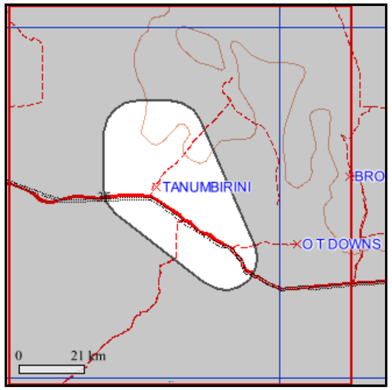
Group	Family Name	Scientific Name	Common Name	NT Status	National Status	#Observations	Latest Observation Date	#Specimens	Latest Specimen Date	#Surveys	Latest Survey Record
Reptiles	Varanidae	*Varanus mertensi*	Mertens` Water Monitor	VU		3	1993	0	Unknown	1	1993
Mammals	Dasyuridae	*Pseudantechinus mimulus*	Carpentarian Antechinus		VU	0	Unknown	1	1987	0	Unknown

EX = Extinct
EW = Extinct in the Wild
ER = Extinct in the NT
EN = Endangered
EN/VU = One Endangered subspecies/One Vulnerable subspecies
VU=Vulnerable
VU/- = One or more subspecies vulnerable EN/- = One or more subspecies endangered

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the ID number from the tables above for the species of interest.

Species listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap Custom area



Custom area Native Species

Native species that have been recorded in the grid cell(s) in which Custom area occurs

Group	Family Name	Scientific Name	Common Name	NT Status	National Status	#Observations	#Latest Observation Date	#Specimens	#Latest Speciman Date	#Surveys	#Latest Survey Record
Ferns	Lygodiaceae	*Lygodium microphyllum*	Climbing Maidenhair Fern			0	Unknown	2	1977	0	Unknown
Ferns	Marsileaceae	*Marsilea angustifolia*	Narrow-leaf Nardoo			0	Unknown	4	1977	0	Unknown
Ferns	Lindsaeaceae	*Lindsaea brachypoda*	Wedgefern			0	Unknown	2	1977	0	Unknown
Ferns	Lindsaeaceae	*Lindsaea ensifolia*	Common Wedgefern			0	Unknown	2	1977	0	Unknown
Ferns	Pteridaceae	*Cheilanthes brownii*	Northern Rock-fern			0	Unknown	2	1977	0	Unknown
Ferns	Pteridaceae	*Cheilanthes nudiuscula*	Fern			0	Unknown	10	1989	0	Unknown
Ferns	Pteridaceae	*Cheilanthes pumilio*	Fern			0	Unknown	2	1967	0	Unknown
Ferns	Pteridaceae	*Cheilanthes tenuifolia*	Rock Fern			0	Unknown	2	2001	0	Unknown
Flowering Plants	Lauraceae	*Cassytha filiformis*	Hairy Dodder-laurel			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Hernandiaceae	*Gyrocarpus americanus*	Stinkwood			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Alismataceae	*Caldesia oligococca var. oligococca*	Caldesia			0	Unknown	2	1994	0	Unknown
Flowering Plants	Hydrocharitaceae	*Vallisneria rubra*	Eel Grass			0	Unknown	2	1994	0	Unknown
Flowering Plants	Colchicaceae	*Iphigenia indica*	Iphigenia			0	Unknown	1	1989	0	Unknown
Flowering Plants	Eriocaulaceae	*Eriocaulon carpentariae*	Hatpins	DD		0	Unknown	4	1994	0	Unknown
Flowering Plants	Eriocaulaceae	*Eriocaulon cinereum*	Hatpins			0	Unknown	2	1993	0	Unknown
Flowering Plants	Cyperaceae	*Bulbostylis barbata*	Short-leaved Rush			0	Unknown	4	1983	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus astartodes*	Sedge			0	Unknown	4	1983	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus betchei*	Sedge			0	Unknown	2	1983	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus betchei subsp. commiscens*	Sedge			0	Unknown	2	1977	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus carinatus*	Sedge			0	Unknown	4	1988	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus castaneus*	Sedge			0	Unknown	2	1977	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus concinnus*	Trim Sedge			0	Unknown	2	1991	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus crispulus*	Sedge			0	Unknown	4	1987	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus cristulatus*	Sedge			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus cunninghamii subsp. uniflorus*	Sedge			0	Unknown	2	1983	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus dactylotes*	Sedge			0	Unknown	3	1988	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus eleusinoides*	Sedge			0	Unknown	2	1986	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus exaltatus*	Giant Sedge			0	Unknown	2	1986	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus fucosus*	Sedge	DD		0	Unknown	2	1947	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus holoschoenus*	Umbrella Rush			0	Unknown	8	1986	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus iria*	Rice Flat Sedge			0	Unknown	1	1983	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus javanicus*	Saw Rush			0	Unknown	2	1977	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus macrostachyos*	Tick Grass			0	Unknown	6	1995	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus microcephalus*	Sedge			0	Unknown	4	1977	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus oxycarpus*	Sedge	DD		0	Unknown	2	1977	0	Unknown

Group	Family Name	Scientific Name	Common Name	NT Status	National Status	#Observations	#Latest Observation Date	#Specimens	#Latest Speciman Date	#Surveys	#Latest Survey Record
Flowering Plants	Cyperaceae	*Cyperus polystachyos*	Bunchy Sedge			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus pulchellus*	White Button Sedge			0	Unknown	2	1983	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus sexflorus*	Sedge			0	Unknown	2	1983	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus squarrosus*	Bearded Flatsedge			0	Unknown	2	1977	0	Unknown
Flowering Plants	Cyperaceae	*Cyperus tenuispica*	Pink-root Sedge			0	Unknown	4	1983	0	Unknown
Flowering Plants	Cyperaceae	*Eleocharis pallens*	Pale Spike-Rush			0	Unknown	1	1994	0	Unknown
Flowering Plants	Cyperaceae	*Eleocharis triquetra*	Spike-Rush			0	Unknown	4	1994	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis acuminata*	Fringe-Rush			0	Unknown	1	1947	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis bisumbellata*	Fringe-Rush	DD		0	Unknown	2	1988	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis caespitosa*	Fringe-Rush			0	Unknown	2	Unknown	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis cardiocarpa*	Fringe-Rush			0	Unknown	2	1977	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis corynocarya*	Fringe-Rush	DD		0	Unknown	2	2001	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis costiglumis*	Fringe-Rush			0	Unknown	2	1983	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis depauperata*	Fringe-Rush			0	Unknown	2	1971	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis dichotoma*	Eight Day Grass			0	Unknown	2	1988	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis ferruginea*	Fringe-Rush			0	Unknown	2	1987	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis laxiglumis*	Fringe-Rush			0	Unknown	2	1947	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis littoralis*	Fringe-Rush			0	Unknown	6	1988	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis littoralis var. littoralis*	Fringe-Rush			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis microcarya*	Fringe-Rush			0	Unknown	2	1991	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis oxystachya*	Iukarrara			0	Unknown	2	1987	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis phaeoleuca*	Water Grass			0	Unknown	3	1988	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis rupestris*	Fringe-Rush			0	Unknown	2	1977	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis schultzii*	Fringe-Rush			0	Unknown	2	1977	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis sphaerocephala*	Fringe-Rush			0	Unknown	4	1977	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis squarrulosa*	Fringe-Rush			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis trigastrocarya*	Fringe-Rush			0	Unknown	2	1977	0	Unknown
Flowering Plants	Cyperaceae	*Fimbristylis tristachya*	Fringe-Rush			0	Unknown	2	1977	0	Unknown
Flowering Plants	Cyperaceae	*Rhynchospora exserta*	Star Sedge			0	Unknown	2	1976	0	Unknown
Flowering Plants	Cyperaceae	*Rhynchospora longisetis*	Tick Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Cyperaceae	*Rhynchospora subtenuifolia*	Star Sedge			0	Unknown	2	1987	0	Unknown
Flowering Plants	Cyperaceae	*Rhynchospora wightiana*	Star Sedge			0	Unknown	4	1991	0	Unknown
Flowering Plants	Cyperaceae	*Schoenoplectus laevis*	Club-Rush			0	Unknown	2	1988	0	Unknown
Flowering Plants	Cyperaceae	*Scleria brownii*	Sedge			0	Unknown	2	1987	0	Unknown
Flowering Plants	Cyperaceae	*Scleria novae-hollandiae*	Sedge			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Cyperaceae	*Scleria rugosa*	Mildrop Sedge			0	Unknown	2	1987	0	Unknown
Flowering Plants	Cyperaceae	*Scleria sphacelata*	Razor Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Acrachne racemosa*	Goose Grass	DD		0	Unknown	2	1991	0	Unknown
Flowering Plants	Poaceae	*Alloteropsis semialata*	Cockatoo Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Aristida calycina*	Dark Wiregrass			0	Unknown	4	2001	0	Unknown
Flowering Plants	Poaceae	*Aristida calycina var. calycina*	Dark Wiregrass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Aristida contorta*	Bunched Kerosene Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Aristida exserta*	Wire Grass			0	Unknown	2	1977	0	Unknown
Flowering Plants	Poaceae	*Aristida holathera*	Erect Kerosene Grass			0	Unknown	0	Unknown	0	Unknown

Group	Family Name	Scientific Name	Common Name	NT Status	National Status	#Observations	#Latest Observation Date	#Specimens	#Latest Speciman Date	#Surveys	#Latest Survey Record
Flowering Plants	Poaceae	*Aristida holathera var. holathera*	Erect Kerosene Grass			0	Unknown	4	1988	0	Unknown
Flowering Plants	Poaceae	*Aristida hygrometrica*	Northern Kerosene Grass			0	Unknown	3	1991	0	Unknown
Flowering Plants	Poaceae	*Aristida inaequiglumis*	Unequal Threeawn			0	Unknown	2	2008	0	Unknown
Flowering Plants	Poaceae	*Aristida ingrata*	Wire Grass			0	Unknown	2	1977	0	Unknown
Flowering Plants	Poaceae	*Aristida latifolia*	Feathertop Wiregrass			0	Unknown	4	1986	0	Unknown
Flowering Plants	Poaceae	*Aristida perniciosa*	Noxious Wiregrass	DD		0	Unknown	2	1977	0	Unknown
Flowering Plants	Poaceae	*Aristida pruinosa*	Gulf Feathertop Wiregrass			0	Unknown	2	1987	0	Unknown
Flowering Plants	Poaceae	*Aristida queenslandica var. queenslandica*	Wire Grass			0	Unknown	1	1987	0	Unknown
Flowering Plants	Poaceae	*Arundinella setosa*	Reed Grass			0	Unknown	1	1971	0	Unknown
Flowering Plants	Poaceae	*Astrebla lappacea*	Curly Mitchell Grass	DD		0	Unknown	2	1971	0	Unknown
Flowering Plants	Poaceae	*Astrebla squarrosa*	Bull Mitchell Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Bothriochloa bladhii*	Forest Bluegrass			0	Unknown	4	1986	0	Unknown
Flowering Plants	Poaceae	*Bothriochloa bladhii subsp. bladhii*	Forest Bluegrass			0	Unknown	2	1972	0	Unknown
Flowering Plants	Poaceae	*Brachyachne convergens*	Spider Grass			0	Unknown	2	1971	0	Unknown
Flowering Plants	Poaceae	*Brachyachne tenella*	Slender Native Couch			0	Unknown	4	1988	0	Unknown
Flowering Plants	Poaceae	*Chionachne cyathopoda*	River Grass			0	Unknown	2	1971	0	Unknown
Flowering Plants	Poaceae	*Chloris lobata*	Lobed Chloris			0	Unknown	4	1995	0	Unknown
Flowering Plants	Poaceae	*Chrysopogon fallax*	Golden-beard Grass			0	Unknown	5	1991	0	Unknown
Flowering Plants	Poaceae	*Chrysopogon pallidus*	Ribbon Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Cymbopogon bombycinus*	Silky Oilgrass			0	Unknown	4	1987	0	Unknown
Flowering Plants	Poaceae	*Cymbopogon procerus*	Scentgrass			0	Unknown	2	1971	0	Unknown
Flowering Plants	Poaceae	*Cymbopogon refractus*	Barbed-Wire Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Dichanthium fecundum*	Curly Bluegrass			0	Unknown	7	1988	0	Unknown
Flowering Plants	Poaceae	*Dichanthium sericeum*	Queensland Bluegrass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Dichanthium sericeum subsp. humilius*	Dwarf Bluegrass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Dichanthium sericeum subsp. polystachyum*	Tassel Bluegrass			0	Unknown	2	1971	0	Unknown
Flowering Plants	Poaceae	*Digitaria benthamiana*	Finger Grass	DD		0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Digitaria brownii*	Cotton Panic Grass			0	Unknown	5	2001	0	Unknown
Flowering Plants	Poaceae	*Digitaria cowiei*	Finger Grass			0	Unknown	3	1991	0	Unknown
Flowering Plants	Poaceae	*Digitaria ctenantha*	Comb Finger Grass			0	Unknown	4	1991	0	Unknown
Flowering Plants	Poaceae	*Digitaria gibbosa*	Finger Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Digitaria longiflora*	Finger Grass			0	Unknown	2	1977	0	Unknown
Flowering Plants	Poaceae	*Digitaria nematostachya*	Finger Grass			0	Unknown	4	2001	0	Unknown
Flowering Plants	Poaceae	*Digitaria papposa*	Finger Grass			0	Unknown	2	1977	0	Unknown
Flowering Plants	Poaceae	*Ectrosia agrostoides*	Haresfoot Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Ectrosia leporina*	Haresfoot Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Ectrosia scabrida*	Haresfoot Grass			0	Unknown	2	1971	0	Unknown
Flowering Plants	Poaceae	*Elytrophorus spicatus*	Spike-grass			0	Unknown	4	1993	0	Unknown
Flowering Plants	Poaceae	*Enneapogon lindleyanus*	Wiry Nine-awn			0	Unknown	2	1971	0	Unknown
Flowering Plants	Poaceae	*Enneapogon oblongus*	Rock Nine-awn			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Enneapogon pallidus*	Conetop Nine-awn			0	Unknown	2	1972	0	Unknown
Flowering Plants	Poaceae	*Enneapogon polyphyllus*	Leafy Nine-awn			0	Unknown	8	1991	0	Unknown

Group	Family Name	Scientific Name	Common Name	NT Status	National Status	#Observations	#Latest Observation Date	#Specimens	#Latest Speciman Date	#Surveys	#Latest Survey Record
Flowering Plants	Poaceae	*Enneapogon purpurascens*	Purple Nineawn			0	Unknown	2	1972	0	Unknown
Flowering Plants	Poaceae	*Enteropogon minutus*	Windmill Grass	DD		0	Unknown	2	1987	0	Unknown
Flowering Plants	Poaceae	*Eragrostis confertiflora*	Spike Lovegrass			0	Unknown	2	1991	0	Unknown
Flowering Plants	Poaceae	*Eragrostis cumingii*	Cuming`s Lovegrass			0	Unknown	10	1987	0	Unknown
Flowering Plants	Poaceae	*Eragrostis exigua*	Lovegrass			0	Unknown	4	1995	0	Unknown
Flowering Plants	Poaceae	*Eragrostis fallax*	Lovegrass			0	Unknown	6	1988	0	Unknown
Flowering Plants	Poaceae	*Eragrostis pubescens*	Giant Fairy Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Eragrostis schultzii*	Lovegrass			0	Unknown	2	1977	0	Unknown
Flowering Plants	Poaceae	*Eragrostis tenellula*	Delicate Lovegrass			0	Unknown	8	1988	0	Unknown
Flowering Plants	Poaceae	*Eriachne armitii*	Long-awn Wanderrie			0	Unknown	2	1971	0	Unknown
Flowering Plants	Poaceae	*Eriachne basalis*	Wanderrie Grass	DD		0	Unknown	1	1947	0	Unknown
Flowering Plants	Poaceae	*Eriachne ciliata*	Slender Wanderrie			0	Unknown	2	1987	0	Unknown
Flowering Plants	Poaceae	*Eriachne glauca*	Pan Wanderrie			0	Unknown	4	1991	0	Unknown
Flowering Plants	Poaceae	*Eriachne glauca var. glauca*	Wanderrie Grass			0	Unknown	2	1987	0	Unknown
Flowering Plants	Poaceae	*Eriachne nervosa*	Plains Wanderrie			0	Unknown	2	1977	0	Unknown
Flowering Plants	Poaceae	*Eriachne nodosa*	Wanderrie Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Eriachne obtusa*	Northern Wanderrie			0	Unknown	6	1988	0	Unknown
Flowering Plants	Poaceae	*Eriachne schultziana*	Salt-and-Pepper Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Eriochloa pseudoacrotricha*	Early Spring Grass			0	Unknown	3	1995	0	Unknown
Flowering Plants	Poaceae	*Eulalia aurea*	Silky Browntop			0	Unknown	6	1988	0	Unknown
Flowering Plants	Poaceae	*Heterachne gulliveri*	Heterachne			0	Unknown	2	1987	0	Unknown
Flowering Plants	Poaceae	*Heteropogon contortus*	Black Speargrass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Iseilema macratherum*	Bull Flinders Grass			0	Unknown	4	1987	0	Unknown
Flowering Plants	Poaceae	*Iseilema vaginiflorum*	Red Flinders Grass			0	Unknown	2	1986	0	Unknown
Flowering Plants	Poaceae	*Leptochloa neesii*	Swamp Grass			0	Unknown	4	1972	0	Unknown
Flowering Plants	Poaceae	*Lepturus xerophilus*	Lepturus	DD		0	Unknown	1	2001	0	Unknown
Flowering Plants	Poaceae	*Mnesithea formosa*	Red Grass			0	Unknown	5	1991	0	Unknown
Flowering Plants	Poaceae	*Mnesithea rottboellioides*	Northern Canegrass			0	Unknown	2	1977	0	Unknown
Flowering Plants	Poaceae	*Oryza australiensis*	Australian Wild Rice			0	Unknown	6	2002	0	Unknown
Flowering Plants	Poaceae	*Panicum decompositum*	Australian Millet			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Panicum effusum*	Hairy Panic			0	Unknown	2	1987	0	Unknown
Flowering Plants	Poaceae	*Panicum laevinode*	Pepper Grass			0	Unknown	2	2002	0	Unknown
Flowering Plants	Poaceae	*Panicum latzii*	Panic	DD		0	Unknown	1	1988	0	Unknown
Flowering Plants	Poaceae	*Panicum mindanaense*	Native Panic			0	Unknown	2	1987	0	Unknown
Flowering Plants	Poaceae	*Panicum trachyrhachis*	Whistle Grass			0	Unknown	2	1991	0	Unknown
Flowering Plants	Poaceae	*Panicum trichoides*	Jungle Grass			0	Unknown	4	2001	0	Unknown
Flowering Plants	Poaceae	*Paspalidium constrictum*	Knotty-butt Paspalidium			0	Unknown	2	1987	0	Unknown
Flowering Plants	Poaceae	*Paspalidium gracile*	Slender Panic	DD		0	Unknown	6	2001	0	Unknown
Flowering Plants	Poaceae	*Paspalidium rarum*	Bunch Paspalidium			0	Unknown	6	1988	0	Unknown
Flowering Plants	Poaceae	*Paspalidium retiglume*	Paspalidium			0	Unknown	2	1971	0	Unknown
Flowering Plants	Poaceae	*Perotis rara*	Comet Grass			0	Unknown	4	1991	0	Unknown
Flowering Plants	Poaceae	*Pseudopogonatherum contortum*	Black Top			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Pseudoraphis spinescens*	Spiny Mudgrass			0	Unknown	8	1991	0	Unknown
Flowering Plants	Poaceae	*Schizachyrium fragile*	Fire Grass			0	Unknown	4	1991	0	Unknown
Flowering Plants	Poaceae	*Schizachyrium pseudeulalia*	Short-leaved Silk Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Sehima nervosum*	White Grass			0	Unknown	2	1987	0	Unknown

Group	Family Name	Scientific Name	Common Name	NT Status	National Status	#Observations	#Latest Observation Date	#Specimens	#Latest Speciman Date	#Surveys	#Latest Survey Record
Flowering Plants	Poaceae	*Setaria apiculata*	Pigeon Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Setaria surgens*	Brown`s Pigeon Grass			0	Unknown	2	1991	0	Unknown
Flowering Plants	Poaceae	*Sorghum matarankense*	Sorghum			0	Unknown	4	1991	0	Unknown
Flowering Plants	Poaceae	*Sorghum plumosum*	Plume Sorghum			0	Unknown	2	1979	0	Unknown
Flowering Plants	Poaceae	*Sorghum plumosum var. plumosum*	Plume Sorghum			0	Unknown	2	1988	0	Unknown
Flowering Plants	Poaceae	*Sorghum timorense*	Downs Sorghum			0	Unknown	2	1987	0	Unknown
Flowering Plants	Poaceae	*Sporobolus australasicus*	Australian Dropseed			0	Unknown	4	1988	0	Unknown
Flowering Plants	Poaceae	*Thaumastochloa pubescens*	Thaumastochloa			0	Unknown	2	1977	0	Unknown
Flowering Plants	Poaceae	*Themeda arguens*	Annual Kangaroo Grass			0	Unknown	2	1988	0	Unknown
Flowering Plants	Poaceae	*Themeda avenacea*	Oat Kangaroo Grass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Themeda triandra*	Kangaroo Grass			0	Unknown	2	1986	0	Unknown
Flowering Plants	Poaceae	*Triodia bitextura*	Curly Spinifex			0	Unknown	8	1988	0	Unknown
Flowering Plants	Poaceae	*Triodia latzii*	Spinifex			0	Unknown	4	1988	0	Unknown
Flowering Plants	Poaceae	*Triodia microstachya*	Spinifex			0	Unknown	2	1977	0	Unknown
Flowering Plants	Poaceae	*Triodia stenostachya*	Spinifex			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Tripogon loliiformis*	Five-minute Grass			0	Unknown	2	1988	0	Unknown
Flowering Plants	Poaceae	*Urochloa holosericea*	Silkytop Armgrass			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Urochloa pubigera*	Armgrass Millet			0	Unknown	3	1991	0	Unknown
Flowering Plants	Poaceae	*Whiteochloa airoides*	Creeping Panic			0	Unknown	4	1988	0	Unknown
Flowering Plants	Poaceae	*Whiteochloa capillipes*	Whiteochloa			0	Unknown	4	1991	0	Unknown
Flowering Plants	Poaceae	*Yakirra australiensis*	Desert Flinders Grass			0	Unknown	2	1971	0	Unknown
Flowering Plants	Poaceae	*Yakirra majuscula*	Yakirra			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Yakirra muelleri*	Yakirra	DD		0	Unknown	2	1971	0	Unknown
Flowering Plants	Poaceae	*Yakirra nulla*	Yakirra			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Poaceae	*Yakirra pauciflora*	Yakirra			0	Unknown	4	1991	0	Unknown
Flowering Plants	Commelinaceae	*Commelina agrostophylla*	Commelina			0	Unknown	2	1979	0	Unknown
Flowering Plants	Commelinaceae	*Commelina ensifolia*	Wandering Jew			0	Unknown	2	1959	0	Unknown
Flowering Plants	Commelinaceae	*Cyanotis axillaris*	Commelina			0	Unknown	2	1994	0	Unknown
Flowering Plants	Commelinaceae	*Murdannia graminea*	Pink Swamp Lily			0	Unknown	5	1989	0	Unknown
Flowering Plants	Commelinaceae	*Murdannia vaginata*	Day Flower			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Pontederiaceae	*Monochoria cyanea*	Monochoria			0	Unknown	2	1979	0	Unknown
Flowering Plants	Haemodoraceae	*Haemodorum coccineum*	Scarlet-flowered Bloodroot			0	Unknown	2	1988	0	Unknown
Flowering Plants	Menispermaceae	*Tinospora smilacina*	Snake Vine			0	Unknown	1	1988	0	Unknown
Flowering Plants	Proteaceae	*Grevillea dryandri*	Dryander`s Grevillea			0	Unknown	2	1988	0	Unknown
Flowering Plants	Proteaceae	*Grevillea heliosperma*	Rock Grevillea			0	Unknown	2	1971	0	Unknown
Flowering Plants	Proteaceae	*Grevillea parallela*	Silver Grevillea			0	Unknown	2	1987	0	Unknown
Flowering Plants	Proteaceae	*Grevillea pteridifolia*	Fern-leaved Grevillea			0	Unknown	2	1988	0	Unknown
Flowering Plants	Proteaceae	*Grevillea refracta*	Silver-leaved Grevillea			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Proteaceae	*Grevillea refracta subsp. refracta*	Silver-leaved Grevillea			0	Unknown	2	1971	0	Unknown
Flowering Plants	Proteaceae	*Grevillea striata*	Western Beefwood			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Proteaceae	*Hakea arborescens*	Yellow Hakea			0	Unknown	2	1977	0	Unknown
Flowering Plants	Proteaceae	*Hakea chordophylla*	Northern Corkwood			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Proteaceae	*Hakea lorea subsp. borealis*	Northern Long-leaf Corkwood			0	Unknown	2	1947	0	Unknown
Flowering Plants	Proteaceae	*Persoonia falcata*	Milky Plum			0	Unknown	0	Unknown	0	Unknown

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Flowering Plants	Proteaceae	*Stenocarpus acacioides*	Stenocarpus			0	Unknown	2	1986	0	Unknown
Flowering Plants	Dilleniaceae	*Hibbertia lepidota*	Scaly Guinea Flower			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Droseraceae	*Drosera indica*	Narrow-leaved Sundew			0	Unknown	2	2001	0	Unknown
Flowering Plants	Caryophyllaceae	*Polycarpaea breviflora*	Polycarpaea			0	Unknown	2	1991	0	Unknown
Flowering Plants	Caryophyllaceae	*Polycarpaea corymbosa*	Polycarpaea			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Caryophyllaceae	*Polycarpaea involucrata*	Polycarpaea			0	Unknown	3	1987	0	Unknown
Flowering Plants	Caryophyllaceae	*Polycarpaea spirostylis*	Copper Plant			0	Unknown	2	1971	0	Unknown
Flowering Plants	Amaranthaceae	*Achyranthes aspera*	Prickly Chaff Flower			0	Unknown	5	1986	0	Unknown
Flowering Plants	Amaranthaceae	*Alternanthera denticulata var. denticulata*	Lesser Joyweed			0	Unknown	2	1991	0	Unknown
Flowering Plants	Amaranthaceae	*Alternanthera nana*	Hairy Joyweed			0	Unknown	4	1988	0	Unknown
Flowering Plants	Amaranthaceae	*Alternanthera nodiflora*	Common Joyweed			0	Unknown	2	1986	0	Unknown
Flowering Plants	Amaranthaceae	*Amaranthus interruptus*	Native Amaranth			0	Unknown	2	1977	0	Unknown
Flowering Plants	Amaranthaceae	*Amaranthus pallidiflorus*	Pale-flowered Amaranth			0	Unknown	2	1977	0	Unknown
Flowering Plants	Amaranthaceae	*Gomphrena breviflora*	Gomphrena			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Amaranthaceae	*Gomphrena canescens*	Batchelor`s Buttons			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Amaranthaceae	*Gomphrena canescens subsp. canescens*	Batchelor`s Buttons			0	Unknown	2	1987	0	Unknown
Flowering Plants	Amaranthaceae	*Gomphrena flaccida*	Gomphrena Weed			0	Unknown	6	1995	0	Unknown
Flowering Plants	Amaranthaceae	*Gomphrena lanata*	Gomphrena			0	Unknown	7	1986	0	Unknown
Flowering Plants	Amaranthaceae	*Ptilotus exaltatus*	Pink Mulla Mulla			0	Unknown	6	2008	0	Unknown
Flowering Plants	Amaranthaceae	*Ptilotus fusiformis*	Skeleton plant			0	Unknown	6	1988	0	Unknown
Flowering Plants	Amaranthaceae	*Ptilotus polystachyus*	Long Pussy-tails			0	Unknown	4	2008	0	Unknown
Flowering Plants	Amaranthaceae	*Ptilotus spicatus*	Mulla Mulla			0	Unknown	2	1986	0	Unknown
Flowering Plants	Amaranthaceae	*Salsola australis*	Rolypoly			0	Unknown	2	1979	0	Unknown
Flowering Plants	Molluginaceae	*Glinus lotoides*	Hairy Carpet-weed			0	Unknown	2	1959	0	Unknown
Flowering Plants	Molluginaceae	*Glinus oppositifolius*	Slender Carpet-weed			0	Unknown	2	1977	0	Unknown
Flowering Plants	Portulacaceae	*Calandrinia quadrivalvis*	Parakeelya			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Portulacaceae	*Calandrinia uniflora*	Parakeelya			0	Unknown	2	1988	0	Unknown
Flowering Plants	Portulacaceae	*Portulaca bicolor*	Heart Plant			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Portulacaceae	*Portulaca sp. Elliott*	Pigweed			0	Unknown	2	1986	0	Unknown
Flowering Plants	Nyctaginaceae	*Boerhavia coccinea*	Scarlet Tar Vine			0	Unknown	6	1988	0	Unknown
Flowering Plants	Nyctaginaceae	*Boerhavia dominii*	Tar Vine			0	Unknown	4	1986	0	Unknown
Flowering Plants	Opiliaceae	*Opilia amentacea*	Opilia			0	Unknown	2	1977	0	Unknown
Flowering Plants	Santalaceae	*Santalum lanceolatum*	Plumbush			0	Unknown	8	1988	0	Unknown
Flowering Plants	Loranthaceae	*Amyema bifurcata*	Twin-fork Mistletoe			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Loranthaceae	*Amyema maidenii subsp. maidenii*	Pale-leaf Mistletoe			0	Unknown	2	1979	0	Unknown
Flowering Plants	Loranthaceae	*Amyema miquelii*	Box Mistletoe			0	Unknown	2	1947	0	Unknown
Flowering Plants	Loranthaceae	*Amyema sanguinea*	Blood Mistletoe			0	Unknown	2	1986	0	Unknown
Flowering Plants	Loranthaceae	*Amyema villiflora*	Mistletoe			0	Unknown	2	1987	0	Unknown
Flowering Plants	Loranthaceae	*Dendrophthoe glabrescens*	Orange-Flowered Mistletoe			0	Unknown	4	1979	0	Unknown
Flowering Plants	Loranthaceae	*Diplatia grandibractea*	Royal Mistletoe			0	Unknown	2	1979	0	Unknown
Flowering Plants	Loranthaceae	*Lysiana spathulata subsp. spathulata*	Flat-leaved Mistletoe			0	Unknown	2	1959	0	Unknown
Flowering Plants	Haloragaceae	*Myriophyllum filiforme*	Water Milfoil			0	Unknown	2	1991	0	Unknown
Flowering Plants	Vitaceae	*Cayratia trifolia*	Native Grape			0	Unknown	2	1988	0	Unknown

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Flowering Plants	Combretaceae	*Macropteranthes kekwickii*	Bullwaddy			0	Unknown	19	2001	0	Unknown
Flowering Plants	Combretaceae	*Terminalia bursarina*	Bendee			0	Unknown	8	1987	0	Unknown
Flowering Plants	Combretaceae	*Terminalia canescens*	Winged Nut Tree			0	Unknown	14	2008	0	Unknown
Flowering Plants	Combretaceae	*Terminalia platyphylla*	Red Plum			0	Unknown	5	1987	0	Unknown
Flowering Plants	Combretaceae	*Terminalia pterocarya*	Wing-fruited Terminalia			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Combretaceae	*Terminalia volucris*	Rosewood			0	Unknown	4	1991	0	Unknown
Flowering Plants	Lythraceae	*Ammannia multiflora*	Jerry-Jerry			0	Unknown	4	1986	0	Unknown
Flowering Plants	Lythraceae	*Nesaea muelleri*	Neasea			0	Unknown	4	1994	0	Unknown
Flowering Plants	Lythraceae	*Rotala diandra*	Rotala			0	Unknown	2	1991	0	Unknown
Flowering Plants	Lythraceae	*Rotala mexicana*	Rotala			0	Unknown	4	1994	0	Unknown
Flowering Plants	Onagraceae	*Ludwigia octovalvis*	Willow Primrose			0	Unknown	2	1988	0	Unknown
Flowering Plants	Onagraceae	*Ludwigia perennis*	Ludwigia			0	Unknown	2	1971	0	Unknown
Flowering Plants	Myrtaceae	*Calytrix exstipulata*	Turkey Bush			0	Unknown	10	1988	0	Unknown
Flowering Plants	Myrtaceae	*Corymbia bella*	Ghost Gum			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Myrtaceae	*Corymbia confertiflora*	Roughleaf Cabbage Gum			0	Unknown	4	1988	0	Unknown
Flowering Plants	Myrtaceae	*Corymbia dichromophloia*	Variable-barked Bloodwood			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Myrtaceae	*Corymbia drysdalensis*	Bloodwood			0	Unknown	5	1993	0	Unknown
Flowering Plants	Myrtaceae	*Corymbia ferruginea*	Rusty Bloodwood			0	Unknown	3	1986	0	Unknown
Flowering Plants	Myrtaceae	*Corymbia ferruginea subsp. ferruginea*	Rusty Bloodwood			0	Unknown	2	1987	0	Unknown
Flowering Plants	Myrtaceae	*Corymbia flavescens*	Cabbage Gum			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Myrtaceae	*Corymbia grandifolia*	Large-leaved Cabbage Gum			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Myrtaceae	*Corymbia grandifolia subsp. grandifolia*	Large-leaved Cabbage Gum			0	Unknown	2	1988	0	Unknown
Flowering Plants	Myrtaceae	*Corymbia polycarpa*	Long-fruited Bloodwood			0	Unknown	5	1988	0	Unknown
Flowering Plants	Myrtaceae	*Corymbia ptychocarpa*	Swamp Bloodwood			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Myrtaceae	*Corymbia ptychocarpa subsp. ptychocarpa*	Swamp Bloodwood			0	Unknown	2	1986	0	Unknown
Flowering Plants	Myrtaceae	*Corymbia terminalis*	Northern Bloodwood			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus brevifolia*	Snappy Gum			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus camaldulensis subsp. obtusa*	Northern River Red Gum			0	Unknown	10	1991	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus chlorophylla*	Green-leaf Box			0	Unknown	11	2001	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus chlorophylla subsp. chlorophylla*	Greenleaf Box			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus cyanoclada*	Box			0	Unknown	4	2001	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus distans*	Katherine Box			0	Unknown	2	1987	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus leucophloia*	Snappy Gum			0	Unknown	4	1988	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus leucophloia subsp. euroa*	Snappy Gum			0	Unknown	2	1988	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus microtheca*	Western Coolibah			0	Unknown	2	1987	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus miniata*	Darwin Woollybutt			0	Unknown	2	1971	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus patellaris*	Weeping Box			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus pruinosa*	Silver-leaf Box			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus pruinosa subsp. pruinosa*	Silver-leaf Box			0	Unknown	3	1988	0	Unknown

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Flowering Plants	Myrtaceae	*Eucalyptus pruinosa subsp. tenuata*	Silver-leaf Box			0	Unknown	4	1988	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus tectifica*	McArthur River Box			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Myrtaceae	*Eucalyptus tetrodonta*	Darwin Stringybark			0	Unknown	2	1988	0	Unknown
Flowering Plants	Myrtaceae	*Lithomyrtus hypoleuca*	Lithomyrtus			0	Unknown	2	1977	0	Unknown
Flowering Plants	Myrtaceae	*Lophostemon grandiflorus*	Northern Swamp Box			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Myrtaceae	*Melaleuca acacioides*	Coastal Paperbark			0	Unknown	2	1988	0	Unknown
Flowering Plants	Myrtaceae	*Melaleuca argentea*	Silver-leaved Paperbark			0	Unknown	2	1988	0	Unknown
Flowering Plants	Myrtaceae	*Melaleuca citrolens*	Lemon-scented Paperbark			0	Unknown	9	1988	0	Unknown
Flowering Plants	Myrtaceae	*Melaleuca leucadendra*	Weeping Paperbark			0	Unknown	2	1988	0	Unknown
Flowering Plants	Myrtaceae	*Melaleuca nervosa*	Yellow-barked Paperbark			0	Unknown	2	1988	0	Unknown
Flowering Plants	Myrtaceae	*Melaleuca viridiflora*	Broad-leaved Paperbark			0	Unknown	4	1988	0	Unknown
Flowering Plants	Zygophyllaceae	*Tribulopis angustifolia*	Tribulopis			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Celastraceae	*Denhamia cunninghamii*	Yellowberry Bush			0	Unknown	8	1988	0	Unknown
Flowering Plants	Celastraceae	*Denhamia obscura*	Orange Root			0	Unknown	2	1988	0	Unknown
Flowering Plants	Celastraceae	*Stackhousia intermedia*	Wiry Stackhousia			0	Unknown	2	1977	0	Unknown
Flowering Plants	Violaceae	*Hybanthus aurantiacus*	Orange Spade Flower			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Violaceae	*Hybanthus enneaspermus*	Blue Spade Flower			0	Unknown	7	1986	0	Unknown
Flowering Plants	Violaceae	*Hybanthus enneaspermus subsp. enneaspermus*	Blue Spade Flower			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Euphorbiaceae	*Euphorbia biconvexa*	Euphorbia			0	Unknown	10	1988	0	Unknown
Flowering Plants	Euphorbiaceae	*Euphorbia bifida*	Euphorbia			0	Unknown	4	1988	0	Unknown
Flowering Plants	Euphorbiaceae	*Euphorbia mitchelliana*	Native Gypsophila			0	Unknown	4	1986	0	Unknown
Flowering Plants	Euphorbiaceae	*Euphorbia schultzii var. comans*	Euphorbia			0	Unknown	6	1989	0	Unknown
Flowering Plants	Euphorbiaceae	*Euphorbia schultzii var. schultzii*	Euphorbia			0	Unknown	6	1988	0	Unknown
Flowering Plants	Phyllanthaceae	*Antidesma ghesaembilla*	Black Currant Bush			0	Unknown	2	1986	0	Unknown
Flowering Plants	Phyllanthaceae	*Antidesma parvifolium*	Currant Bush			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Phyllanthaceae	*Breynia cernua*	Breynia			0	Unknown	4	1988	0	Unknown
Flowering Plants	Phyllanthaceae	*Flueggea virosa*	White Currant			0	Unknown	8	1988	0	Unknown
Flowering Plants	Phyllanthaceae	*Flueggea virosa subsp. melanthesoides*	White Currant			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Phyllanthaceae	*Margaritaria dubium-traceyi*	Tracey's Puzzle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Phyllanthaceae	*Phyllanthus carpentariae*	Phyllanthus			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Phyllanthaceae	*Phyllanthus exilis*	Phyllanthus			0	Unknown	15	1995	0	Unknown
Flowering Plants	Phyllanthaceae	*Phyllanthus fuernrohrii*	Sand Spurge			0	Unknown	2	1988	0	Unknown
Flowering Plants	Phyllanthaceae	*Phyllanthus hebecarpus*	Phyllanthus			0	Unknown	3	1987	0	Unknown
Flowering Plants	Phyllanthaceae	*Phyllanthus indigoferoides*	Phyllanthus			0	Unknown	1	1971	0	Unknown
Flowering Plants	Phyllanthaceae	*Phyllanthus maderaspatensis*	Phyllanthus			0	Unknown	2	1988	0	Unknown
Flowering Plants	Phyllanthaceae	*Phyllanthus minutiflorus*	Phyllanthus			0	Unknown	2	1989	0	Unknown
Flowering Plants	Phyllanthaceae	*Phyllanthus virgatus*	Seed-under-leaf			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Phyllanthaceae	*Poranthera microphylla*	Small Poranthera			0	Unknown	4	1977	0	Unknown
Flowering Plants	Phyllanthaceae	*Sauropus rhytidospermus*	Sauropus			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Picrodendraceae	*Petalostigma banksii*	Quinine Bush			0	Unknown	4	1987	0	Unknown
Flowering Plants	Picrodendraceae	*Petalostigma pubescens*	Quinine Tree			0	Unknown	10	1988	0	Unknown

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Flowering Plants	Erythroxylaceae	*Erythroxylum ellipticum*	Kerosene Wood			0	Unknown	2	1988	0	Unknown
Flowering Plants	Fabaceae	*Abrus precatorius*	Crab`s Eye			0	Unknown	3	1988	0	Unknown
Flowering Plants	Fabaceae	*Abrus precatorius subsp. precatorius*	Crab`s Eye			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia alleniana*	Needle-leaved Wattle			0	Unknown	3	1986	0	Unknown
Flowering Plants	Fabaceae	*Acacia ancistrocarpa*	Fitzroy Wattle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia calligera*	Wattle			0	Unknown	39	1993	0	Unknown
Flowering Plants	Fabaceae	*Acacia conspersa*	Wattle			0	Unknown	2	1971	0	Unknown
Flowering Plants	Fabaceae	*Acacia difficilis*	River Wattle			0	Unknown	4	1987	0	Unknown
Flowering Plants	Fabaceae	*Acacia dimidiata*	Swamp Wattle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia drepanocarpa subsp. latifolia*	Wattle			0	Unknown	2	1977	0	Unknown
Flowering Plants	Fabaceae	*Acacia galioides*	Wattle			0	Unknown	28	1986	0	Unknown
Flowering Plants	Fabaceae	*Acacia gonoclada*	Wattle			0	Unknown	8	1992	0	Unknown
Flowering Plants	Fabaceae	*Acacia hammondii*	Wattle			0	Unknown	11	1991	0	Unknown
Flowering Plants	Fabaceae	*Acacia hemignosta*	Club-leaf Wattle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia holosericea*	Candelabra Wattle			0	Unknown	4	1991	0	Unknown
Flowering Plants	Fabaceae	*Acacia humifusa*	Cape York Wattle			0	Unknown	2	1977	0	Unknown
Flowering Plants	Fabaceae	*Acacia latescens*	Ball Wattle			0	Unknown	4	1977	0	Unknown
Flowering Plants	Fabaceae	*Acacia limbata*	Wattle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia lycopodiifolia*	Cypress Wattle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia lysiphloia*	Turpentine Bush			0	Unknown	2	1987	0	Unknown
Flowering Plants	Fabaceae	*Acacia megalantha*	Wattle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia monticola*	Hill Turpentine			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia oncinocarpa*	Wattle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia platycarpa*	Ghost Wattle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia plectocarpa*	Wattle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia plectocarpa subsp. tanumbirinensis*	Wattle			0	Unknown	4	1988	0	Unknown
Flowering Plants	Fabaceae	*Acacia shirleyi*	Lancewood			0	Unknown	5	1991	0	Unknown
Flowering Plants	Fabaceae	*Acacia sublanata*	Spiny Wattle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia subternata*	Wattle			0	Unknown	6	1986	0	Unknown
Flowering Plants	Fabaceae	*Acacia umbellata*	Wattle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia wickhamii*	Wickham`s Wattle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Acacia wickhamii subsp. wickhamii*	Wattle			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Aeschynomene indica*	Budda Pea			0	Unknown	2	1959	0	Unknown
Flowering Plants	Fabaceae	*Bauhinia cunninghamii*	Butterfly Tree			0	Unknown	4	1987	0	Unknown
Flowering Plants	Fabaceae	*Bossiaea bossiaeoides*	Holly-leaved Pea-flower			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Cajanus pubescens*	Pigeon-pea			0	Unknown	8	1986	0	Unknown
Flowering Plants	Fabaceae	*Chamaecrista absus var. absus*	Hairy Cassia			0	Unknown	12	1995	0	Unknown
Flowering Plants	Fabaceae	*Chamaecrista mimosoides*	Five-leafed Cassia			0	Unknown	2	1986	0	Unknown
Flowering Plants	Fabaceae	*Chamaecrista nomame*	Cassia			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Chamaecrista nomame var. nomame*	Cassia			0	Unknown	2	1991	0	Unknown
Flowering Plants	Fabaceae	*Chamaecrista symonii*	Dwarf Cassia			0	Unknown	6	1985	0	Unknown

Group	Family Name	Scientific Name	Common Name	NT Status	National Status	#Observations	#Latest Observation Date	#Specimens	#Latest Speciman Date	#Surveys	#Latest Survey Record
Flowering Plants	Fabaceae	*Crotalaria brevis*	Rattlepod			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Crotalaria medicaginea*	Trefoil Rattlepod			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Crotalaria medicaginea var. neglecta*	Trefoil Rattlepod			0	Unknown	2	1986	0	Unknown
Flowering Plants	Fabaceae	*Crotalaria montana*	Rattlepod			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Crotalaria montana var. angustifolia*	Rattlepod			0	Unknown	2	1988	0	Unknown
Flowering Plants	Fabaceae	*Crotalaria novae-hollandiae*	New Holland Rattlepod			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Crotalaria ramosissima*	Rattlepod			0	Unknown	1	1988	0	Unknown
Flowering Plants	Fabaceae	*Cullen cinereum*	Annual Verbine			0	Unknown	2	1947	0	Unknown
Flowering Plants	Fabaceae	*Cullen plumosum*	Scurf-pea			0	Unknown	6	1987	0	Unknown
Flowering Plants	Fabaceae	*Desmodium brachypodum*	Large Tick-trefoil			0	Unknown	4	1989	0	Unknown
Flowering Plants	Fabaceae	*Desmodium campylocaulon*	Creeping Tick-trefoil			0	Unknown	4	2001	0	Unknown
Flowering Plants	Fabaceae	*Desmodium muelleri*	Tick-trefoil			0	Unknown	8	1994	0	Unknown
Flowering Plants	Fabaceae	*Dichrostachys spicata*	Single Thorn Prickly Bush			0	Unknown	2	1986	0	Unknown
Flowering Plants	Fabaceae	*Erythrina vespertilio subsp. vespertilio*	Bat Wing Coral Tree			0	Unknown	2	1987	0	Unknown
Flowering Plants	Fabaceae	*Erythrophleum chlorostachys*	Northern Ironwood			0	Unknown	2	1987	0	Unknown
Flowering Plants	Fabaceae	*Flemingia pauciflora*	Flemingia			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Galactia muelleri*	Mueller's Pea			0	Unknown	2	1988	0	Unknown
Flowering Plants	Fabaceae	*Galactia tenuiflora*	Poison Pea			0	Unknown	2	1987	0	Unknown
Flowering Plants	Fabaceae	*Glycine tomentella*	Rusty Glycine			0	Unknown	4	2001	0	Unknown
Flowering Plants	Fabaceae	*Indigofera colutea*	Sticky Indigo			0	Unknown	2	1986	0	Unknown
Flowering Plants	Fabaceae	*Indigofera haplophylla*	Indigo			0	Unknown	6	1988	0	Unknown
Flowering Plants	Fabaceae	*Indigofera linifolia*	Native Indigo			0	Unknown	4	1988	0	Unknown
Flowering Plants	Fabaceae	*Indigofera linnaei*	Birdsville Indigo			0	Unknown	6	1988	0	Unknown
Flowering Plants	Fabaceae	*Indigofera trita*	Indigo			0	Unknown	6	1988	0	Unknown
Flowering Plants	Fabaceae	*Jacksonia dilatata*	Cladode Pea			0	Unknown	4	1977	0	Unknown
Flowering Plants	Fabaceae	*Jacksonia odontoclada*	Jacksonia			0	Unknown	2	1971	0	Unknown
Flowering Plants	Fabaceae	*Mirbelia viminalis*	Yellow Broom			0	Unknown	2	1977	0	Unknown
Flowering Plants	Fabaceae	*Neptunia dimorphantha*	Sensitive Plant			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Neptunia gracilis*	Native Sensitive Plant			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Neptunia monosperma*	One-seeded Sensitive Plant			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Rhynchosia minima*	Native Pea			0	Unknown	6	1988	0	Unknown
Flowering Plants	Fabaceae	*Senna costata*	Cassia			0	Unknown	4	1991	0	Unknown
Flowering Plants	Fabaceae	*Senna venusta*	Graceful Cassia			0	Unknown	2	1986	0	Unknown
Flowering Plants	Fabaceae	*Sesbania muelleri*	Peabush			0	Unknown	1	1986	0	Unknown
Flowering Plants	Fabaceae	*Tephrosia brachyodon*	Red Pea-bush			0	Unknown	4	1988	0	Unknown
Flowering Plants	Fabaceae	*Tephrosia brachyodon var. longifolia*	Red Pea-bush			0	Unknown	1	1991	0	Unknown
Flowering Plants	Fabaceae	*Tephrosia conspicua*	Tephrosia			0	Unknown	2	1971	0	Unknown
Flowering Plants	Fabaceae	*Tephrosia delestangii*	Tephrosia			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Tephrosia leptoclada*	Tephrosia			0	Unknown	4	1986	0	Unknown
Flowering Plants	Fabaceae	*Tephrosia remotiflora*	Tephrosia			0	Unknown	2	1970	0	Unknown
Flowering Plants	Fabaceae	*Tephrosia rosea*	Flinder`s River Poison			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Tephrosia simplicifolia*	Tephrosia			0	Unknown	4	1979	0	Unknown

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Flowering Plants	Fabaceae	*Tephrosia sp. OT Station*	Tephrosia			0	Unknown	8	1986	0	Unknown
Flowering Plants	Fabaceae	*Uraria lagopodioides*	Purple Clover-weed			0	Unknown	6	1989	0	Unknown
Flowering Plants	Fabaceae	*Vachellia ditricha*	Wattle			0	Unknown	6	1986	0	Unknown
Flowering Plants	Fabaceae	*Vachellia valida*	Wattle			0	Unknown	2	1986	0	Unknown
Flowering Plants	Fabaceae	*Vigna lanceolata*	Maloga Bean			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Vigna lanceolata var. filiformis*	Maloga Bean			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Vigna lanceolata var. lanceolata*	Maloga Bean			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Fabaceae	*Zornia albiflora*	Zornia			0	Unknown	2	1947	0	Unknown
Flowering Plants	Fabaceae	*Zornia muriculata*	Zornia			0	Unknown	6	1988	0	Unknown
Flowering Plants	Fabaceae	*Zornia muriculata subsp. angustata*	Zornia			0	Unknown	2	1972	0	Unknown
Flowering Plants	Fabaceae	*Zornia prostrata*	Zornia			0	Unknown	2	1986	0	Unknown
Flowering Plants	Polygalaceae	*Polygala barbata*	Milkwort			0	Unknown	4	1991	0	Unknown
Flowering Plants	Polygalaceae	*Polygala longifolia*	Milkwort			0	Unknown	2	1995	0	Unknown
Flowering Plants	Polygalaceae	*Polygala orbicularis*	Milkwort			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Polygalaceae	*Polygala pterocarpa*	Milkwort			0	Unknown	2	2007	0	Unknown
Flowering Plants	Rhamnaceae	*Alphitonia excelsa*	Red Ash			0	Unknown	7	1989	0	Unknown
Flowering Plants	Rhamnaceae	*Ventilago viminalis*	Supplejack			0	Unknown	2	1987	0	Unknown
Flowering Plants	Cannabaceae	*Trema tomentosa*	Peach-leaved Poison-bush			0	Unknown	2	1977	0	Unknown
Flowering Plants	Moraceae	*Ficus cerasicarpa*	Fig			0	Unknown	6	1987	0	Unknown
Flowering Plants	Moraceae	*Ficus subpuberula*	Fig			0	Unknown	4	1977	0	Unknown
Flowering Plants	Moraceae	*Ficus virens var. virens*	Banyan			0	Unknown	2	1977	0	Unknown
Flowering Plants	Cucurbitaceae	*Cucumis argenteus*	Melon			0	Unknown	2	2008	0	Unknown
Flowering Plants	Cucurbitaceae	*Cucumis melo*	Ulcardo Melon			0	Unknown	0	Unknown	5	1991
Flowering Plants	Casuarinaceae	*Casuarina cunninghamiana subsp. miodon*	River Oak			0	Unknown	2	1988	0	Unknown
Flowering Plants	Capparaceae	*Capparis lasiantha*	Split-arse-jack			0	Unknown	2	1987	0	Unknown
Flowering Plants	Capparaceae	*Capparis umbonata*	Northern Wild Orange			0	Unknown	4	1986	0	Unknown
Flowering Plants	Cleomaceae	*Cleome viscosa*	Tickweed			0	Unknown	4	1991	0	Unknown
Flowering Plants	Bixaceae	*Cochlospermum fraseri*	Kapok Bush			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Bixaceae	*Cochlospermum gregorii*	Cotton Tree			0	Unknown	5	1989	0	Unknown
Flowering Plants	Malvaceae	*Abutilon fraseri subsp. fraseri*	Dwarf Lantern-bush			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Malvaceae	*Abutilon hannii*	Mallow			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Malvaceae	*Abutilon hannii subsp. prostrate*	Lantern Bush			0	Unknown	7	1988	0	Unknown
Flowering Plants	Malvaceae	*Abutilon otocarpum*	Desert Chinese Lantern			0	Unknown	6	1991	0	Unknown
Flowering Plants	Malvaceae	*Brachychiton diversifolius subsp. diversifolius*	Northern Kurrajong			0	Unknown	2	1977	0	Unknown
Flowering Plants	Malvaceae	*Brachychiton paradoxus*	Red-flowering Kurrajong			0	Unknown	2	1991	0	Unknown
Flowering Plants	Malvaceae	*Corchorus aestuans*	Grubweed			0	Unknown	2	1988	0	Unknown
Flowering Plants	Malvaceae	*Corchorus sidoides*	Flannel Weed			0	Unknown	2	1991	0	Unknown
Flowering Plants	Malvaceae	*Corchorus sidoides subsp. sidoides*	Flannel Weed			0	Unknown	8	1991	0	Unknown

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Flowering Plants	Malvaceae	*Corchorus sidoides subsp. vermicularis*	Flannel Weed			0	Unknown	2	1992	0	Unknown
Flowering Plants	Malvaceae	*Corchorus tridens*	Grubweed			0	Unknown	2	2001	0	Unknown
Flowering Plants	Malvaceae	*Gossypium australe*	Native Cotton			0	Unknown	5	1991	0	Unknown
Flowering Plants	Malvaceae	*Grewia breviflora*	Coffee Fruit			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Malvaceae	*Grewia mesomischa*	Grewia			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Malvaceae	*Grewia retusifolia*	Emu Berries			0	Unknown	8	1987	0	Unknown
Flowering Plants	Malvaceae	*Helicteres isora*	Spiral Bush			0	Unknown	2	1972	0	Unknown
Flowering Plants	Malvaceae	*Herissantia crispa*	Indian Mallow			0	Unknown	6	1991	0	Unknown
Flowering Plants	Malvaceae	*Hibiscus leptocladus*	Variable-leaf Hibiscus			0	Unknown	2	1972	0	Unknown
Flowering Plants	Malvaceae	*Hibiscus meraukensis*	Ballerina Hibiscus			0	Unknown	8	1989	0	Unknown
Flowering Plants	Malvaceae	*Hibiscus pentaphyllus*	Native Hibiscus			0	Unknown	11	1991	0	Unknown
Flowering Plants	Malvaceae	*Hibiscus sturtii*	Sturt`s Hibiscus			0	Unknown	4	1989	0	Unknown
Flowering Plants	Malvaceae	*Hibiscus sturtii var. campylochlamys*	Sturt`s Hibiscus			0	Unknown	10	1979	0	Unknown
Flowering Plants	Malvaceae	*Hibiscus sturtii var. grandiflorus*	Sturt`s Hibiscus			0	Unknown	2	1987	0	Unknown
Flowering Plants	Malvaceae	*Hibiscus verdcourtii*	Bladder Ketmia			0	Unknown	4	1979	0	Unknown
Flowering Plants	Malvaceae	*Hibiscus zonatus*	Pink Perennial Hibiscus			0	Unknown	1	1977	0	Unknown
Flowering Plants	Malvaceae	*Melhania oblongifolia*	Velvet Hibiscus			0	Unknown	6	1987	0	Unknown
Flowering Plants	Malvaceae	*Sida brachypoda*	Sida			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Malvaceae	*Sida fibulifera*	Silver Sida			0	Unknown	3	1986	0	Unknown
Flowering Plants	Malvaceae	*Sida filiformis*	Fine Sida			0	Unknown	2	1989	0	Unknown
Flowering Plants	Malvaceae	*Sida hackettiana*	Sida			0	Unknown	10	1987	0	Unknown
Flowering Plants	Malvaceae	*Sida rohlenae*	Shrub Sida			0	Unknown	2	1987	0	Unknown
Flowering Plants	Malvaceae	*Sida rohlenae subsp. rohlenae*	Shrub Sida			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Malvaceae	*Sida sp. Mt Bundey*	Sida			0	Unknown	2	2001	0	Unknown
Flowering Plants	Malvaceae	*Sida spinosa*	Spiny Sida			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Malvaceae	*Sida trichopoda*	High Sida			0	Unknown	2	1986	0	Unknown
Flowering Plants	Malvaceae	*Triumfetta fissurata*	Burbark	DD		0	Unknown	2	1977	0	Unknown
Flowering Plants	Malvaceae	*Triumfetta glaucescens*	Burbark			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Malvaceae	*Triumfetta micracantha*	Burbark			0	Unknown	6	1986	0	Unknown
Flowering Plants	Malvaceae	*Triumfetta plumigera*	Burbark			0	Unknown	6	1986	0	Unknown
Flowering Plants	Malvaceae	*Waltheria indica*	Waltheria			0	Unknown	3	1987	0	Unknown
Flowering Plants	Thymelaeaceae	*Thecanthes punicea*	Red Wax Plant			0	Unknown	6	2001	0	Unknown
Flowering Plants	Thymelaeaceae	*Thecanthes sanguinea*	Thecanthes			0	Unknown	2	1985	0	Unknown
Flowering Plants	Sapindaceae	*Atalaya hemiglauca*	Whitewood			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Sapindaceae	*Dodonaea hispidula*	False Hopbush			0	Unknown	1	1986	0	Unknown
Flowering Plants	Sapindaceae	*Dodonaea lanceolata*	Yellow Hop-bush			0	Unknown	2	1987	0	Unknown
Flowering Plants	Sapindaceae	*Dodonaea lanceolata var. lanceolata*	Yellow Hop-bush			0	Unknown	2	1979	0	Unknown
Flowering Plants	Sapindaceae	*Dodonaea oxyptera*	Hop Bush			0	Unknown	2	1977	0	Unknown
Flowering Plants	Sapindaceae	*Dodonaea physocarpa*	Balloon Hopbush			0	Unknown	17	1989	0	Unknown
Flowering Plants	Sapindaceae	*Dodonaea platyptera*	Hop Bush			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Sapindaceae	*Dodonaea stenophylla*	Netted Hopbush			0	Unknown	15	2001	0	Unknown
Flowering Plants	Meliaceae	*Owenia vernicosa*	Emu Apple			0	Unknown	2	1988	0	Unknown

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Flowering Plants	Rutaceae	*Boronia lanceolata*	Boronia			0	Unknown	2	1977	0	Unknown
Flowering Plants	Ebenaceae	*Diospyros humilis*	Small-leaved Ebony			0	Unknown	2	1987	0	Unknown
Flowering Plants	Ebenaceae	*Diospyros rugosula*	Iron Tree			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Boraginaceae	*Coldenia procumbens*	Coldenia			0	Unknown	2	1988	0	Unknown
Flowering Plants	Boraginaceae	*Ehretia saligna*	Coonta			0	Unknown	2	1988	0	Unknown
Flowering Plants	Boraginaceae	*Ehretia saligna var. membranifolia*	Coonta			0	Unknown	4	1988	0	Unknown
Flowering Plants	Boraginaceae	*Heliotropium bracteatum*	Heliotrope			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Boraginaceae	*Heliotropium glabellum*	Heliotrope			0	Unknown	4	1986	0	Unknown
Flowering Plants	Boraginaceae	*Heliotropium tenuifolium*	Devil’s Son			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Boraginaceae	*Trichodesma zeylanicum*	Cattle Bush			0	Unknown	2	1988	0	Unknown
Flowering Plants	Rubiaceae	*Gardenia ewartii subsp. ewartii*	Native Gardenia			0	Unknown	6	1988	0	Unknown
Flowering Plants	Rubiaceae	*Gardenia megasperma*	Native Gardenia			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Rubiaceae	*Gardenia pyriformis subsp. orientalis*	Native Gardenia			0	Unknown	2	1977	0	Unknown
Flowering Plants	Rubiaceae	*Oldenlandia argillacea*	Oldenlandia			0	Unknown	2	1986	0	Unknown
Flowering Plants	Rubiaceae	*Oldenlandia galioides*	Oldenlandia			0	Unknown	4	1995	0	Unknown
Flowering Plants	Rubiaceae	*Oldenlandia mitrasacmoides*	Oldenlandia			0	Unknown	4	1991	0	Unknown
Flowering Plants	Rubiaceae	*Psydrax attenuata var. myrmecophila*	Canthium			0	Unknown	2	1977	0	Unknown
Flowering Plants	Rubiaceae	*Spermacoce auriculata*	Buttonweed			0	Unknown	2	1988	0	Unknown
Flowering Plants	Rubiaceae	*Spermacoce brachystema*	Buttonweed	DD		0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Rubiaceae	*Spermacoce dolichosperma*	Buttonweed			0	Unknown	10	2001	0	Unknown
Flowering Plants	Rubiaceae	*Spermacoce platyloba*	Buttonweed			0	Unknown	2	1977	0	Unknown
Flowering Plants	Rubiaceae	*Spermacoce stenophylla*	Blue Buttonweed			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Rubiaceae	*Tarenna dallachiana subsp. expandens*	Tree Ixora			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Loganiaceae	*Mitrasacme micrantha*	Mitre Plant			0	Unknown	2	2001	0	Unknown
Flowering Plants	Apocynaceae	*Carissa lanceolata*	Conkerberry			0	Unknown	4	1987	0	Unknown
Flowering Plants	Apocynaceae	*Marsdenia australis*	Bush Banana			0	Unknown	4	1987	0	Unknown
Flowering Plants	Apocynaceae	*Marsdenia geminata*	Milkvine			0	Unknown	6	2001	0	Unknown
Flowering Plants	Apocynaceae	*Marsdenia trinervis*	Milkvine			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Apocynaceae	*Marsdenia viridiflora subsp. tropica*	Bush Banana			0	Unknown	4	1988	0	Unknown
Flowering Plants	Apocynaceae	*Sarcostemma viminale*	Caustic Vine			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Apocynaceae	*Sarcostemma viminale subsp. brunonianum*	Caustic Vine			0	Unknown	2	1979	0	Unknown
Flowering Plants	Apocynaceae	*Secamone elliptica*	Corky Milk Vine			0	Unknown	7	1991	0	Unknown
Flowering Plants	Apocynaceae	*Tylophora cinerascens*	Tylophora			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Apocynaceae	*Tylophora flexuosa*	Tylophora			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Apocynaceae	*Wrightia saligna*	Milk Bush			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Hydroleaceae	*Hydrolea zeylanica*	False Fiddle-leaf			0	Unknown	3	1991	0	Unknown
Flowering Plants	Solanaceae	*Physalis angulata*	Wild Gooseberry			0	Unknown	2	1988	0	Unknown
Flowering Plants	Solanaceae	*Solanum dioicum*	Wild Tomato			0	Unknown	2	1977	0	Unknown
Flowering Plants	Solanaceae	*Solanum echinatum*	Wild Tomato			0	Unknown	4	1989	0	Unknown
Flowering Plants	Solanaceae	*Solanum ferocissimum*	Spiny Potato-bush			0	Unknown	0	Unknown	0	Unknown

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Flowering Plants	Solanaceae	*Solanum lucani*	Thorny Nightshade			0	Unknown	4	1972	0	Unknown
Flowering Plants	Convolvulaceae	*Bonamia brevifolia*	Bonamia			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Convolvulaceae	*Bonamia media*	Grey-vine			0	Unknown	3	1991	0	Unknown
Flowering Plants	Convolvulaceae	*Bonamia pannosa*	Bonamia			0	Unknown	4	1986	0	Unknown
Flowering Plants	Convolvulaceae	*Evolvulus alsinoides*	Blue Periwinkle			0	Unknown	8	1987	0	Unknown
Flowering Plants	Convolvulaceae	*Evolvulus alsinoides var. decumbens*	Blue Periwinkle			0	Unknown	2	1979	0	Unknown
Flowering Plants	Convolvulaceae	*Ipomoea argillicola*	Cow-vine			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Convolvulaceae	*Ipomoea eriocarpa*	Small Pink Convolvulus			0	Unknown	2	1986	0	Unknown
Flowering Plants	Convolvulaceae	*Ipomoea gracilis*	Slender Bindweed			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Convolvulaceae	*Ipomoea nil*	Morning Glory			0	Unknown	1	2001	0	Unknown
Flowering Plants	Convolvulaceae	*Ipomoea plebeia*	Bell Vine			0	Unknown	4	2001	0	Unknown
Flowering Plants	Convolvulaceae	*Ipomoea polymorpha*	Silky Cow-vine			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Convolvulaceae	*Jacquemontia paniculata*	Purple-flowered Jungle Creeper			0	Unknown	4	1991	0	Unknown
Flowering Plants	Convolvulaceae	*Merremia gemella*	Merremia			0	Unknown	2	1988	0	Unknown
Flowering Plants	Convolvulaceae	*Merremia incisa*	Merremia	DD		0	Unknown	2	1986	0	Unknown
Flowering Plants	Convolvulaceae	*Operculina aequisepala*	Potato Vine			0	Unknown	2	1979	0	Unknown
Flowering Plants	Convolvulaceae	*Polymeria ambigua*	Creeping Polymeria			0	Unknown	5	1991	0	Unknown
Flowering Plants	Convolvulaceae	*Xenostegia tridentata*	Morning Vine			0	Unknown	2	1987	0	Unknown
Flowering Plants	Oleaceae	*Jasminum molle*	Stiff Jasmine			0	Unknown	8	1989	0	Unknown
Flowering Plants	Acanthaceae	*Brunoniella australis*	Blue Trumpet			0	Unknown	5	1991	0	Unknown
Flowering Plants	Acanthaceae	*Hygrophila angustifolia*	Hygrophila			0	Unknown	4	1983	0	Unknown
Flowering Plants	Acanthaceae	*Hypoestes floribunda*	Rosy Hypoestes			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Acanthaceae	*Hypoestes floribunda var. cinerea*	Rosy Hypoestes			0	Unknown	4	1991	0	Unknown
Flowering Plants	Acanthaceae	*Rostellularia adscendens*	Pink Tongues			0	Unknown	2	1989	0	Unknown
Flowering Plants	Acanthaceae	*Rostellularia adscendens var. clementii*	Pink Tongues			0	Unknown	2	1989	0	Unknown
Flowering Plants	Acanthaceae	*Rostellularia adscendens var. latifolia*	Pink Tongues			0	Unknown	2	1988	0	Unknown
Flowering Plants	Bignoniaceae	*Dolichandrone filiformis*	Whistling Tree			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Bignoniaceae	*Dolichandrone heterophylla*	Lemon Wood			0	Unknown	4	1989	0	Unknown
Flowering Plants	Lamiaceae	*Clerodendrum floribundum*	Smooth Spiderbush			0	Unknown	4	1988	0	Unknown
Flowering Plants	Lamiaceae	*Premna acuminata*	Premna			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Phrymaceae	*Glossostigma diandrum*	Two-Anther Mud-Mat			0	Unknown	2	1991	0	Unknown
Flowering Plants	Phrymaceae	*Peplidium muelleri*	Pepilidium			0	Unknown	4	1995	0	Unknown
Flowering Plants	Orobanchaceae	*Buchnera linearis*	Dainty Bush Flower			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Plantaginaceae	*Bacopa floribunda*	Bacopa			0	Unknown	2	1971	0	Unknown
Flowering Plants	Plantaginaceae	*Stemodia glabella*	Smooth Bluerod			0	Unknown	4	1988	0	Unknown
Flowering Plants	Plantaginaceae	*Stemodia lathraia*	Bluerod			0	Unknown	2	1991	0	Unknown
Flowering Plants	Plantaginaceae	*Stemodia lythrifolia*	Bluerod			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Plantaginaceae	*Stemodia viscosa*	Sticky Bluerod			0	Unknown	2	1978	0	Unknown
Flowering Plants	Plantaginaceae	*Striga curviflora*	Witchweed			0	Unknown	2	1991	0	Unknown
Flowering Plants	Lentibulariaceae	*Utricularia stellaris*	Bladderwort	DD		0	Unknown	4	1987	0	Unknown
Flowering Plants	Araliaceae	*Trachymene didiscoides*	Wild Parsnip			0	Unknown	2	1977	0	Unknown
Flowering Plants	Campanulaceae	*Isotoma sp. Tanumbirini*	Isotome	DD		0	Unknown	4	2001	0	Unknown

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Flowering Plants	Campanulaceae	*Lobelia dioica*	Lobelia			0	Unknown	4	1991	0	Unknown
Flowering Plants	Campanulaceae	*Lobelia douglasiana*	Slender Lobelia			0	Unknown	2	1991	0	Unknown
Flowering Plants	Campanulaceae	*Wahlenbergia caryophylloides*	Northern Bluebell			0	Unknown	2	1977	0	Unknown
Flowering Plants	Stylidiaceae	*Stylidium adenophorum*	Trigger Plant			0	Unknown	2	1977	0	Unknown
Flowering Plants	Stylidiaceae	*Stylidium floodii*	Trigger Plant			0	Unknown	2	1991	0	Unknown
Flowering Plants	Menyanthaceae	*Nymphoides crenata*	Wavy Marshwort			0	Unknown	7	1994	0	Unknown
Flowering Plants	Goodeniaceae	*Brunonia australis*	Blue Pincushion			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Goodeniaceae	*Goodenia armitiana*	Narrow-leaved Goodenia			0	Unknown	2	1947	0	Unknown
Flowering Plants	Goodeniaceae	*Goodenia byrnesii*	Split-end Goodenia			0	Unknown	2	1991	0	Unknown
Flowering Plants	Goodeniaceae	*Goodenia gracilis*	Slender Goodenia			0	Unknown	7	2001	0	Unknown
Flowering Plants	Goodeniaceae	*Goodenia hispida*	Goodenia			0	Unknown	6	2001	0	Unknown
Flowering Plants	Goodeniaceae	*Goodenia janamba*	Goodenia			0	Unknown	2	1947	0	Unknown
Flowering Plants	Goodeniaceae	*Goodenia lamprosperma*	Goodenia			0	Unknown	6	2001	0	Unknown
Flowering Plants	Goodeniaceae	*Goodenia leiosperma*	Goodenia			0	Unknown	2	1989	0	Unknown
Flowering Plants	Goodeniaceae	*Goodenia odonnellii*	Goodenia			0	Unknown	2	1977	0	Unknown
Flowering Plants	Goodeniaceae	*Goodenia pilosa*	Hairy Goodenia			0	Unknown	4	1991	0	Unknown
Flowering Plants	Goodeniaceae	*Goodenia viscidula*	Goodenia			0	Unknown	4	1991	0	Unknown
Flowering Plants	Goodeniaceae	*Scaevola revoluta*	Fanflower			0	Unknown	4	1983	0	Unknown
Flowering Plants	Asteraceae	*Bidens bipinnata*	Cobbler's Pegs			0	Unknown	4	1989	0	Unknown
Flowering Plants	Asteraceae	*Blumea diffusa*	Daisy			0	Unknown	2	1977	0	Unknown
Flowering Plants	Asteraceae	*Blumea integrifolia*	Daisy			0	Unknown	2	1978	0	Unknown
Flowering Plants	Asteraceae	*Blumea saxatilis*	Daisy			0	Unknown	2	1989	0	Unknown
Flowering Plants	Asteraceae	*Blumea tenella*	Daisy			0	Unknown	8	2001	0	Unknown
Flowering Plants	Asteraceae	*Centipeda minima subsp. macrocephala*	Spreading Sneezeweed			0	Unknown	4	1991	0	Unknown
Flowering Plants	Asteraceae	*Centipeda nidiformis*	Sneezeweed			0	Unknown	2	1987	0	Unknown
Flowering Plants	Asteraceae	*Eclipta sp. Humpty Doo*	Twin-heads			0	Unknown	2	1978	0	Unknown
Flowering Plants	Asteraceae	*Flaveria australasica*	Yellow Twin Stem			0	Unknown	2	1979	0	Unknown
Flowering Plants	Asteraceae	*Pterocaulon serrulatum*	Fruit Salad Bush			0	Unknown	0	Unknown	0	Unknown
Flowering Plants	Asteraceae	*Pterocaulon serrulatum var. velutinum*	Fruit Salad Bush			0	Unknown	2	1987	0	Unknown
Flowering Plants	Asteraceae	*Pterocaulon sphacelatum*	Apple Bush			0	Unknown	4	1988	0	Unknown
Flowering Plants	Asteraceae	*Wedelia verbesinoides*	Daisy			0	Unknown	1	1977	0	Unknown
Frogs	Myobatrachidae	*Crinia bilingua*	Bilingual Froglet			0	Unknown	2	1987	0	Unknown
Frogs	Myobatrachidae	*Crinia deserticola*	Desert Froglet			0	Unknown	12	1977	0	Unknown
Frogs	Myobatrachidae	*Uperoleia lithomoda*	Stonemason Toadlet			0	Unknown	3	2010	0	Unknown
Frogs	Hylidae	*Litoria australis*	Giant Frog			1	1988	2	2006	0	Unknown
Frogs	Hylidae	*Litoria caerulea*	Green Tree-frog			12	2001	0	Unknown	1	1991
Frogs	Hylidae	*Litoria cultripes*	Knife-footed Frog			0	Unknown	1	2001	0	Unknown
Frogs	Hylidae	*Litoria pallida*	Pale Frog			1	1987	14	1987	0	Unknown
Frogs	Hylidae	*Litoria rothii*	Roth`s Tree-Frog			0	Unknown	2	1977	0	Unknown
Frogs	Hylidae	*Litoria rubella*	Red Tree-frog			2	2001	5	1987	0	Unknown
Reptiles	Crocodylidae	*Crocodylus johnstoni*	Freshwater Crocodile			1	1987	0	Unknown	0	Unknown
Reptiles	Gekkonidae	*Diplodactylus conspicillatus*	Fat-tailed Gecko			11	1994	3	1994	2	1991
Reptiles	Gekkonidae	*Gehyra australis*	Northern Dtella			2	1988	6	2001	2	1991

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Reptiles	Gekkonidae	*Gehyra nana*	Northern Spotted Rock Dtella			0	Unknown	1	1977	0	Unknown
Reptiles	Gekkonidae	*Heteronotia binoei*	Bynoe`s Gecko			2	1988	11	1989	3	1999
Reptiles	Gekkonidae	*Lucasium immaculatum*	Pale-striped Ground Gecko			0	Unknown	1	1994	0	Unknown
Reptiles	Gekkonidae	*Lucasium stenodactylum*	Crowned Gecko			4	1999	3	1988	0	Unknown
Reptiles	Gekkonidae	*Oedura rhombifer*	Zig-zag Gecko			0	Unknown	0	Unknown	2	1999
Reptiles	Gekkonidae	*Rhynchoedura ornata*	Beaked Gecko			3	1994	5	1994	4	1999
Reptiles	Gekkonidae	*Strophurus ciliaris*	Spiny-tailed Gecko			14	1994	0	Unknown	1	1991
Reptiles	Pygopodidae	*Delma borea*	Rusty-topped Delma			2	1994	0	Unknown	0	Unknown
Reptiles	Pygopodidae	*Lialis burtonis*	Burton`s Legless Lizard			17	1994	0	Unknown	0	Unknown
Reptiles	Pygopodidae	*Pygopus steelescotti*	Northern Hooded Scaly-foot			15	1994	0	Unknown	0	Unknown
Reptiles	Scincidae	*Carlia amax*	Two-Spined Rainbow Skink			4	2001	8	1989	1	1993
Reptiles	Scincidae	*Carlia triacantha*	Three-Spined Rainbow Skink			1	1987	2	1987	0	Unknown
Reptiles	Scincidae	*Cryptoblepharus metallicus*	Metallic Snake-eyed Skink			0	Unknown	1	1959	0	Unknown
Reptiles	Scincidae	*Cryptoblepharus plagiocephalus*	Arboreal Snake-eyed Skink			0	Unknown	0	Unknown	4	1991
Reptiles	Scincidae	*Ctenotus borealis*	Northern Ctenotus			0	Unknown	3	1989	0	Unknown
Reptiles	Scincidae	*Ctenotus helenae*	Helen`s Ctenotus			0	Unknown	1	1977	0	Unknown
Reptiles	Scincidae	*Ctenotus inornatus*	Plain Ctenotus			6	1995	5	1994	6	1993
Reptiles	Scincidae	*Ctenotus leonhardii*	Leonhardi`s Ctenotus			1	1995	0	Unknown	0	Unknown
Reptiles	Scincidae	*Ctenotus pantherinus*	Leopard Ctenotus			4	1994	1	1977	2	1991
Reptiles	Scincidae	*Ctenotus pulchellus*	Pretty Ctenotus			1	1994	4	2001	2	1991
Reptiles	Scincidae	*Ctenotus robustus*	Robust Ctenotus			6	1994	3	1988	0	Unknown
Reptiles	Scincidae	*Ctenotus schomburgkii*	Schomburk`s Ctenotus			2	1994	5	1994	2	1991
Reptiles	Scincidae	*Ctenotus spaldingi*	Spalding`s Ctenotus			2	1988	6	2001	1	1999
Reptiles	Scincidae	*Liopholis striata*	Striated Egernia			0	Unknown	1	2001	0	Unknown
Reptiles	Scincidae	*Eremiascincus isolepis*	Smooth-Tailed Skink			2	1994	3	1994	0	Unknown
Reptiles	Scincidae	*Glaphyromorphus darwiniensis*	Darwin Skink			0	Unknown	0	Unknown	2	1991
Reptiles	Scincidae	*Lerista bipes*	Two-Toed Lerista			0	Unknown	1	2001	0	Unknown
Reptiles	Scincidae	*Lerista griffini*	Griffin`s Lerista			0	Unknown	1	1991	2	1991
Reptiles	Scincidae	*Lerista orientalis*	Eastern Lerista			3	1991	4	1991	3	1991
Reptiles	Scincidae	*Menetia greyii*	Grey`s Menetia			2	1988	4	2001	0	Unknown
Reptiles	Scincidae	*Menetia maini*	Main`s Menetia			0	Unknown	0	Unknown	2	1991
Reptiles	Scincidae	*Morethia storri*	Storr`s Snake-Eyed Skink			0	Unknown	2	1988	0	Unknown
Reptiles	Scincidae	*Tiliqua multifasciata*	Centralian Blue-Tongued Lizard			7	1994	0	Unknown	0	Unknown
Reptiles	Scincidae	*Tiliqua scincoides*	Common Blue-Tongued Lizard	DD		3	1994	1	1988	0	Unknown
Reptiles	Agamidae	*Chlamydosaurus kingii*	Frilled Lizard			0	Unknown	0	Unknown	1	1991
Reptiles	Agamidae	*Ctenophorus nuchalis*	Central Netted Dragon			0	Unknown	0	Unknown	1	1993
Reptiles	Agamidae	*Diporiphora bilineata*	Two-Lined Dragon			0	Unknown	1	1971	0	Unknown
Reptiles	Agamidae	*Diporiphora magna*	Yellow-sided Two-line Dragon			0	Unknown	4	2005	0	Unknown
Reptiles	Agamidae	*Lophognathus gilberti*	Gilbert`s Dragon			4	2001	6	2005	7	1993
Reptiles	Varanidae	*Varanus acanthurus*	Ridge-tailed Monitor			5	1995	0	Unknown	0	Unknown

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Reptiles	Varanidae	*Varanus gouldii*	Sand Goanna			3	2001	1	1999	3	1991
Reptiles	Varanidae	*Varanus mertensi*	Mertens` Water Monitor	VU		3	1993	0	Unknown	1	1993
Reptiles	Varanidae	*Varanus scalaris*	Spotted Tree Monitor	DD		2	1988	0	Unknown	0	Unknown
Reptiles	Varanidae	*Varanus tristis*	Black-tailed Monitor			1	2001	1	1977	0	Unknown
Reptiles	Typhlopidae	*Ramphotyphlops diversus*	Northern Blind Snake			0	Unknown	1	2001	0	Unknown
Reptiles	Typhlopidae	*Ramphotyphlops unguirostris*	Claw-snouted Blind Snake			1	1988	1	1988	0	Unknown
Reptiles	Pythonidae	*Antaresia childreni*	Children`s Python			4	1994	1	1988	1	1991
Reptiles	Elapidae	*Brachyurophis incinctus*	Unbanded Shovel-nosed Snake			1	1994	0	Unknown	0	Unknown
Reptiles	Elapidae	*Brachyurophis roperi*	Northern Shovel-nosed Snake			2	1994	0	Unknown	0	Unknown
Reptiles	Elapidae	*Demansia olivacea*	Olive Whip Snake	DD		2	1994	0	Unknown	0	Unknown
Reptiles	Elapidae	*Demansia papuensis*	Papaun Whip Snake			0	Unknown	1	1978	0	Unknown
Reptiles	Elapidae	*Furina ornata*	Orange-naped Snake			1	1994	1	1994	0	Unknown
Reptiles	Elapidae	*Pseudechis australis*	King Brown Snake			1	1988	0	Unknown	0	Unknown
Reptiles	Elapidae	*Pseudonaja nuchalis*	Western Brown Snake			2	1994	0	Unknown	0	Unknown
Reptiles	Elapidae	*Suta punctata*	Little Spotted Snake			4	1994	0	Unknown	0	Unknown
Birds	Phasianidae	*Coturnix ypsilophora*	Brown Quail			4	2001	0	Unknown	3	1999
Birds	Anatidae	*Chenonetta jubata*	Australian Wood Duck			1	1987	0	Unknown	0	Unknown
Birds	Anatidae	*Anas superciliosa*	Pacific Black Duck			2	1987	0	Unknown	0	Unknown
Birds	Podicipedidae	*Tachybaptus novaehollandiae*	Australasian Grebe			1	1978	0	Unknown	0	Unknown
Birds	Podicipedidae	*Poliocephalus poliocephalus*	Hoary-headed Grebe			1	1988	0	Unknown	0	Unknown
Birds	Columbidae	*Phaps chalcoptera*	Common Bronzewing			3	1999	0	Unknown	1	1993
Birds	Columbidae	*Ocyphaps lophotes*	Crested Pigeon			11	2000	0	Unknown	2	1993
Birds	Columbidae	*Geophaps plumifera*	Spinifex Pigeon			0	Unknown	0	Unknown	1	1993
Birds	Columbidae	*Geopelia cuneata*	Diamond Dove			15	2000	0	Unknown	15	1993
Birds	Columbidae	*Geopelia striata*	Peaceful Dove			23	2000	1	1987	5	1993
Birds	Columbidae	*Geopelia humeralis*	Bar-shouldered Dove			7	2000	0	Unknown	4	1993
Birds	Podargidae	*Podargus strigoides*	Tawny Frogmouth			2	1991	0	Unknown	2	1993
Birds	Eurostopodidae	*Eurostopodus argus*	Spotted Nightjar			3	2000	0	Unknown	0	Unknown
Birds	Aegothelidae	*Aegotheles cristatus*	Australian Owlet-nightjar			4	2001	0	Unknown	4	1993
Birds	Anhingidae	*Anhinga novaehollandiae*	Australasian Darter			1	1987	0	Unknown	0	Unknown
Birds	Phalacrocoracidae	*Microcarbo melanoleucos*	Little Pied Cormorant			1	1987	0	Unknown	0	Unknown
Birds	Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican			1	1987	0	Unknown	0	Unknown
Birds	Ciconiidae	*Ephippiorhynchus asiaticus*	Black-necked Stork			1	2000	0	Unknown	0	Unknown
Birds	Ardeidae	*Ardea pacifica*	White-necked Heron			3	1987	0	Unknown	0	Unknown
Birds	Ardeidae	*Ardea modesta*	Eastern Great Egret			1	1978	0	Unknown	0	Unknown
Birds	Ardeidae	*Egretta novaehollandiae*	White-faced Heron			2	1987	0	Unknown	1	1993
Birds	Ardeidae	*Nycticorax caledonicus*	Nankeen Night Heron			2	1987	0	Unknown	0	Unknown
Birds	Threskiornithidae	*Threskiornis spinicollis*	Straw-necked Ibis			1	1978	0	Unknown	0	Unknown
Birds	Threskiornithidae	*Platalea regia*	Royal Spoonbill			2	1987	0	Unknown	0	Unknown
Birds	Threskiornithidae	*Platalea flavipes*	Yellow-billed Spoonbill			2	1987	0	Unknown	0	Unknown
Birds	Accipitridae	*Elanus axillaris*	Black-shouldered Kite			1	2001	0	Unknown	0	Unknown
Birds	Accipitridae	*Haliastur sphenurus*	Whistling Kite			4	2000	0	Unknown	1	1993
Birds	Accipitridae	*Milvus migrans*	Black Kite			4	2001	0	Unknown	1	1993

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Birds	Accipitridae	*Accipiter fasciatus*	Brown Goshawk			4	1993	0	Unknown	3	1993
Birds	Accipitridae	*Accipiter cirrocephalus*	Collared Sparrowhawk			1	1998	0	Unknown	1	1993
Birds	Accipitridae	*Circus assimilis*	Spotted Harrier			3	1999	0	Unknown	0	Unknown
Birds	Accipitridae	*Aquila audax*	Wedge-tailed Eagle			3	2000	0	Unknown	2	1993
Birds	Accipitridae	*Hieraaetus morphnoides*	Little Eagle			1	1999	0	Unknown	0	Unknown
Birds	Falconidae	*Falco cenchroides*	Nankeen Kestrel			2	1999	0	Unknown	0	Unknown
Birds	Falconidae	*Falco berigora*	Brown Falcon			16	2001	0	Unknown	3	1993
Birds	Falconidae	*Falco longipennis*	Australian Hobby			1	1979	0	Unknown	1	1993
Birds	Gruidae	*Grus rubicunda*	Brolga			3	1989	0	Unknown	0	Unknown
Birds	Otididae	*Ardeotis australis*	Australian Bustard			7	2000	0	Unknown	0	Unknown
Birds	Burhinidae	*Burhinus grallarius*	Bush Stone-curlew			8	2001	0	Unknown	2	1993
Birds	Charadriidae	*Elseyornis melanops*	Black-fronted Dotterel			2	1987	0	Unknown	0	Unknown
Birds	Charadriidae	*Vanellus miles*	Masked Lapwing			1	1987	0	Unknown	0	Unknown
Birds	Turnicidae	*Turnix maculosus*	Red-backed Button-quail			3	2001	0	Unknown	2	1991
Birds	Turnicidae	*Turnix pyrrhothorax*	Red-chested Button-quail			0	Unknown	0	Unknown	1	1993
Birds	Turnicidae	*Turnix velox*	Little Button-quail			2	1991	0	Unknown	2	1991
Birds	Cacatuidae	*Calyptorhynchus banksii macrorhynchus*	Red-tailed Black-cockatoo	N		14	2001	0	Unknown	0	Unknown
Birds	Cacatuidae	*Eulophus roseicapilla*	Galah			19	2002	0	Unknown	7	1999
Birds	Cacatuidae	*Nymphicus hollandicus*	Cockatiel			6	1999	0	Unknown	1	1993
Birds	Psittacidae	*Trichoglossus haematodus*	Rainbow Lorikeet			0	Unknown	0	Unknown	1	1993
Birds	Psittacidae	*Psitteuteles versicolor*	Varied Lorikeet			3	2001	0	Unknown	1	1993
Birds	Psittacidae	*Aprosmictus erythropterus*	Red-winged Parrot			14	2001	0	Unknown	2	1993
Birds	Psittacidae	*Psephotus dissimilis*	Hooded Parrot			0	Unknown	0	Unknown	1	1993
Birds	Psittacidae	*Melopsittacus undulatus*	Budgerigar			3	1991	0	Unknown	3	1993
Birds	Cuculidae	*Centropus phasianinus*	Pheasant Coucal			3	2001	0	Unknown	1	1993
Birds	Cuculidae	*Eudynamys orientalis*	Eastern Koel			3	1999	0	Unknown	0	Unknown
Birds	Cuculidae	*Scythrops novaehollandiae*	Channel-billed Cuckoo			1	1988	0	Unknown	0	Unknown
Birds	Cuculidae	*Chalcites basalis*	Horsfield`s Bronze-Cuckoo			4	2001	0	Unknown	1	1991
Birds	Cuculidae	*Cacomantis pallidus*	Pallid Cuckoo			2	1998	0	Unknown	0	Unknown
Birds	Cuculidae	*Cacomantis variolosus*	Brush Cuckoo			2	1999	0	Unknown	0	Unknown
Birds	Strigidae	*Ninox novaeseelandiae*	Southern Boobook			6	2001	0	Unknown	3	1991
Birds	Alcedinidae	*Ceyx azureus*	Azure Kingfisher			1	1987	0	Unknown	0	Unknown
Birds	Halcyonidae	*Dacelo leachii*	Blue-winged Kookaburra			4	2001	0	Unknown	0	Unknown
Birds	Halcyonidae	*Todiramphus pyrrhopygius*	Red-backed Kingfisher			2	1991	0	Unknown	2	1991
Birds	Halcyonidae	*Todiramphus sanctus*	Sacred Kingfisher			3	1999	0	Unknown	1	1991
Birds	Meropidae	*Merops ornatus*	Rainbow Bee-eater			12	2001	0	Unknown	2	1993
Birds	Climacteridae	*Climacteris melanura*	Black-tailed Treecreeper			6	2001	0	Unknown	3	1999
Birds	Ptilonorhynchidae	*Ptilonorhynchus nuchalis*	Great Bowerbird			15	2002	0	Unknown	2	1993
Birds	Maluridae	*Malurus melanocephalus*	Red-backed Fairy-wren			9	2001	0	Unknown	1	1993
Birds	Maluridae	*Malurus lamberti*	Variegated Fairy-wren			11	1999	0	Unknown	6	1991
Birds	Acanthizidae	*Smicrornis brevirostris*	Weebill			15	2001	0	Unknown	8	1999
Birds	Acanthizidae	*Gerygone albogularis*	White-throated Gerygone			6	1999	0	Unknown	0	Unknown
Birds	Pardalotidae	*Pardalotus rubricatus*	Red-browed Pardalote			2	2000	0	Unknown	0	Unknown
Birds	Pardalotidae	*Pardalotus striatus*	Striated Pardalote			12	2001	2	1977	5	1999
Birds	Meliphagidae	*Lichenostomus virescens*	Singing Honeyeater			16	2001	0	Unknown	8	1993
Birds	Meliphagidae	*Lichenostomus plumulus*	Grey-fronted Honeyeater			7	2000	0	Unknown	4	1999

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Birds	Meliphagidae	*Lichenostomus flavescens*	Yellow-tinted Honeyeater			5	2001	0	Unknown	1	1993
Birds	Meliphagidae	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater			1	1987	0	Unknown	0	Unknown
Birds	Meliphagidae	*Ramsayornis fasciatus*	Bar-breasted Honeyeater			1	1978	0	Unknown	0	Unknown
Birds	Meliphagidae	*Conopophila rufogularis*	Rufous-throated Honeyeater			15	2000	0	Unknown	8	1993
Birds	Meliphagidae	*Cissomela pectoralis*	Banded Honeyeater			3	2001	0	Unknown	0	Unknown
Birds	Meliphagidae	*Lichmera indistincta*	Brown Honeyeater			7	2001	0	Unknown	6	1993
Birds	Meliphagidae	*Melithreptus gularis*	Black-chinned Honeyeater			1	1993	0	Unknown	0	Unknown
Birds	Meliphagidae	*Melithreptus albogularis*	White-throated Honeyeater			2	1999	0	Unknown	0	Unknown
Birds	Meliphagidae	*Entomyzon cyanotis*	Blue-faced Honeyeater			0	Unknown	0	Unknown	1	1993
Birds	Meliphagidae	*Philemon argenticeps*	Silver-crowned Friarbird			1	1999	0	Unknown	2	1993
Birds	Meliphagidae	*Philemon citreogularis*	Little Friarbird			4	2000	0	Unknown	3	1993
Birds	Pomatostomidae	*Pomatostomus temporalis*	Grey-crowned Babbler			31	2002	0	Unknown	10	1993
Birds	Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella			10	2001	0	Unknown	4	1999
Birds	Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike			18	2001	0	Unknown	3	1993
Birds	Campephagidae	*Coracina papuensis*	White-bellied Cuckoo-shrike			1	1987	0	Unknown	1	1993
Birds	Campephagidae	*Lalage sueurii*	White-winged Triller			17	2001	0	Unknown	4	1991
Birds	Pachycephalidae	*Pachycephala rufiventris*	Rufous Whistler			37	2001	0	Unknown	17	1999
Birds	Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush			14	2001	4	1977	8	1999
Birds	Pachycephalidae	*Oreoica gutturalis*	Crested Bellbird			3	1991	0	Unknown	4	1999
Birds	Oriolidae	*Oriolus sagittatus*	Olive-backed Oriole			4	2000	0	Unknown	0	Unknown
Birds	Artamidae	*Artamus personatus*	Masked Woodswallow			2	1991	0	Unknown	2	1991
Birds	Artamidae	*Artamus superciliosus*	White-browed Woodswallow			1	2001	0	Unknown	0	Unknown
Birds	Artamidae	*Artamus cinereus*	Black-faced Woodswallow			18	2001	0	Unknown	9	1999
Birds	Artamidae	*Artamus minor*	Little Woodswallow			7	2001	0	Unknown	0	Unknown
Birds	Artamidae	*Cracticus torquatus*	Grey Butcherbird			1	1987	0	Unknown	0	Unknown
Birds	Artamidae	*Cracticus nigrogularis*	Pied Butcherbird			18	2000	0	Unknown	6	1999
Birds	Artamidae	*Cracticus tibicen*	Australian Magpie			3	1999	0	Unknown	1	1993
Birds	Rhipiduridae	*Rhipidura albiscapa*	Grey Fantail			2	1991	0	Unknown	3	1991
Birds	Rhipiduridae	*Rhipidura leucophrys*	Willie Wagtail			36	2002	0	Unknown	16	1999
Birds	Corvidae	*Corvus orru*	Torresian Crow			24	2001	0	Unknown	3	1993
Birds	Monarchidae	*Myiagra rubecula*	Leaden Flycatcher			2	2000	0	Unknown	1	1999
Birds	Monarchidae	*Myiagra inquieta*	Restless Flycatcher			11	2001	0	Unknown	7	1993
Birds	Monarchidae	*Grallina cyanoleuca*	Magpie-lark			21	2000	0	Unknown	4	1993
Birds	Corcoracidae	*Struthidea cinerea*	Apostlebird			26	2002	0	Unknown	7	1993
Birds	Petroicidae	*Microeca fascinans*	Jacky Winter			11	2001	0	Unknown	5	1999
Birds	Petroicidae	*Melanodryas cucullata picata/westralensis*	Hooded Robin			11	2001	0	Unknown	6	1991
Birds	Megaluridae	*Cincloramphus mathewsi*	Rufous Songlark			2	2001	0	Unknown	0	Unknown
Birds	Hirundinidae	*Petrochelidon nigricans*	Tree Martin			1	1987	0	Unknown	0	Unknown
Birds	Nectariniidae	*Dicaeum hirundinaceum*	Mistletoebird			5	2001	0	Unknown	1	1991
Birds	Estrildidae	*Taeniopygia guttata*	Zebra Finch			4	1989	0	Unknown	1	1993
Birds	Estrildidae	*Taeniopygia bichenovii*	Double-barred Finch			13	2002	0	Unknown	4	1993
Birds	Estrildidae	*Poephila acuticauda*	Long-tailed Finch			18	2002	0	Unknown	4	1999
Birds	Estrildidae	*Poephila personata*	Masked Finch			1	1980	0	Unknown	0	Unknown
Birds	Estrildidae	*Heteromunia pectoralis*	Pictorella Mannikin			2	2001	0	Unknown	1	1993
Mammals	Tachyglossidae	*Tachyglossus aculeatus*	Echidna			1	1994	0	Unknown	1	1993
Mammals	Dasyuridae	*Pseudantechinus mimulus*	Carpentarian Antechinus		VU	0	Unknown	1	1987	0	Unknown

Group	Family Name	Scientific Name	Common Name	NT Status	National Status	#Observations	#Latest Observation Date	#Specimens	#Latest Speciman Date	#Surveys	#Latest Survey Record
Mammals	Dasyuridae	*Planigale maculata*	Common Planigale			2	1987	2	1987	0	Unknown
Mammals	Dasyuridae	*Sminthopsis macroura*	Stripe-faced Dunnart			2	1987	2	1987	0	Unknown
Mammals	Pseudocheiridae	*Petropseudes dahli*	Rock Ringtail			1	1987	0	Unknown	0	Unknown
Mammals	Macropodidae	*Lagorchestes conspicillatus*	Spectacled Hare-wallaby			35	1991	13	1992	4	1991
Mammals	Macropodidae	*Macropus agilis*	Agile Wallaby	N		2	1987	1	1996	0	Unknown
Mammals	Macropodidae	*Macropus robustus*	Common Wallaroo			2	2001	0	Unknown	6	1993
Mammals	Macropodidae	*Macropus rufus*	Red Kangaroo			0	Unknown	0	Unknown	1	1993
Mammals	Macropodidae	*Onychogalea unguifera*	Northern Nailtail Wallaby			13	1991	5	1987	7	1991
Mammals	Pteropodidae	*Pteropus scapulatus*	Little Red Flying-fox			0	Unknown	0	Unknown	1	1993
Mammals	Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied Sheath-tailed Bat			0	Unknown	1	1959	0	Unknown
Mammals	Emballonuridae	*Taphozous georgianus*	Common Sheath-tailed Bat			0	Unknown	1	1977	0	Unknown
Mammals	Molossidae	*Mormopterus beccarii*	Beccari`s Free-tailed Bat			1	1982	0	Unknown	0	Unknown
Mammals	Vespertilionidae	*Nyctophilus geoffroyi*	Lesser Long-eared Bat			2	1987	2	1987	0	Unknown
Mammals	Vespertilionidae	*Chalinolobus nigrogriseus*	Hoary Wattled Bat			2	1987	3	1987	0	Unknown
Mammals	Vespertilionidae	*Scotorepens greyii*	Little Broad-nosed Bat			1	1982	1	1982	0	Unknown
Mammals	Muridae	*Leggadina lakedownensis*	Northern Short-tailed Mouse			2	1988	5	2001	4	1999
Mammals	Muridae	*Pseudomys delicatulus*	Delicate Mouse			0	Unknown	1	2001	0	Unknown
Mammals	Muridae	*Zyzomys argurus*	Common Rock-rat			0	Unknown	0	Unknown	1	1993
Mammals	Canidae	*Canis lupus*	Dingo / Wild dog	N		1	1987	0	Unknown	1	1993

EX = Extinct EW = Extinct in the Wild ER= Extinct in the NT EN = Endangered
EN/VU = One Endangered subspecies/One Vulnerable subspecies
VU=Vulnerable
VU/- = One or more subspecies vulnerable EN/- = One or more subspecies endangered

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the ID number from the tables above for the species of interest.

Species listed in the table above were recorded from all the grid cells (red/blue line) shown below that overlap Custom area

Custom area Weeds and Potential Weeds

Introduced plants recorded in the grid cell(s) in which Custom area occurs and that have been identified as problem weeds in one or more locations in northern Australia. Occurrence based on Northern Territory Government databases.

Family Name	Scientific Name	Common Name	NT Status	National Status	Other Status	#Surveys	Latest Record
Poaceae	*Cenchrus ciliaris*	Buffel Grass			*MP Gr G&M DEU*	0	Unknown
Cucurbitaceae	*Cucumis melo*	Ulcardo Melon			*DEU*	5	1991
Poaceae	*Echinochloa colona*	Awnless Barnyard Grass			*DEU*	2	1991
Fabaceae	*Macroptilium atropurpureum*	Siratro			*C&E*	0	Unknown
Malvaceae	*Malvastrum americanum*	Spiked Malvastrum			*DEU*	1	1988
Plantaginaceae	*Scoparia dulcis*	Bitter Broom			*DEU*	0	Unknown
Malvaceae	*Sida rhombifolia*	Paddy`s Lucerne	*B C*		*MP G&M DEU*	0	Unknown
Malvaceae	*Sida spinosa*	Spiny Sida			*DEU*	0	Unknown
Fabaceae	*Stylosanthes hamata*	Caribbean Stylo			*DEU*	0	Unknown
Poaceae	*Urochloa mosambicensis*	Sabi Grass			*DEU*	0	Unknown
Asteraceae	*Xanthium strumarium*	Noogoora Burr	*B C*		*MP WA1 WA2 WA4 DEU NSW SA*	0	Unknown

Status Codes:

1. NATIONAL STATUS CODES

Alert, Alert List for Environmental Weeds (Please call Exotic Plant Pest Hotline 1800 084 881 if you think you have seen this weed)
Sleeper, National Sleeper Weed
Target,Targeted for eradication. (www.landmanager.com.au/view/index.aspx?id=449837)
WONS, Weeds of National Significance

2. NT STATUS CODES

A, NT Class A Weed (to be eradicated)
B, NT Class B Weed (growth & spread to be controlled)
C, NT Class C Weed (not to be introduced) (www.landmanager.com.au/view/index.aspx?id=449869)

3. OTHER STATUS CODES

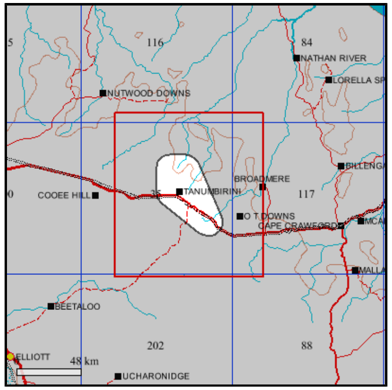
C&E, Csurhes, S. & Edwards, R. (1998) Potential Environmental Weeds in Australia. Candidate Species for Preventative Control. Environment Australia, Canberra (www.landmanager.com.au/view/index.aspx?id=394504)
CYP, Draft Cape York Peninsula Pest Management Plan 2006-2011 (www.landmanager.com.au/view/index.aspx?id=371200)
DEU, Plants listed as environmental weeds by the Desert Uplands Strategic Land Resource Assessment (www.landmanager.com.au/view/index.aspx?id=332123)
G&M, Grice AC, Martin TG. 2005. The Management of Weeds and Their Impact on Biodiversity in the Rangelands. Cooperative Research Centre (CRC) for Australian Weed Management and CSIRO Sustainable Ecosystems. Commonwealth Australia (www.landmanager.com.au/view/index.aspx?id=163572)
Gr, Groves et al. 2003. Weed categories for natural and agricultural ecosystem management. Bureau of Rural Sciences (www.landmanager.com.au/view/index.aspx?id=388018)
K0, High Priority Weeds not yet established in the Katherine region
K1, High Priority Weeds posing environmental threats in the Katherine region
K2, High Priority Weeds posing existing threats in the Katherine region, as described in the Katherine Regional Weed Management Strategy 2005-2010 (www.landmanager.com.au/view/index.aspx?id=130286)
MP, Northern Territory Parks & Conservation Masterplan (www.landmanager.com.au/view/index.aspx?id=144141)
NAQS, North Australian Quarantine Strategy Target List (www.landmanager.com.au/view/index.aspx?id=449416)
NSW, Declared Noxious Weed in NSW (www.landmanager.com.au/view/index.aspx?id=449983)
Q1, QLD Class 1 Weed (not to be introduced, kept or supplied-
Q2, Class 2 Weed (eradicate where possible, not to be introduced, kept or supplied)
Q3, Qld Class 3 Weed (to be controlled near environmentally sensitive areas- not to be supplied/sold without a permit) (www.landmanager.com.au/view/index.aspx?id=190714)
SA, Declared Plant in South Australia (www.landmanager.com.au/view/index.aspx?id=449996)
WeedsAus, Listed as a significant weed by Weeds Australia (www.landmanager.com.au/view/index.aspx?id=14576)
WA1, WA Weed Class P1 (movement prohibited)
WA2, WA Weed Class P2 (aim to eradicate)

WA3, WA Weed Class P3 (control infestations)
WA4, WA Weed Class P4 (prevent spread)
WA5, WA Weed Class P3 (control infestations on public land) (www.landmanager.com.au/view/index.aspx?id=449884).

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the ID number from the tables above for the species of interest.

Plants listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap Custom area



Custom area Introduced Species

Introduced plants in Custom area (ordered alphabetically) that have been identified as introduced species in one or more locations in northern Australia.

Family Name	Scientific Name	Common Name	NT Status	National Status	Other Status	ID	#Surveys (Latest)	Latest Record
Euphorbiaceae	*Euphorbia hirta*	Asthma Plant				289244	0	Unknown
Cucurbitaceae	*Momordica balsamina*	Balsam Apple				291344	0	Unknown
Fabaceae	*Indigofera hirsuta*	Hairy Indigo				290754	0	Unknown
Portulacaceae	*Portulaca pilosa*	Hairy Pigface				292104	0	Unknown
Poaceae	*Eragrostis amabilis var. amabilis*	Lovegrass				.	0	Unknown
Malvaceae	*Melochia pyramidata*	Pyramid Flower				291234	0	Unknown
Poaceae	*Digitaria ciliaris*	Summer Grass				289974	0	Unknown

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

Custom area Pest and Potential Pest Animals

Animals with pest potential recorded in the grid cell(s) in which Custom area occurs. Occurrence based on Northern Territory Government databases.

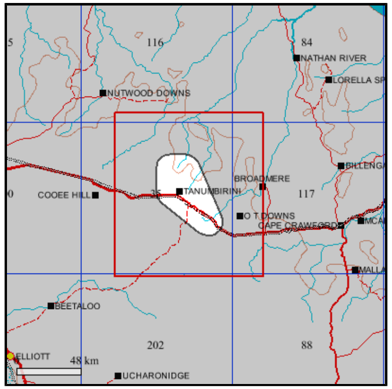
Common Name	Scientific Name	NT Status	National Status	ID	#Observations (Latest)	#Specimens (Latest)	#Surveys (Latest)
Cane Toad	*Rhinella marina*	P	.	183252	1 (2001)	0 (Unknown)	1 (1993)
Red-tailed Black-cockatoo	*Calyptorhynchus banksii macrorhynchus*	N	.	223765	14 (2001)	0 (Unknown)	0 (Unknown)
Agile Wallaby	*Macropus agilis*	N	.	223786	2 (1987)	1 (1996)	0 (Unknown)
Dingo / Wild dog	*Canis lupus*	N	.	183280	1 (1987)	0 (Unknown)	1 (1993)
Horse	*Equus caballus*	P	.	183315	1 (1987)	0 (Unknown)	0 (Unknown)
Cattle	*Bos taurus*	P	.	183266	1 (1987)	0 (Unknown)	2 (1993)

NT STATUS CODES:
Int, Introduced species (all non-prohibited vertebrates, and all other exotic species (www.landmanager.com.au/view/index.aspx?id=280771)
N, Native species with pest potential.
P, Prohibited species (all exotic vertebrates except those listed as non-prohibited (www.landmanager.com.au/view/index.aspx?id=450509)

Survey = this category refers to data collected using systematic survey methodology
Specimen = this category refers to museum or other records where a specimen has been collected and lodged
Observation = this category refers to all other incidental recordings where systematic methodology may not have been used consistently.

More species info: Go to www.landmanager.org.au/view/index.aspx?id=####
where #### is the ID number from the tables above for the species of interest.

Potential pest animals listed in the table above were recorded from all the grid cells shown below (red/blue line) that overlap Custom area



Soils and vegetation graphs and tables refer to area of soils and vegetation only. Fire graphs and tables refer to entire selected area including sea if present. Calculations are derived from map images or vector data, and should be taken as a guide only. Accuracy cannot be guaranteed. For small areas, figures should be rounded to the nearest whole number.

Fire map layers used in these reports have been updated in 2018 so their pixels are aligned to the same grid.

Santos

Appendix D: Ecological Assessment Report

Ecology report
2019 exploration program
Santos

www.ecoz.com.au

DOCUMENT CONTROL RECORD

Job	EZ19041
Document ID	176327-33
Author(s)	Aiden Campbell

DOCUMENT HISTORY

Rev	Reviewed by	Approved by	Issued to	Date
1	Felicity Watt	Ray Hall	Santos	27 March 2019
2	Felicity Watt	Ray Hall	Santos	2 April 2019

Recipients are responsible for eliminating all superseded documents in their possession.

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1 INTRODUCTION

Santos is planning their 2019 exploration program within their Exploration Permit area (EP161) on Tanumbirini Station. The exploration works will be regulated through an Environmental Management Plan (EMP) approved by the Department of Environment and Natural Resources (DENR). For the development of the EMP, an assessment of biodiversity values within the exploration area and the 2019 exploration program footprint (project area) is required.

1.1 Purpose and objectives

EcOz Environmental Consultants (EcOz) were engaged to complete a desktop assessment of the biodiversity values within a defined survey area.

The desktop assessment had two objectives:

- To provide sufficient information for Santos to update their EMP for the proposed exploratory drilling program, or develop future EMPs for exploratory drilling or seismic operations.
- To identify biodiversity values within the survey area, such that Santos can incorporate this information into project planning. This includes determining the 'likelihood of occurrence' of threatened species occurring within the survey area.

The desktop assessment is largely desktop based, with some supplementary fieldwork to verify biodiversity values. Fieldwork was limited to the use of existing access tracks within the survey area. The report includes a description of habitat types, and a 'likelihood of occurrence' assessment of threatened species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) and NT *Territory Parks and Wildlife Conservation Act* (*TPWC Act*). This information can be used to avoid any adverse impacts on identified biodiversity values and to meet the (DENR) requirements during the update of the EMP or development of future EMPs for exploratory drilling or seismic operations. It is also used to identify specific environmental values which warrant further field based investigation.

The desktop report provided a number of recommendations for Santos to consider when planning any further works. Principally, it was recommended that:

- Undertaking a weed survey at exploratory drilling and/or seismic exploration sites and along access tracks would provide baseline data. This would enable Santos to ensure that activities do not introduce or spread weeds.
- Prior to more intensive works being undertaken, further assessment of habitat for Gouldian Finch and potential impact to this species be undertaken. This would include desktop assessment and on-ground studies and would be assessed in relation to a project area.
- As the identified exploration activities may intersect watercourses that may support sensitive vegetation in the form of riparian vegetation, Santos required the location of any sensitive vegetation to be identified so that potential impact to these communities could be avoided or minimised during exploration.

Given that Santos is planning to undertake the 2019 exploration program, EcOz was engaged to complete surveys targeting these recommendations within the project area. EcOz completed the following two assessments of environmental values within the project area (Section 2.1):

- Ecology report – EP161 work program 2018 (field assessment) (EcOz, 2018a)
- Inacumba bore weed survey and sensitive vegetation assessment (field assessment) (EcOz, 2018b)

Santos has reduced the scope and project area of the 2019 exploration program from the areas identified in the above assessments. The project area has also deviated slightly from the surveyed areas. Additionally, the Northern Territory Government (NTG) has provided feedback on the draft Environmental Management Plan, and requested clarifications around the assessment of the above listed environmental values.

1.2 Scope

The scope of this report is to consolidate the existing environmental assessments to focus on the two proposed drilling sites and associated activities relevant to the project area.

No new field assessment has been undertaken as part of this report. Data and information detailed in the existing reports has been drawn on, along with available datasets and an updated exploration program layout (provided by Santos). EcOz has reviewed the information presented in the existing reports, addressed any issues raised by Government departmental review, and provided clarity in this report where required.

1.3 Report structure

To achieve the outlined purpose, this report contains three primary sections as outlined below:

- Section 2 – details the project area and the relationship of this area to that which has been surveyed.
- Section 3 – details the methods and results of the desktop assessment undertaken in 2017 and provides recommendations for further work to be undertaken.
- Section 4 – details the outcomes of the field surveys completed for the project area, based on the recommendations of the desktop assessment.

2 PROJECT AREA

The project area includes the following components:

- Two new exploration wells
  - Tanumbirini-2
  - Inacumba-1
- A single 2D seismic profiling line crossing the proposed Tanumbirini-2 well site
- Access tracks
- Borrow pits

The components of the 2019 exploration program are shown in Figure 2-1

Tanumbirini-2 will be located within the existing Tanumbiri-1 lease area, which was drilled in 2014. Exploration activities are expected to occur within the existing disturbance footprint of Tanumbirini-1; however, may extend outside the previously disturbed area, but not more than 500 m from the well head. Inacumba-1 is located south east of Tanumbirini-2, but still within Tanumbirini Station. The proposed well is approximately 12 km north of the Carpentaria Highway. All disturbance for the wells (well drill pad, camps, dams etc.) will be located within a 500 m buffer of the proposed well locations; however, the development will not disturb the entirety of this area.

The proposed 2D seismic profiling line runs in a NNW-SSE direction passing through the proposed Tanumbirini-2 well site. The 2D seismic profiling line extends 5 km each side of the proposed well. The seismic profiling will involve 2-3 small trucks with measurement instruments (hydrophone, geophone or similar) driving along the 2D seismic profiling line and recoding reflected seismic energy originating from an energy source. A tracked bulldozer, with blade up, will precede the seismic trucks to ensure passage. The bulldozer will avoid the majority of trees along the 2D seismic profiling line but may remove obstacles such as termite mounds and understorey thicket, and reduce the approach angle for trucks at watercourse crossings. The bulldozer will remove only what is required for passage of trucks.

Access to Tanumbirini-2 will be along existing station access tracks. These tracks were used for access to the previously drilled Tanumbirini-1. Existing tracks will be used for the majority of the access to Inacumba-1. The access track starts from the Carpentaria Highway and follows a route north-east to the north west side of the proposed Inacumba-1 location. One of two new access tracks would be created from here to reach to Inacumba-1 well location; each of these proposed new access tracks is less than 900 m in length

Two locations for borrow pits have been identified - one location is adjacent to the access track to Inacumba-1 and the other is along the access track to Tanumbirini-2. The borrow pits will be located within one or both of the identified locations, however, only a portion of the identified area will be disturbed for borrow material.

There will also be a laydown area along the access track to Tanumbirini-2.

2.1 Survey area

2.1.1 Desktop assessment

Santos defined a survey area, which incorporated all existing and planned exploration drilling activities including the project area. The survey area, along with the project area, is shown in Figure 2-1.

2.1.2 Field surveys

Two surveys have been completed within the project area; locations and survey tracks are shown in Figure 2-1. Both surveys were undertaken by a team of environmental consultants, all with experience in surveying weeds and vegetation in the Northern Territory. Surveys were completed in August 2018 (Tanumbirini-2 and associated areas) and November 2018 (Inacumba-1 and associated areas).

The area covered by the surveys included:

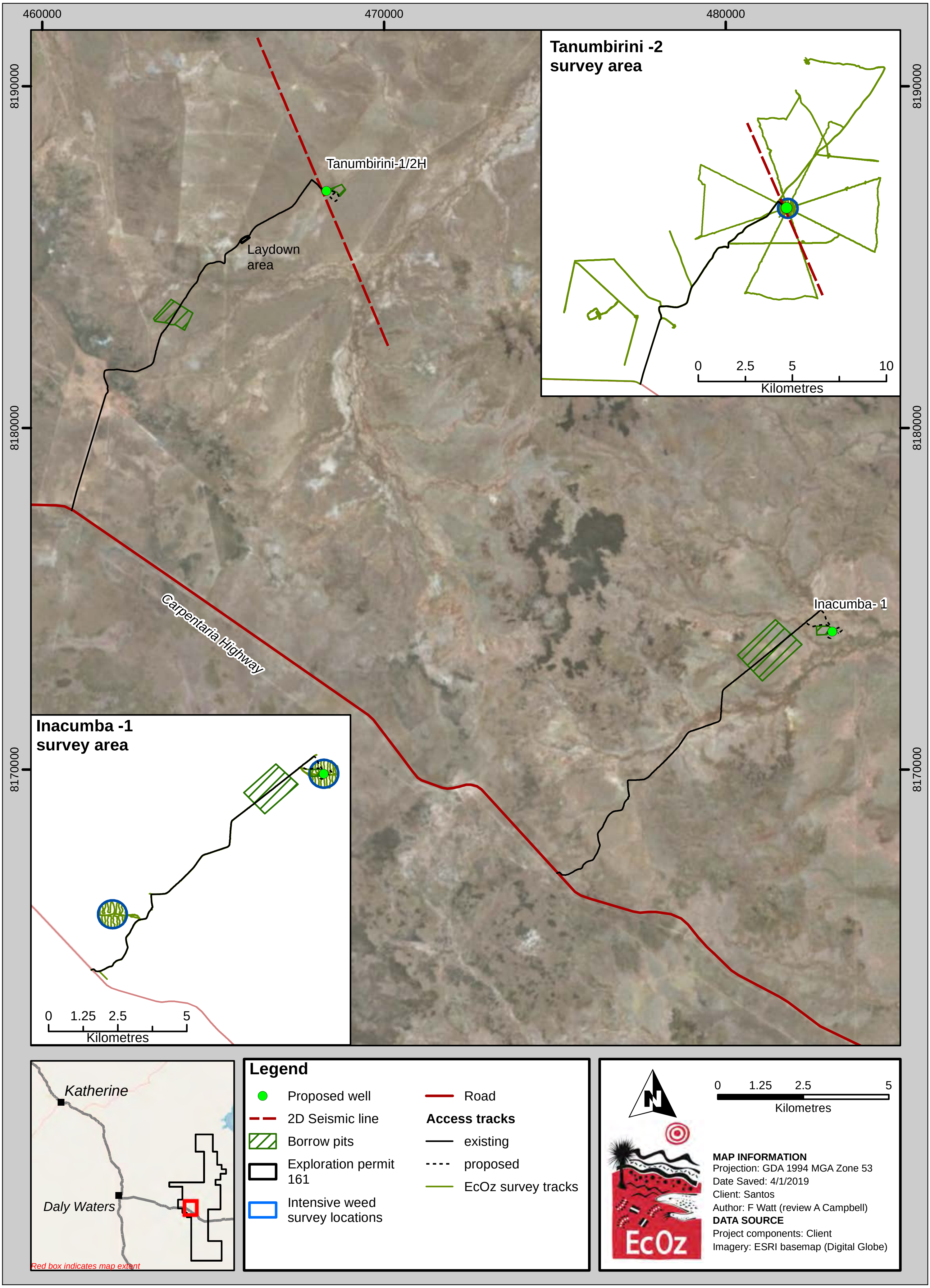
- The 500 m buffer of the proposed Tanumbirini-2 and Inacumba-1 well sites
- Access track to Tanumbirini
- Access track Option 1 and 2 to Inacumba-1
- 40 km of linear transects radiating from Tanumbirini-2

Within each 500 m buffer, a 100 m x 100 m grid was applied over the area. Surveyors walked transects through these areas ensuring they passed through each 100 m x 100 m grid cell once. Field maps of these grid cells were displayed as a moving map on a GPS enabled device for accurate interpretation and field navigation.

Access tracks to the well sites were surveyed by vehicle. Tracks were driven slowly and where a weed species was seen, the vehicle was stopped and data recorded. Stock watering points were also searched for weeds.

Surveyors walked a total of 40 km of linear transects radiating from Tanumbirini-2. There were eight transects in total – each 5 km long. Locations of the transects were based on the previous scope of the exploration program provided by Santos.

The exact location of the 2D seismic line identified in the 2019 exploration program is slightly different to the linear transects surveyed. There is one survey transect in close proximity to the proposed 2D seismic line; the landforms and vegetation through which the updated 2D seismic line passes are consistent with those of this survey transect. The location of the borrow pits have not been surveyed.



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19041 - Santos EP161 EMP aspects\01 Project Files\Figure 2-1. 2019 exploration program.mxd

Figure 2-1. Map of project area and survey area

3 DESKTOP ASSESSMENT

3.1 Environmental context

3.1.1 Climate

The survey area experiences two distinct seasons - a dry season with little/no rainfall between approximately May to October, and a monsoonal wet season from November to March. The nearest weather station with Bureau of Meteorology regional climatic data is the Daly Waters' airport weather station, which lies 120 km to the east of the survey area.

Figure 3-1 provides a summary of climate information; January and February are the wettest months, both with over 150 mm rainfall on average per year. June and July are the coolest months, with an average maximum of 29°C, contrasting with an average maximum of 38°C in the hottest month of November.

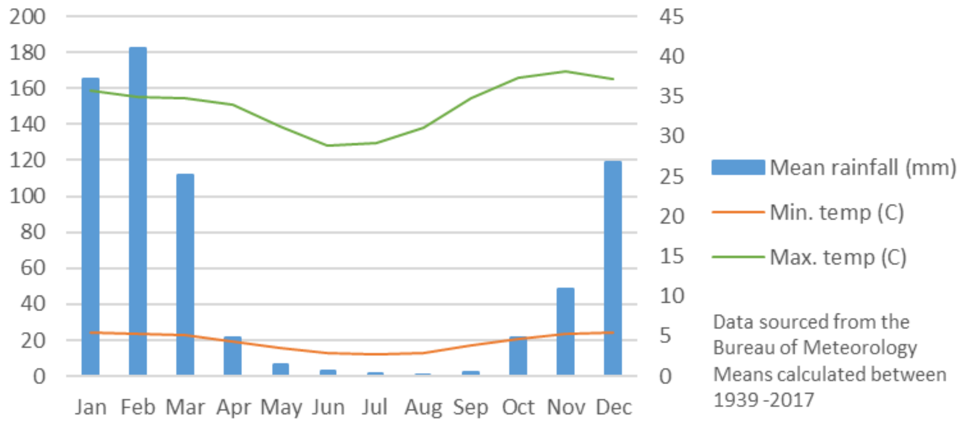
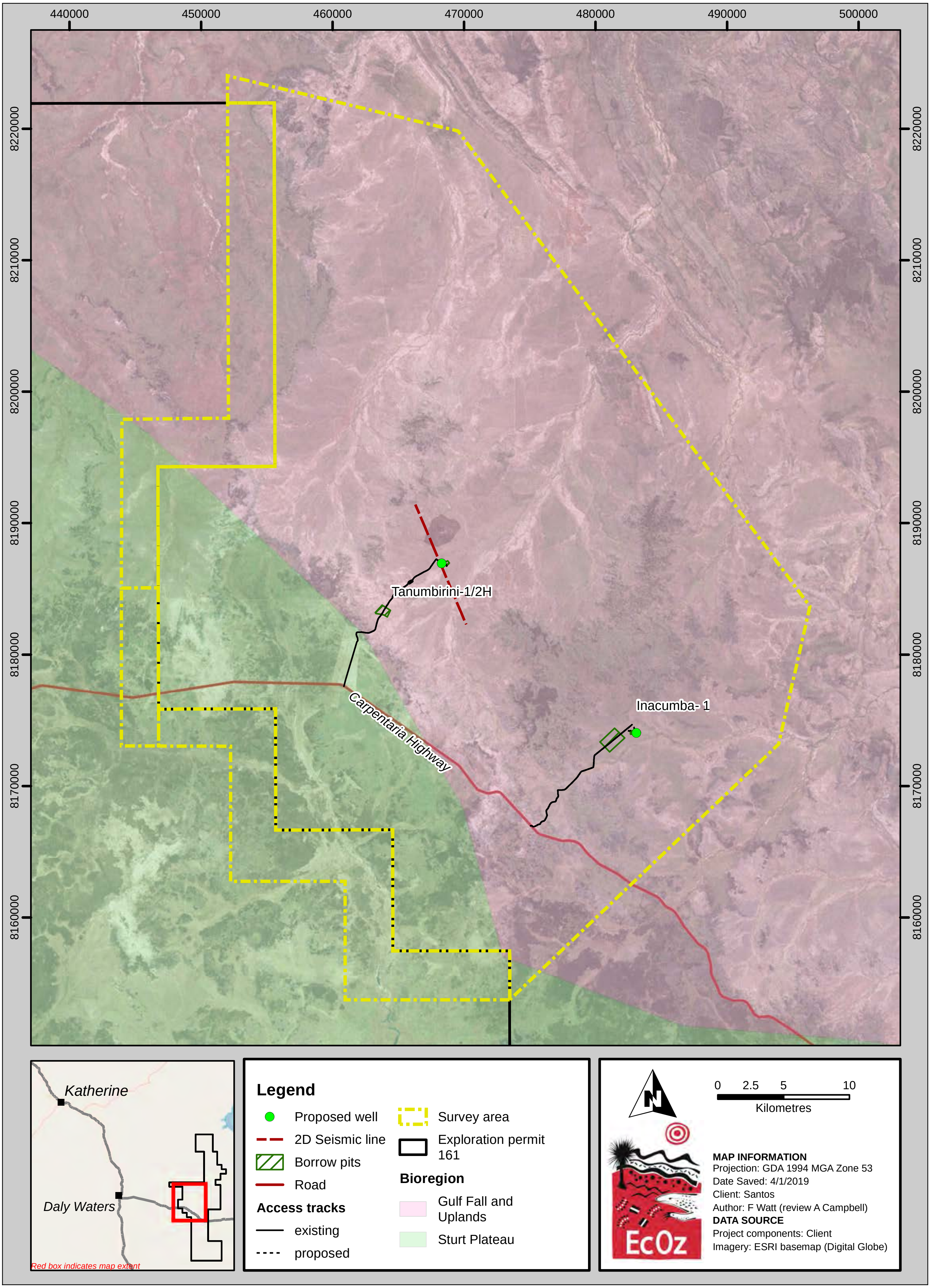


Figure 3-1. Average monthly temperature and rainfall Daly Waters airstrip, Northern Territory

3.1.2 Bioregions

The Interim Biogeographic Regionalisation for Australia divides Australia into geographically-distinct units – called *bioregions* – of broadly similar climate, landform, geology and biodiversity (Baker et al. 2005). The survey area covers the following two bioregions (see Figure 3-2):

- The south-western portion of the survey area falls within the Sturt Plateau bioregion, a gently undulating plain. Vegetation is mostly *Eucalyptus dichromophloia* woodlands with spinifex understorey. There are also large areas of Lancewood thickets (*Acacia shirleyi*), Bullwaddy Woodlands (*Macropteranthes kekwickii*) and open *Eucalyptus* woodlands to the north.
- Approximately two-thirds of the survey area (the north-east) falls within the Gulf Fall and Uplands bioregion, which is comprised of scattered low steep hills on skeletal soils. Vegetation is mostly *Eucalyptus tetrodonta* and *Corymbia dichromophloia* woodland with a spinifex understorey, and also *Eucalyptus tectifica* with a tussock grass understorey.



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19041 - Santos EP161 EMP aspects\01 Project Files\Figure 3-2. Map showing survey area, project area and bioregions.mxd

Figure3-2. Map showing bioregions within survey area

3.2 Methods

The assessment of biodiversity values primarily utilised government databases to identify values within the survey area. This was augmented by an on-ground survey to verify the land system, identify important habitat for threatened species, and look for any other biodiversity values on site. This section of the report describes the methods used for both the desktop and field surveys.

3.2.1 Land systems

A land system is ‘an area or group of areas throughout which there is a recurring pattern of topography, soils and vegetation’ (Christian & Stewart 1968). This recurrent composition gives each land system a characteristic pattern which can be mapped from aerial imagery.

Land systems within the survey area were determined using the *Land Systems of the Northern Part of the NT (1:250,000)* dataset (DENR 2008) and the *Land Systems of the Southern Part of the NT (1: 1,000,000)* dataset (DENR 2011). The datasets are managed by the Northern Territory Government.

Land systems were verified through on-ground assessment of land form and vegetation characteristics. This land systems’ mapping has then been used to assist in the determination of the presence of suitable habitat for threatened species.

3.2.2 Vegetation

Vegetation within the survey area was determined using the *National Vegetation Information System 4.2* (DEE 2016) spatial dataset, which is maintained by the Commonwealth Department of Environment and Energy (DEE).

3.2.3 Sensitive vegetation communities

Sensitive vegetation types are those considered to be significant under the NT *Land Clearing Guidelines* (NRETAS 2010), such as monsoon forest, riparian vegetation, mangrove, groundwater-dependent ecosystems, and wetlands. These areas are either unique to the region and/or have high biodiversity values. A review of existing vegetation mapping, land systems, and aerial imagery indicated that two sensitive vegetation types could occur within the survey area – riparian vegetation and wetlands.

Ecologists visited areas of potential sensitive vegetation communities during surveys and assessed whether sensitive vegetation communities were present.

3.2.4 Watercourses, wetlands and waterholes

The major watercourses, lakes, dams and wetlands within the survey area were identified using Bureau of Meteorology geo-fabric and aerial imagery. The *Directory of Important Wetlands in Australia* – a database of nationally-important wetlands, compiled in cooperation with conservation agencies and other resource managers in all jurisdictions – was queried to identify wetlands within the survey area.

All accessible watercourses were assessed during on-ground biodiversity values assessment. An assessment of the stream order at each watercourse survey site was made, along with identification of the vegetation community and a description of the watercourse profile. Photos were taken at each site.

Permanent waterholes are important habitat for biodiversity. Waterholes which are potentially permanent through the dry season were identified from aerial imagery. Site visits were undertaken where access to permanent waterholes was possible. Characterisation of potential habitat value was undertaken at these sites.

3.2.5 Threatened species

A 'likelihood of occurrence' assessment was conducted to determine which threatened species have potential to occur within the survey area. This is a preliminary assessment and, although augmented by a field visit, may require further field work for future approvals.

The International Union for the Conservation of Nature (IUCN) nominates a set of criteria used to identify species at risk of extinction which is used to define categories of risk (Figure 3-3). These criteria and categories are used by both the NT Government to identify threatened species listed under the *TPWC Act*, and by the Commonwealth Government to identify national threatened species under the *EPBC Act*. The focus of this report is species that are listed as threatened under either the *TPWC Act* or the *EPBC Act* (or both) – i.e. species that are listed as Vulnerable, Endangered, or Critically Endangered.

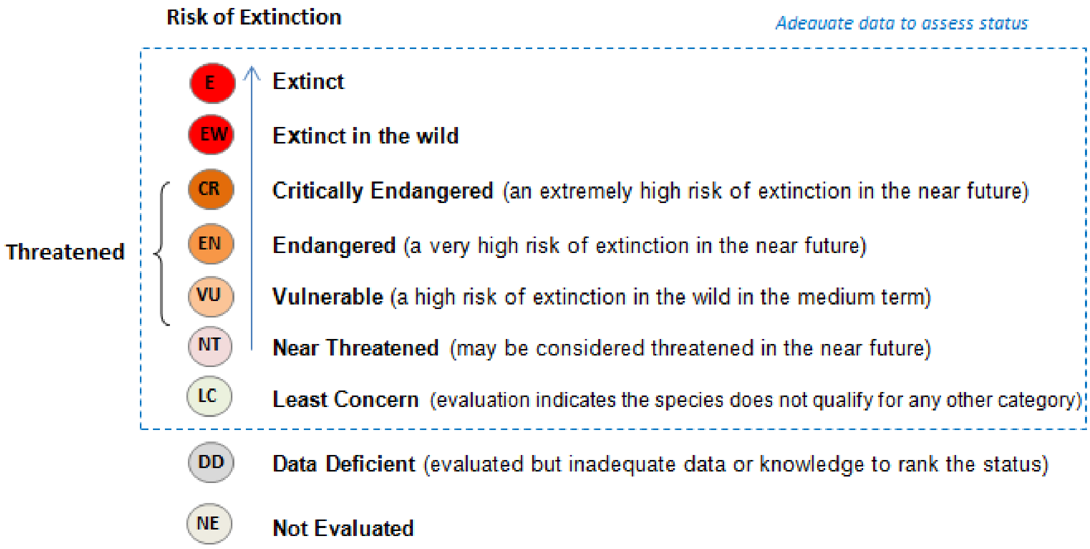


Figure 3-3. IUCN list categories of risk for threatened species

The following datasets were searched to generate a list of potential threatened species:

- **EPBC Protected Matters Search Tool (PMST).** An online database managed by DEE which interrogates existing flora and fauna records and uses predictive habitat modelling to return a list of species which may occur in the defined area and a likelihood of each of these threatened and migratory species occurring. This dataset was interrogated within a 100 km buffer of the survey area. The results of the PMST search are provided in Appendix A.
- **Northern Territory Flora & Fauna Atlas.** A database maintained by the Department of Environment and Natural Resources (DENR) of point records of fauna and flora species identified through biological surveys (either as validated incidental observations or voucher specimens) conducted in the NT under a Wildlife Permit. The updated dataset was obtained by EcOz from the DENR on 17 October 2016. The dataset was spatially interrogated using the boundaries of the Gulf Fall and Uplands, and Sturt Plateau bioregions.

For each of the species returned from the database searches, the likelihood of it occurring within the survey area was assessed based on habitat requirements, distribution, and the number and dates of proximate records. On-ground habitat assessment was also used to assist the assessment.

In this assessment, the likelihood of a species occurring is ranked as none, low, medium, and high. In the context of this report, this means:

- **None** – There is no likelihood of this species occurring within the survey area.

- **Low** – The survey area occurs outside of the core distribution for the species and there is no or only marginally-suitable habitat. Some vagrant records may exist.
- **Medium** – There is suitable habitat within the survey area but records are either old, infrequent or some distance from the survey area.
- **High** – There is suitable habitat within the survey area and records are proximate and recent.

3.2.6 Migratory and marine species

Listed migratory and marine species are protected in Australia due to Australia's obligations under international conventions.

Migratory and marine species, which potentially occur within the survey area, were identified through the PMST database search (100 km buffer around the survey area). This search area includes a portion of coastline and marine habitat in the Gulf of Carpentaria. This inclusion expands the list of identified species. A 'likelihood of occurrence' assessment for these species was done following the same procedure as for threatened species.

3.3 Results

3.3.1 Land condition

Pastoralism

The survey area is located within Tanumbirini Station, an active pastoral property. Impact across the survey area was evident during field surveys. Cattle impact consisted of grazing to understorey species and trampling impacts around watercourses – this trampling has led to erosion around these watercourses.

Weeds and pests

NT listed weeds identified within the region include Prickly Acacia (*Acacia nilotica*), Bellyache Bush (*Jatropha gossypiifolia*), Spinyhead Sida (*Sida acuta*), Noogoora Burr (*Xanthium pungens / X. strumarium*), Parkinsonia (*Parkinsonia aculeata*), Mesquite (*Prosopis spp*.), Khaki Weed (*Alternanthera pungens*), Rubber Bush (*Calotropis procera*), and Hyptis (*Hyptis suaveolens*) (DLRM 2017). Mexican poppy (*Argemone ochroleuca*) occurs in some catchments including the McArthur River, and Rubber Vine (*Cryptostegia grandiflora*) is a potential threat in this region.

The Katherine Regional Weed Management Plan 2015-2020 (Weed Management Plan) (DLRM 2015) includes the survey area. The Weed Management Plan identifies priority weeds within the region (Table 3-1).

Table 3-1. Priority weeds within the Katherine Region Weed Management Plan

Species	Class	Weed of National Significance (WoNS)
Mesquite - *Prosopis spp.*	A/C	Y
Prickly acacia - *Vachellia nilotica*	A/C	Y
Parkinsonia - *Parkinsonia aculeata*	B/C	Y
Chinee Apple - *Ziziphus mauritiana*	A/C	-
Mimosa - *Mimosa pigra*	A/C	Y
Bellyache Bush - *Jatropha gossypiifolia*	A/C	Y
Gamba Grass - *Andropogon gayanus*	A/C	Y
Neem - *Azadirachta indica*	B/C	-
Grader grass - *Themeda quadrivalvis*	B/C	Y
Snake weed - *Stachytarpheta spp.*	B/C	-
Devils Claw - *Martynia annua*	A/C	-

There are a number of records of Parkinsonia, Gamba Grass and Bellyache Bush near to the survey area. Hyptis was observed within the survey area.

Weed distribution is often related to environmental disturbances caused by the construction of roads and tracks, cattle grazing and feral animals. Weeds are most prevalent on land under pastoral lease, with infestations generally concentrated around infrastructure such as water points, fence lines and tracks, and also along the banks of watercourses where cattle and feral animals tend to congregate.

Pests that may occur within the survey area include Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo, Donkey and Cane Toads (DoE 2017). Donkeys and Pigs were observed during field surveys.

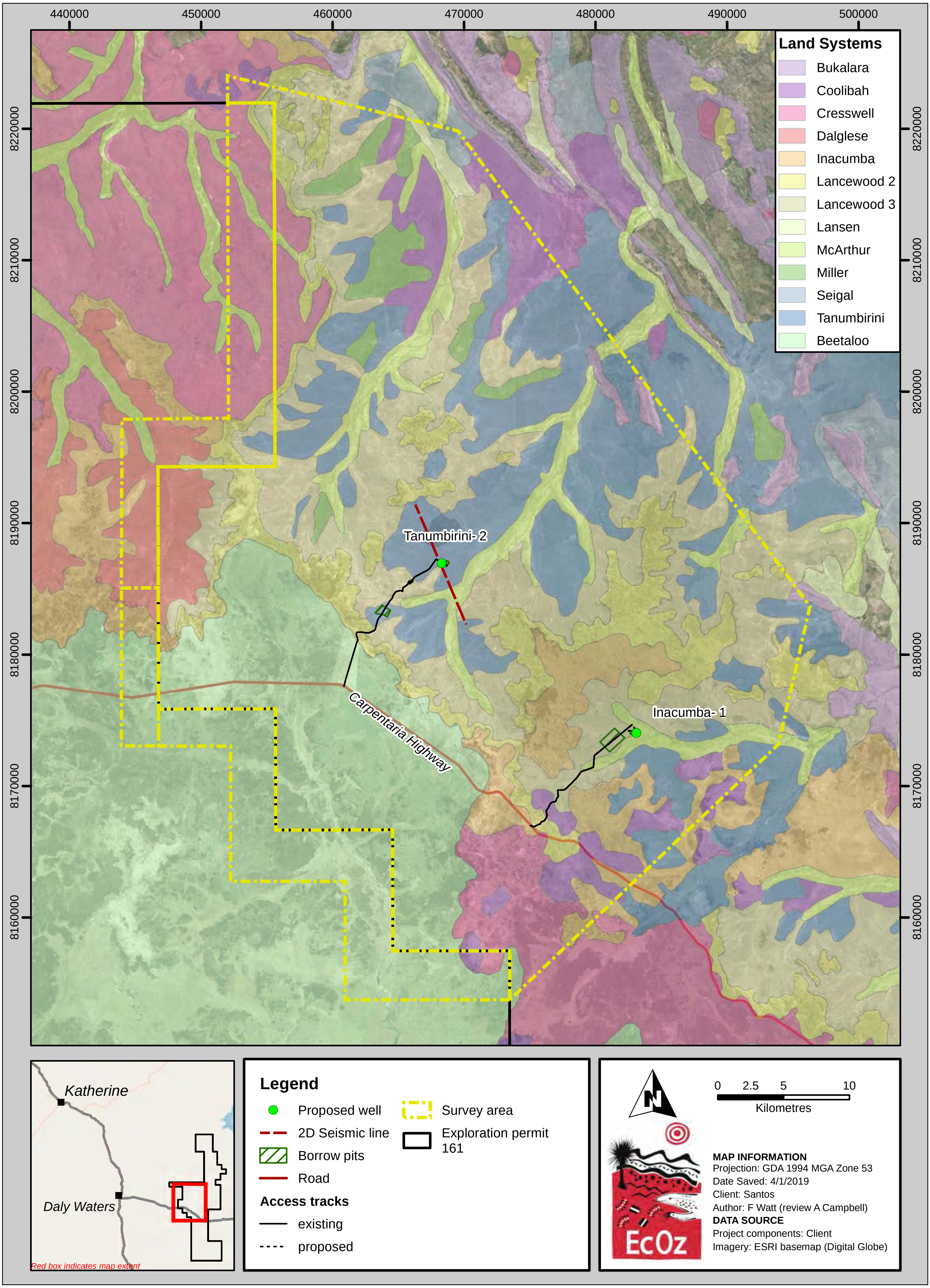
3.3.2 Land systems

There are 13 land systems mapped within the survey area (Table 3-2 and Figure 3-4). The land systems within the survey area consist primarily of lateritic plains, lateritic plateau, alluvial plains, and sandstone plains and rises. The landform and vegetation characteristics at each of the survey sites corresponded to the mapped land system.

Table 3-2. Land systems within the survey area (as per Lynch & Wilson 1998)

Name	Landform	Soils	Main vegetation*
Beetaloo (BE)	Plains and rises on weathered sedimentary rocks	Red clayey sands, red earths and texture contrast soils	*Acacia shirleyi* Lancewood forest
Dalglese (Tcd)	Plains and rises associated with deeply weathered profiles (laterite) including sand sheets and other depositional products	Sandy and earth soils	Mid-high open woodland of *Eucalyptus pruinosa, Corymbia terminalis, Erythrophleum chlorostachys, Melaleuca citrolens, Lysiphyllum cunninghamii* over sparse grass cover (*Chrysopogon fallax, Sehima nervosum, Heteropogon contortus*)
Inacumba (Lwi)	Plains and rises associated with deeply weathered profiles (laterite) including sand sheets and other depositional products	Sandy and earth soils	Mid-high open woodland of *C. dichromophloia, E. miniata, E. tetrodonta, Corymbia ferruginea, E. leucophloia* with isolated stands of *A. shirleyi* on steeper slopes over *Eriachne spp, Chrysopogon fallax, Triodia pungens*
Lancewood 2 (Lwl)	Crenulate escarpments, rugged low hills and gently undulating lower slopes on actively eroding, ferruginised Lower Cretaceous sediments (claystone and laterite)	Grey and Brown Vertosols and Leptic Rudosols; shallow soils with rock outcrop	Mid high open woodland of *E. pruinosa* with areas of mixed grasslands, *Acacia shirleyi* on cliffs and slopes
Lancewood 3 (Lwl)			
McArthur (Tam)	Broad or narrow fluvial corridors conducting regional drainage across various Land Systems towards the coast	Aquic Vertosols, Red and Yellow Kandosols and Orthic Tenosols; sandy, silty and clay soils on Quaternary alluvium	Mid high open woodland of *E. microtheca* with some *Corymbia papuana* and *Corymbia polycarpa,* tall fringing riparian vegetation often including *Melaleuca* spp.
Miller (Tcm)	Level plains to gently undulating clay plains	Cracking clay soils	Mid-high open woodland of *E. pruinosa* over *Eulalia fulva, Chrysopogon fallax, Aristida inaequiglumis*
Tanumbirini (Tct)	Plains and rises associated with deeply weathered profiles (laterite) including sand sheets and other depositional products	Sandy and earth soils	Mid-high open woodland of *Eucalyptus chlorophylla, Erythrophleum chlorostachys, Corymbia polycarpa, Eucalyptus tetrodonta, Terminalia grandifolia* over *Chrysopogon fallax, Eulalia fulva, Triodia pungens*
Bukalara (Asb)	Rugged rocky plateaux and steep linear ridges on massive sandstones such as the Bukalara and Kombolgie Sandstones	Leptic Rudosols; shallow sandy soils and rock outcrop	Mid high open woodland of *Eucalyptus dichromophloia* with *Eucalyptus miniata, Eucalyptus tetrodonta* and *Eucalyptus leucophloia,* some *Eucalyptus kombolgiensis*
Coolibah (Tac)	Level to gently undulating plains on unconsolidated, transported materials, rarely sedentary	Aquic Vertosols; sandy, silty and clay soils on Quaternary alluvium	Mid high open woodland of *Eucalyptus microtheca* with some *Excoecaria parvifolia* and Corymbia *papuana*
Cresswell (Lwc)	Erosionally stable, gently undulating lateritic plains and rises	Leptic Rudosols, Leptic Tenosols, Red and Yellow Kandosols; sandy and earth soils	Mid high open woodland of *C. dichromophloia* and *Corymbia bleeseri* with isolated stands of *Acacia shirleyi*

Name	Landform	Soils	Main vegetation*
Lansen (All)	Long, low, often terraced rises with linear outcrop on prominently bedded sandstones	Leptic Rudosols; commonly shallow soils with surface stone and rock outcrop	Mid high open woodland of *E. ferruginea* with some *Lysiphyllum cunninghamii*
Seigal (Als)	Gently undulating to undulating rises with abundant, often linear rocky outcrops	Leptic Rudosols and Leptic Tenosols; often linear rocky outcrops and shallow sandy soils	Mid high open woodland of *Eucalyptus miniata, Eucalyptus tetrodonta* and *Eucalyptus ferruginea* with *Corymbia. dichromophloia* and *Eucalyptus leucophloia*



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19041 - Santos EP161 EMP aspects\01 Project Files\Figure 3-4. Map land systems intersected by the survey and project areas.mxd

Figure 3-4. Map of Land Systems within the survey area

3.3.3 Vegetation

The dominant vegetation types within the survey area are *Eucalyptus* and *Corymbia* communities (in the plains and undulating hills), *Acacia* woodlands/forests, and *Melaleuca* communities (within drainages lowlands, and depressions), Lancewood woodland/forests and Bulwaddy woodlands.

Although not indicated on the NVIS mapping, sections of the survey area were identified during the field survey as tussock grasslands on lateritic plains or alluvial plains. These areas were too small to be picked up at the NVIS scale. These grasslands were surrounded by either *Eucalyptus* or *Melaleuca* woodlands.

Vegetation exhibited impacts from cattle. Understorey grass species showed extensive impact from cattle grazing. Trampling and impacts to the soil surface was also evident.

Eucalyptus woodlands containing *Eucalyptus leucophloia,* which occurs on rises (particularly within the lateritic plateau land systems), may provide habitat for Gouldian Finch (see Section 5). This species is one of the preferred nesting trees.

Photos of typical vegetation communities within the survey area are shown below.

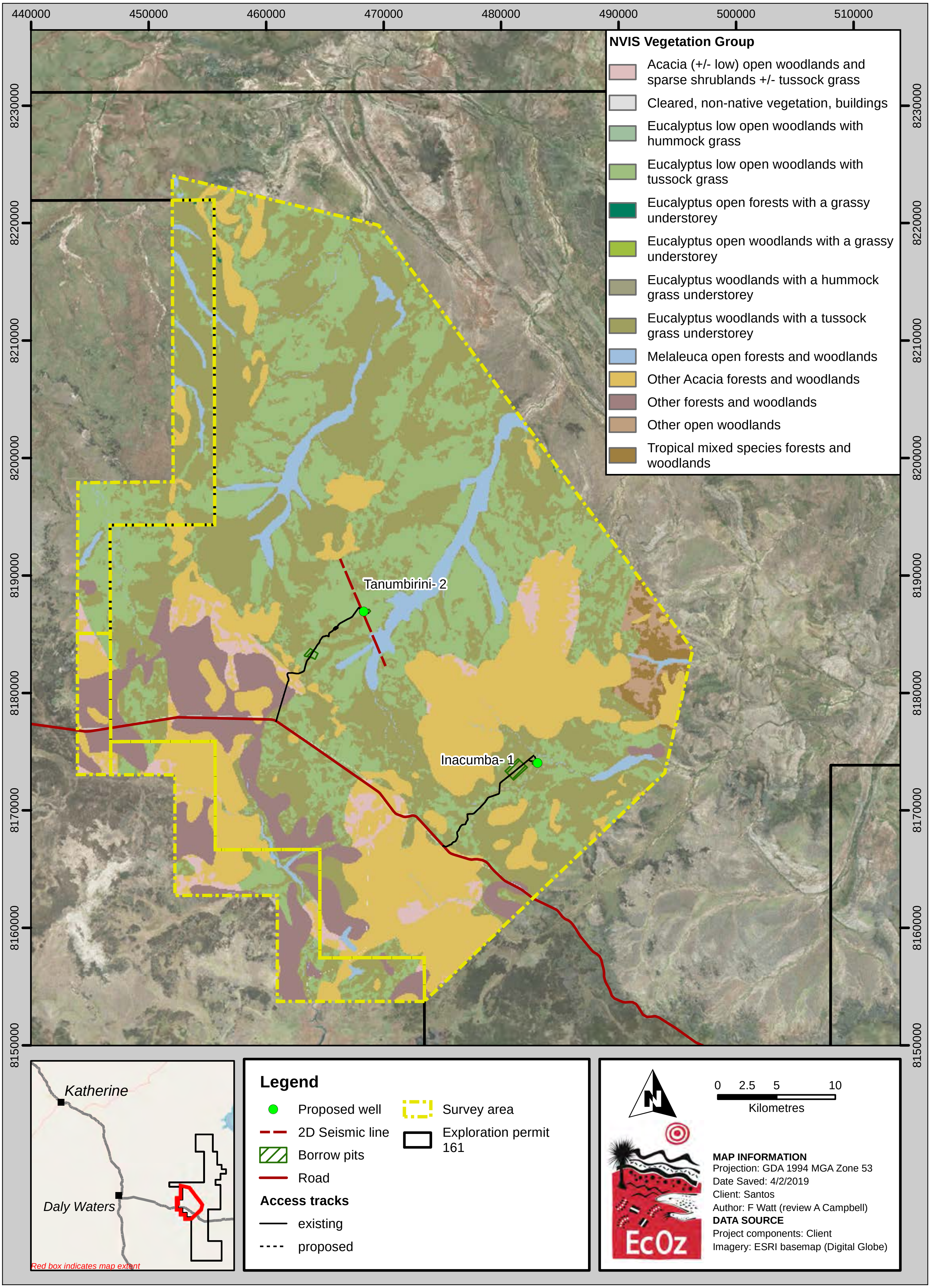
Eucalyptus woodlands with tussock understorey

Eucalyptus woodlands with hummock understorey

Corymbia woodlands

Tussock grassland

 Melaleuca woodland	 Acacia woodland/forest
 Bullwaddy woodland	



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19041 - Santos EP161 EMP aspects\01 Project Files\Figure 3-5. Map showing NVIS vegetation within the survey and project areas.mxd

Figure 3-5. Map showing NVIS vegetation within the survey area

3.3.4 Sensitive vegetation communities

There was a single sensitive vegetation community type identified within the survey area.

Riparian vegetation occurs along freshwater waterways (ephemeral or permanent). It is a distinct, closed forest community that creates suitable conditions for a range of species (terrestrial and aquatic) by providing shade (DLRM 2013). It covers a relatively small land area and provides unique habitat features and dry season refuge for a range of native fauna species (DLRM 2013).

Six riparian sites were visited during field survey (this is a representative set of sites within the survey area). Typical riparian vegetation in the region consists of *Eucalyptus* and *Melaleuca* communities with tussock grass understoreys. Riparian vegetation within the survey area was confined to the banks of the watercourse and did not extend far into the surrounding country.

Like other areas within the survey area, riparian vegetation exhibited impacts from cattle. Erosion from cattle trampling was evident on the banks of all watercourses visited. Understorey grass species showed extensive impact from cattle grazing; this has likely exacerbated the erosion along the watercourse banks.

Figure 3-6. Photos showing typical riparian vegetation within the survey area

3.3.5 Watercourses, wetlands and waterholes

There are no wetlands of international or national significance within the survey area.

There are two ephemeral (seasonal) watercourses within the survey area – Lagoon Creek, and Tanumbirini Creek. Newcastle Creek is also within the survey area. These watercourses are associated with the McArthur land system.

Three permanent waterholes were visited during field survey (those which were accessible using existing access tracks). One of these permanent waterholes, 'Rocky Hole', is used for pastoral operations (water is pumped from this site and it is evidently visited by stock). Rocky Hole is a relatively large waterhole with a sandstone cliff to the upstream end. It is fringed with *Melaleuca sp.* with a tussock grass understorey. Multiple Freshwater Crocodiles (*Crocodylus johnstonii*) were observed within the waterhole, and numerous bird species were utilising this environment.

The second waterhole was a large, elongate waterhole which appeared to have a similar profile to the surrounding watercourse. The waterhole is located between two bands of quartz sandstone outcropping to the north-east of the survey area. The third waterhole was smaller and was surrounded by flat plains. This waterhole was on the same watercourse as Rocky Hole, further upstream.

Aerial imagery indicates that there are multiple other waterholes in the survey area; however, access to these was not possible.

3.3.6 Threatened species

There are records for 31 threatened species (Commonwealth and/or Northern Territory-listed) within the two relevant bioregions – 30 fauna and one flora species. It should be noted that the project occurs within Beetaloo Basin, an area which has very few records of threatened species compared to the savanna woodland habitats to the north and in the arid lands to the south (DEWHA 2009).

The key points of the 'likelihood of occurrence' assessment are summarised below and in Table 3-3, and detailed in Appendix B.

- No species were ranked as having a 'high' chance of occurring within the survey area.
- Four species were ranked as having a 'medium' chance of occurring within the survey area.
- Thirteen species were ranked as having a 'low' chance of occurring within the survey area
- Fifteen species were considered to not occur within the survey area.

Only species which have a medium likelihood of occurring within the survey area are considered further in this report.

Table 3-3. Threatened species 'Likelihood of Occurrence' assessment (summary)

Likelihood	Common name	Scientific name	Group	Status NT	Status Cth
Medium	Gouldian Finch	*Erythrura gouldiae*	Bird	VU	EN
	Grey Falcon	*Falco hypoleucos*	Bird	VU	-
	Crested Shrike-tit (northern subspecies)	*Falcunculus frontatus whitei*	Bird	-	VU
	Mertens' Water Monitor	*Vananus mertensi*	Reptile	VU	-
Low	Red Goshawk	*Erythrotriorchis radiata*	Bird	VU	VU
	Partridge Pigeon (eastern subspecies)	*Geophaps smithii smithii*	Bird	VU	VU
	Painted Honeyeater	*Grantiella picta*	Bird	VU	VU
	Australian Painted Snipe	*Rostratula (benghalensis) australis*	Bird	VU	EN
	Masked Owl (northern subspecies)	*Tyto novaehollandiae kimberli*	Bird	VU	VU
	Brush-tailed Rabbit-Rat	*Conilurus penicillatus*	Mammal	EN	VU
	Ghost Bat	*Macroderma gigas*	Mammal	-	VU
	Carpentarian Antechinus	*Pseudantechinus mimulus*	Mammal	-	VU
	Pale Field-rat	*Rattus tunneyi*	Mammal	VU	-
	Bare-rumped Sheathtail Bat	*Saccolaimus saccolaimus (nudicluniatus)*	Mammal	-	VU
	Plains Death Adder	*Acanthophis hawkei*	Reptile	VU	VU
	Mitchell's Water Monitor	*Varanus mitchelli*	Reptile	VU	-
	Floodplain Monitor	*Varanus panoptes*	Reptile	VU	-

Key: EN – Endangered, VU – Vulnerable

Gouldian Finch, Grey Falcon, Crested Shrike-tit and Mertens' Water Monitor were considered to have a medium likelihood of occurrence. Two of these species (Grey Falcon and Crested Shrike-tit) have broad ranges and utilise woodland habitat that is common to the region. As such, it is considered that an exploratory drilling program or seismic exploration program is unlikely to have any significant impact on these species or their habitat.

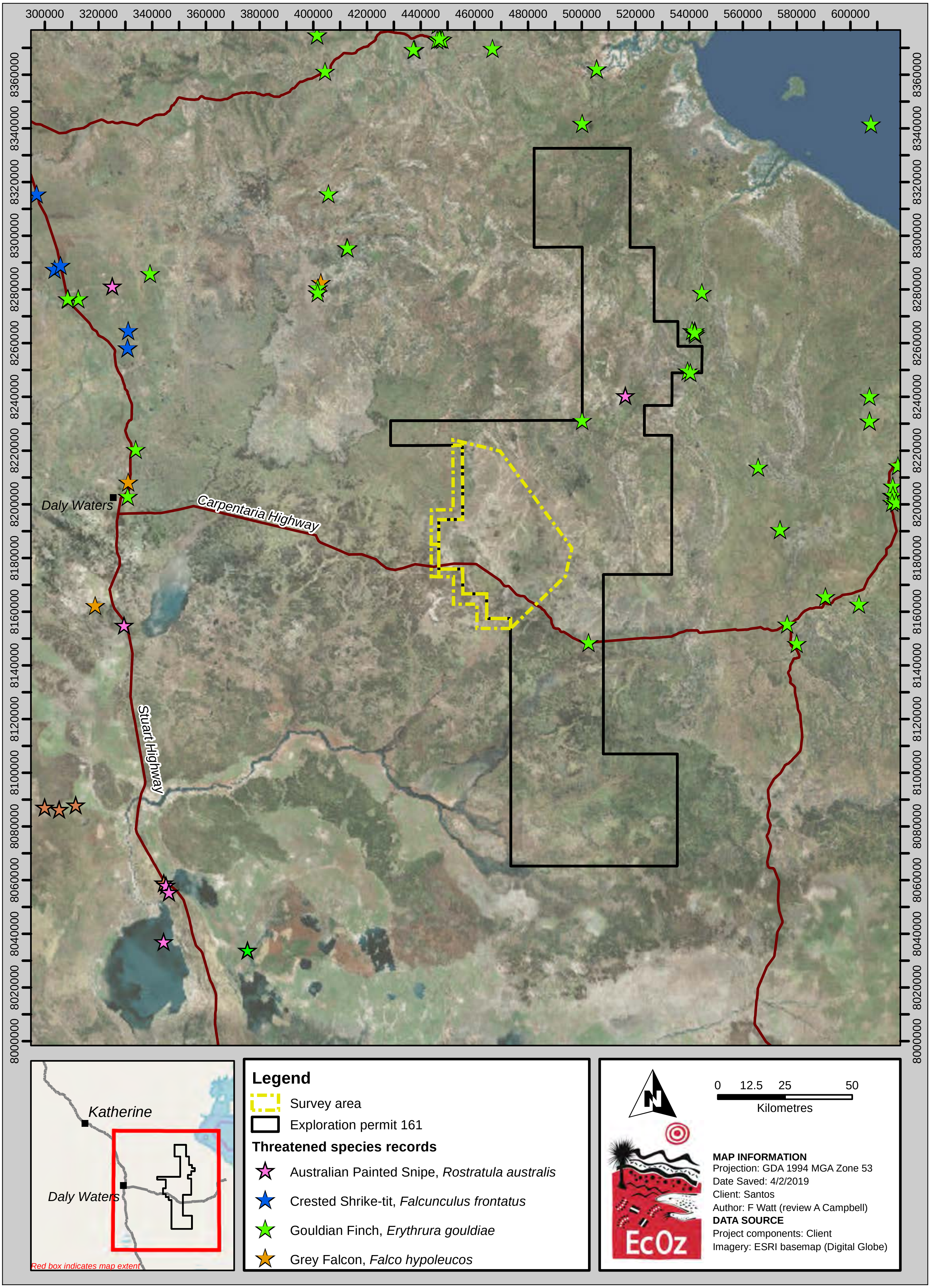
There is a single record of Merten's Water Monitor (record date 1993) close to the project area, but south of the Carpentaria Highway. The species is widespread across the NT, occupying all of the Top End river systems (Ward et al. 2006). It occupies edges of freshwater watercourses and lagoons, but is seldom seen far from water (Christian 2004). Any impact from an exploratory drilling or seismic program would only occur if there was significant disturbance to riparian habitat where the species occurred; this is not proposed.

The Gouldian Finch has more specific habitat requirements. In particular, in the late wet season and entire dry season (February to October) the species occurs in rocky hills that support Eucalyptus species commonly referred to as Snappy Gum or Salmon Gum (which provide suitable hollows for nesting purposes). *Eucalyptus leucophloia* is one of these preferred nesting species. Nest sites are between two and four kilometres from small permanent waterholes or springs (O'Malley et al. 2006). Gouldian Finch feed on annual spear grasses and native sorghum (i.e. *Sorghum* species) during this period.

The field survey identified a number of sites where *E. leucophloia* was present. These sites were on hilled areas within the survey area. These sites correlated to land systems that had an identified landform of lateritic plateau. The understorey species consisted of hummock, tussock or a mixture of hummock/tussock grass species. In a number of areas, the habitat was considered long unburnt (there were large spinifex hummocks) and there were considerable hollows that, through preliminary assessment, appeared to be suitable nesting locations.

From the field observations and the available land system mapping of the survey area, Gouldian Finch breeding habitat may occur within the following land systems – Lancewood 2[2], Inacumba and Bukalara. There are areas of each of these land systems in the survey area.

[2] Although *Eucalyptus leucophloia* is not associated with the Lancewood 2 land system in Table 3-2, the field survey identified numerous areas of this within the land system.



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19041 - Santos EP161 EMP aspects\01 Project Files\Figure 3-7. Map of proximate records for medium likelihood threatened species.mxd

Figure 3-7. Map of proximate records for medium likelihood threatened species

3.3.7 Migratory species

A Protected Matters Search Report identified 16 EPBC-listed migratory species as potentially occurring within the survey area. Three of the migratory species were identified by a Likelihood of Occurrence assessment as having a medium likelihood of occurrence in the survey area, and a further eight had a low likelihood of occurrence, the remaining five were assessed as having no likelihood of occurring within the survey area.

When assessing if a project will significantly impact upon a migratory species, the key considerations under the *EPBC Significant Impact Guidelines 1.1* (DOE 2013) are whether an important habitat for a migratory species or an ecologically-significant population of a migratory species is involved. Although the migratory species in question have very different habitats and ecologies, they are all similar in that the project area neither represents important habitat for them, nor are ecologically-significant populations likely to be present.

Table 3-4. Migratory species 'likelihood of occurrence' assessment (summary)

Likelihood	Common name	Scientific name	Group
Medium	Fork-tailed Swift	*Apus pacificus*	Migratory marine bird
	Oriental Plover	*Charadrius veredus*	Migratory wetland species
	Oriental Pratincole	*Glareola maldivarum*	Migratory wetland species
Low	Oriental Cuckoo	*Cuculus optatus*	Migratory marine species
	Barn Swallow	*Hirundo rustica*	Migratory terrestrial species
	Red-rumped Swallow	*Cecropis daurica*	Migratory terrestrial species
	Grey Wagtail	*Motacilla cinerea*	Migratory terrestrial species
	Yellow Wagtail	*Motacilla flava*	Migratory terrestrial species
	Common Sandpiper	*Actitis hypoleucos*	Migratory wetland species
	Sharp-tailed Sandpiper	*Calidris acuminata*	Migratory wetland species
	Pectoral Sandpiper	*Calidris melanotos*	Migratory wetland species

None of the three species identified as having a medium likelihood of occurring within the survey area are expected to be impacted by an exploratory drilling program. The Fork-tailed Swift would only be found above the survey area as it is an exclusively aerial species. The Oriental Plover and the Oriental Pratincole potentially occur within the survey area, however, these species are unlikely to be impacted by an exploratory drilling program or seismic exploration program as the area of disturbance will be small and the species' preferred habitat covers large areas.

3.3.8 Avifauna observations

Thirty-three species were observed within the survey area during field surveys (August 2017) – see Table 3-5. Avian species were recorded in all land systems; however, the majority of records come from areas surrounding the waterholes/watercourses, and the Eucalypt/Corymbia woodlands. No threatened species were observed.

Table 3-5. List of avian species observed during field surveys

Double-barred Finch	Brown Honeyeater	Black Falcon
Peaceful Dove	Nankeen Night Heron	Australian Pratincole
Black-faced Wood-swallow	Straw-necked Ibis	Red-tailed Black-Cockatoo
Nankeen Kestrel	Great Bowerbird	Galah
Black Kite	Darter	Zebra Finch
Willy Wagtail	Great Egret	Cattle Egret
Whistling Kite	Mistletoebird	Black-faced Cuckoo-shrike
Diamond Dove	Yellow-tinted honeyeater	Red-backed Fairy-wren
Long-tailed Finch	Plumed Whistling Duck	Apostlebird
Royal Spoonbill	Crested Pigeon	Grey-crowned Babbler
Great Cormorant	Wedge-tailed Eagle	Common Bronzewing

3.4 Conclusion and recommendations

The desktop assessment provided broad-scale environmental descriptions and a detailed review of threatened species for the survey area. The next sections outline the recommendations made that should be addressed when considering the final project area of any exploration program.

3.4.1 Land condition

Weed invasion and spread is a key risk to biodiversity values and pastoral activities. Exploration activities can be a vector for the transport of weed material. A number of weeds are present within the region and the Katherine Region Weed Management Plan 2015-2020 identifies priority weeds.

3.4.2 Biodiversity values

The following biodiversity values were identified by desktop assessment and limited field survey.

Sensitive vegetation

The survey area supports one sensitive vegetation type – riparian vegetation. Riparian vegetation was observed within the survey area and is likely located at multiple locations along the two major watercourses. At the sites surveyed, riparian vegetation was limited to the immediate stream banks (i.e. it did not extend far from the watercourse). Given its confined extent, it is likely that riparian vegetation can be avoided by an exploratory drilling program.

Watercourses, wetlands and waterholes

The survey area supports some permanent freshwater waterholes. The waterholes (particularly Rocky Hole) support much higher biodiversity values than the surrounding area; they should be avoided by any drilling or seismic exploration program.

Threatened species

The survey area potentially supports populations or habitat for the following four threatened species (listed under the *TPWC Act* and/or the *EPBC Act)*

- Gouldian Finch
- Grey Falcon
- Crested Shrike-tit

- Mertens' Water Monitor

As two of these species (Grey Falcon and Crested Shrike-tit) have broad ranges and utilise woodland habitat that is common to the region, it is considered that an exploratory drilling or seismic exploration program is unlikely to have any significant impact on these species or their habitat.

The Gouldian Finch has more specific habitat requirements. There was potential habitat for the species found within the survey area. These areas were associated with hilled regions were there was *Eucalyptus leucophloia* present (nesting habitat).

Potential impacts to this species will be associated with clearing vegetation for drill pads, roads, and other related infrastructure; with the main direct impact being removal of current (or potential) nest sites. If the project avoids areas of Snappy Gum (*Eucalyptus leucophloia*), then there will not be a significant impact to the species. Even if areas of Snappy Gum need to be removed for project operations, it is unlikely that there will be a significant impact on the species; however, this should be confirmed prior to operations.

If more extensive works are proposed to be undertaken (for example a production operation), it is recommended that further work be undertaken to assess the risk and impact to Gouldian Finch. The steps involved in such work are outlined below:

- Phase 1: Conduct a habitat suitability assessment (desk-based assessment), which will include inspection if the proposed disturbance area falls within the land systems containing suitable habitat.
- Phase 2: If potential habitat is suspected to occur, follow up with on-ground studies to refine habitat features and update the 'likelihood of occurrence' assessment for the specific disturbance sites. For this species, the on-ground studies should also include a survey for evidence of Gouldian Finch (i.e. direct observation, potential nest sites, viable food resources, proximity to dry season water supply) and also characterisation of nesting habitat based on known hollow requirements. These surveys can be conducted at any time of year. Surveys should include a detailed habitat assessment of the site.
- Phase 3: If the habitat assessment indicates it is possible that Gouldian Finch inhabit the site, and if the habitat cannot be avoided from disturbance activities, more intensive survey methodology will be required to provide a more rigorous interrogation of the species' likelihood of occurrence. Standard survey techniques applicable for Gouldian Finch detection will be to undertake surveillance (i.e. stake-outs) on the suspected nest sites to determine if they are active, and if they belong to Gouldian Finch. Confirmed nest sites will be considered to be significant, and potential nest sites will also be considered to be significant if 'flyover' sightings are observed in the area. These surveys should occur in the late wet to mid dry season to ensure that breeding populations are encountered.

The abovementioned methods align with the *Survey Guidelines for Australia's Threatened Birds* (Commonwealth of Australia 2010).

Migratory species

Although there are three migratory species identified as having a medium likelihood of occurring within the survey area, it is not expected that an exploratory drilling program or seismic exploration program will have a significant impact on the species.

3.4.3 Recommendations

The biodiversity values mentioned in this document are either associated with habitat types that can be avoided (i.e. riparian vegetation) or that will not be significantly impacted through an exploratory drilling program or seismic exploration program (i.e. threatened species) due to the small area of disturbance.

Given the results of the biodiversity values assessment contained within this report, the following recommendations are made to minimise environmental impact:

- Ensure that the minimum setback distance as per the *Land Clearing Guidelines* are met to avoid impact to sensitive vegetation. These buffers should be measured from the boundary of the disturbance area to the edge of the riparian vegetation (rather than from the drill site/well head).
- Where possible, locate drill sites and seismic exploration activities within lateritic plains land systems, as field surveys and 'likelihood of occurrence' assessment indicated that these systems are the least likely to provide significant habitat for threatened species.
- Where possible, avoid impacts to Snappy Gums (*E. leucophloia)* (located primarily in the lateritic plateau land system but can occur on any rise); this will minimise any impact to Gouldian Finch.
- Prior to more-intensive works, further assessment of habitat for Gouldian Finch and potential impact to this species should be undertaken. This would include desktop assessment and on-ground studies, and assessed in relation to a project area (see Section 3.3.6).
- Prior to any works being undertaken ensure that appropriate weed management procedures are in place. All vehicles and equipment should be certified wee free prior to entry onto the property.
- Undertaking a weed survey at exploratory drilling sites and/or seismic exploration sites and along access tracks would provide baseline data. This would enable Santos to ensure that activities do not introduce or spread weeds.

4 FIELD ASSESSMENT

4.1 Purpose and scope

Santos has identified a project area for the 2019 exploration program (Section 2). Field assessments were undertaken in 2018 to address the recommendations of the desktop assessment. Particularly:

- Undertaking a weed survey at exploratory drilling and/or seismic exploration sites and along access tracks would provide baseline data. This would enable Santos to ensure that activities do not introduce or spread weeds.
- Prior to more intensive works being undertaken, it is recommended that further assessment of habitat for Gouldian Finch and potential impact to this species be undertaken. This would include desktop assessment and on-ground studies and would be assessed in relation to a project area
- As the identified exploration activities may intersect watercourses that may support sensitive vegetation in the form of riparian vegetation, Santos required the location of any sensitive vegetation to be identified so that potential impact to these communities could be avoided or minimised during exploration.

The project area is within the 2018 survey areas, as discussed in Section 2 and depicted in Figure 2-1.

4.2 Weed survey

4.2.1 Background

There are three classes of weeds declared under the NT *Weeds Management Act*, some of which are also considered Weeds of National Significance (WoNS). These weed classes, categorised based on the risk of impact and how difficult they are to control, are:

- Class A – to be eradicated
- Class B – growth and spread to be controlled
- Class C – not to be introduced into the NT (all Class A and B weeds are also Class C).

Weed surveys within EP 161 focused on the weed species already recorded on the property (see Table 4-1). Potential weeds of concern within the Katherine Region, outlined in the Katherine Regional Weed Management Plan 2015-2020 (DLRM 2015), were also considered (see Table 4-2).

Table 4-1. Declared weed species recorded within the EP

Common name	Scientific name	NT Class
Hyptis	*Hyptis suaveolens*	B/C
Rubber Bush[3]	*Calotropis procera*	B/C
Spinyhead sida	*Sida acuta*	B/C
Sicklepod	*Senna obtusifolia*	B/C

[3] Although Rubber Bush is only declared south of 16°30' S, it was included in this list as current exploration areas are just north of this latitude and EP161area crosses this line of declaration.

Table 4-2. Potential weeds within the project area

	Common name	Scientific name	NT Class	WoNS
Katherine region priority weeds	Mesquite*	*Prosopis spp.*	A/C	Y
	Prickly acacia*	*Vachellia nilotica*	A/C	Y
	Parkinsonia	*Parkinsonia aculeata*	B/C	Y
	Chinee Apple*	*Ziziphus mauritiana*	A/C	
	Mimosa*	*Mimosa pigra*	A/C	Y
	Bellyache Bush*	*Jatropha gossypiifolia*	A/C[4]	Y
	Gamba Grass*	*Andropogon gayanus*	A/C	Y
	Neem*	*Azadirachta indica*	B/C	
	Grader grass*	*Themeda quadrivalvis*	B/C	Y
	Snake weed	*Stachytarpheta spp.*	B/C	
	Devils Claw	*Martynia annua*	A/C	
Other declared weeds	Parthenium[5]	*Parthenium hysterophorus*	A/C	Y
	Starburr	*Acanthospermum hispidum*	B/C	
	Mossman River Grass	*Cenchrus echinatus*	B/C	
	Spiny-head Sida	*Sida acuta*	B/C	
	Flannel Weed	*Sida cordifolia*	B/C	
	Paddy`s Lucerne	*Sida rhombifolia*	B/C	
	Caltrop	*Tribulus terrestris*	B/C	
	Noogoora Burr	*Xanthium strumarium*	B/C	
	Khaki Weed	*Alternanthera pungens*	B/C	

* indicates weeds with an associated weed management plan

EcOz liaised with the Department of Environment and Natural Resources (DENR) Weeds Management Branch to confirm that the lists of species in Table 4-1 and Table 4-2 were comprehensive. The Weeds Management Branch agreed that the lists covered all weeds for which surveys should be conducted, whilst noting it was the wrong time of year (November) to survey for some weeds, e.g. Parthenium and Grader Grass.

The Weeds Management Branch were also consulted on the survey approach. The agreed approach was to walk all disturbance areas to search for weeds. The Weeds Management Branch also suggested surveying surrounding areas adjacent to the project area, i.e. infrastructure and access tracks, as any disturbance may provide opportunity for the establishment of weed seeds present within the soil.

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4 Bellyache bush classification depends on its location within the NT; the EP is within the Class A eradication zone.

5 Parthenium, previously eradicated from the NT, has recently been recorded in the Katherine region.

4.2.2 Methods

Weed species were recorded according to data attributes outlined in the NT Weed Data Collection Manual (*Weed Management Branch NT 2015*) and included the following:

- Weed species name (using two letter initials)
- Patch size (m): 5, 20, 50, 100
- Density (%): 1 = absent
  2 = <1
  3 = 1 - 10
  4 = 11 - 50
  5 = >50
- Seed occurrence (seed dropped): S

4.2.3 Results

The baseline weed survey recorded 48 occurrences of a total of five declared weed species. The number of occurrences of each weed species is shown in Table 4-3, the location of weed records is shown in Figure 4-1. The majority of weeds occurred along station tracks.

Hyptis was the most abundant weed recorded, with 35 records, and had the broadest distribution. It was recorded primarily along access tracks and at watering points, with a few small patches of low density recorded within 5 km of Tanumbirini-2 well location and within the 500 m buffer.

One patch of Rubber Bush was found in paddocks adjacent to a station track Figure 4-1. The patch was relatively dense in a disturbed area, and appeared to extend into the paddock to the south west. Individuals in the patch were flowering and four plants were observed to have seed present. It is likely that seed is contained in the soil in the station track adjacent to the infestation. Although not declared at this location, it can cause significant environmental and financial damage. It is a declared weed south of the Carpentaria Highway – including in areas of EP161. The track adjacent to the infestation is not part of the project area, however, the infestation is noted here for benefit of planning future activities.

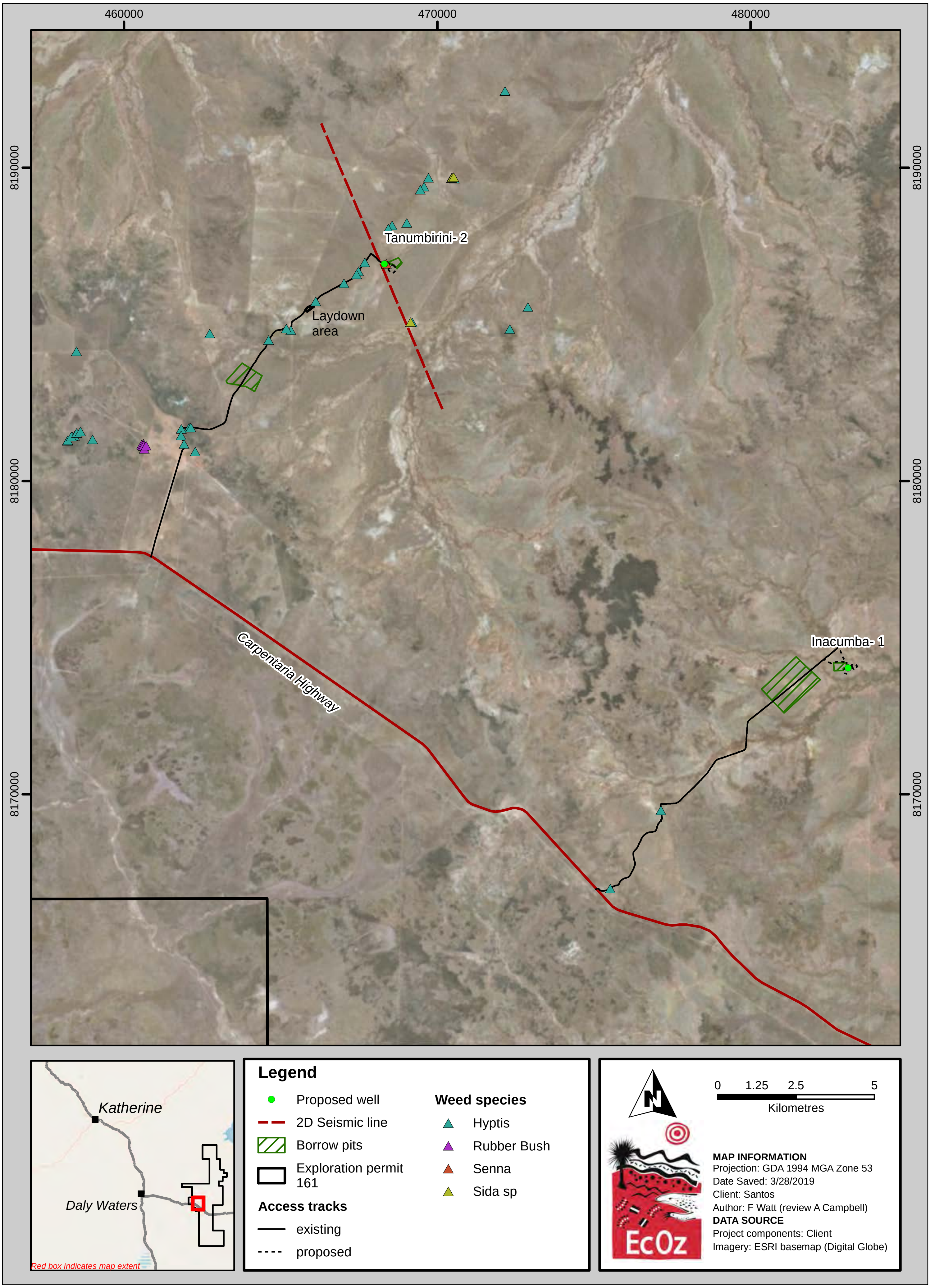
Surveyed patches of *Sida* sp. were only recorded at cattle watering points (Figure 4-1).

Table 4-3. Declared weed species with Tanumbirini-2 survey area

Common name	Scientific name	NT Class	No. of records	Seeded
Hyptis	*Hyptis suaveolens*	B and C	35	4 plants
Rubber Bush	*Calotropis procera*	B and C[6]	7	4 plants
Sida sp	*Sida* sp	B and C	4	None
Sicklepod	*Senna obtusifolia*	B and C	1	None

No weeds were observed within 500 m buffer of the Inacumba-1 well site. Two records of *Hyptis suaveolens,* were recorded along access track option 1 and 2. The location of recorded weeds is shown in Figure 4-1.

[6] South of 16°30'S



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19041 - Santos EP161 EMP aspects\01 Project Files\Figure 3-2. Location of weed occurrences within or adjacent to 2019 exploration program area.mxd

Figure 4-1. Weed occurrences within, or adjacent to, project area

4.3 Threatened species habitat

4.3.1 Background

The desktop assessment determined that Gouldian Finch (*Erythrura gouldiae*) had a medium chance of occurring with the survey area (which included the project area) (Section 3.2.5). Gouldian Finch is listed as endangered under both the *Environment Protection and Biodiversity Conservation Act* (*EPBC Act*) (1999) and the *Territory parks and Wildlife Conservation Act* (*TPWC Act*).

The critical components of suitable habitat for the Gouldian Finch vary seasonally. In the dry season, the critical components are hollow-bearing Eucalyptus trees (especially *E. tintinnans, E. brevifolia and E. leucophloia*) (Higgins et al. 2006; O'Malley 2006; Tidemann 1996; Tidemann et al. 1999) with an understorey of the favoured annual grass (*Sorghum* spp., *Schizachyrium* spp.) and a nearby (within 4 km) source of surface water. In the wet season, Gouldian finches rely on a variety of perennial grass species, and birds will move from area to area as the seeds from each species become available (Dostine and Franklin 2002; Dostine et al. 2001).

The breeding season extends from February to April, with a longer season (January to August) in years of extended wet season rainfall (Woinarski & Tidemann 1991; Tidemann & Woinarski 1994; Tidemann et al. 1999). Individuals or groups appear first to select patches of habitat with high densities of potential nesting sites, and breeding pairs then select specific nest sites based on a suite of preferred hollow morphometric attributes (Brazill-Boast et al. 2010).

The field inspections as part of the previous study (EcOz 2017) identified a number of sites where *E. leucophloia* was present on hilled areas within EP 161. The understorey species at these sites consisted of hummock, tussock or a mixture of hummock/tussock grass species. In a number of areas, the habitat was considered long unburnt (given the presence of large spinifex hummocks) and there were considerable hollows, which, through preliminary assessment, appeared to be suitable nesting locations.

4.3.2 Methods

Surveyors marked any occurrence of *E. leucophloia* within the project area. At each patch of *E. leucophloia* the following information was recorded:

- Tree density
- Tree heights (m)
- Type of trunk (single or ‘Mallee’)
- Hollow heights (m)
- Number of hollow > 25 mm
- General hollow angle
- Understorey vegetation description
- Fire impact

The habitat suitability of each patch of *E. leucophloia* for Gouldian Finch was categorised based on these characteristics.

4.3.3 Results

There are few patches of *E. leucophloia* within the project area. There is a small patch of *E. leucophloia* within the 500 m buffer of Tanumbirini-2. There are an additional nine patches of *E. leucophloia* within 5 km of Tanumbirini-2; the linear transects radiating out from Tanumbirini-2 crossed seven patches, and another two patches were observed opportunistically. The locations of *E. Leucophloia* patches detected during the survey, both within and outside the project area, are shown in Figure 4-2.

The access track to Tanumbirini-2 passed through a patch of *E. leucophloia*; however, this patch will not be disturbed by the project area. Similarly, the access track to Inacumba-1 passes by a patch of *E. leucophloia* that will not be disturbed by the project area.

There were no *E. leucophloia* trees within the 500 m buffer of the Inacumba-1 well site, nor will the use of the access track to Inacumba-1 result in the removal of any *E. leucophloia* trees.

The few patches of *E. leucophloia* represented typical open-woodland to woodland vegetation communities. The characteristics of six patches and the derived habitat suitability is shown in Table 4-4 (these patches were representative of the nine crossed by the linear transects). Although unconfirmed, it is likely that the patches are within 4 km of water given the number and location of stock watering points in addition to the small residual pools, which were present within the ephemeral drainages.

E. leucophloia trees within the survey area most commonly showed a 'mallee-like' growth form (i.e. many thin trunks emanating from a common base). The number of hollows per tree was between zero and five across all patches. However, the number of hollows greater than 25 mm was low in all but one patch (discussed below). In all cases, the *E. leucophloia* patches had a tussock grass understorey with minimal signs of recent fire impact.

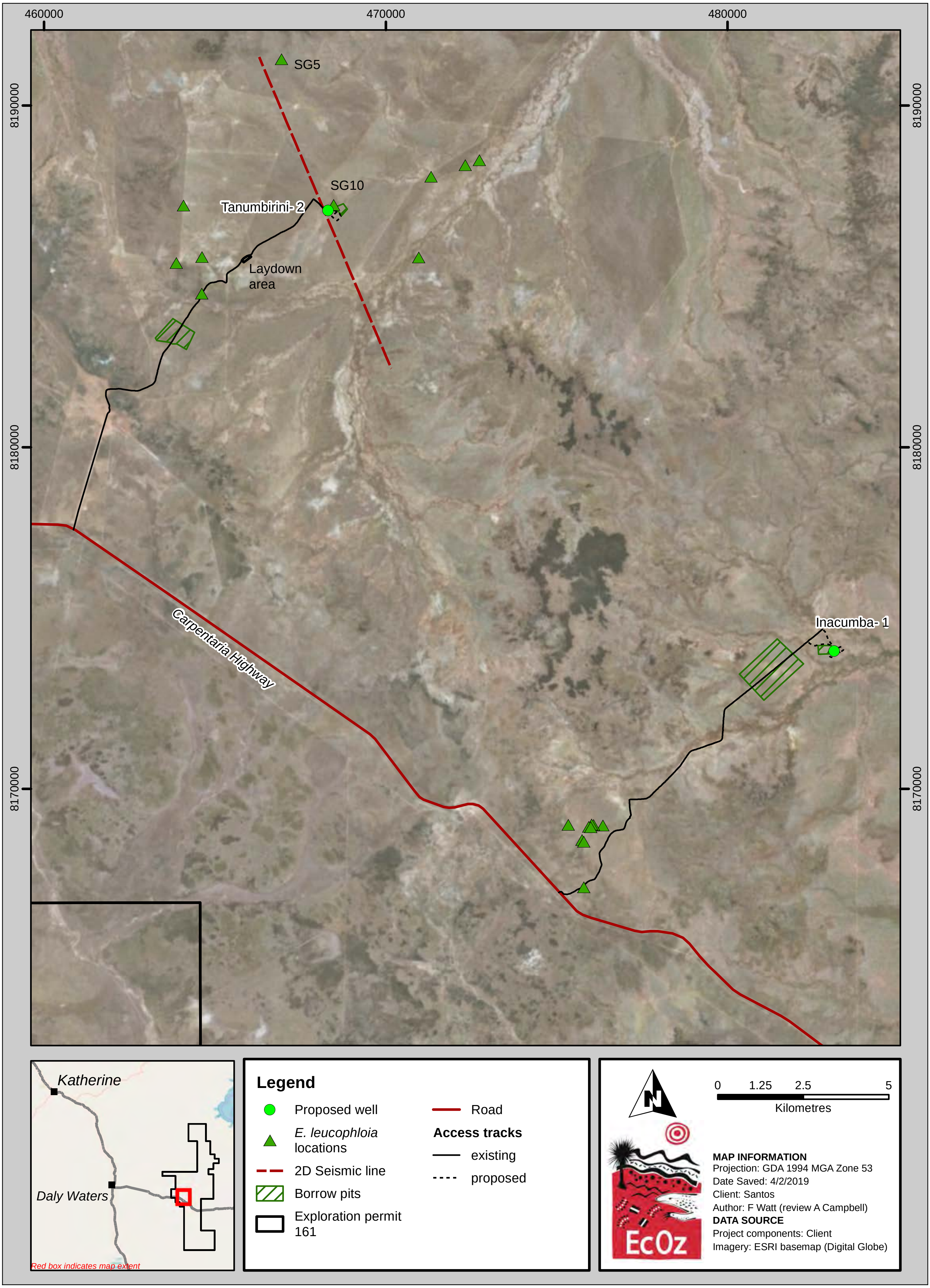
One patch (SG5) consisted of trees with single, larger trunks. Trees within this patch were relatively dense (40/ha) compared to other patches intersected. The number of hollows per tree were generally consistent with other patches; however, a larger percentage of hollows were greater than 25 mm wide.

No threatened species were observed during surveys. Long-tailed Finches were observed at a number of locations during the survey, and were consistently found at stock watering points. Anecdotal evidence suggests that Gouldian Finches do, or at least have occurred on Tanumbirini Station (and within EP161); however, they are more likely to occur in the northern sections – well outside the project area.

Habitat suitability assessment

The results of previous studies have shown that Gouldian Finches have strong preferences for specific hollow characteristics (Brazill-Boast 2010, Tidemann et al. 1992). Based on Brazill-Boast et al (2010), Gouldian Finches select hollows that are located in living tissue, are located in robust trees, are high off the ground, have smaller entrances, are deep into the trunk, and are close to horizontal. Studies investigating suitability of habitat for Gouldian Finch have found that density of hollows in preferred nesting habitat for the species is 4.6 hollows per hectare (Brazill-Boast et. al 2011) and 2 to 27 per hectare (Gibbons and Lindenmayer 2002).

Given these findings, although it is unknown whether these patches are used by nesting Gouldian Finches, three patches (SG8, SG9 and SG5) do present habitat that could be used by the species. Although there were hollows present, SG2 is not considered suitable habitat as only one hollow larger than 25 mm was found. Only two patches (SG5 and SG10) are intersected by the project area. SG5 is considered the best habitat for the species, as there were more hollows greater than 25 mm, tree density was high, the trees were single stemmed rather than mallee-like and the hollows were roughly horizontal. There are no hollows present within patch SG10, thus it is not considered suitable Gouldian Finch nesting habitat.



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19041 - Santos EP161 EMP aspects\01 Project Files\Figure 4-1. Location of E leucophloia patches near 2019 exploration program area.mxd

Figure 4-2. Location of *E. leucophloia* patches near the project area

Table 4-4. Habitat characteristics of *E. leucophloia* patches within survey area.

Patch	Tree density (#/ha)	Tree heights (m)	Trunk type	Hollows per tree	Hollow heights (m)	Number hollows > 25 mm	General hollow angle	Vegetation	Fire impact	Suitability
SG8	4	8	Mallee	5	2 - 5	2*	45°	Open woodland of *Hakea sp* and *Acacia sp* over Tussock grassland	Nil	Moderate
SG9	7	8	Mixed	1 – 3	2 - 5	5*	90°	Sparse Acacia spp. shrubland over Tussock grassland	Nil	Moderate
SG2	10	6	Mallee	3	1 – 3	1*	40°	Sparse mid-story of *Hakea* spp. over Tussock grassland	-	Low
SG10	4	6	Mallee	0	N/A	N/A	N/A	*Themeda triandra* and *Heteropogon contortus*	Nil	Low
SG4	8	6 -7	Mixed	0	N/A	N/A	N/A	*Themeda triandra* and *Heteropogon contortus*	Nil	Low
SG5	40	6	Single	3 – 4	2.5 – 5	50% of hollows	90°	*Acacia* sp and *Grevillea* sp. over Tussock grassland, some *Themeda triandra*	Nil	High

** - total number of hollows (indicating percentage hollows > 25 mm is low)*

4.4 Riparian and sensitive vegetation

4.4.1 Background

Significant or sensitive vegetation communities are described in the *NT Land Clearing Guidelines* (NRETAS 2010). They are vegetation communities that are distinct and limited in extent or support important ecological values, and include rainforest, vine thicket, closed forest or riparian vegetation, mangroves, monsoon vines forest, sand-sheet heath and vegetation containing large trees with hollows suitable for fauna.

Within the project area, riparian vegetation is the most likely sensitive vegetation community to occur. Where it comprises sensitive vegetation, riparian vegetation is a distinct, closed forest community that creates suitable conditions for a range of species (terrestrial and aquatic) by providing shade (DLRM 2013). It covers a relatively small land area, provides unique habitat features and dry season refuge for a range of native fauna species, and is important for maintaining bank stability and reducing erosion (DLRM 2013).

Initial site visits determined that such closed forest community riparian vegetation was present within the survey area (Figure 4-3 left). Analysis of aerial imagery indicates the project area crosses ephemeral watercourses; however, not all the vegetation along these watercourses should be considered a sensitive riparian community. The majority of vegetation along the ephemeral watercourses in the area is an extension of the surrounding vegetation communities, or consists of species not found in the surrounding vegetation (e.g. *Eucalyptus camaldulensis*) but is sparse and does not provide the habitat characteristics or bank stabilising properties of sensitive riparian vegetation communities (Figure 4-3 right).

In this report, two terms are used to describe vegetation along a watercourse:

- Riparian vegetation – vegetation considered sensitive under the *NT Land Clearing Guidelines* (e.g. Figure 4-3 left).
- Drainage line vegetation – vegetation along a drainage line but not considered sensitive riparian vegetation under the *NT Land Clearing Guidelines* (e.g. Figure 4-3 right).

Figure 4-3. Examples of sensitive riparian vegetation (left) and drainage line vegetation (right).

Field surveys were undertaken to determine where the project area intersected riparian vegetation and drainage line vegetation.

4.4.2 Methods

Surveyors recorded the location of riparian and drainage line vegetation on a handheld GPS when encountered along the survey transect, and the dominant upper strata species of the vegetation. Photographs were taken to confirm the presence of drainage channels and any vegetation present along the drainage channel.

Waypoints were loaded into an ArcGIS project to indicate the location of riparian and drainage line vegetation on aerial imagery (ESRI Base maps). Inside the 500 m well buffers, aerial imagery at a 1:10,000 scale was used to differentiate riparian and drainage line vegetation from surrounding vegetation types. Polygons were drawn to delineate patch boundaries; polygons were created for both riparian vegetation and drainage line vegetation.

4.4.3 Results

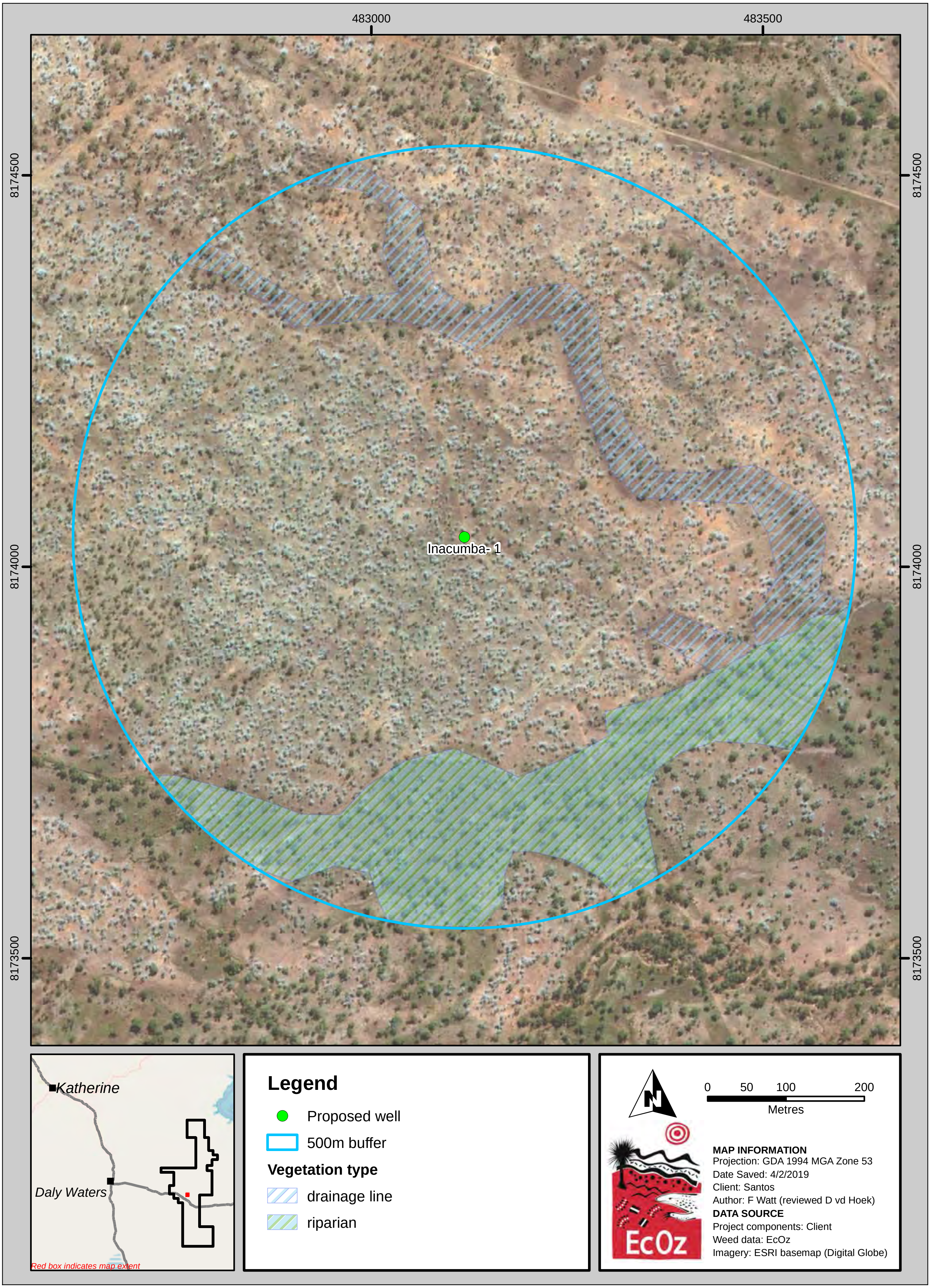
There is a patch of riparian vegetation along the edge of drainage channels within the southern sections of the Inacumba-1 survey area. *Eucalyptus camaldulensis* and *Terminalia bursarina* are the dominant species in this open woodland community. This vegetation is associated with Inacumba Creek, a minor watercourse of stream order three. There is also a patch of drainage line vegetation extending from the north of the survey to the south east. This vegetation community consists of *Eucalyptus camaldulensis* and *Terminalia bursarina*, as well as *Eucalyptus pruinosa*, a species that dominates the surrounding open woodland within the Inacumba-1 survey area.

The location of riparian and drainage areas has been mapped for the Inacumba-1 survey area and is shown in Figure 4-5. Photos of riparian and drainage line vegetation within Inacumba-1 are shown in Figure 4-4.

Figure 4-4. Photos of riparian (left) and drainage line (right) vegetation within Inacumba-1 survey area

The vegetation intersected by linear transects radiating out from Tanumbirini-2 at watercourse crossings comprised primarily a narrow strip of *Eucalyptus camaldulensis* in the upper-storey. Canopy cover along this strip is higher than the surrounding woodland and open plains; however, visual inspection did not indicate that canopy foliage cover was sufficiently dense for the vegetation to be classified as a forest community.

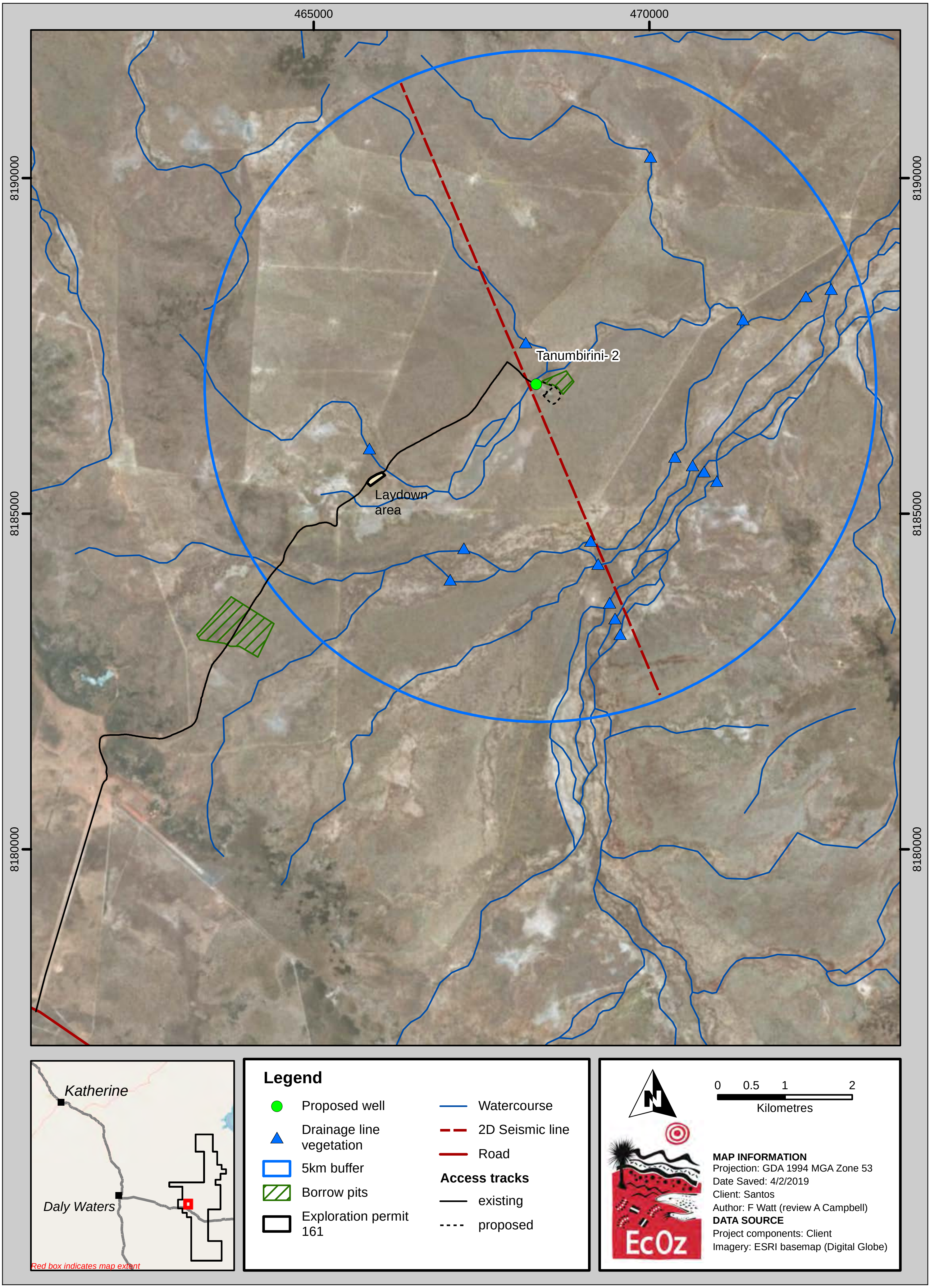
Height of upper-storey of riparian vegetation was between 5 and 10 metres. There was limited mid-storey vegetation at any of the watercourse crossing sites. Ground cover comprised tussock grasses consistent with the surrounding vegetation community. Vegetation at a number of drainage lines did not show any distinction between that of the surrounding landscape. Photos of vegetation at locations watercourses are shown in Figure 4-6.



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19041 - Santos EP161 EMP aspects\01 Project Files\Figure 5-2. Location of riparian and drainage line vegetation within Inacumba 1_1H survey area.mxd

Figure 4-5. Map showing location of riparian and drainage line vegetation within Inacumba-1 survey area

Figure 4-6. Photos of drainage line vegetation along transects radiating from Tanumbirini-2



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19041 - Santos EP161 EMP aspects\01 Project Files\Figure 5-5. Map showing locations of drainage line vegetation along transects from Tanumbirini- 2.mxd

Figure 4-7. Map showing locations of drainage line vegetation along transects from Tanumbirini- 2

4.5 Discussion

Surveys within the project area were completed targeting:

- Listed weed species
- Threatened species habitat and incidental species observations
- Sensitive vegetation

Weed diversity within the project area is low, with only five weed species recorded. Weeds are also at low densities except for Hyptis, which also occurs outside the project area and is common throughout the region. There is one patch of Rubber Bush beside an access track; however, this track is not part of the project area. The majority of weeds were recorded along access tracks or at stock watering points. Although it is likely that there is Hyptis seed within the station access tracks, the species is currently wide spread along the access tracks likely to be used in exploration activities.

The project area intersects two patches of *E. leucophloia*. The *E. leucophloia* patches, although relatively small should be considered as potential Gouldian Finch habitat. Although the density of trees with SG5 is relatively high, densities of *E. leucophloia* is such that seismic activities should be able to avoid impacting trees. In the event that a tree does need to be removed for seismic activities, it is likely that only a small number of trees will be affected. Best practice environmental management of minimising the disturbance to the smallest extent required should be employed as routine; however, it is not considered that specific management controls be undertaken.

The vegetation along the watercourses crossed by the 2D seismic line, although denser than surrounding communities, is not considered to be a riparian forest community and, as such, not sensitive vegetation. The vegetation is also sparse enough that the vehicles involved in 2D seismic exploration should be able to avoid impact to vegetation along drainage lines. Minimising the disturbance to vegetation along the drainage lines will help maintain stability of the watercourses, reduce sedimentation and retain wildlife habitat.

Patches of riparian vegetation were recorded within the southern section of Inacumba-1. Clearing within these areas should be avoid if possible to minimise the risk of erosion and sediment transfer within these areas during periods of concentrated overland flow. The appropriate buffers, as detailed in the *NT Land Clearing Guidelines*, should be applied.

EcOz makes the following recommendations for the 2019 exploration activities:

Weeds

- All vehicles involved in exploration activities should be certified weed free prior to entering Tanumbirini Station.
- Weeds should be surveyed and controlled according to the requirements outlined within the Santos – Weed Management Plan – EP 161 (EcOz, 2019)

Gouldian Finch

- Avoid removal of *E. leucophloia* trees within the patches along the 2D seismic line. This should be achievable through the design of the seismic survey (i.e. vehicles weave through trees) without specific management controls. If significant numbers of trees are to be removed, consideration should be given to having environmental staff on site to identify ways to minimise impact to *E. leucophloia*.
- Although considered unlikely, if Gouldian Finches are observed incidentally during further environmental assessments (such as post Wet Season weed assessment) or project activities, Santos will engage experienced ecologists to complete further assessment. This may include population characterisation or further habitat assessment.

Sensitive vegetation

- Clearing within areas mapped as riparian vegetation within Inacumba-1 buffer should be avoided where possible.

Borrow pits

- Prior to disturbance of areas for the extraction of borrow material, environmental staff (either from Santos or a consultant) should ensure that there are no significant environmental values in the final areas selected.

Although there is not expected to be any impact to Mertens' Water Monitor, if the species are observed incidentally during further environmental assessments (such as post Wet Season weed assessment) or project activities, Santos will engage experienced ecologists to complete further assessment.

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APPENDIX B LIKELIHOOD OF OCCURRENCE ASSESSMENT FOR THREATENED SPECIES WITHIN SURVEY AREA

Name	Status		Summary	Likelihood of occurrence
	Cth	NT		
BIRDS				
Carpentarian Grasswren *Amytornis dorotheae*	EN	EN	**Habitat:** NT population is restricted to dissected, topographically complex, sandstone and conglomerate hills and plateaux with infrequent fires (Lewis & Woinarski 2006). The only recent observations were recorded in a site that had been burnt only twice in the preceding 12 years. All other historic sites with no recent observations had been burnt between three and eight times. **Distribution:** Gulf of Carpentaria hinterland – between Limmen River in the NT and Mount Isa in Qld. No records in the Borroloola area since 1986 despite several targeted surveys in the last decade (Martin & McKean 1986; Garnett et al. 2011). Within the NT, now restricted to a tiny isolated population approximately 6 km to the west of Calvert Hills Station in the Wollogorang area (TSSC 2016).	**NONE** • Only a small area of rocky quartz sandstone outcropping (recently burnt) within the survey area which is unlikely to provide suitable habitat. • This species has a very restricted range that is not proximate to the survey area. • Closest known occurrence is approx. 100km ENE and pre-2000.
	Garnett, S.T., Szabo, J.K. and Dutson, G. (2011). *The Action Plan for Australian Birds 2010*. CSIRO Publishing. Collingwood, Australia. Lewis, M. & Woinarski, J. (2006). *Threatened Species of the Northern Territory - Carpentarian Grass-wren - Amytornis dorotheae.* Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0007/373543/carpentarian-grasswren.pdf [Accessed 18 April 2017]. Martin, K.C. & McKean, J.L. (1986). *A study of the distribution and status of the endangered Carpentarian grasswren Amytornis dorotheae.* Report to the Conservation Commission of the Northern Territory, Palmerston, NT. Threatened Species Scientific Committee (2016). *Conservation Advice – Amytornis dorotheae – Carpentarian Grasswren.* Canberra: Department of the Environment. In effect under the EPBC Act from 05-May-2016. [online] Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/558-conservation-advice-05052016.pdf [Accessed 18 April 2017].			
Red Goshawk *Erythrotriorchis radiates*	VU	VU	**Habitat:** Prefers tall, open *Eucalyptus* forest and riparian areas. Nests in large trees, frequently the tallest and most massive in a tall stand, nest trees are invariably within 1 km of permanent water (Debus & Czechura 1988; Aumann & Baker-Gabb 1991). **Distribution:** Sparsely distributed across much of the northern Australia, from the Kimberley in WA to south-eastern Qld. Within this range, generally occurs in taller forests characteristic of higher rainfall areas, but there are some isolated records from central Australia (Woinarski 2006).	**LOW** • No tall open *Eucalyptus* forest within 1 km of permanent water observed within the survey area. • This is the southern extent of core range. • There is little riparian habitat within survey area. • Closest known occurrence is approx. 150km NW in 2010.
	Aumann, T. & Baker-Gabb, D. (1991). *A Management Plan for the Red Goshawk*. RAOU Report 75, Royal Australasian Ornithologists Union, Melbourne. Debus, S. & Czechura, G. (1988). Field identification of the Red Goshawk Erythrotriorchis radiates. *Australian Bird Watcher*, Vol. 12, pp. 154-159. Woinarski, J. (2006). *Threatened Species of the Northern Territory - Red Goshawk - Erythrotriorchis radiates*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0018/206352/red-goshawk.pdf [Accessed 18 April 2017].			
Gouldian Finch			**Habitat:** Prefers annual and perennial grasses (especially *Sorghum*), a	**MEDIUM**

Erythrura gouldiae	EN	VU	nearby source of surface water and – in the breeding season – unburnt, hollow-bearing Eucalyptus trees (especially *E. tintinnans, E. brevifolia* and *E. leucophloia*) (Tidemann 1996; O'Malley 2006). **Distribution:** Sparsely across northern Australia from the Kimberley to north-central Qld (Dostine 1998; Franklin et al. 1999; Barrett et al. 2003; Franklin et al. 2005). In the NT, most known breeding populations occur in the Top End. Non-breeding birds disperse widely (Garnett et al. 2011), greatly increasing the possible range of this species.	• *Eucalyptus leucophloia* woodlands provide suitable breeding habitat within the survey area. • The survey area is towards the edge of the known range of this species. • Two closest known occurrences are within 30km of the survey area, in 2009 and 1962.
	Barrett, G., Silcocks, A., Barry, S., Cunningham, R. & Poulter, R. (2003). *The New Atlas of Australian Birds*. Royal Australian Ornithologists Union, Melbourne, Victoria. Dostine, P. (1998). *Gouldian Finch Recovery Plan Erythrura gouldiae*. Gouldian Finch Recovery Team and Parks & Wildlife Commission NT, Darwin. Franklin, D.C., Burbidge, A.H. & Dostine, P.L. (1999). The harvest of wild birds for aviculture: an historical perspective on finch trapping in the Kimberley with special emphasis on the Gouldian Finch. *Australian Zoologist,* Vol. 31, pp. 92-109. Franklin, D.C., Whitehead, P.J., Pardon, G., Matthews, J., McMahon, P. & McIntyre, D. (2005). Geographic patterns and correlates of the decline of granivorous birds in northern Australia. *Wildlife Research*, Vol. 32, pp. 399-408. Garnett, S.T., Szabo, J.K. and Dutson, G. (2011). *The Action Plan for Australian Birds 2010*. CSIRO Publishing. Collingwood, Australia. O'Malley, C. (2006). *National Recovery Plan for the Gouldian Finch (Erythrura gouldiae*). WWF-Australia, Sydney and Parks and Wildlife NT, Department of Natural Resources, Environment and the Arts, NT Government, Palmerston. Tidemann, S.C. (1996). Causes of the decline of the Gouldian Finch *Erythrura gouldiae*. *Biological Conservation International*, Vol. 6, pp. 49-61.			
Grey Falcon *Falco hypoleucos*	-	VU	**Habitat:** Occurs in areas of lightly-timbered lowland plains, typically on inland drainage systems, where the average annual rainfall is less than 500 mm (Ward 2012). **Distribution:** Sparsely distributed through much of the arid and semi-arid areas of Australia but is recorded in all Australian mainland states and territories. In the NT, the majority of records are from the southern half, but there are records all the way up to Darwin (Ward 2012).	**MEDIUM** • Region experiences higher rainfall than 500 mm annually. • Open woodland vegetation within the survey area may provide suitable habitat. • The species has a broad range but is naturally rare. • Closest known occurrence was 100km NW in 2000.
	Ward, S. (2012). *Threatened Species of the Northern Territory - Grey Falcon - Falco hypoleucos*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0020/206354/grey-falcon.pdf [Accessed 23 March 2017].			
Crested Shrike-tit (northern subspecies) *Falcunculus frontatus whitei*	VU	-	**Habitat:** Recorded in eight different woodland types in northern Australia, mainly those dominated by *Eucalyptus miniata, E. tetrodonta* or *E. bleeseri* (Robinson & Woinarski 1992). **Distribution:** North-western Australia from the Kimberley in WA, across the Top End of the NT to Borroloola (TSSC 2016). In the NT, recorded in very low densities in many isolated subpopulations (Garnett & Crowley 2000) between north-east Arnhem land and semi-arid Victoria River District. Scarcity of records suggests that populations are at very low density (Woinarski 2004). Not known to have disappeared from any area where recorded historically (TSSC 2016).	**MEDIUM** • Woodland vegetation within the survey area is potential habitat for the species. • Known occurrences are more than 150km from the survey area. • Although suitable habitat exists within the survey area, they are naturally rare.
	Garnett, S.T. & Crowley, G.M. (2000). *The Action Plan for Australian Birds 2000*. Environment Australia and Birds Australia, Canberra, ACT. Robinson, D. and Woinarski, J.C.Z. (1992). 'A review of records of the Northern Shrike-tit *Falcunculus frontatus whitei* in north-western Australia'. *South Australian Ornithologist*, Vol. 31, pp. 111-117. Threatened Species Scientific Committee (2016). *Approved Conservation Advice for Falcunculus frontatus whitei - crested shrike-tit (northern)*. Canberra: Department of the Environment. In effect under the			

	EPBC Act from 02-May-2016. Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/26013-conservation-advice-05052016.pdf [Accessed 18 April 2017]. Woinarski, J.C.Z. (2004). *National multi-species Recovery Plan for the Partridge Pigeon [eastern subspecies] Geophaps smithii smithii; crested shrike-tit [northern (sub)-species] Falcunculus (frontatus) whitei; masked owl [north Australian mainland subspecies] Tyto novaehollandiae kimberli; and masked owl [Tiwi Islands subspecies] Tyto novaehollandiae melvillensis, 2004-2008*. NT Department of Infrastructure Planning and Environment, Darwin.			
Partridge Pigeon (eastern subspecies) *Geophaps smithii smithii*	VU	VU	**Habitat:** Occurs in open forests and woodlands with an understorey of grasses (Woinarski 2006). Prefers woodland dominated by *Eucalyptus tetrodonta* and *Eucalyptus miniata* (Braithwaite 1985; Garnett et al. 2011; Higgins & Davies 1996). **Distribution:** Historically, across the Top End (from Kununurra in WA to Borroloola in the NT). Since early 20th century a severe range contraction from the western, eastern and southern parts of the former distribution (Higgins & Davies 1996; Woinarski et al. 2007). Currently, distribution is limited to sub-coastal NT from Yinberrie Hill in the south, Litchfield NP in the west and (western) Arnhem Land in the east (Garnett et al. 2011).	**LOW** • Preferred *E. tetrodonta* and *E. miniata* dominated woodland is not present within survey area. • The survey area is at the edge of the known range. • Closest known occurrences are more than 100km E. • This species has likely experienced a significant range contraction.
	Braithwaite, R.W. (1985). *The Kakadu fauna survey: an ecological survey of Kakadu National Park*. Australian National Parks & Wildlife Service, Canberra. Garnett, S.T., Szabo, J.K. and Dutson, G. (2011). *The Action Plan for Australian Birds 2010*. Birds Australia, CSIRO Publishing, Melbourne. Higgins, P.J. and Davies S.J.J.F. (eds) (1996). *Handbook of Australian, New Zealand and Antarctic Birds. Volume Three: Snipe to Pigeons*. Oxford University Press. Melbourne, Victoria. Woinarski, J.C.Z. (2006). *Threatened Species of the Northern Territory - Partridge Pigeon (eastern subspecies) - Geophaps smithii*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0003/206355/partridge-pigeon.pdf [Accessed 18 April 2017]. Woinarski, J., Pavey, C., Kerrigan, R., Cowie, I. and Ward, S. (Eds) (2007). *Lost from Our Landscape: Threatened Species of the Northern Territory*. Northern Territory Government, Darwin.			
Painted Honeyeater *Grantiella picta*	VU	VU	**Habitat:** Acacia and Eucalyptus-dominated woodlands and open forest, preferring habitats with more mature trees that host more mistletoe. Breeding times and seasonal movements (south to north) likely governed by the fruiting of mistletoe (Garnett et al. 2011). **Distribution:** Across eastern and northern parts of the country – but nowhere very numerous (Ward 2012). Many birds move after breeding to semi-arid regions such as north-eastern SA, central and western Qld, and central NT (TSSC 2015). Few NT records – most from the Barkly Tablelands – but no evidence of a breeding population in the NT, and the records are likely irregular visitors from south-eastern Australia (Ward 2012).	**LOW** • Acacia and Eucalyptus woodlands within the survey area may provide suitable habitat. • While there are two more recent occurrences (2001 & 2005) located ~100km NE and SW of survey area, it is considered an irregular visitor to the NT.
	Garnett, S.T., Szabo, J.K. and Dutson, G. (2011). *The Action Plan for Australian Birds 2010*. CSIRO Publishing, Collingwood, Australia. Threatened Species Scientific Committee (TSSC) (2015). *Approved Conservation Advice for Grantiella picta (Painted Honeyeater)*. Canberra: Department of the Environment. Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/470-conservation-advice.pdf [Accessed 7 April 2017]. Ward, S. (2012). *Threatened Species of the Northern Territory – Painted Honeyeater - Grantiella picta.* Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0009/373554/painted-honeyeater.pdf [Accessed 7 April 2017].			
Masked Owl (northern subspecies) *Tyto novaehollandiae kimberli*	VU	VU	**Habitat:** Mainly in *Eucalyptus* tall open forests (especially those dominated by *Eucalyptus miniata* and *E. tetrodonta*), but also roosts in monsoon rainforests and forages in more open vegetation types, including grasslands (Woinarski & Ward 2012). **Distribution:** Poorly known, with few records from across a broad range in northern Australia. In the NT, records from the Top End, Kakadu, Coburg Peninsula (majority of records) and south-west Gulf country (Woinarski &	**LOW** • No suitable tall open Eucalyptus forest for roosting habitat is present in the survey area. Open woodland habitat may provide suitable foraging habitat. • Naturally rare, one known occurrence >100km E of survey area in 1977.

			Ward 2012).	• Survey area is located at the edge of known range.
	Woinarski, J.C.Z. and Ward, S. (2012). *Threatened Species of the Northern Territory - Masked Owl (north Australian mainland subspecies) - Tyto novaehollandiae kimberli.* Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/word_doc/0008/373553/masked-owl-mainland-top-end.docx [Accessed 7 April 2017].			
Eastern Curlew **Greater Sand Plover** **Curlew Sandpiper**	-	VU	**Habitat:** Coastal and estuarine with tidal mudflats. May roost during high tide on nearby beaches. May also be found at near-coastal swamps and lakes (apart from Red and Great Knot) **Distribution:** Mostly widespread around the northern Australian coast, less common in the south, with few inland records. Eastern Curlew is uncommon across Australia while Asian Dowitcher is rare. Every year these species breed in the northern hemisphere in the summer, and migrate to Australia for the southern hemisphere summer. Some birds remain in Australia during the winter. [Information above summarised from Chatto (2003), DoE (2015) and Garnett et al. (2011)].	**NONE** • There are no tidal mudflats, preferred by these species, within the survey area.
	Chatto, R. (2003). *The distribution and status of shorebirds around the coast and coastal wetlands of the Northern Territory*. Technical Report 73, Parks and Wildlife Commission of the Northern Territory, Darwin. [online] Available at: https://dtc.nt.gov.au/__data/assets/pdf_file/0008/279917/2003_shorebirds_rpt76.pdf [Accessed 19 April 2017]. Department of the Environment (2015). *EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species.* Commonwealth of Australia, Canberra, ACT. [online] Available at: http://www.environment.gov.au/epbc/publications/shorebirds-guidelines [Accessed 19 April 2017]. Garnett, S.T., Szabo, J.K. and Dutson, G. (2011). *The Action Plan for Australian Birds 2010*. CSIRO Publishing. Collingwood, Australia.			
Australian Painted Snipe *Rostratula (benghalensis) australis*	EN	VU	**Habitat:** Fringes of permanent and temporary wetlands, swamps and inundated grasslands (Taylor et al. 2013). **Distribution:** Nomadic and scattered across Australia with no predictable occurrence (Rogers 2001), but could occur at any wetland or inundated grassland across its distribution, including nearly all of the NT and Qld (Garnett et al. 2011).	**LOW** • Closest known occurrence is approx. 50km NE (record from 1985), others are >100km away. • Nomadic species. • Inundation of grassland may provide seasonally suitable (but not core) habitat.
	Garnett, S.T., Szabo, J.K. and Dutson, G. (2011). *The Action Plan for Australian Birds 2010*. CSIRO Publishing. Collingwood, Australia. Rogers, D. (2001). Painted Snipe. *Wingspan*, Vol. 11 (No. 4), pp. 6-7. Taylor, R., Chatto, R. and Woinarski, J.C.Z. (2013). *Threatened Species of the Northern Territory - Australian pained snipe - Rostratula australis*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0018/206361/australian-painted-snipe.pdf [Accessed 23 March 2017].			
MAMMALS (TERRESTRIAL)				
Brush-tailed Rabbit-Rat *Conilurus penicillatus*	VU	EN	**Habitat:** Largely restricted to mixed *Eucalyptus* open forest and woodland, or on dunes with *Casuarina* – seeming to prefer habitats that are not burnt annually, that have an understorey of predominantly perennial grasses and a sparse-to-moderate middle storey (Firth et al. 2006; Firth 2007; Kemper & Firth 2008). **Distribution:** Formerly widespread across northern Australia, but has declined extensively from Qld and lower rainfall areas of the Kimberley in WA and the Top End in the NT. No recent records from much of the historically-recorded NT range between near the mouth of Victoria River (in the west) and Sir Edward Pellew island group (in east). Most recently known from	**LOW** • There are no known occurrences nearby, with the closest more than >150km N (2 specimens) – date not specified. • This species has likely experienced a significant range contraction and they may now be locally extinct .

<table>
<tr><td></td><td></td><td></td><td>Cobourg Peninsula, Tiwi Islands, Groote Eylandt and a small area within Kakadu National Park (Woinarski & Hill 2012).</td><td></td></tr>
<tr><td></td><td colspan="4">Firth, R.S.C. (2007). Ecology and conservation status of the brush-tailed rabbit-rat Conilurus penicillatus. PhD thesis, Charles Darwin University, Darwin, Northern Territory.
Firth, R.S.C., Woinarski, J.C.Z. and Noske, R.A. (2006). Home range and den characteristics of the brush-tailed rabbit-rat Conilurus penicillatus in the monsoonal tropics of the Northern Territory, Australia. Wildlife Research, Vol. 33, pp. 397-408.
Kemper, C.M. and Firth, R.S.C. (2008). Brush-tailed Rabbit-rat. In: Van Dyck, S. and Strahan, R. (eds). The Mammals of Australia. Reed New Holland, Chatswood, NSW.
Woinarski, J.C.Z. and Hill, B. (2012). Threatened Species of the Northern Territory - Brush-tailed rabbit-rat, Brush-tailed tree-rat - Conilurus penicillatus. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0016/205504/brush-tailed-rabbit-rat.pdf [Accessed 20 April 2017].</td></tr>
<tr><td>Western Quoll
Dasyurus geoffroii</td><td>VU</td><td>EX</td><td>Habitat: In central Australia, occurred throughout a range of habitats (Pavey 2006).
Distribution: Historically occurred throughout the arid interior of the NT, now restricted to the south-west of WA (Pavey 2006). Considered extinct in the NT since the 1960’s.</td><td>NONE
• Locally extinct.</td></tr>
<tr><td></td><td colspan="4">Pavey, C. (2006). Threatened Species of the Northern Territory - Western Quoll, Chuditch - Dasyurus geoffroii. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0018/205470/western-quoll.pdf [Accessed 23 March 2017].</td></tr>
<tr><td>Northern Quoll
Dasyurus hallucatus</td><td>EN</td><td>CR</td><td>Habitat: Wide range of habitats – especially coastal Eucalyptus tall open forests – but since Cane Toads the most suitable habitats are rocky areas (Van Dam et al. 2002). Prime habitat in the NT consists of rocky sandstone escarpments (Braithwaite & Griffiths 1994).
Distribution: Historically occurred from Borroloola in the south-east as far west as the NT/WA border (Woinarski et al. 2007). Dramatic range contraction associated with Cane Toad invasion. Now occurs across northern Australia in five regional populations – including the Top End in the NT.</td><td>NONE
• No suitable rocky sandstone escarpments within the survey area, nor preferred coastal Eucalyptus tall open forest.
• Closest known occurrences are approx. 120km NE & W in 1986.
• The survey area is outside the distribution of the species.
• This species has experienced a significant reduction in population sizes and ranges since the invasion of Cane Toads.</td></tr>
<tr><td></td><td colspan="4">Braithwaite, R.W. and Griffiths, A.D. (1994). Demographic variation and range contraction in the Northern Quoll, Dasyurus hallucatus (Marsupialia: Dasyuridae). Wildlife Research, Vol. 21, pp. 203-218.
Van Dam, R.A., Walden, D.J. and Begg, G.W. (2002). A preliminary risk assessment of cane toads in Kakadu National Park. Supervising Scientist Report 164, Darwin, Northern Territory.
Woinarski, J.C.Z., Rankmore, B.R., Fisher, A. and Milne, D. (2007). The natural occurrence of northern quolls Dasyurus hallucatus on islands of the Northern Territory: assessment of refuges from the threat posed by cane toads Bufo marinus. Report to Natural Heritage Trust.</td></tr>
<tr><td>Golden Bandicoot
Isoodon auratus (auratus)</td><td>VU</td><td>EN</td><td>Habitat: Mainly in heathland and shrubland on sandstone sheets, avoiding vegetation with greater tree cover (Palmer et al. 2012; Southgate et al. 1996).
Distribution: Formerly across most of northern, central and western Australia (across a broad range of habitats), but now only recorded population on mainland Australia is within the Kimberley. Within the NT, confined to the offshore islands of Arnhem Land. The only records from mainland NT are from the north-east corner of Arnhem Land between 1950 and 1980 (Palmer et al. 2012). Now extinct on the mainland except in a few locations in the north-west Kimberley (TSSC 2015).</td><td>NONE
• Extinct on the mainland NT.</td></tr>
</table>

	Palmer, C., Woinarski, J. and Hill, B. (2012). *Threatened Species of the Northern Territory - Golden Bandicoot - Isoodon auratus*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0017/205505/golden-bandicoot.pdf [Accessed 23 March 2017]. Southgate, R., Palmer, C., Adams, C., Masters, M., Triggs, B. and Woinarski, J. (1996). Population and habitat characteristics of the Golden Bandicoot (*Isoodon auratus*) on Marchinbar Island, Northern Territory. *Wildlife Research*, Vol. 23, pp. 647-664. Threatened Species Scientific Committee (TSSC) (2015). *Approved Conservation Advice for Isoodon auratus auratus (golden bandicoot (mainland))*. Canberra: Department of the Environment. [online] Available at:http://www.environment.gov.au/biodiversity/threatened/species/pubs/66665-conservation-advice-01102015.pdf [Accessed 23 March 2017].			
Ghost Bat *Macroderma gigas*	VU	-	**Habitat:** Ranging from the arid Pilbara (WA) to tropical savannah woodlands and north Qld rainforests (TSSC 2016). Permanent roost sites are generally deep natural caves or disused mines (TSSC 2016). **Distribution:** Geographically-disjunct colonies occur in the Pilbara and Kimberley in WA, NT north of approximately 17º latitude (including Elcho Island and Groote Eylandt), the Gulf of Carpentaria, eastern Qld from Cape York to near Rockhampton, and western Qld (including Riversleigh and Camooweal districts) (TSSC 2016). Distribution likely influenced by the availability of suitable caves and mines for roost sites (Ward & Milne 2016). Only 14 breeding sites known (Worthington Wilmer 2012). In arid Australia, including southern NT until the early 1960's (Ward & Milne 2016).	**LOW** • No suitable permanent roost sites within the survey area. • No occurrences close to survey area.
	Milne, D. and Ward, S. (2016). *Threatened Species of the Northern Territory – Ghost Bat - Macroderma gigas*. Northern Territory Department of Environment and Natural Resource. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0010/376138/ghost-bat.pdf [Accessed 20 April 2017]. Threatened Species Scientific Committee (2016). *Approved Conservation Advice for Macroderma gigas (ghost bat).* Canberra: Department of the Environment. Available at:http://www.environment.gov.au/biodiversity/threatened/species/pubs/174-conservation-advice-05052016.pdf [Accessed 20 April 2017]. Worthington Wilmer, J. (2012). Ghost Bat Macroderma gigas. In: Curtis et al. (eds.). *Queensland's Threatened Animals*. CSIRO, Canberra: pp. 382-383.			
Greater Bilby *Macrotis lagotis*	VU	VU	**Habitat:** In the NT, hummock grasslands on sandy soils with a preference for palaeo-drainage lines (Southgate 1990). Has large foraging area and will move home range in search for food (Johnson 2008). **Distribution:** Historically widespread in arid Australia. Currently arid WA, the Tanami Desert in the NT and south-western Qld (Woinarski et al. 2014).	**NONE** • No suitable hummock grasslands on sandy soils within the survey area. • There are no nearby records – survey area is outside of historic extent.
	Johnson, K.A. (2008). Bilby Macrotis lagotis. In: Van Dyck, S. and Strahan, R. (eds.). *Mammals of Australia*. Third Edition. Reed New Holland, Queensland Government, Queensland Museum: pp. 191-193. Southgate, R. (1990). Habitat and diet of the greater bilby *Macrotis lagotis* Reid (Marsupalia: Peramelidae). In: Seebeck et al. (eds.). *Bandicoots and Bilbies*. Surrey Beatty & Sons, Sydney, NSW. Woinarski, J., Burbidge, A. & Harrison, P. (2014). *The Action Plan for Australian Mammals 2012*. CSIRO Publishing: pp. 203-205.			
Golden-backed Tree-rat *Mesembriomys macrurus*	VU	CR	**Habitat:** In the NT, little known of the ecology apart that all three records were from riverine vegetation. In the Kimberley, known to occur in open *Eucalyptus* forests with tussock grass understorey, rainforest patches, sandstone screes, beaches, and black soil plains (Woinarski et al. 2012). **Distribution:** Historically, known to have occurred in three localities in the NT (Parker 1973) with no new records in the last 30 years. In 1993, reportedly spotted in Kakadu National Park; however, further surveys of suitable habitats in the NT failed to locate the species (Lee 1995). Now only known to occur in some areas of the north-western Kimberley and associated offshore islands (Palmer et al. 2003).	**NONE** • Locally extinct.
	Lee, A.K. (1995). *The Action Plan for Australian Rodents*. Australian Nature Conservation Agency, Endangered Species Program, Canberra.			

	Palmer, C., Taylor, R. & Burbidge, A. (2003). *Recovery plan for the Golden Bandicoot Isoodon auratus and golden-backed tree-rat Mesembriomys macrurus 2004-2009*. Northern Territory Department of Infrastructure Planning and Environment, Darwin. Parker, S.A. (1973). An annotated checklist of the native land mammals of the Northern Territory. *Records of the South Australian Museum*, Vol. 16, pp. 1-57. Woinarski, J.C.Z., Palmer, C. & Hill, B. (2012). *Threatened Species of the Northern Territory - Golden-backed tree-rat - Mesembriomys macrurus*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0006/205476/golden-backed-tree-rat.pdf [Accessed 20 April 2017].			
Northern Hopping-Mouse *Notomys aquilo*	VU	VU	**Habitat:** Most often sandy substrates, seemingly favouring coastal sand dunes and sand sheets with a cover of tussock grass or heath. Also shrubland, *Eucalyptus* open forest, and the margins of coastal rainforest thickets (Woinarski 2004; Woinarski & Flannery 2008). **Distribution:** Restricted to the NT – mostly Groote Eylandt, but also central north-east Arnhem Land (Woinarski & Ward 2012). No confirmed records from the Australian mainland for at least 10 years (Woinarski et al. 2014).	**NONE** • Species favours coastal sand dunes and sandsheets under tussock grass/heath, of which there is none within the survey area. • Closest known occurrence is more than 150km NE.
	Woinarski, J., Burbidge, A. & Harrison, P. (2014). *The Action Plan for Australian Mammals 2012*. CSIRO Publishing: pp. 609-611. Woinarski, J.C.Z. & Flannery, T.F. (2008). Northern Hopping-mouse. in Van Dyck, S. & Strahan, R. (eds.) *The Mammals of Australia*, *3rd Edition*. Reed New Holland, Sydney. Woinarski, J.C.Z. (2004). *National Multi-species Recovery Plan for the Carpentarian Antechinus Pseudantechinus mimulus, Butler's Dunnart Sminthopsis butleri and Northern Hopping-mouse Notomys aquilo, 2004 - 2008*. Department of the Environment and Heritage, ACT. [online] Available at: https://www.environment.gov.au/system/files/resources/dfb8a0ed-9e3e-4315-9e35-e28236ee96ba/files/p-mimulus-s-butleri-n-aquilo.pdf [Accessed 20 April 2017]. Woinarski, J. and Ward, S. (2012). *Threatened Species of the Northern Territory – Northern Hopping Mouse – Notomys aquilo*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0019/205516/northern-hopping-mouse.pdf [Accessed 20 April 2017].			
Southern Marsupial Mole *Notoryctes typhlops*	-	VU	**Habitat:** Sandy deserts mostly associated with dunes, sandy plains and river flats (Pavey 2015). **Distribution:** Central WA, northern SA and southern NT. Seems to be confined to the southern and western sections of the NT (Benshemesh & Schultz 2008) where has been found as far north as Barrow Creek (Pavey 2015).	**NONE** • No sandy deserts utilised by this species are present within the survey area. • Closest known occurrence is more than 250km SW.
	Pavey, C. (2015). *Threatened Species of the Northern Territory - Southern Marsupial Mole - Notoryctes typhlops*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0016/205522/southern-marsupial-mole.pdf [Accessed 23 March 2017]. Benshemesh, J. & Schultz, M. (2008). *Survey of the underground signs of marsupial moles in the WA Great Victoria Desert*, Tropicana Joint Venture and the Department of Natural Resources, Environment and the Arts, NT Government			
Carpentarian Antechinus *Pseudantechinus mimulus*	VU	-	**Habitat**: In the NT, sloping sandstone hills with boulders, pavement, outcrops and rocky surface, with open woodland of *Eucalyptus tetrodonta* and *E. aspera*, and a dense understorey and ground cover of *Plectrachne pungens* (DoE 2017). **Distribution:** In the NT, the Sir Edward Pellew island group and Pungalina-Seven Emu (mainland reserve south-west of Borroloola (Woinarski & Ward 2012). Also a few records around Mount Isa in Qld (DoE 2017).	**LOW** • Only a small area of rocky outcropping which has been recently burnt and is unlikely to provide sufficient habitat. • Survey area is towards the edge of the species' distribution and outside areas of known populations.
	Department of the Environment (2017). *Pseudantechinus mimulus — Carpentarian Antechinus.* Species Profile and Threats Database. Department of the Environment, Canberra. [online] Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59283 [Accessed 21 April 2017]. Woinarski, J.C.Z. and Ward, S. (2012). *Threatened Species of the Northern Territory - Carpentarian Antechinus - Pseudantechinus mimulus*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0005/376133/carpentarian-antechinus.pdf [Accessed 20 April 2017].			
Pale Field-rat *Rattus tunneyi*	-	VU	**Habitat:** Historically occurred in a wide range of habitats, but now primarily in dense vegetation along creeks (Aplin et al. 2008).	**LOW** • Limited dense vegetation along ephemeral

			Distribution: Higher rainfall areas of northern Australia, extending from Kimberley in WA to south-eastern Qld, including the Top End of the NT (Braithwaite & Griffiths 1996).	watercourses and waterholes is unlikely to provide suitable habitat. • Survey area is located on the edge of known range. • Two occurrences approx. 100km N and W (1999 and 1982), others are >150km NE.
	Aplin, K., Braithwaite, R. and Baverstock, P. (2008). Pale Field-rat: *Rattus tunneyi*. In: Van Dyck, S. and Strahan, R. (eds.). *The Mammals of Australia (3rd Edition)*. Reed New Holland, Sydney, NSW. Braithwaite, R. and Griffiths, A. (1996). The paradox of *Rattus tunneyi*: endangerment of a native pest. *Wildlife Research,* Vol. 23, pp. 1-21.			
Bare-rumped Sheathtail Bat *Saccolaimus saccolaimus (nudicluniatus)*	VU	-	**Habitat:** In the NT, specimens have been collected from Pandanus woodland fringing the sedgelands of the South Alligator River and *Eucalyptus* tall open forests (Friend & Braithwaite 1986; Churchill 1998). Predominantly found throughout the monsoonal tropics. Most records occur within near-coastal habitats with one recent exception (Jasper Gorge) 150 km inland (Woinarski et al. 2014). **Distribution:** Widely distributes from India through south-eastern Asia to the Solomon Islands including north-eastern Qld and the NT. The north-eastern Australian population is described as the subspecies *S. s. nudicluniatus*, although it is not clear whether this should be applied to the NT (Milne & Woinarski 2006).	**LOW** • Dry open woodlands and grasslands area unlikely to provide suitable habitat for the species. • Generally, prefers habitat closer to the coast. • One occurrence in 2001 about 150km NE, no others nearby. • Survey area is on the edge of known range.
	Churchill, S. (1998). *Australian Bats*. Reed New Holland, Sydney. Friend, G.R. and Braithwaite, R.W. (1986). Bat fauna of Kakadu National Park, Northern Territory. *Australian Mammalogy*, Vol. 9, pp. 43-52. Milne, D. and Woinarski, J. (2006). *Threatened Species of the Northern Territory - Bare-rumped Sheathtail Bat - Saccolaimus saccolaimus*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0007/376117/bare-rumped-sheathtail-bat.pdf [Accessed 21 April 2017]. Woinarski, J., Burbidge, A. and Harrison, P. (2014). *The Action Plan for Australian Mammals 2012*. CSIRO Publishing: pp. 511-514.			
Carpentarian Rock-rat *Zyzomys palatalis*	EN	CR	**Habitat:** Restricted to sandstone gorges and escarpments containing a core of dry or wet rainforest vegetation, mixed with woodland, scree slopes and permanent water, surrounded by savannah woodlands (Puckey & Woinarski 2006). **Distribution:** Restricted to the NT, where known only from five locations within a radius of 35 km (Puckey 2003) at Wollogorang Station in the Gulf of Carpentaria (Kitchener 1989).	**NONE** • No suitable sandstone gorge or escarpment which would provide suitable habitat. • No proximate records.
	Kitchener, D.J. (1989). Taxonomic appraisal of Zyzomys (Rodentia, Muridae) with descriptions of two new species from the Northern Territory, Australia. *Records of the Western Australian Museum*, Vol. 14, pp. 331-373. Puckey, H. (2003). Additional records of the Carpentarian rock-rat *Zyzomys palatalis* at Redbank, close to the type locality. *Northern Territory Naturalist*, Vol. 17, pp. 43-45. Puckey, H. and Woinarski, J. (2006). *Threatened Species of the Northern Territory - Carpentarian Rock-rat - Zyzomys palatalis*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0008/205478/carpentarian-rock-rat.pdf [Accessed 21 April 2017].			
REPTILES (TERRESTRIAL)				
Plains Death Adder *Acanthophis hawkei*	VU	VU	**Habitat:** Floodplains and cracking soil plains (Webb et al. 2002). **Distribution**: Habitat mapping suggests the potential geographic range extends from western Qld, across the north of the NT to north-eastern WA. Fragmented populations occur in the Mitchell Grass Downs of western Qld, the Barkly Tablelands on the NT/Qld border and east of Darwin in the NT	**LOW** • No proximate records and at the edge of the species' range. • Potentially-suitable cracking clay habitat occurs in

			(TSSC 2012).	alluvial plains within survey area.
	Webb, J.K., Christian, K.A. & Fisher, P. (2002). Fast growth and early maturation in a viviparous sit-and-wait predator, the northern death adder (*Acanthophis praelongus*) from tropical Australia. *Journal of Herpetology*, Vol. 36, no. 3, pp. 505-509. Threatened Species Scientific Committee (2015). *Approved Conservation Advice – Acanthophis hawkei – Plains Death Adder.* Canberra: Department of the Environment. [online] Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/83821-conservation-advice.pdf [Accessed 21 April 2017].			
Mertens' Water Monitor *Varanus mertensi*	-	VU	**Habitat:** Semi-aquatic, occupying edges of freshwater watercourses and lagoons, but seldom seen far from water (Christian 2004). **Distribution:** Across far northern Australia from the western Cape York Peninsula in Qld to the Kimberley in WA (Christian 2004). Widespread in the NT, occupying all of the Top End river systems (Ward et al. 2006). Susceptible to ingesting toxic Cane Toads resulting in reduced abundance (Griffiths & McKay 2007).	**MEDIUM** • Record south of Carpentarian Highway, near to project area. • Wide distribution and potential habitat within the survey area.
	Christian, K. (2004). Varanus mertensi. In: Pianka et al. (eds.). *Varanoid lizards of the world*. Indiana University Press, Bloomington, Indianapolis. Griffiths, A.D. and McKay (2007). Cane toads reduce the abundance and site occupancy of Merten's water monitor (Varanus mertensi). *Wildlife Research,* Vol. 34, pp. 609-615. Ward, S., Woinarski, J., Griffiths, T. and McKay, L. (2006). *Threatened Species of the Northern Territory - Mertens Water Monitor - Varanus mertensi*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0018/206460/mertens-water-monitor.pdf [Accessed 1 May 2018].			
Mitchell's Water Monitor *Varanus mitchelli*	-	VU	**Habitat:** Semi-aquatic and arboreal, inhabiting margins of watercourses, swamps and lagoons (Ward 2012). **Distribution:** Top End of the NT and Kimberley in WA (Schultz & Doody 2004). In the NT, recorded in most catchments flowing into the Timor Sea, Arafura Sea and the Gulf of Carpentaria (Ward 2012).	**LOW** • Ephemeral watercourses and limited pools are unlikely to provide suitable habitat. • Survey area at the edge of known range.
	Doody, J.S., Green, B., Rhind, D., Castellano, C., Sims, R. and Robinson, T. (2009). Population-level declines in Australian predators caused by an invasive species. *Animal Conservation*, Vol. 12, pp. 46-53. Schultz, T. and Doody, S. (2004). Varanus mitchelli. In: Pianka et al. (eds.). *Varanoid lizards of the world*. Indiana University Press, Bloomington, Indianapolis. Ward, S. (2012). *Threatened Species of the Northern Territory - Mitchell's Water Monitor - Varanus mitchelli*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0019/206461/mitchells-water-monitor.pdf [Accessed 21 April 2017].			
Floodplain Monitor *Varanus panoptes*	-	VU	**Habitat:** Broad range of habitats from coastal beaches to savannah woodlands (Christian 2004). Also common throughout floodplains grasslands and a variety of native woodlands (Ward et al. 2012). **Distribution:** Across northern Australia from the Kimberley in WA to Cape York Peninsula, and southwards through most of Qld. In the NT, recorded across most of the Top End and the Gulf Region (Christian 2004). Experienced significant declines due to cane toad poisoning (Doody et al. 2009).	**LOW** • Open woodlands within the survey area may provide potential habitat. • Survey area is at the edge of known range. • Closest known occurrence is more than 100km E and NW of survey area and prior to 1990.
	Christian, K. (2004). Varanus panoptes. In: Pianka et al. (eds). *Varanoid lizards of the world*. Indiana University Press, Bloomington, Indianapolis. Doody, J.S., Green, B., Rhind, D., Castellano, C., Sims, R. and Robinson, T. (2009). Population-level declines in Australian predators caused by an invasive species. *Animal Conservation*, Vol. 12, pp. 46-53. Ward, S., Woinarski, J., Griffiths, T. & McKay, L. (2012). *Threatened Species of the Northern Territory - Yellow Spotted Monitor, Northern Sand Goanna, Floodplain Monitor - Varanus panoptes.* Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0006/206466/floodplain-monitor.pdf [Accessed 7 April 2017].			

REPTILES (MARINE)				
Gulf Snapping Turtle *Elseya lavarackorum*	EN	-	**Habitat:** Large rivers and their associated overflow lagoons and oxbow lakes (Cogger 2000; Woinarski 2006). Found in deeper permanent pools most often with muddy, sandy or rocky bottoms. Also found in the middle reaches of rivers, upstream of saline regions and downstream of escarpments, including plunge pools. Steep rocky gorges, and river reaches with intact river banks seem to be preferred habitats (Thomson et al. 1997). **Distribution:** Rivers in far eastern NT and far western Qld which discharge into the Gulf of Carpentaria. In the NT this includes the Roper, Limmen Bight, Robinson and Nicholson Rivers (DoE 2017).	**NONE** • No large rivers preferred by this species are present within the survey area. • No proximate records.
	Cogger, H.G. (2000). *Reptiles and Amphibians of Australia - 6th edition*. Reed New Holland, Sydney, NSW. Department of the Environment (2017). *Elseya lavarackorum - Gulf Snapping Turtle.* Species Profile and Threats Database, Department of the Environment, Canberra. [online] Available at: https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=67197 [Accessed 21 April 2017]. Thomson, S., White, A. and Georges, A. (1997). Re-evaluation of *Emydura lavarackorum*: identification of a living fossil. *Memoirs of the Queensland Museum*, Vol. 42 (No. 1), pp. 327-336. Woinarski, J. (2006). *Threatened Species of the Northern Territory - Gulf Snapping Turtle - Elseya lavarackorum.* Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0008/376181/gulf-snapping-turtle.pdf [Accessed 21 April 2017].			
FISH				
Freshwater or Largetooth Sawfish *Pristis pristis*	VU	VU	**Habitat:** Tropical marine and estuarine habitats, entering estuarine or fresh waters to breed during the wet season and moving into marine waters following the wet season (Peverell 2005). **Distribution:** Circumtropical, with distinct populations in the eastern Atlantic, western Atlantic, eastern Pacific and Indo-West Pacific – including northern Australia (TSSC 2014). In the NT, reported in Adelaide, Victoria, Daly, East and South Alligator, Goomadeer, Roper, McArthur, Wearyan and Robinson Rivers (TSSC 2014).	**NONE** • No marine / estuarine habitat used by this species is present within the survey area. • No proximate records.
	Peverell, S.C. (2005). Distribution of sawfishes (Pristidae) in the Queensland Gulf of Carpentaria, Australia, with notes on their ecology. *Environmental Biology of Fishes,* Vol. 73, pp. 391-402. Threatened Species Scientific Committee (2014). *Approved Conservation Advice - Pristis pristis (largetooth sawfish).* Canberra: Department of the Environment. In effect under the EPBC Act from 11-April-2014. [online] Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/60756-conservation-advice.pdf [Accessed 26 April 2017].			
FLORA				
Swordfern *Macrothelypteris torresiana*	-	EN	**Habitat:** Sheltered sandstone gorges associated with springs and groundwater seepages (Cowie & Westaway 2012). **Distribution:** Isolated populations in northern WA, eastern Qld, north-eastern NSW and the NT (two locations on Wollogorang Station in the Gulf region, adjacent to the Qld border) (Cowie & Westaway 2012). There are substantial areas of potentially-suitable habitat in Western Arnhem Land that are poorly surveyed at the scale and intensity necessary to exclude the possibility that more subpopulations exist; however, the chance of finding additional subpopulations in that area appears relatively low (Cowie & Westaway 2012).	**NONE** • The survey area contains no sandstone gorges that this species prefers. • No proximate records.
	Cowie, I. and Westaway, J. (2012*). Threatened Species of the Northern Territory - Macrothelypteris torresiana*. Northern Territory Department of Environment and Natural Resources. [online] Available at: https://nt.gov.au/__data/assets/pdf_file/0006/208473/macrothelypteris-torresiana.pdf [Accessed 28 April 2017].			

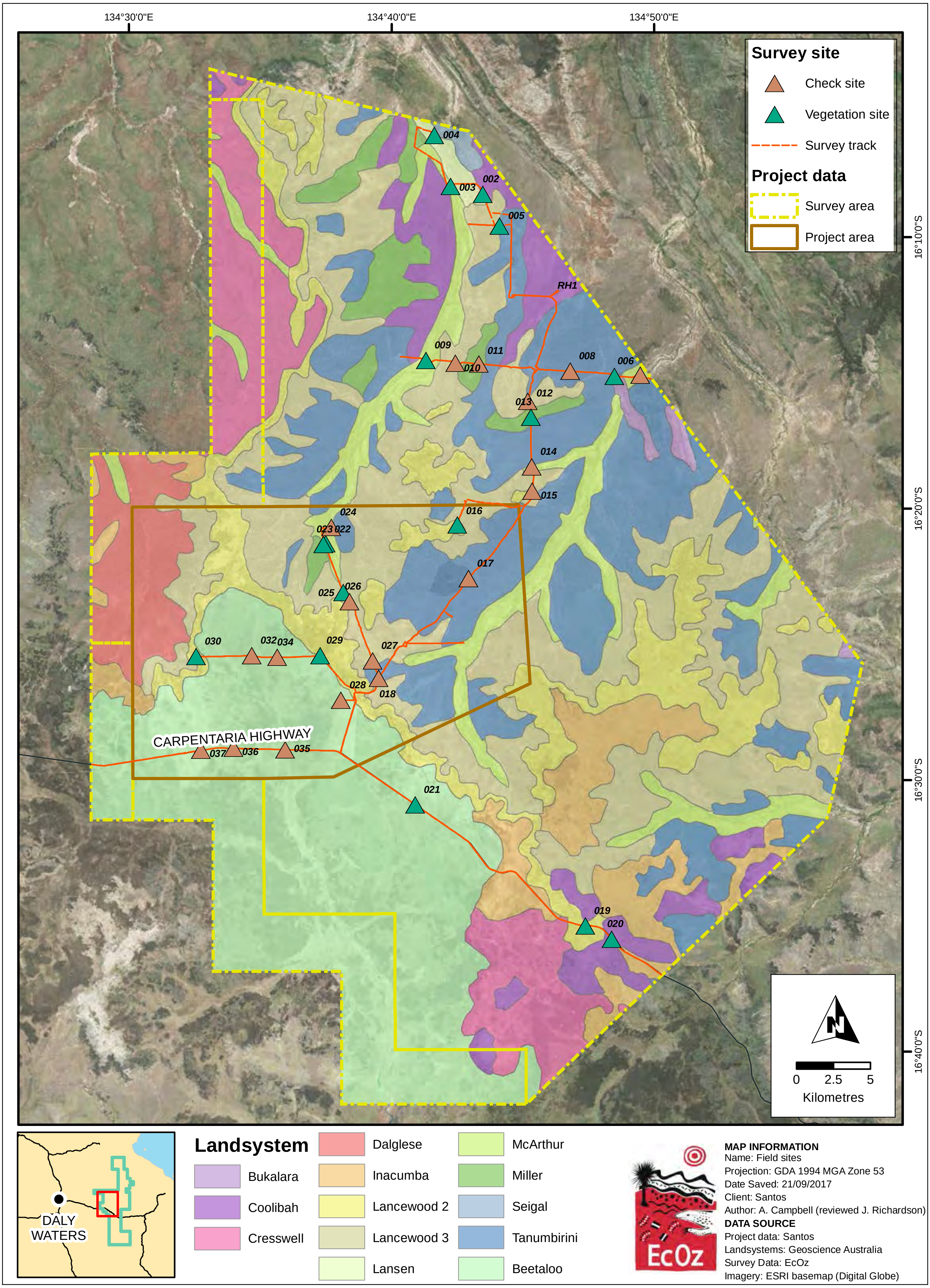
APPENDIX C LIKELIHOOD OF OCCURRENCE ASSESSMENT FOR MIGRATORY SPECIES WITHIN SURVEY AREA

Species	Species details	Likelihood of occurrence
MIGRATORY MARINE BIRDS		
Apus pacificus **Fork-tailed Swift**	**Habitat:** Almost exclusively aerial. Mostly occurs over dry or open habitats, including riparian woodland and tea-tree swamps, low scrub, heathland or saltmarsh. Catches insects on the wing (DoE 2017). **Distribution:** A non-breeding visitor to all states and territories of Australia. Breeds in Siberia and migrates southward during the northern winter (DoE 2017).	**MEDIUM (above the project area)** • Given the broad distribution and wide ranging nature of *Apus pacificus* it is likely to be present (at some time period) within/over the project area. • The project area is within the species' distribution. • The dry, open grasslands and riparian woodland occurring in the project area would provide suitable habitat for this species.
	Department of Environment (DoE) 2017, *Apus pacificus* in Species Profile and Threats Database, Department of the Environment, Canberra, viewed September 2017, http://www.environment.gov.au/.	
MIGRATORY MARINE SPECIES		
Crocodylus porosus **Saltwater Crocodile**	**Habitat:** Mostly occurs in tidal rivers, coastal floodplains and channels, billabongs and swamps (Webb et al. 1987) up to 150 km inland from the coast **Distribution:** Northern Australia coastal waters, estuaries, lakes, inland swamps and marshes.	**NONE** • No major river systems utilised by this species occur within the project area. • The project area is over 200km inland from the coast.
MIGRATORY TERRESTRIAL SPECIES		
Cecropis daurica **Red-rumped Swallow**	**Habitat:** Predominately forages over wetlands or open areas such as golf courses. Perches on bare branches or wires (DoE 2017). **Distribution:** Vagrant to Australia; may be found between December and February in around the Top End including Darwin (DoE 201).	**LOW** • Vagrant to Australia • The woodland vegetation of the project area is unlikely to provide suitable foraging habitat for the species, which forages over wetlands.
	Department of Environment (DoE) 2017, *Cecropis daurica* in Species Profile and Threats Database, Department of the Environment, Canberra, viewed September 2017, http://www.environment.gov.au/.	

Species	Species details	Likelihood of occurrence
Cuculus optatus **Oriental Cuckoo**	**Habitat:** Uses a range of vegetated habitats such as monsoon rainforest, wet sclerophyll forest, open woodlands and appears quite often along edges of forests, or ecotones between forest types (DoE 2017). **Distribution:** Widespread in Top End from Darwin, north to Melville and South Goulburn Islands, east to Gove Peninsula, Groote Eylandt and Sir Edward Pellew Group and south to Roper River (DoE 2017).	**LOW** • The project area is within the distribution of the species • The open woodland vegetation and creek line vegetation within the project area does not provide suitable habitat for the species
	Department of Environment (DoE) 2017, *Cuculus optatus* in Species Profile and Threats Database, Department of the Environment, Canberra, viewed September 2017, http://www.environment.gov.au/.	
Hirundo rustica **Barn Swallow**	**Habitat:** Found above open vegetated areas including farmland, sports grounds, native grasslands and airstrips as well as over open water such as billabongs, lagoons, creeks and sewage treatment plants. Perch on bare branches or wires, and gather in flocks to during the day, and roost at night perched in vegetation, usually tall wetland grasses (DoE 2017). **Distribution:** Found between December and February in around the Top End including Darwin (DoE 2017).	**LOW** • Vagrant to the area. • Nearest records > 200km to the NE
	Department of Environment (DoE) 2017, *Hirundo rustica* in Species Profile and Threats Database, Department of the Environment, Canberra, viewed September 2017, http://www.environment.gov.au/.	
Motacilla cinerea **Grey Wagtail**	**Habitat:** Has a strong association with water with all confirmed Australian records being associated with water; especially creeks, rivers and waterfalls (DoE 2017). **Distribution:** Scarce but regular visitor to northern Australia, including the Top End of the Northern Territory around the greater Darwin region (DoE 2017).	**LOW** • The species is a vagrant visitor to Australia. • The project area is south of the known distribution of the species in Australia. • Creek areas within the project area may provide limited suitable habitat for the species. • One record (2002) from the Roper River (>150km north of project area)
	Department of Environment (DoE) 2017, *Motacilla cinerea* in Species Profile and Threats Database, Department of the Environment, Canberra, viewed September 2017, http://www.environment.gov.au/.	
Motacilla flava **Yellow Wagtail**	**Habitat:** Typically inhabit open grassy flats near water, including open areas with low vegetation such as grasslands, airstrips, pastures, sports fields; damp open areas such as muddy or grassy edges of wetlands, rivers, irrigated farmland, dams, waterholes; sewage farms, sometimes utilise tidal mudflats and edges of mangroves (DEE, 2015). **Distribution:** Regular summer visitor to Northern Australia including the greater Darwin area (DEE, 2015).	**LOW** • The vegetation of the project area is unlikely to provide limited suitable open areas for foraging of the species. • The project area is south of the known distribution of the species in Australia.
	Department of Environment (DoE) 2017, Apus pacificus in Species Profile and Threats Database, Department of the Environment, Canberra, viewed September 2017, http://www.environment.gov.au/.	

Species	Species details	Likelihood of occurrence
MIGRATORY WETLAND SPECIES		
Actitis hypoleucos **Common Sandpiper**	**Habitat:** In Australia, the species inhabits mainly coastal but some inland wetlands where the species forages in shallow water on mudflats (DoE 2017). **Distribution:** Widespread across coastal regions of the Top End of the Northern Territory, and widespread but scattered inland, mostly north of Tennant Creek (DoE 2017).	**LOW** • There is no suitable habitat within the project area for the species.
	Department of Environment (DoE) 2017, *Actitis hypoleucos* in Species Profile and Threats Database, Department of the Environment, Canberra, viewed September 2017, http://www.environment.gov.au/.	
Calidris acuminata **Sharp-tailed Sandpiper**	**Habitat:** Prefers muddy edges of shallow wetlands, with inundated low vegetation (DoE 2017). **Distribution:** Widespread summer migrant to coastal and inland Australia. (DoE 2017)	**LOW** • There is little suitable habitat within the project area for the species.
	Department of Environment (DoE) 2017, *Calidris acuminata* in Species Profile and Threats Database, Department of the Environment, Canberra, viewed September 2017, http://www.environment.gov.au/.	
Calidris melanotos **Pectoral Sandpiper**	**Habitat:** Shallow fresh waters, often with low grass or other herbage, flooded pastures, sewage ponds, occasionally tidal areas, saltmarshes. (Pizzey & Knight, 2012) **Distribution:** Widespread, common summer migrant Australia; mostly coastal. (Pizzey & Knight, 2012) In the Northern Territory (NT), the Pectoral Sandpiper is found at Darwin and Alice Springs (Higgins & Davies 1996).	**LOW** • Given the preference for wetland areas, there is little suitable habitat within the project area for this species.
	Department of Environment (DoE) 2017, *Calidris melanotos* in Species Profile and Threats Database, Department of the Environment, Canberra, viewed September 2017, http://www.environment.gov.au/.	
Charadrius veredus **Oriental Plover**	**Habitat:** After moving from coastal environments *Charadrius veredus* usually inhabit flat, open, grasslands, where short grass is interspersed with hard, bare ground (Boekel 1980; Carruthers 1966; Pedler 1982) **Distribution:** Oriental Plover is a non-breeding visitor to Australia, where the species occurs in both coastal and inland areas, mostly in northern Australia. It is found on black soil plains in the Northern Territory and Queensland (DoE, 2016).	**MEDIUM** • The project area is within the species range. • The grasslands (and black soil plains) within the project area represent suitable habitat.
	Department of Environment (DoE) 2017, *Charadrius veredus* in Species Profile and Threats Database, Department of the Environment, Canberra, viewed September 2017, http://www.environment.gov.au/.	

APPENDIX D MAP OF DESKTOP ASSESSMENT SURVEY SITES



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ17088 - Santos Rehab and Ecology\01 Project Files\Ecology report maps\Field sites.mxd

Map showing survey sites and land systems

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Appendix E: Weed Management Plan

Weed Management Plan

2019 exploration program - EP 161

Santos

DOCUMENT CONTROL RECORD

Job	EZ19041
Document ID	176876-11
Author(s)	Felicity Watt,

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1 INTRODUCTION

Santos plan to undertake exploration works within their onshore shale gas exploration permit (EP) on Tanumbirini Station (EP 161). This work includes the installation of two exploration wells, associated civil works and infrastructure development, to be undertaken in 2019. The exploration works will be regulated through an Environmental Management Plan (EMP) approved by the Department of Environment and Natural Resources (DENR). EcOz were engaged to prepare an associated weed management plan – this document – required as a component of the EMP under the *Petroleum (Environment) Regulations* (the Regulations).

1.1 Scope & objectives

The scope of this weed management plan is to outline the weed management measures that will be implemented to prevent the introduction and spread of weeds during the works associated with the exploration program.

The objectives of this weed management plan are to:

- Comply with all applicable legislation, regulations, conditions and regional weed management plans.
- Address the specific weed management requirements of station owners.
- Provide controls for construction activities to avoid introducing new weed species into the 2019 exploration program project area.
- Avoid or control the spread of existing weed species into new areas within the exploration program project area.
- Detail the monitoring, reporting and incident response procedures appropriate for the management measures.

The weed management plan is applicable to all activities associated with the exploration program, and will be used by all personnel (including contractors) involved in program activities.

1.2 Dedicated weed officer

The *Scientific Inquiry into Hydraulic Fracturing* recommended a dedicated weed officer for each gas field. Contact details for Santos' weed officer for EP 161 are:

Mitch Bird, Senior Environmental Advisor, Tel: 07 3838 3799, Email: mitch.bird@santos.com

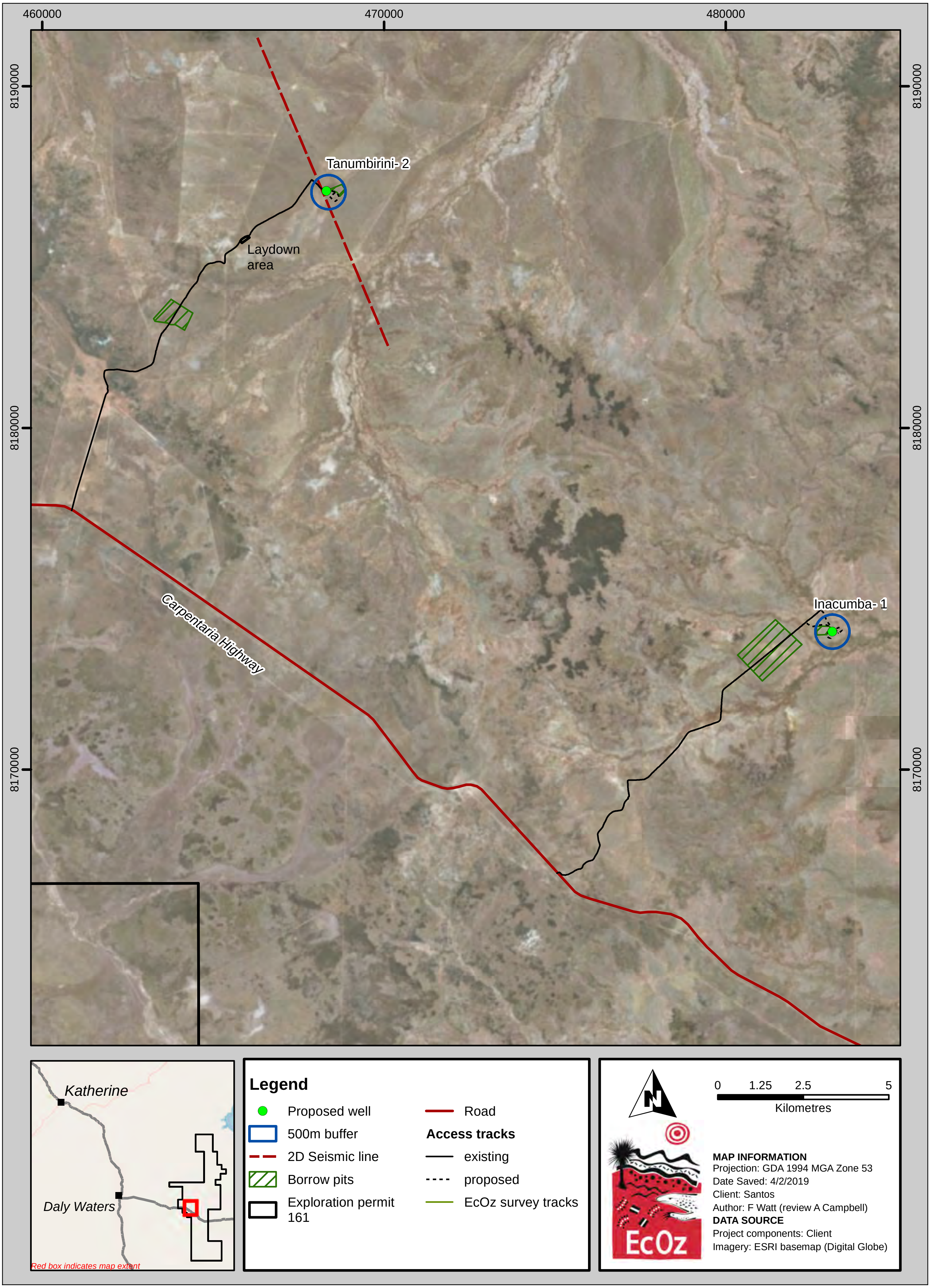
1.3 Project area

EP 161 is located on Tanumbirini Station on the Carpentaria Highway south east of Katherine. Activities involved with the 2019 exploration program project area are mapped in

Figure 1-1 and include:

- Drilling of two new exploration wells – Tanumbirini-2 and Inacumba-1. All disturbance for the wells (well drill pad, camps, dams etc) will be located within a 500 m buffer of the proposed well locations.
- A single 2D seismic profiling line crossing the proposed Tanumbirini-2 well site
- Construction of two short access tracks ~900 m each, from existing station tracks to the proposed well sites

- Clearing for a laydown area along the access track to Tanumbirini-2, and for borrow material. Two borrow pit locations have been identified; borrow material will come from only a portion of the identified area, with pits located within one or both identified locations.



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19041 - Santos EP161 EMP aspects\01 Project Files\WMP Figure 1-1. Map showing 2019 project area.mxd

Figure 1-1. Map showing 2019 project area

2 LEGAL REQUIREMENTS

This following legislation, statutory obligations and guidelines were considered during the preparation of this weed management plan.

2.1.1 Petroleum (Environment) Regulations

The Petroleum (Environment) Regulations, (the Regulations), require submission of an EMP prior to any petroleum exploration or production activity. This weed management plan represents of component of the 2019 exploration program EMP, as required under the regulations.

2.1.2 Weeds Management Act

This Act aims to:

> *Protect the Territory's economy, community, industry and environment from the adverse impact of weeds*

It declares undesirable species of plants as weeds, and requires these species to be controlled, eradicated or prevented from entering the Northern Territory (NT) depending on their classification. Under the Act, weeds are classified into one of three classes:

- Class A declared plant – to be eradicated
- Class B declared plant – growth and spread to be controlled
- Class C declared plant – not to be introduced into the NT (all Class A and B weeds are also Class C)

The Act specifies how weeds in each of the classes must be treated. Weed management plans for specific weeds are endorsed under this Act.

2.1.3 Management plans and guidelines

Statutory Weed Management Plans

These plans are legal documents containing specific information about management requirements for certain high priority weeds. Section 4 lists weeds that are present or have the potential for introduction onto EP 161, and notes those with an associated statutory weed management plan.

Guidelines and standards

The following guidelines associated with the management of weeds in the NT have also been considered during the preparation of this WMP:

- *Northern Territory Weed Management Handbook* (Weed Management Branch, 2015a)
- *Northern Territory Weed Data Collection Manual* (Weed Management Branch, 2015b)

2.1.4 Santos environmental policy

Santos' Corporate Environmental Policy is a public declaration of its understanding of the environmental impacts and risks associated with its operations, as well as a demonstration of its compliance with all relevant environmental, health and safety regulations, legislation and guidelines. A copy is provided as Appendix A.

3 WEED RISK MITIGATION MEASURES

The EMP risk assessment process identified a number of weed introduction and/or spread risks associated with the scope of this plan. Table 3-1 documents these risks as well as the mitigation measures that will be implemented to reduce this risk.

Table 3-1 Weed risk and mitigation measures

Weed risk	Mitigation measures	Measurement criteria	Responsible
Introduction of new weed species to EP 161 from machinery and equipment.	All vehicles / machinery /equipment entering the EP to be cleaned and free of soil and vegetative matter, and have a valid weed hygiene declaration	A register of vehicle / equipment / machinery cleaning is kept.[1] Spot checks on vehicle / equipment / machinery to ensure inspections are completed correctly	Santos Dedicated Weed Officer
	Site environmental inductions for all personnel and contractors to include vehicle weed hygiene requirements	All project staff undertake an environmental induction, to be recorded in the Santos Training Register	Santos Dedicated Weed Officer
Weed spread resulting from vehicles/machinery traversing existing weed infestations	All infestations of declared weeds mapped; all personnel and contractors made aware of existing infestation locations and trained in the identification of existing weeds	All project staff undertake an environmental induction, to be recorded in the Santos Training Register Weed maps and factsheets included as part of environmental induction All operational staff to attend weed identification training delivered by the NT Weed Management Branch	Santos Dedicated Weed Officer
	All vehicles, machinery and equipment to stay on formed access tracks, except for those involved in clearing	All project staff undertake an environmental induction, as recorded in the Santos Training Register	Santos Dedicated Weed Officer
	If infestations are identified during the 2019 program they will be demarcated and avoided, where possible, via a detour around the infestation	Maintain demarcation during operations and inspect (and rectify if needed) daily	Santos Field Representative
	If infestations cannot be avoided, treat prior to traversing using methods set out in Table 5-1. Vehicles/plant to be cleaned and free of soil and vegetative matter prior to moving beyond infestation	Work plan to reflect additional tasks required Spot checks on vehicle / equipment / machinery to ensure inspections are completed correctly	Santos Field Representative / Santos Dedicated Weed Officer

[1] Weed hygiene declaration included as Appendix B.

Weed risk	Mitigation measures	Measurement criteria	Responsible
Existing weed distribution not fully known due to survey conducted outside of prime growth period	Further monitoring to be undertaken, as set out in Section 6 of this document	Annual reporting against this WMP, as per Section 6.3	Santos Dedicated Weed Officer

4 WEED SPECIES

Baseline surveys for weeds were undertaken in August and November 2018 and focused along access tracks, within a 500 m buffer around the proposed exploration wells, and 40 km of linear transects radiating from Tanumbirini-2. The exact location of the 2D seismic line identified in the 2019 exploration program is slightly different to the linear transects surveyed; however, there is one survey transect in close proximity to the proposed 2D seismic line, as seen in Figure 4-1 . The landforms and vegetation through which the updated 2D seismic line passes are consistent with those of this survey transect. The proposed locations of the borrow pits have not been surveyed.

Declared weed species observed are listed in Table 4-1, with locations mapped in

Figure 4-2

Table 4-1. Declared weed species recorded within the EP

Common name	Scientific name	NT Class
Hyptis	*Hyptis suaveolens*	B/C
Rubber Bush[2]	*Calotropis procera*	B/C
Spinyhead sida	*Sida acuta*	B/C
Sicklepod	*Senna obtusifolia*	B/C

Other weed species with the potential to occur in the region more broadly, and considered as part of this plan are shown below in Table 4-2.

Table 4-2. Potential weeds within the exploration permit

	Common name	Scientific name	NT Class	WoNS
Katherine region priority weeds	Mesquite*	*Prosopis spp.*	A/C	Y
	Prickly acacia*	*Vachellia nilotica*	A/C	Y
	Parkinsonia	*Parkinsonia aculeata*	B/C	Y
	Chinee Apple*	*Ziziphus mauritiana*	A/C	
	Mimosa*	*Mimosa pigra*	A/C	Y
	Bellyache Bush*	*Jatropha gossypiifolia*	A/C[3]	Y
	Gamba Grass*	*Andropogon gayanus*	A/C	Y
	Neem*	*Azadirachta indica*	B/C	
	Grader grass*	*Themeda quadrivalvis*	B/C	Y
	Snake weed	*Stachytarpheta spp.*	B/C	
	Devils Claw	*Martynia annua*	A/C	
Other declared weeds	Parthenium[4]	*Parthenium hysterophorus*	A/C	Y
	Starburr	*Acanthospermum hispidum*	B/C	
	Mossman River Grass	*Cenchrus echinatus*	B/C	
	Spiny-head Sida	*Sida acuta*	B/C	

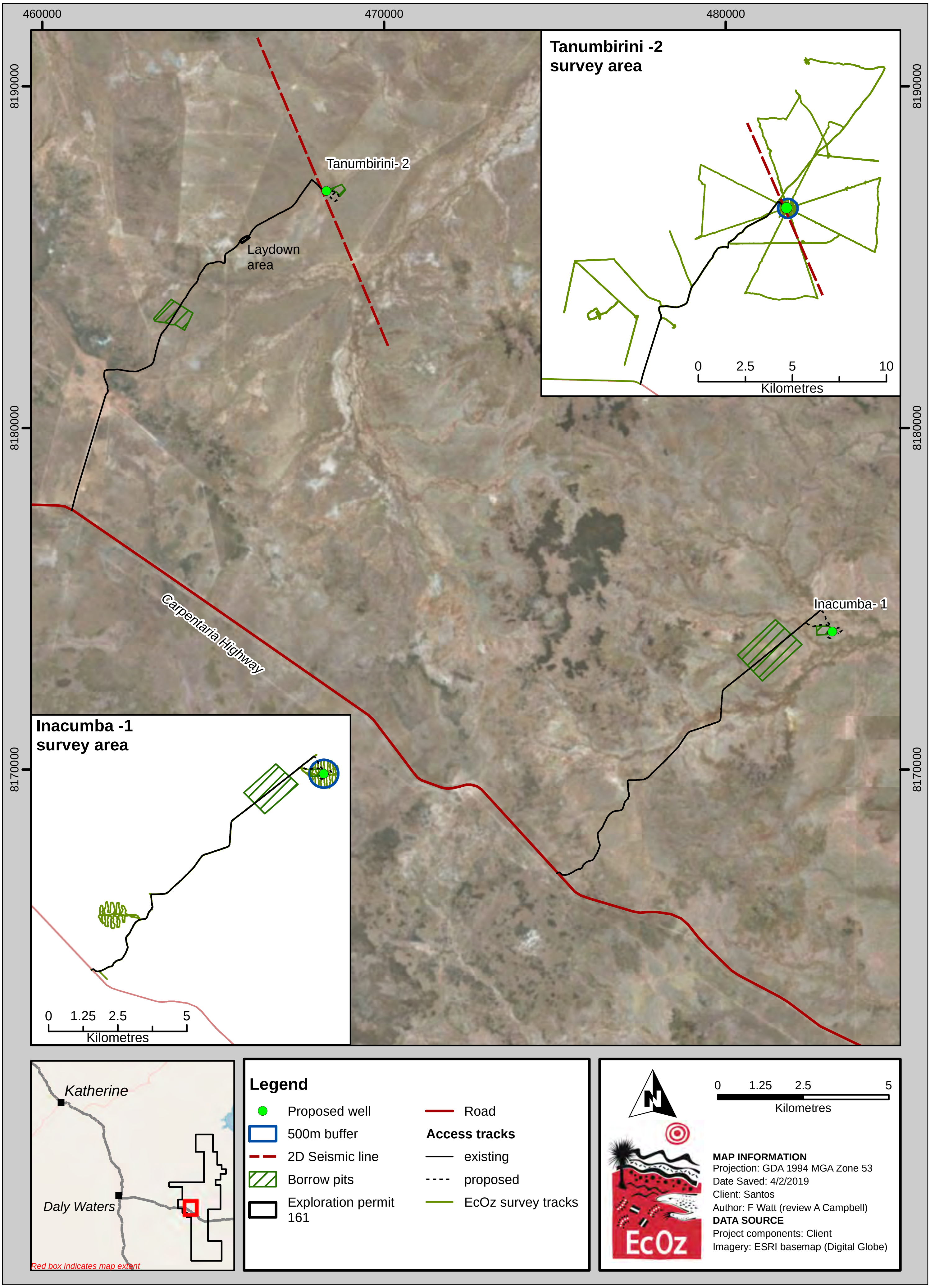
[2] Although Rubber Bush is only declared south of 16°30' S, it was included in this list as current exploration areas are just north of this latitude and the exploration permit area crosses this line of declaration

[3] Bellyache bush classification depends on its location within the NT; the EP is within the Class A eradication zone

[4] Parthenium, previously eradicated from the NT, has recently been recorded in the Katherine region

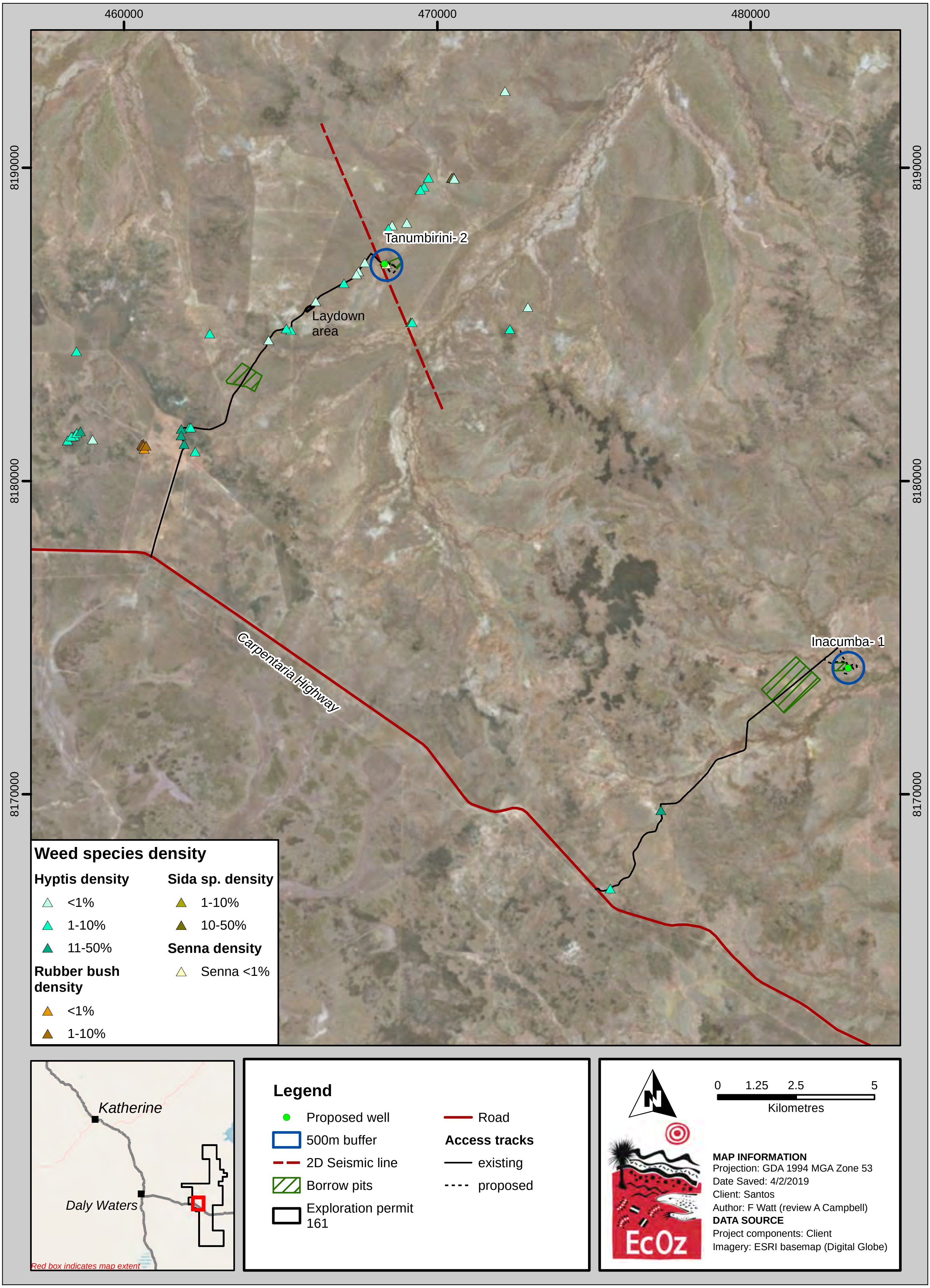
	Common name	Scientific name	NT Class	WoNS
	Flannel Weed	*Sida cordifolia*	B/C	
	Paddy`s Lucerne	*Sida rhombifolia*	B/C	
	Caltrop	*Tribulus terrestris*	B/C	
	Noogoora Burr	*Xanthium strumarium*	B/C	
	Khaki Weed	*Alternanthera pungens*	B/C	

* indicates weeds with an associated weed management plan



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19041 - Santos EP161 EMP aspects\01 Project Files\WMP Figure 4-1. Proximity of 2019 project area to baseline surveys.mxd

Figure 2-1. Map of 2019 exploration program project area and survey area



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19041 - Santos EP161 EMP aspects\01 Project Files\WMP Figure 4-2. Location of weed occurrences within or adjacent to 2019 exploration program area.mxd

Figure 4-2. Weed occurrences within, or adjacent to, project area

5 ANNUAL ACTION PLAN

The annual action plan in Table 5-1 details the survey and control activities for weeds recorded within EP 161.

Table 5-1. Annual action plan

Weed Management Area	Weed species	Management objective	Survey / monitoring time/s	Treatment time/s	Control method/s	Herbicide
Tanumbirini- 2	Sicklepod	No spread	End of wet season – March depending on site access	End of wet season – March depending on site access	Foliar spray seedlings and adults	Dicamba 500 g/L Rate: 500mL/100 L
	Hyptis	No spread	End of wet season – March depending on site access	End of wet season – March depending on site access	Foliar spray seedlings and adults	2, 4-D amine 625 g/L Rate: 320 mL/100 L
Laydown area	Hyptis	No spread	End of wet season – March depending on site access	End of wet season – March depending on site access	Foliar spray seedlings and adults	2, 4-D amine 625 g/L Rate: 320 mL/100L
Tanumbirini Borrow Pit	No weeds	Prevent the introduction of weeds	End of wet season – March depending on site access	Immediately if weeds are found	Refer to the NT Weed Management Handbook	
2D Seismic line	Hyptis	No spread	End of wet season – March depending on site access	End of wet season – March depending on site access	Foliar spray seedlings and adults	2, 4-D amine 625 g/L Rate: 320 mL/100L
	Sicklepod	No spread	End of wet season – March depending on site access	End of wet season – March depending on site access	Foliar spray seedlings and adults	Dicamba 500 g/L Rate: 500mL/100 L
Tanumbirini	Spinyhead sida	No spread	End of wet season – March depending on site	End of wet season – March depending on	Foliar spray seedlings and	2, 4-D amine 625

Weed Management Area	Weed species	Management objective	Survey / monitoring time/s	Treatment time/s	Control method/s	Herbicide
Access tracks			access	site access	adults	g/L Rate: 320 mL/100 L
	Hyptis	No spread	End of wet season – March depending on site access	End of wet season – March depending on site access	Foliar spray seedlings and adults	2, 4-D amine 625 g/L Rate: 320 mL/100L
	Rubber Bush	No spread	End of wet season – March depending on site access	End of wet season – March depending on site access	Foliar spray seedlings	Triclopyr 300 g/L Rate: 750 mL/100 L (water)
					Basal Bark <5 cm stems – spray to point of runoff Cut stump > 5 cm stems	Triclopyr 240 g/L + Picloram 120 g/L 1 L/60 L (diesel)
Inacumba-1	No weeds	Prevent the introduction of weeds	End of wet season – March depending on site access	Immediately if weeds are found	Refer to the NT Weed Management Handbook	
Inacumba Access Tracks	Hyptis	No spread	End of wet season – March depending on site access	End of wet season – March depending on site access	Foliar spray seedlings and adults	2, 4-D amine 625 g/L Rate: 320 mL/100L
Inacumba Borrow Pit	No weeds	Prevent the introduction of weeds	End of wet season – March depending on site access	Immediately if weeds are found	Refer to the NT Weed Management Handbook	

Treatment times, control methods and herbicide application rates have been taken from the NT Weed management handbook

6 WEED MONITORING

The requirements for weed monitoring within each component of the project area are outline above in Section 5. Additional to the survey / monitoring times listed in Table 5-1, monitoring for weed incursions will be ongoing during operations, as all operational staff will have a responsibility to report new weed incursions to Santos' dedicated weed officer. Should new weed incursions be identified during the initial survey and monitoring, follow-up surveys will be within three months to ensure effective eradication of the incursions.

Upon commencement of construction, access to the proposed exploration wells will be restricted to approved access tracks. Once constructed, the potential for weed spread within the project area should be largely reduced to access tracks, the 2D seismic line and exploration well infrastructure. To target survey efforts within areas at high risk of weed establishment, weed monitoring will focus on the following areas:

- Known weed locations
- Along access tracks
- 2D seismic line
- Borrow pits and laydown areas
- 50 m buffer around stock watering points traversed by access tracks
- 50 m buffer around exploration wells
- Any other areas that were disturbed during track, seismic line or well construction process

6.1 Notification procedure

All new weed incursions will be reported to the NT Weed Management Branch by Santos' dedicated weed officer. Initial notification will be verbal, followed by written notification of preliminary species identification and location within seven working days.

6.2 Recording

All weed monitoring and survey activities will be recorded in accordance with the NT Weed Data Collection Guidelines available at: https://nt.gov.au/environment/weeds/weed-mapping-and-data-sharing.

The following attributes of any new weed infestations will be recorded into a GPS enabled device:

- Site ID
- Weed name
- ID confidence
- Date of record
- Coordinate information
- Recorder / organisation
- Infestation size
    - 20 m diameter
    - 50 m diameter
    - 100 m diameter
- Infestation density
    - 1 = Absent, no weeds of this species in the area
    - 2 = < 1%; very few, not many weeds
    - 3 = 1 – 10%; more than one or two isolate plants
    - 4 = 11 – 50%; Many plants, covering up to half the area
    - 5 = > 50%; Weed forms the dominant cover

Weed data will be submitted as an excel spreadsheet to the Weeds Management Branch (refer Appendix C for an example template)

6.3 Reporting

Santos' weed management officer will submit annual reporting against this WMP as a component of environmental reporting requirements. This will include

- Details of activities implemented to address weed spread and introduction risks
- Submission of all weed data collected
- Details of survey and monitoring events, including dates, personnel, maps and track data
- An overview of weed control events and success rates

This annual report will be reviewed by the NT Government's Onshore petroleum weed management officer.

7 REFERENCES

Weed Management Branch 2015a, *Northern Territory Weed Management Handbook*, Department of Land Resource Management, Northern Territory Government, Darwin

Weed Management Branch 2015b, *Northern Territory Weed Data Collection Manual*, Department of Land Resource Management, Northern Territory Government, Darwin

APPENDIX A SANTOS CORPORATE ENVIRONMENTAL POLICY

Environment, Health and Safety

Santos

Policy

Our Commitment

Santos is committed to a workplace where we all go home without injury or illness and manage the impact of our operations on the environment.

Our Actions

We will:

1. implement a structured and systematic approach to environmental, health and safety management and monitor its effectiveness
2. include environmental, health and safety considerations in business planning and decision-making processes
3. understand and manage the impact of our operations on the environment
4. comply with all relevant environmental, health and safety laws
5. promote a strong and consistent safety culture across all aspects of business
6. work pro-actively and collaboratively with our stakeholders and the communities in which we operate
7. set, measure and review objectives and targets which drive continuous improvement
8. report publicly on our environmental, health and safety performance

Governance

The Environment Health Safety & Sustainability Committee is responsible for reviewing the effectiveness of this policy.

This Policy will be reviewed at appropriate intervals and revised when necessary to keep it current.

Kevin Gallagher

Managing Director & CEO

Status: APPROVED

Document Owner:	Naomi James, Executive Vice President, EHS & Governance		
Approved by:	The Board	Version:	1

APPROVED 28 October 2016 Page 1 of 1

Weed Hygiene Declaration

This declaration is valid for transport and movement of vehicles and equipment from ______ to ______ (provide locations) and will stay current pursuant to the definition of clean in Definitions.

VEHICLE DESCRIPTION

Make: ______ Registration # or engine number: ______

Was clean prior to entry to ______ (destination)

Add equipment examined to the Equipment Register

Certifier name ______

Certifier qualification ______ Qualification date ______

DECLARATION

I, ______ (name),of ______ (street)

______ town ______ state ______ telephone

declare the information I provided in this declaration is true and correct and I have read the accompanying explanatory notes before completion of this declaration.

Signature ______ Date ______

EXPLANATORY NOTES

This certification process was developed to fulfill one of the stated purposes of the NT *Weed Management Act* and the Qld Land Protection *(Pest and Stock Route Management) Act 2002*.

It applies to, as a minimum, all weeds listed as weeds in the relevant jurisdiction and any plants that a stakeholder does not want transported or introduced.

DEFINITIONS

Clean:

- Means that no soil or organic matter is present on vehicles or equipment
- Vehicles and equipment are considered clean if, after certified weed free, it does not touch soil or vegetative material, ie for a vehicle this means it travels on sealed or well-maintained unsealed roads.

Equipment means anything other than a vehicle.

Vehicle includes anything used for carrying a thing or person by land, water or air.

Weed reproductive material means any part of a plant that is capable of producing another plant by sexual or asexual means. This includes seeds, bulbs, rhizomes, tuber, stem, leaf cuttings or a whole plant.

Well-maintained unsealed road means roads that do not have vegetation growing on or encroaching onto the area occupied by traffic.

Checklist-Cars, 4WD, trucks and trailer

Vehicle Rego Number	Date of inspection

INTERIOR	Pass ☐	Fail ☐

- Inspect foot wells
- Inspect under mats and carpet as well as the pile of carpet

BOOT OR TRAY	Pass ☐	Fail ☐

- Inspect under mats or carpet
- Inspect inside spare tyre area/behind spare tyre
- Inspect other recesses in the boot/rear of the vehicle
- Inspect recess of boot lid

ENGINE BAY	Pass ☐	Fail ☐

Inspect all areas of the engine bay with a particular focus on areas listed below

- Inspect the radiator
- Inspect the grill
- Inspect the top of transmission gearbox
- Inspect the recess under windscreen wipers
- Inspect air filter box

UNDERSIDE OF VEHICLE	Pass ☐	Fail ☐

- Inspect the wheel arches, wheel trims, flares, step treads, bumpers
- Inspect the mud flaps
- Inspect the tyre rims (particularly the rear side)
- Inspect the top of axels and differentials
- Inspect the top of muffler and surrounds
- Inspect the spare tyres on 4WDs and station wagons (they are often suspended underneath). Remove to check
- Inspect top side of any bash plates

Note: these are potentially a high risk area as contaminants collect inside the horizontal positioned rim of the spare tyre.

CARGO	Pass ☐	Fail ☐

- Inspect all equipment, list in the equipment register below

FOR UTILITIES AND TRUCKS	Pass ☐	Fail ☐

- Inspect the floor of the tray. Inspect channels of tail gates and tray drop sides
- Inspect side guards.
- Inspect under chassis rails, including within steel sections
- Inspect the gaps in the floor welds or boards and bolt holes on tray.

TRAILERS	Pass ☐	Fail ☐

- Inspect wheels
- Inspect guards and trays
- Inspect channels and draw bar
- Inspect underbody

APPENDIX C WEED CONTROL RECORDING TEMPLATE

RECORDER		Fred Smith		**Location or Project Name:**									
ORGANISATION NAME		Weed Terminators NT		**Recorder Method:**				E.g. High precision GPS					
Your reference	eg. 2/11/2006	Set the Datum on your GPS receiver to WGS84 or GDA94 using decimal degrees Lat: -14.56341 Long: 132.34521		Common name	5, 20, 50, 100, 200	1,2,3,4,5	Use list	Yes, No, Not recorded			use list	use list	
WAYPOINT (SITE_ID)	**DATE_REC**	**LAT_G94**	**LONG_G94**	**WEED_NAME**	**SIZE_DIA_M**	**DENS_CAT**	**TREATMENT**	**Seedlings**	**juveniles**	**adults**	**HERBICIDE**	**SEED_PRES**	**COMMENTS**
006	*13/08/2015*	*132.31142*	*-14.51862*	*Athel Pine*	*5*	*2*	*Stem injection*	*No*	*No*	*Yes*	*Triclopyr 600g/*	*Not recorded*	*Example only*

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Appendix F: Aboriginal and Non-indigenous Archaeological Assessment

An Aboriginal and non-Indigenous archaeological assessment of proposed works in EP161, Northern Scope, McArthur Basin, Northern Territory

A report to Santos Ltd

by

Johan Kamminga
Allan Lance

Heritage Consulting Australia Pty Ltd
GPO Box 2677
Canberra ACT 2601

March 2019

Table of Contents

Executive summary

Heritage Consulting Australia Pty Ltd (HCA) has been engaged by Santos Ltd to undertake a cultural heritage (archaeological) survey and assessment of Aboriginal and non-Indigenous heritage for the Tanumbirini North and Inacumba North areas in Exploration Permit 161 (EP161) in the Northern Territory's McArthur Basin.

The area is to be subject to a further exploration program (the Northern Works Program) seeking to evaluate potential gas reserves that were identified during exploration first conducted in 2013 with subsequent seismic survey and drilling undertaken. In the earlier seismic study, 500km of 2D seismic data were acquired to map the regional sub-surface geology and an exploration well (Tanumbirini 1) was drilled in June 2014.

The area under investigation is part of the Exploration Permit Area 161, situated 350 km south-east of Katherine. The location where the next phase of exploration is to occur is near the previously drilled Tanumbirini well, located 12 km north of the Carpentaria Highway (Highway 1) and approximately 135 km east of the township of Daly Waters at the junction of the Stuart Highway and Highway 1.

The further work program will entail a 2D seismic survey along a 10 km transect through the Tanumbirini North area, a drilling program (initially one horizontal well) in the same area, and a drilling program (initially one vertical and one horizontal well) in the Inacumba North area. There will be additional activities associated with this program including upgrading of access tracks to facilitate the entry and egress of vehicles during the seismic survey program. The Inacumba North area is situated ~15 km east of the Tanumbirini North location. At both locations where drilling is to occur there will be impacts within an area of approximately 200 m of the hole centre to accommodate drilling infrastructure, in addition to upgrades to access tracks and safe access to the Carpentaria Highway.

An archaeological field assessment was carried out by archaeologist Dr Johan Kamminga over 3 days in early March 2019, adopting a methodology consistent with the Northern Territory Cultural Heritage Act, 2011. The proposed seismic survey line route, locations of proposed upgrades to existing roads and tracks, well locations and the general project area were intensively examined for traces of prior Aboriginal habitation and resource use, and non-Indigenous settlement, to allow the development of appropriate management strategies to ensure the protection of the region's cultural heritage values.

This archaeological study did not address places of contemporary Indigenous significance, as defined by the *Northern Territory Aboriginal Sacred Sites Act,* 1989. The relevant statutory body for the project area is the Northern Land Council which has previously carried out an assessment in the project area and its vicinity. Two recorded sites of special Aboriginal significance were identified during this Sacred Site assessment and these sites have been protected from any potential impacts by broad exclusion zones. These Sacred Sites were not visited during the present study, nor were the exclusion zones entered.

Site register search and archaeological sensitivity modelling

Prior to the field inspection of the project area, a review of previously located sites, as recorded in the Northern Territory Heritage Register, was undertaken. The mapping of these sites and the development of models of Aboriginal site distribution that this permits, revealed the most archaeologically sensitive zones throughout the project area. This modelling assisted with the formulation of a field survey strategy to identify locations most likely to contain evidence of prior Aboriginal activity and cover any areas that may experience ground disturbance during the planned exploration and drilling program.

No Aboriginal, Macassan or non-Aboriginal archaeological places, sites or relics had previously been recorded within the project area. The closest registered Aboriginal archaeological sites or relics are at least 7 km distant from the project area. These are mostly isolated stone artefacts or stone artefact scatters. There are, however, restricted Aboriginal rock art sites 18km from the project area. These are found in rocky escarpments, a landform that does not occur in the area where construction activities are to occur.

Field investigation

The archaeological survey and assessment focused on the identification of Aboriginal, Macassan and other non-Aboriginal archaeological places, sites and relics as defined by the *Northern Territory Heritage Act,* 2011.

The field survey covered all environmental zones within the project area. The areas that were investigated included the 10km long route of a proposed seismic line that traversed the Tanumbirini North project area; areas around the proposed Inacumba pilot well location, and around existing infrastructure including roads and well leases; and a number of other locations in and around the project area. The site inspection assisted with an understanding of the distribution of items of Aboriginal cultural heritage significance in this landscape.

Results

This archaeological field survey carried out as a core component of the archaeological assessment revealed no Aboriginal relics or sites (for example stone tools, former camp sites, or culturally modified trees), nor any non-Aboriginal relics or sites. This indicates that Aboriginal sites and relics are relatively sparse to very sparse within the more general area of northern Tanumbirini Station.

There is no indication that any Aboriginal archaeological or historical sites/relics will be encountered or impacted by proposed activities in this portion of EP161.

Conclusions

The results of this archaeological study indicated that there are no identifiable archaeological heritage constraints on proposed work activities in the project area. This includes any activities in the vicinity of the existing gas and water well, the proposed seismic line, the proposed Inacumba pilot well, and the proposed widening or other modification to access tracks, or turning areas along the Carpentaria Highway.

In the unlikely event that previously undetected items of Aboriginal or non-Indigenous cultural heritage are encountered in the project area during planned exploration or construction activities, these should be noted, assessed, recorded and avoided. If avoidance is impracticable, a further assessment should be undertaken to evaluate cultural heritage significance, and in consultation with the Heritage Branch of the Northern Territory Department of Tourism, Sport and Culture, decide on the most appropriate remediation measures.

1. Introduction

Heritage Consulting Australia Pty Ltd (HCA) has been engaged by Santos Ltd to undertake a cultural heritage (archaeological) survey and assessment of Aboriginal and non-Indigenous heritage for the Tanumbirini North and Inacumba North areas in Exploration Permit 161 (EP161) in the Northern Territory's McArthur Basin.

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The further work program will entail a 2D seismic survey along a 10 km transect through the Tanumbirini North area, a drilling program (initially one horizontal well) in the same area, and a drilling program (initially one vertical and one horizontal well) in the Inacumba North area. There will be additional activities associated with this program including upgrading of access tracks to facilitate the entry and egress of vehicles during the seismic survey program. The Inacumba North area is situated ~15 km east of the Tanumbirini North location. At both locations where drilling is to occur there will be impacts within an area of approximately 200 m of the hole centre to accommodate drilling infrastructure, in addition to upgrades to access tracks and safe access to the Carpentaria Highway.

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This archaeological study did not address places of contemporary Indigenous significance, as defined by the *Northern Territory Aboriginal Sacred Sites Act,* 1989. The relevant statutory body for the project area is the Northern Land Council which has previously carried out an assessment in the project area and its vicinity. Two recorded sites of special Aboriginal significance were identified during this Sacred Site assessment and these sites have been protected from any potential impacts by broad exclusion zones. These Sacred Sites were not visited during the

Figure 1. Location of the project area.

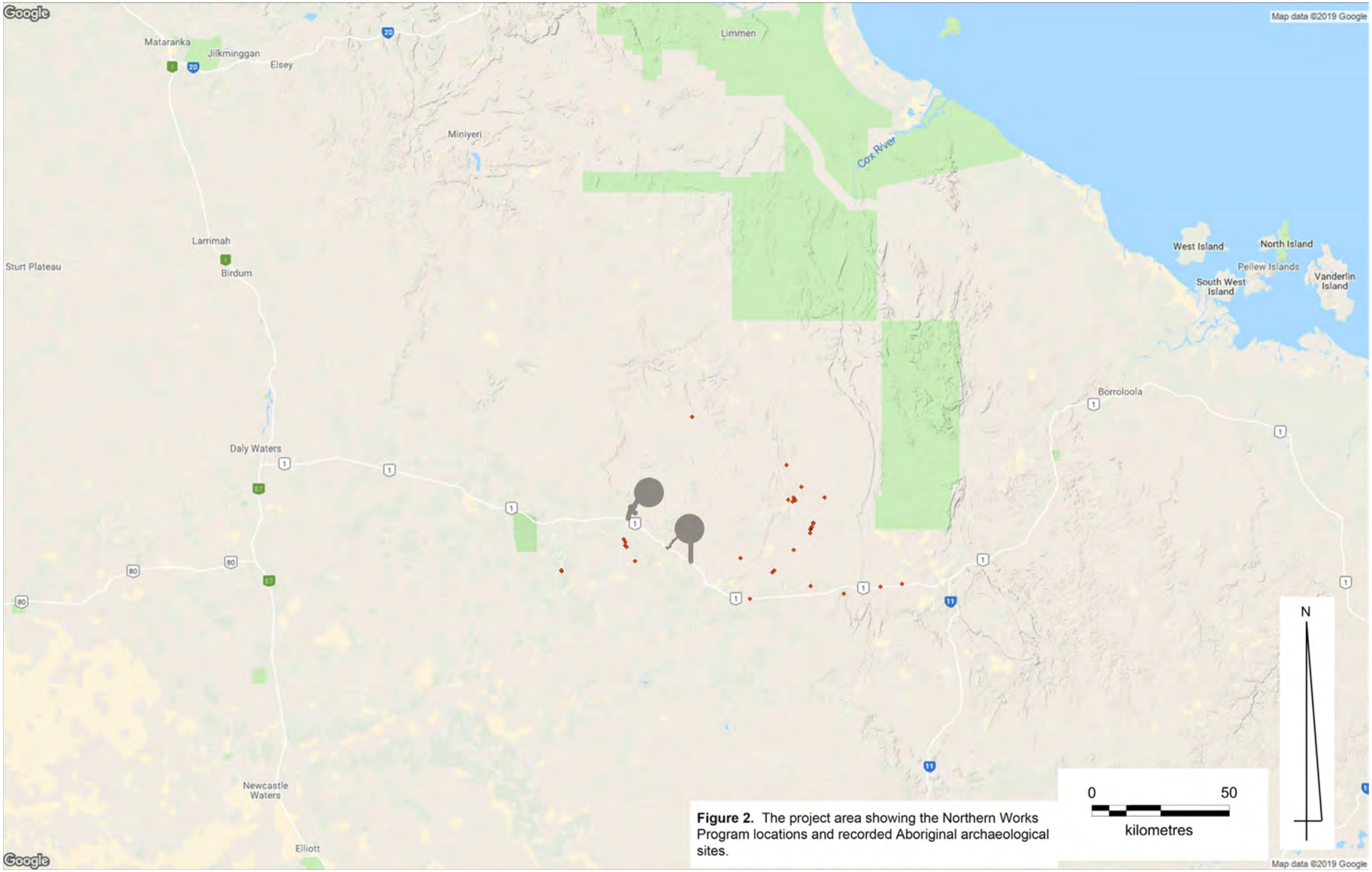

Figure 2. The project area showing the Northern Works Program locations and recorded Aboriginal archaeological sites.

present study, nor were the exclusion zones entered.

2. The project area

The project area lies within Santos exploration lease EP161, located on Tanumbirini Station, a 5,000 km^2 beef cattle grazing property located 420 km southeast of Katherine in the McArthur Basin, situated in the north-east of the Northern Territory. The project area is located within Barkly Shire and in NT Cadastral Parcel 701 of Arnold. The closest towns are Daly Waters (approximately 135 km to the west) and Borroloola (approximately 165 km to the east).

Cattle grazing is the primary activity on Tanumbirini Station, with some minor cropping around the station homestead. In the 1960s, pastoral activity was restricted to the northern, northeastern, and extreme western parts of the station, the remaining area being vegetated by scattered dense patches of lancewood (*Acacia shirleyi*) and “poor grass” (Paine 1963:1).

Tanumbirini Station Homestead settlement (the only permanent dwellings on the property) and the Santos project areas are accessed from the Carpentaria Highway, an all-weather public road constructed in 1959.

3. Environmental setting

3.1 Topography

The topography of the project area comprises gently undulating plain, moderately graded slopes in the order of 0-2°, and ephemeral drainage features such has creek channels and washouts (Santos 2013). The elevation of the Santos project area within the station ranges from 200 to about 260 m asl.

3.2 Land systems

The Northern Works Program areas (Tanumbirini North and Inacumba North) are located at the boundary of the Gulf Falls and Uplands Bioregion and Sturt Bioregions (Figure 3). A detailed investigation of the regional ecosystems has been prepared for the Bullwaddy Conservation Area, situated 33 km to the west and appropriate descriptions have been derived from the Conservation Area Management Plan (NT Parks and Wildlife Commission 2005) and earlier CSIRO investigations of regional Land Systems (Christian *et al.* 1954 and Perry 1960; Perry 1963).

The region is characterised by flat erosional plains dominated by savannah woodlands with mixed eucalypt species, overlying an understory of mixed grasses, with open woodlands on the clay floodplains (NT Parks and Wildlife Commission 2005:5). There are pockets of acacia woodland through this region, including the lancewood (*Acacia shirleyi*) found in the Bullwaddy Conservation Area.

3.3 Geology

The project area contains bedrock formations of Upper Proterozoic, Lower Cambrian, and Lower Cretaceous age, and forms a tableland, which is part of the extensive Barkly-Beetaloo Tableland (Dunn, Smith and Roberts 1962). The low-relief plain is present throughout the project area and

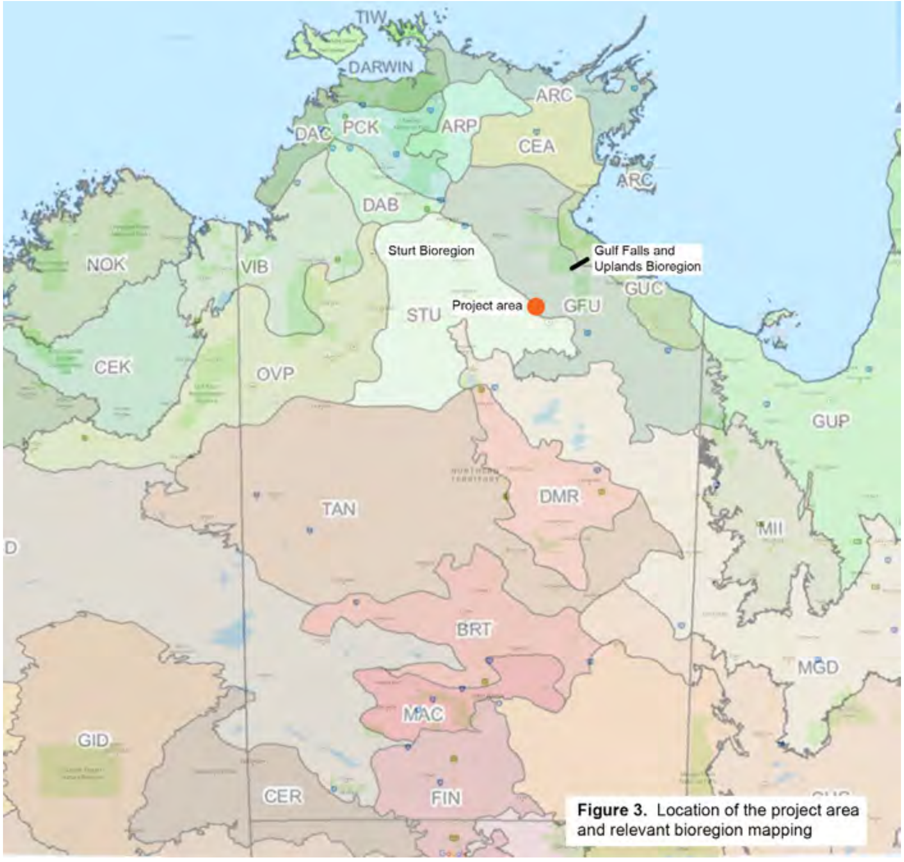

Figure 3. Location of the project area and relevant bioregion mapping

is bounded on the north by a well-defined scarp about 60 m high (Figure 4). The surface of the tableland, which lies between 230 and 274 m asl, is gently undulating and represents parts of an extensive laterite land surface which extends across the entirety of Tanumbirini Station (Paine 1963:3).

The project area is located within the 'Mature Gulf Fall area' (Paine 1963: Fig. 1), where the exposed Upper Proterozoic rocks have altered a drainage system inherited from an early Tertiary laterite surface. Relief in this area is generally 30 to 46 m and locally 76 m. Lower Cretaceous rocks abut the ranges of Upper Proterozoic rocks. Tanumbirini Creek, in the vicinity of the homestead, has been superimposed on Upper Proterozoic rocks, flowing north east across two major sandstone strike ridges of Roper Group rocks (Paine 1963:4).

The Upper Proterozoic rocks up to 5,500 m thick (Paine 1963:12), which outcrop only in the north eastern part of Tanumbirini Station, belong to a sequence laid down in the McArthur Basin, which extended from Arnhem Land to the Queensland border. The sequence is divided into Tawallah, McArthur, and Roper Groups. The Tawallah and Roper Groups are represented in the Tanumbirini Station area (Paine 1963:5).

A small outcrop of altered dolerite/basalt of the Settlement Creek Volcanics overlies glauconitic sandstone of the Rosie Creek Formation at Eight Mile Creek to the northeast of the project area (Paine 1963:5).

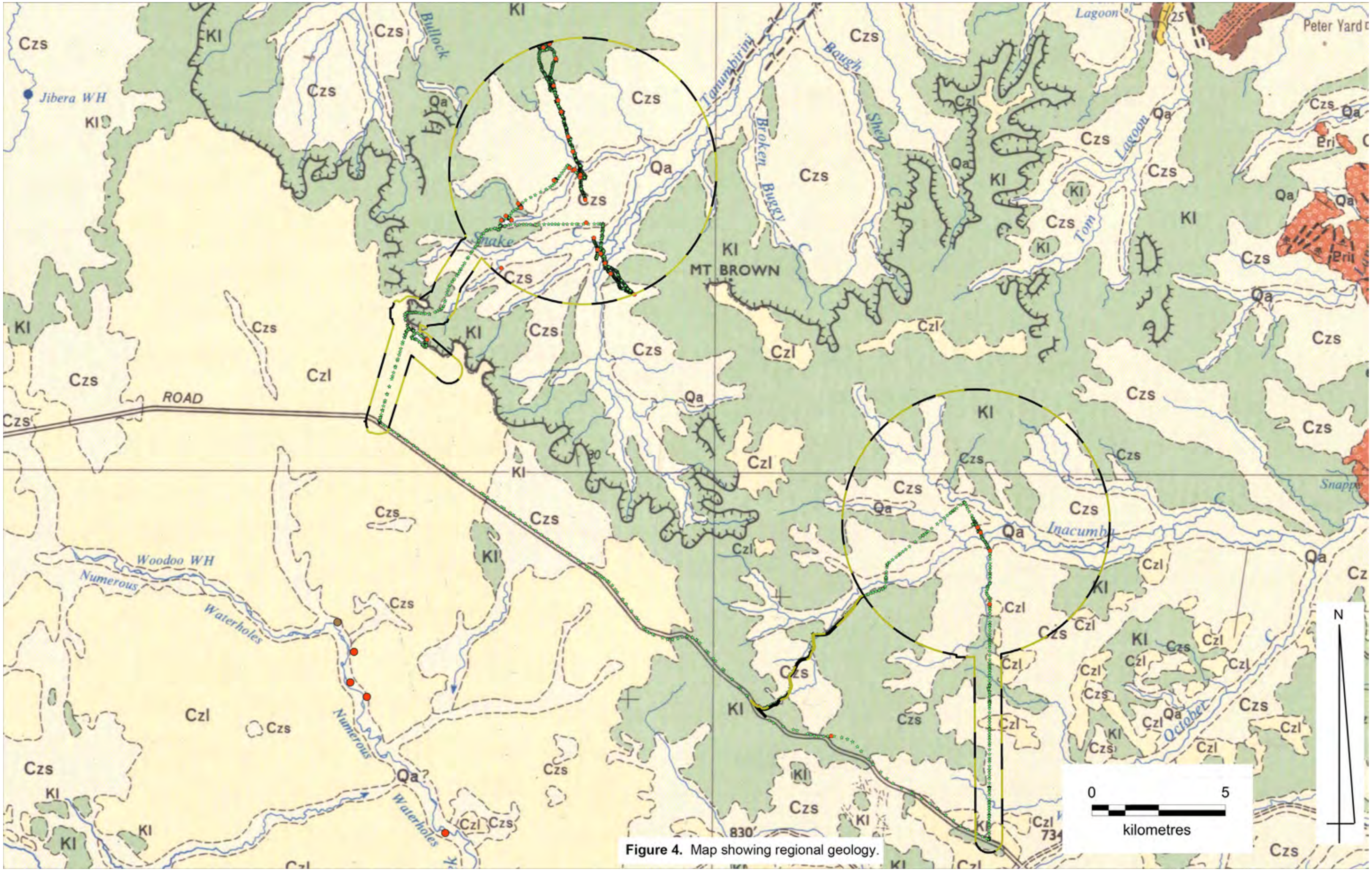

Figure 4. Map showing regional geology.

A layer of unlateritized, partly lithified white leached claystone that exhibits sub-conchoidal fracture outcrops in a road cutting of the Carpentaria Highway in the proposed road modification area at the T-intersection of the Inacumba North Area and also along the southernmost portion of the access track to the Inacumba North Area (see Paine 1963:9).

3.4 Hydrology

A watershed dividing inland from seaward drainage systems extends across the property from northwest to southeast. This watershed is of very low relief and the inland drainage system is poorly developed (Paine 1963: 1). The catchment within the project area drains north-easterly towards the Gulf of Carpentaria.

Watercourses flow at intervals after rain during the wet season but are dry for the remainder of the year. Scattered waterholes may survive the dry season and, other than modern bores with reservoirs, are the only source of water for stock throughout the station during the dry season.

More specifically, water flow in Tanumbirini Creek and Inacumba Creek and in their very minor tributary and overflow drainage lines within the general project area occurs during the wet season, predominantly due to cyclones and monsoonal rainfall. The creeks and their tributary drainage lines are largely ephemeral and usually run dry during the dry season. The flow is of short duration and characterised by high turbidity causing undercutting and creation of creek channel banks especially on bends.

3.5 Vegetation

In general, vegetation types include woodland, open woodland, open forest, tussock grassland and hummock grassland. The dominant species within the vegetation communities present include Darwin stringybark (*Eucalyptus tetrodonta*) and variable-barked bloodwood (*Corymbia dichromophloia*) with a spinifex understorey, and woodland dominated by Kullingal (*Eucalyptus pruinose*) or *Melaleuca* spp. with tussock grass understorey. There are also areas of Lancewood (*Acacia shirleyi*) thicket, Bullwaddy (*Macropteranthes keckwickii*) woodland and Acacia scrub (Santos 2013:5).

Within a radius of ten kilometres of the project area the vegetation types are woodland open forest and tussock grassland. The dominant vegetation type in the immediate area of the Tanumbirini North and Inacumba North project area is woodland, and along the Carpentaria Highway junction for Inacumba North it is woodland and open forest (Santos 2016). The species within the woodland vegetation communities present are dominated by Kullingal and variable barked bloodwood with *Melaleuca* spp. and tussock grass understorey.

3.6 Fauna

Food resources available to Aboriginal people in the past would have been varied and would have included birds, marsupials, reptiles and insects, and plant parts and honey. (see Mulvaney and Kamminga 1999:79-88).

The wider McArthur Basin region supports a diverse range of fauna. Over 435 vertebrate species have been recorded from the Gulf Falls and Uplands bioregion. The sandstone ranges and stony hills of the region support a range of marsupials, reptiles, fish and birds, including a number of endemic species, including Carpentarian Rock Gecko (*Gehyra Borroloola*), Hosmer's Skink (*Egernia hosmeri*) and the Carpentarian Grass-wren (*Amytornis dorotheae*). Major river systems are important environments for many species because of the much lower annual rainfall than the more northern savannas, and the very high summer temperatures.

In the project area itself, the range of plants and animals would have been more restricted, with the dominant fauna being reptiles and when local rainfall permitted, grazing macropods and birds. Spectacled hare-wallabies (*Lagorchestes conspicillatus leichardtii*) find refuge in vine thickets and are common (NT Parks and Wildlife Commission of the Northern Territory 2005:10).

3.7 Climate

The region experiences a 'grassland' climate, based on the Köppen classification system. This classification consists of two distinct seasons: the wet season which lasts from December to March; and the generally dry conditions which last for the remainder of the year (winter drought).

Mean maximum temperature ranges from 29.7°C in June to 38.6°C in November and historically the highest temperatures recorded have been in November. The mean minimum temperature ranges from 12.2°C in July to 24.9°C in December-January. Coolest temperatures occur in June-July. At Daly Waters the average annual rainfall total is 660 mm.

The highly seasonal rainfall and absence of reliable waterholes in the minor creeks that cross the project area may have discouraged sustained occupation of the region by Aboriginal people during the dry season.

3.8 Soils

The landscape of northern and central Australia is ancient and highly weathered. Soil types are susceptible to erosion given that the region experiences long dry periods followed by intense rainfall. In this environment, the soils become disturbed and once disturbed are highly erodible. Termite and other invertebrate bioturbation also reduce and even eliminate the original stratigraphic integrity of biomantle loose sediments.

The project area is characterised by plains and rises associated with deeply weathered soil profiles (laterite) including sand sheets, sandy and earth soils, in particular lateritic yellow earths and brown clays.

In general, the soils in the project area are mostly shallow and gravelly, often overlaying discontinuous layers of detrital ferruginous gravel (commonly termed ironstone), derived from the weathering of haematitic laterite, preserved as iron-rich rock layers in the Sturt Plateau bioregion south of the Carpentaria Highway, along with locally exposed claystone bedrock. This detrital ironstone is ubiquitous and at times extremely abundant on ground surfaces throughout the project area (see Paine 1963:10).

The soils are Quaternary and Holocene in age and are dominated by kandosols and rudosols. Kandosols are massive and earthy soils (formerly red, yellow and brown earths) that are widespread across the Sturt plateau to the south. More specifically this soil type is a Ferric brown kandosol that has well-developed B2 horizon in which the major part is massive or has only a weak grade of structure (for descriptive classification see Isbell 1993). Rudosols are very shallow soils or those with minimal soil development and include very shallow gravely soils. In particular, this soil in the project area is a gravelly leptic rudosol originating from lateritic lithosols (Tasker 2017).

Brown demosol also occurs in the project area (Tasker 2017) and these originate from locally occurring lateritic yellow earths/brown clays. This is a clayey soil with a strong blocky structure and no clear or abrupt textural changes between horizons and tends to have a B2 horizon with structure more developed than weak.

Surficial Quaternary alluvium occurs along watercourse corridors and washouts and in other areas of watercourse catchments (Figure 4).

4. Aboriginal history and settlement in the region

4.1 Local Aboriginal organisation

In his historical reconstruction of pre-contact Aboriginal Australia, Tindale (1974) identified the tribal affiliation of the area as *Jingulu*. Tindale defined 'tribal' groups on the basis of written accounts of variable quality; however, many of these records were unreliable. Tindale's tribal boundaries were largely defined according to what he understood to be language groups and his work was conceptualised according to a model of band social organisation in which the clan or 'horde' was considered to be the group which possessed political power and proprietary rights to land.

The assumptions inherent in this conflation of language group with the concept of a 'tribe' are no longer regarded by anthropologists as appropriate. Similarly, the concept of 'tribe' as a territorial group is debatable. In Aboriginal society, people were invariably multilingual rather than monolingual and representing language groups as bounded social groupings is now thought to be inappropriate. In the Radcliffe-Brown model, the land/language relationship was seen as indirect: the estate of a tribe was defined as the aggregation of all the clan estates who shared a common language. This relationship is now viewed to be direct – it is recognised that the importance of land/language relations in Aboriginal society is that particular languages and particular tracts of country were directly linked according to Dreaming events and activity.

While it was previously assumed that tribes or language groups functioned as politically cohesive corporate groups, it is now recognised by anthropologists that linguistic groupings do not structure the Aboriginal social and geographical landscape. Sutton and Rigsby (1979:722) argue that Tindale's tribal boundaries are not meaningful at either a demographic or political level. In order to overcome Tindale's limited and flawed tribal boundary model, recourse must be made to more contemporary anthropological concepts and understanding.

Drawing on accounts of a number of early ethnographers, Wesson (2000) has defined the multi-dimensional aspect of Aboriginal social geography based on habitual place of residence, dominant mode of livelihood, and language. This approach is more meaningful that those underpinning earlier anthropological models.

4.2 Tribal groups in the area

Tanumbirini Station is located within the territory of two language or tribal groups, Jingili and Alawa speakers (Tindale 1974; Sharpe 1969). The Jingili language was spoken by people who inhabited the area including Hodgson Downs, Nutwood Downs, and Tanumbirini stations, south of the Roper River and east of the Stuart Highway (Sharpe 1969).

The Jingulu language is classified as belonging to the Mirndi family of non Pama-Nyungan languages. An early word-list was compiled by F.A. Gillen (Pensalfini 2004:143). Following in the wake of pioneering work by Neil Chadwick in the 1970s, Robert Pensalfini wrote a grammar of Jingulu on the basis of fieldwork with its last known fluent speakers (Pensalfini 1997).

According to Jingulu oral tradition, the Jingili originally migrated from the Great Western Desert (Tindale 1974:236). Tindale estimated the size of Jingili territory to be approximately 15,00 km^2, with the southern frontier around Renner Springs extending northwards to Newcastle Waters and also taking in the area of the Ashburton Range. To the east the territory encompassed Cattle Creek south to Wave Hill and Ucharonidge. Their western extension of their territory approached Lake Woods (Tindale 1974:236).

There has been very little academic study of the Alawa language or people (also known as Galawa or Waliburu). The most recent work was a study of the language by Sharpe nearly 50 years ago (Sharpe 1969).

In the early 1960s, Tanumbirini Station was inhabited by a single station manager and several Aboriginal people who lived and worked on the station with a number of their family members. The language or tribal affiliation of these residents was not reported.

5. Nature of the proposed work activities

There are a number of activities proposed as part of Santos Northern Works Program in EP161. The locations where the impacts will occur are shown in Figure 6. Proposed activities will include a 2D seismic survey along a 10 km transect through the Tanumbirini North area. There will be additional activities associated with this seismic survey program including upgrading of access tracks to facilitate the entry and egress of vehicles.

Impacts from the seismic survey will be minimal. It will be necessary for vehicle access along the 10 km line, which may require some clearing of uneven ground and to allow crossing of minor watercourses. The line will then be prepared and geophone arrays laid by hand with access provided by four wheel drive vehicles. Once the geophone lines have been laid, the seismic survey will be conducted using vibroseis trucks shod with pneumatic tyres. The impacts from this activity will be localised and shallow and will mainly arise when access for the seismic line is prepared. Once the seismic survey program has been completed the vehicle tracks should, over time, revert to their pre-survey state.

The second area where works are planned is situated 15 km further to the east, in the Inacumba North area. Here a pilot well is to be drilled, requiring impacts within an area of approximately 200 m of the hole centre to accommodate drilling infrastructure, in addition to upgrades to access tracks and modifications of access onto the Carpentaria Highway, to permit safe entry and egress for trucks.

Construction activities for the well will require ground works that will include:

- Site preparation for a well pad,
- New access roads and upgraded access roads,
- Site preparation for a temporary camp including temporary sewerage treatment plant,
- Site preparation of laydown areas,
- Construction of borrow pits,
- Construction and equipping of water bores,
- Dedicated area for equipment storage,
- Installation of temporary fencing, gates and motor grids.

6. Aboriginal cultural heritage assessment methodology

Ideally, there are five major steps that are required in archaeological heritage assessment.

Step 1 – Register search

A search of relevant heritage registers and databases is undertaken to:

- ascertain if any known Aboriginal or non-Aboriginal heritage sites/relics occur within or in close proximity to the project area;
- provide data to assist in predicting the types and frequency of Aboriginal and non-Aboriginal sites/relics that may occur in the development area, within the local area or region generally.

Step 2 – Assessment of landscape features and sediments

The second stage of the assessment process requires the examination of the landscape setting and environment of the project area. These include an understanding of the surface geology, geomorphology and sediments, which may have affected past land-use practices, survival of sites in the landscape and the detectability of sites. This assessment also includes noting of tree varieties and tree ages to assist in identifying culturally modified trees. In particular, certain landscape features have a higher potential to contain Aboriginal relics.

Step 3 – Desktop assessment and visual inspection

An archaeologist identifies landscape features with the potential to contain sites and undisturbed relics. Relevant archaeological research reports for sites within the project area and for the

area or region generally, as appropriate, are examined to provide baseline data and a broader understanding of the cultural heritage context of the area subject to potential impact.
A field assessment entails a pedestrian archaeological survey of the subject land, with particular attention to archaeologically sensitive landscape features such as watercourses, rocky escarpments, areas of exposure, and pavements with exposed gravel on which stone artefact scatters are readily detectable.

Step 4 – Reporting results
Reporting of the findings and recommendations from the assessment. A written report documenting the procedures, results and recommendations of the archaeological heritage assessment is produced to support the conclusions.

Step 5 – Further investigation and impact assessment (if required)
After assessing the significance of the archaeological site/relic, recommendations are made regarding compliance with the provisions of the Northern Territory *Heritage Act,* 2011.

The specific aims of this archaeological assessment were to:

1. Identify known Aboriginal and non-Aboriginal archaeological heritage sites and/or relics within the subject land area and assess the area for its potential to contain unidentified sites/ objects.

2. Identify any potential archaeological heritage constraints and formulate recommendations and management strategies and options with regard to the proposed activity/development.

3. Provide an assessment as to whether or not further archaeological heritage investigation or assessment is required prior to the commencement of the proposed development.

4. Determine whether further detailed investigations may be needed to be undertaken to meet statutory requirements.

7. Results of the background research and the Site Register searches

Searches of the NT Heritage Register, Aboriginal Areas Protection Authority (AAPA) database, and NT Archaeological Sites Database were undertaken on 4 March 2019. (Table 1, and Figure 5).

Other documents reviewed included the relevant work program issued to Northern Lands Council (NLC), an update to that work program, geospatial data and maps of the project area derived from the database searches, archaeological, historical and anthropological literature, and scientific literature relating to environment and geology.

Archaeological research over the past five decades has shown that Aboriginal people have occupied Australia for at least 40,000+ years (Mulvaney and Kamminga 1999:2). By 35,000 years

Site_Name	Zone	East GDA94	North GDA94	Site_Type	Contents
Broadmere St. 1				rock art	paintings
Balbirini Creek 6	53			Stone artefact scatter, grindstone portable	artefact scatter
Balbirini Creek1	53			Stone artefact scatter	artefact scatter
Balbirini Creek2	53			Stone artefact scatter	artefact scatter
Balbirini Creek3	53			Stone artefact scatter	knapping floo
Balbirini Creek4	53			quarry	quarry
Balbirini Creek5	53			Stone artefact scatter, grindstone portable	artefact scatter
Bauhinia Downs1	53			Stone artefact scatter	artefact scatter
Binda	53			Rock art, Restricted anthropological site, ceremonial ground	petroglyph
Broadmere St. 10	53			Stone artefact scatter	artefact scatter
Broadmere St. 11	53			rock art	paintings
Broadmere St. 3	53			Stone artefact scatter, midden	artefact scatter, midden
Broadmere St. 4	53			Stone artefact scatter, quarry	artefact scatter, quarry
Broadmere St. 5	53			Stone artefact scatter	artefact scatter
Broadmere St. 7	53			Stone artefact scatter, midden	artefact scatter, midden
Broadmere St. 8	53			rock art	paintings
Broadmere St. 9	53			rock art	paintings
Carpenteria Hwy 1	53			Stone artefact scatter, grindstone portable	artefact scatter
Eleanor Pool Yard1	53			stone artefact scatter, historic site, stone arrangement, grindstone portable	artefact scatter, stone arrangement , faunal remains
Favenc Site (Telecom)	53			Stone artefact scatter	artefact scatter
Goanna Site (Telecom) [Pipeline Site B - Mitchell: not located]	53			Stone artefact scatter	artefact scatter
Lansen Springs (Broadmere St. 6)	53			Stone artefact scatter	artefact scatter
Newcastle Creek 1	53			Isolated stone artefact	stone artefact
Newcastle Creek 2	53			Stone artefact scatter	artefact scatter
Newcastle Creek 3	53			Stone artefact scatter	artefact scatter
Newcastle Creek 4	53			Stone artefact scatter	artefact scatter
Newcastle Creek 5	53			Stone artefact scatter	artefact scatter
Old Tanumbirini Station	53			Skeletal remains, stone arrangement	skeletal remains, stone arrangement
OT Down2	53			Stone artefact scatter	artefact scatter
OT Down3	53			Stone artefact scatter, grindstone portable	artefact scatter
OT Downs1	53			quarry	quarry

Table 1. List of sites recorded on the Northern Territory Heritage Register for the region around the project area. Old AGD66 coordinates have been converted into GDA94 format.

Pipeline Site A - Go-anna Creek 2	53			rockshelter deposit, rock art, stone artefact scatter, shell scatter, grindstone portable	artefact scatter, paintings, midden
Pipeline Site C - Little Creek 2	53			Stone artefact scatter	artefact scatter
Urrwalala [DML - 1975, MH - 1986]	53			Stone artefact scatter, shell midden, rock art, grinding place non-portable	artefact scatter, midden, paintings, grinding hollows / grooves
Yaroo 1	53			Stone artefact scatter	artefact scatter
Yaroo 2	53			Stone artefact scatter	artefact scatter
McArthur River 2D Seismic Site 1	53			Stone artefact scatter, hearths, camp sites, knapping floor	Stone artefact scatter

Table 1. List of sites recorded on the Northern Territory Heritage Register for the region around the project area. Old AGD66 coordinates have been converted into GDA94 format.

ago all major environmental zones in Australia, including semi-desert and desert country and even periglacial environments of Tasmania, were occupied (Mulvaney and Kamminga 1999:114).

At the time of early Aboriginal occupation, Australia experienced moderate temperatures. At the commencement of the Last Glacial Maximum (LGM) at about 24-22,000 years ago, sea levels fell to about 130 m below present levels and accordingly, the continent was correspondingly larger. However, between 24,000 and 12,000 years ago (at the height of the Last Glacial Maximum) dry and either intensely hot or cold temperatures prevailed over the continent.

With the amelioration of glacial conditions, temperatures rose with a concomitant rise in sea levels. By ca. 6000 BP sea levels had more or less stabilised at their current position (but now again rising slowly). With the changes in climate during the Holocene, Aboriginal inhabitants had to deal not only with reduced landmass but with changing hydrological systems and vegetation; forests and woodlands again spread across the grasslands and shrublands of the Late Glacial Maximum.

Human occupation of the study area must have been very sparse throughout prehistory into modern times, especially so for earlier millennia. The area was environmentally challenging, only becoming more habitable during the later Holocene period.

Only one major archaeological consultancy report is available for the wider region generally (Guse and Collis 1998). This survey and assessment report was prepared for North Australian Basins Resource Evaluations, AGSO. The study was along a proposed 70+ km 2D seismic line in the McArthur River Region, well to the east of the project area. The topographic, geological and environmental contexts do not correspond sufficiently to those of the current archaeological survey areas to provide more than the most general information. For instance, there are rock shelters habitation sites, rock art sites and rock shelters with burials in the MacArthur River region. The land systems in which these sites occur are not present in the vicinity of the current survey

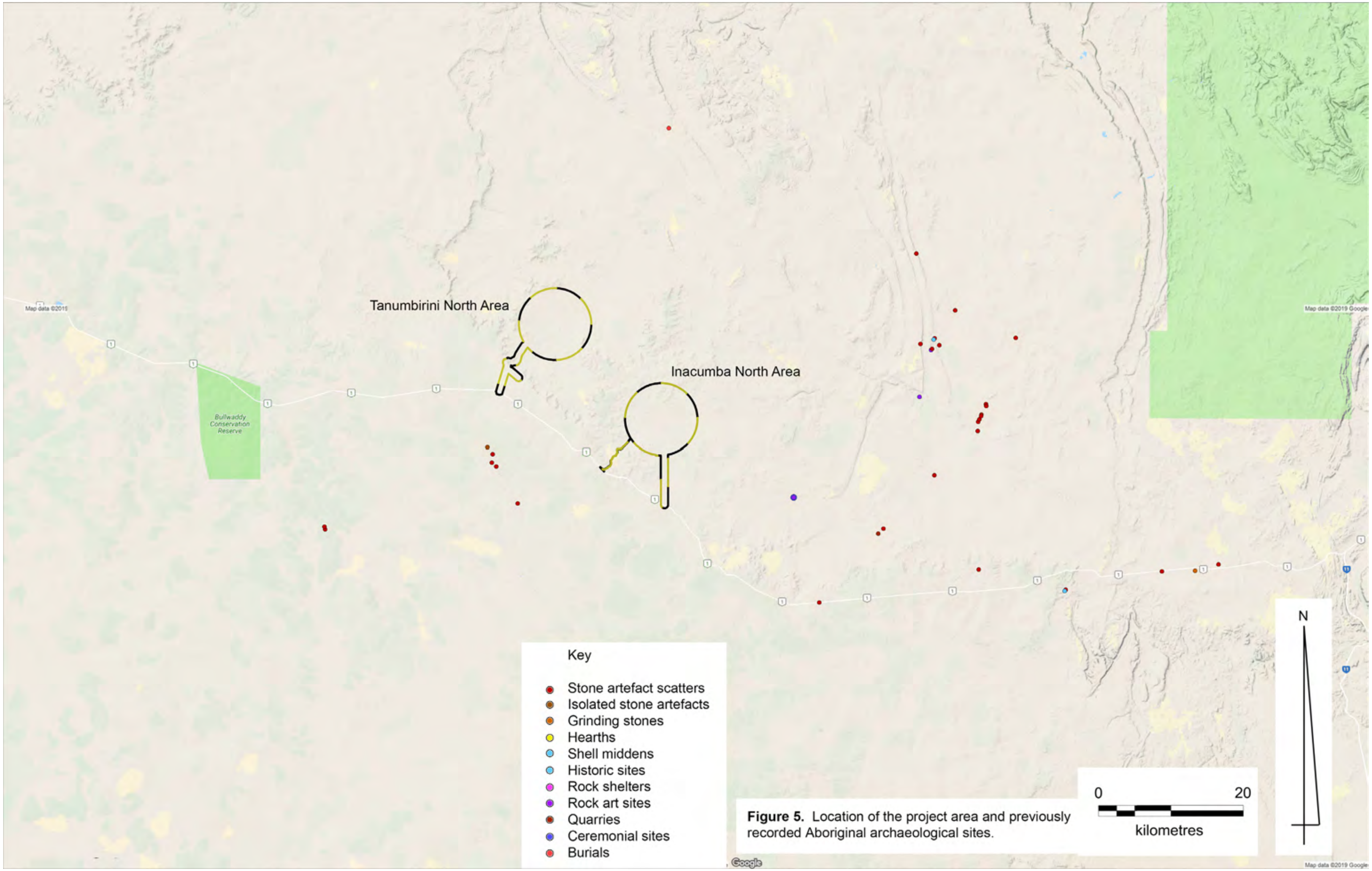

Figure 5. Location of the project area and previously recorded Aboriginal archaeological sites.

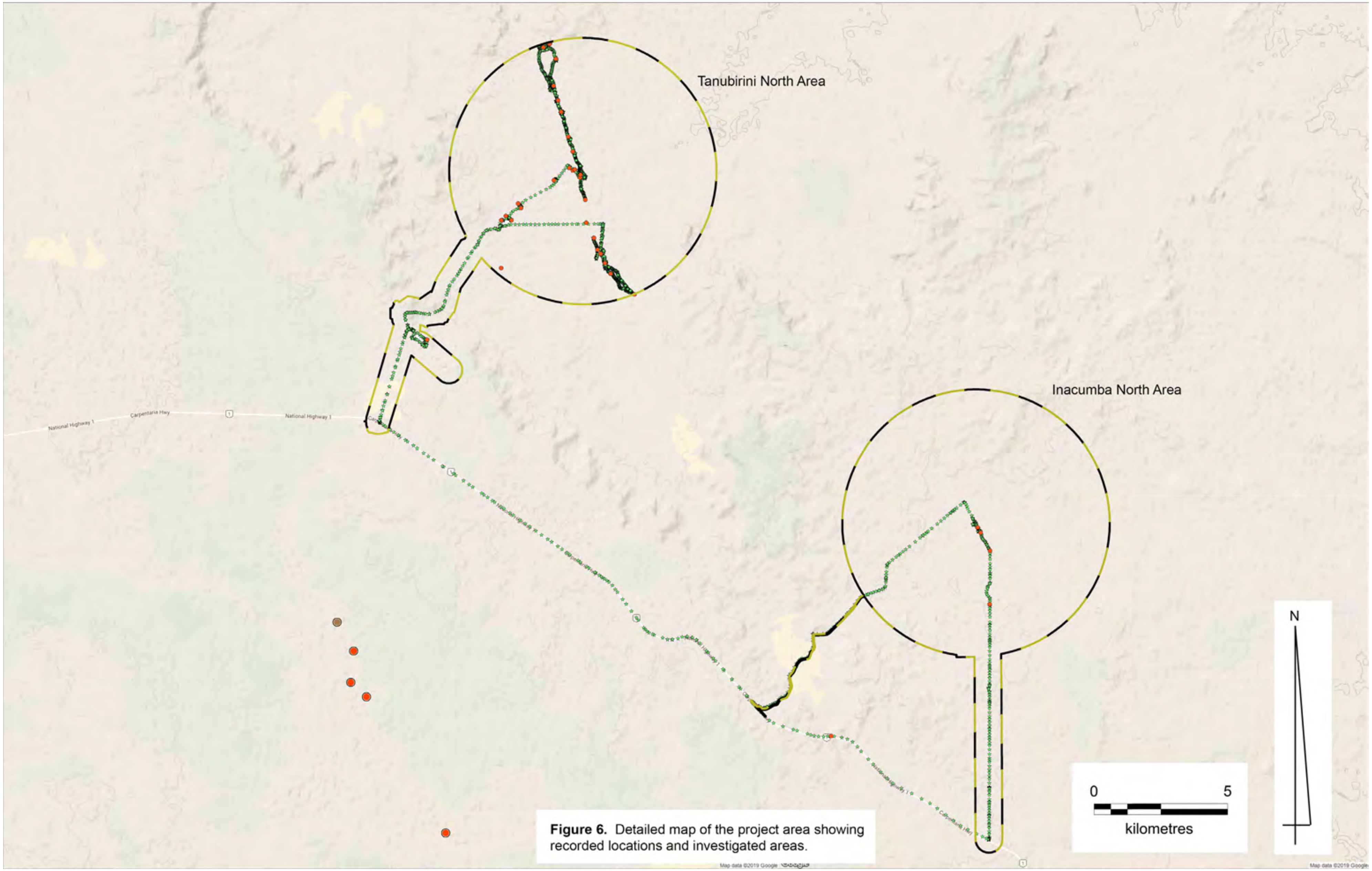

Figure 6. Detailed map of the project area showing recorded locations and investigated areas.

areas because of an absence of bedrock suitable for shelter or cave development.

Closer to the project area, small archaeological surveys have been undertaken in previous decades for various developments such as telecommunications infrastructure. Within this more proximal general area but still well beyond the current archaeological survey areas, stone artefact scatters (mostly flaking débitage) are the predominant site type, followed by a single hearth and skeletal remains, two stone arrangements, three shell middens, six rock art sites and two postulated ‘quarry’ sites.

The closest archaeological sites are approximately seven kilometres south of the Carpentaria Highway, and at least 15 km from the nearest significant construction or seismic survey impacts. This cluster of four stone artefact scatters and one isolated stone artefact are found beside waterholes in Newcastle Creek, a southward flowing stream. A rock art site is found approximately 16 km southeast of the Inacumba North Area. This site is found in a rocky escarpment near the headwaters of Parsons Creek. Further sites (quarries, stone artefact scatters and hearths) are found in the escarpments to the east of these sites and more than 30 km from the project area.

7.1 Historical places

A search of the NT Heritage Register has indicated that there are no listed heritage items or places in the vicinity of the project footprint. (Santos 2018:53). Only two declared historical places have been registered in the region NRETAS (2010). Both of these places are south of the village of Elliot and more than 150 km from the project area (NRETAS 2010).

Ucharonidge Station is located 19 kilometres south of Elliott and 77 kilometres east on the Barkly Stock Route on the Barkly Tableland. Powell Creek Overland Telegraph Station, south of the village of Elliott and over 170 km distant from the proposed project area. This site was listed on the Register of the National Estate and declared a Heritage Place under provision of the *Heritage Act*. The station was established in 1872 and is one of 11 repeater stations built along the Overland Telegraph Line.

8. Predictive modelling of the nature of Aboriginal sites/relics

8.1 Degree of preservation Aboriginal material culture

Items of organic material culture, such as wooden spears, digging sticks and small bags and nets will not have been preserved in the moderately acidic open-air sediments found in the project area.

However, various stone artefacts are likely to occur in the general region and will be preserved indefinitely:

- Macroblades (Mulvaney and Kamminga 1999:Map 12)
- Hatchet heads
- Unifiacial and bifacial points (Mulvaney and Kamminga 1999:Map 12c)
- Unretouched and retouched flakes used for light-duty cutting

- A number of other flaked stone tool type
- knapping debitage
- grinding stones

Stone quarry

Background research has indicated no likelihood for the occurrence of geological sources of stone suitable for Aboriginal stone tool making, hence stone quarries are highly unlikely to occur within or in the vicinity of the project area. There are recorded quarries distant from the project area in geologically complex areas near the McArthur River.

Culturally modified tree (scarred tree)

Culturally scarred old-growth trees may occur in the general area but generally will be difficult to identify with confidence (see scarred tree discussion in Appendix 2).

Aboriginal ancestral remains

Generally, Aboriginal people were buried in unconsolidated sandy sediment such as sand bodies along watercourses or in sand dunes occurring in other environmental contexts. The presence of human burials of relatively recent age within or in the general vicinity of the project area cannot be completely excluded. However, there is no evidence for the occurrence of strongly alkaline sediment that would be conducive to bone preservation. The pH readings of the surficial sediment taken at different locations in the project area were consistently 6.8, indicating slightly acidic conditions. Given the prevailing climatic conditions, in particular the high wet season rainfall, and the lack of ground-surface sheltering, and the physical and chemical character of the sediments, the preservation of bone remains is unlikely.

8.2 Incidence and size of stone artefact scatters and stratified sites

As well as the issue of stone availability, low human population density in prehistoric times equates to relatively low discard rate of stone artefacts such as flaking debris which typically marks the location of a former camping area.

A corollary of low population density in the study area is that a small number of spatially restricted base camps is the most likely prehistoric settlement pattern, along with small more transitory habitation sites. Both large and small camping areas would tend to be very close to water sources, especially during the dry season. The presence of the cluster of stone artefact scatter sites beside waterholes on the southern side of the Carpentaria Highway is evidence of such a settlement pattern.

Aboriginal hearths or remnants of hearths may be preserved in sandy sediment. Such hearths usually contain pieces of termite mound (e.g. Basedow 1907), or locally available stone.

Given the general environmental context, Aboriginal camping areas, and in particular ‘base camps’ occupied for more extended periods, would have been focussed on more permanent water sources such as watercourse channels, and waterholes during the dry season. Repeated occupation of favoured camping areas normally resulted in repeated discard of stone artefacts in areas where stone suitable for making stone tools occurs locally. The vast majority of preserved stone artefacts at camp sites are pieces, often quite small pieces, of stone waste ('débitage') created during the making and resharpening of stone tools, rather than the tools themselves.

Appendix 2 provides descriptions of the types of Aboriginal sites that have previously been recorded in this region.

The review of available data, particularly the sites recorded during earlier studies throughout this region, indicated that the range of Aboriginal cultural heritage sites more likely to be preserved within the project area includes:

1. Isolated stone artefacts.
2. Aboriginal hearths (earth ovens).
3. Stone artefact scatters. (sometimes associated with Potential Archaeological Deposits (PADs) comprising subsurface artefacts and other objects or features).
4. Scarred trees.

The background data review indicates that:

There appear to be no local sources of stone for stone tool making. All stone, other than ironstone for red and yellow pigment, would have had to be brought into the project area; possibly well beyond daily hunting and foraging distance from the encampment area. The potential distances of suitable stone sources are not known at this time, other than that sandstone possibly suitable for grinding stones and abraders; brittle siliceous stone with conchoidal fracture properties, and tough volcanic or metamorphic stone for ground stone tools, are likely to occur within the general area. The quarry sites previously recorded to the east of the project area are found in areas of siltstone and sandstone, not usually associated with quarries, except as quarries used for the projection of grinding stones.

In areas where more effort was needed to acquire stone by direct travel or through trade, it would have had increased value as a necessary material or commodity. This means that the stone tools used in the area are much more likely to have brought on site in a prepared state (rather than as unmodified or partially modified cores), hence there will be very little stone knapping débitage in campsites. Also, the stone tools were curated for longer to get the most use-life from them, making it most likely that those stone tools that are found will be small and highly reduced.

This general maxim indicates that suitable stone close at hand is more likely to have be knapped and the knapping débitage discarded in relative abundance in the areas around the sources of stone. There will be no large workshop sites in areas distant from the stone sources.

On the basis of the background environmental (particularly hydrological) and geological data it is concluded that only a small number of spatially-restricted base camps are likely to have existed and be detectable in this region. Such sites are unlikely to occur within the project area, but rather near waterholes in more substantial creeks. Preferred camping areas would have been located very close to the more reliable water sources, especially those used during the dry season.

Within the project area in general, the human population density would have been low overall, and consequently low discard rates of stone artefacts such as flaking debris and of grinding stones will have led to small, low-density and hence low-visibility sites.

9. Field survey methodology

An archaeological field survey was carried out within and around areas potentially subject to impact from work activities associated with the proposed exploration and drilling activities on Tanumbirini Station. This archaeological survey was undertaken by Principal Archaeologist Dr Johan Kamminga over a three-day period (6-8 March 2019). Mr. Trevor Edwards (Projects Specialist, Land Access & Management Services Pty Ltd) assisted in liaising with station staff and as guide and informant.

One main focus of the survey was the 10 km route of a proposed seismic line. This provided a transect across the Tanumbirini North Area from northwest to southeast, crossing all of the main land units present in the project area: Quaternary sediments, undifferentiated Cainozoic laterites, lateritic rubble and soil, and more resistant areas of Cretaceous lateritised claystone, soft grey claystone, sandstone and conglomerate (Figure 4).

Detailed inspection of areas along the seismic line allowed a comprehensive search for traces of prior Aboriginal visitation. These pedestrian surveys were conducted giving a coverage of approximately 5 m wide and perpendicular to the seismic survey line. Areas with relatively high ground surface visibility were selected as these offered the greatest possibility for the detection of small stone artefacts. Erosional scours were uncommon through this area. Generally, the recorded survey paths were sampled approximately between 100 and 200 m. Vehicle traverses were also carried out at a speed of approximately 5 km/hr. The vehicle traverses suited observation of the ground surface along tracks and road verges and also large expanses of flood overflow areas with exceptional ground surface visibility, generally around 100%.

Along survey routes and in other selected areas, mature trees were examined for evidence of cultural scarring. Tracks and sample locations were recorded using a hand-held GPS receiver, accurate to within 5 m. A low-magnification Wild M5 stereomicroscope was used to examine stone samples during the field survey (Plate 1).

In addition to the seismic survey line transect, areas along access tracks and a transect across the eastern portion of the Inacumba North Area were also inspected. The landscape setting of this area was similar to that found in the Tanumbirini North Area, with laterite gravel over much of the land surface. A number of sample areas were selected here and a detailed search for traces of prior Aboriginal visitation was undertaken. The environmental and landscape conditions of each sample area were recorded.

10. Results of the archaeological field survey

The nature and distribution of Aboriginal site types recorded on the registers and databases was reviewed during background research for this study. In reference to the environmental, geological and topographic contexts of the local and wider area, the types and distributions of sites/relics was predictable. As discussed below, the field survey has revealed no evidence for the presence of Aboriginal or non-Aboriginal archaeological sites/relics of any kind.

Ground surface visibility (GSV) within areas examined closely was generally good to very good (commonly 50-100% GSV).

The field survey corroborates the background research finding that there appear to be no local sources of stone for stone-tool making. All stone, other than ironstone for red and yellow pigment, would have had to be brought in to the area; possibly from well beyond daily hunting and foraging distances from the encampment area. The potential distances of suitable stone sources are not known at this time, other than that sandstone possibly suitable for grinding stones and abraders, and brittle siliceous stone with conchoidal fracture properties (located approximately 30 km to the east), and also volcanic or metamorphic stone for ground-stone tools, may occur within the general region.

In areas where a greater effort was needed to acquire stone by direct travel or by barter, that stone would have had increased value as a necessary material or commodity. This means that the stone tools used in the area are much more likely to have been pre-knapped, hence very little

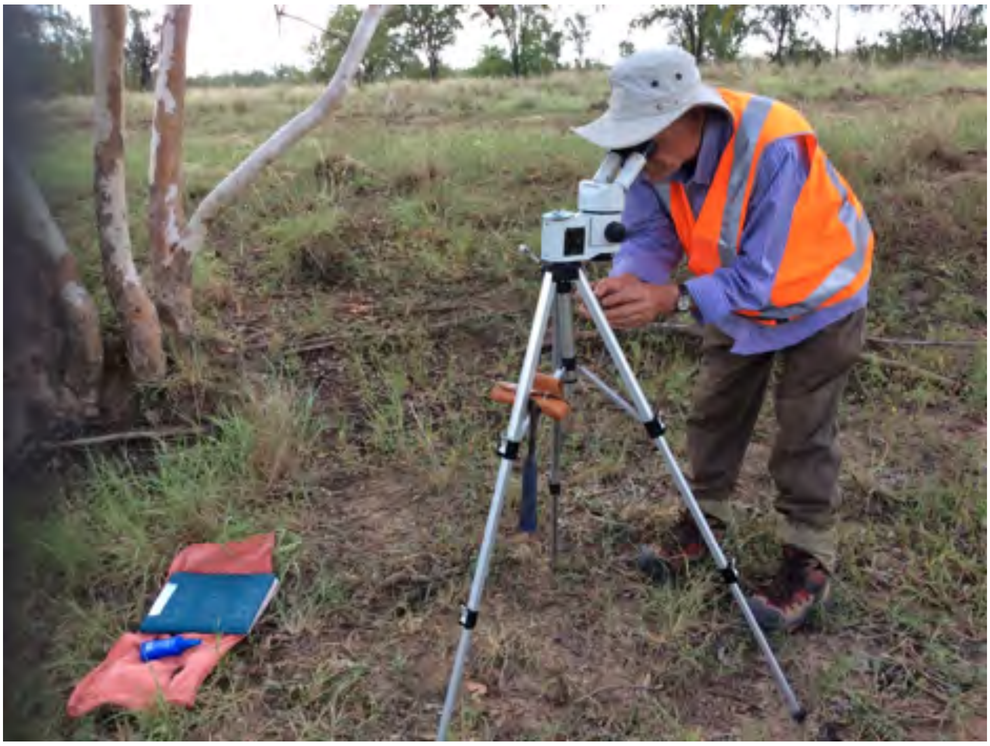

Plate 1. Low-magnification microscopic examination of natural stone occurring in a creek bank in the Tanumbirini North Area.

Plate 2. Area of clear ground surface visibility within a washout adjacent to a small watercourse in the Tanumbirini North Area.

Plate 3. Area of exposed ground at the Tanumbirini 1 well.

Plate 4. Meandering steep outer side of bend in a creek channel where ironstone lag has been concentrated on the more gently inclined inside slope of the channel. No Aboriginal stone artefacts were found in this location, despite the clear ground surface visibility on the ironstone gravel pavement.

Plate 5. Ironstone gravel lag pavement in a washout in the Ianumbirini North Area.

Plate 6. Actively migrating creek channel, exhibiting erosion causing tree fall and a steep outer channel margin exposing depth of loose clayey sand sediment. Located in the Tanumbirini North Area. Aboriginal stone artefacts are absent in the section along the channel bank or within the channel.

Plate 7. Termite mounds in the Ianumbirini North Area. Termite mounds are ubiquitous throughout this region.

Plate 8. Dense pavement of rain-washed ironstone gravel adjacent to the Tanumbirini 1 Well.

stone knapping débitage would be found in the camps. Also, the stone tools would have been curated for longer to get the most use-life from them, making them fewer and smaller.

The rule more or less means that high stone artefact densities and larger sites are more common in areas with abundant raw materials, while in areas with sparse or distant raw material soures, these sites tend to be smaller, with more heavily curated and smaller tools.

It was noted that almost all of the project area would not have been suitable for sustained or repeated encampment during prehistoric times. The watercourses in the area were mostly ephemeral first-order streams flowing northeast and they tended to be dry for extended periods.

The surficial soil layer over much of the project area appears to be shallow to very shallow, though less so along watercourses.

Termite mounds and ant nests (Plate 7.) are ubiquitous throughout much of the survey area, indicating that intensive invertebrate bioturbation of the loose sediment of the biomantle has been occurring over thousands of years up to the present time (c.f. Cahen & Moeyerson 1977; Dean-Jones & Mitchell 1993:43, 46; Mitchell 1988:52; Moeyersons 1978; O'Connell *et al.* 2018). As a consequence of this ongoing low-intensity long-term invertebrate bioturbation, many or most Aboriginal artefacts are not likely to be in their original stratigraphic context (cf., O'Connell *et al.*

2018).

11. Conclusions

No World Heritage Properties or National Heritage Places are registered within 10 km of the project area (see also Santos 2018:39). In addition, a search of the Northern Territory Heritage Register (DTC 2018) for NT Portion 701 (on which the Tanumbirini project area is located) was conducted and no previously recorded Aboriginal heritage items or places have been found in the project area (Santos 2018:39).

During the archaeological field survey, no Aboriginal or non-Aboriginal sites/relics were identified in the project area. It is considered that the survey coverage provides a good indication of the distribution of habitation sites through the areas likely to be affected by exploration and construction activities. The field survey has revealed that if there are traces of Aboriginal habitation in the project area, they occur at very low densities and/or are very localised. If this is the case, as we would argue, it is considered very unlikely that Aboriginal and non-Indigenous sites and relics would be disturbed or otherwise affected by the work associated with the proposed activities in the Northern Locations of the Santos McArthur Basin work program.

12. General recommendations

In general, ground surface visibility was relatively high in the areas examined. It is notable that no Aboriginal or non-Aboriginal sites/relics were identified during the survey. It is recommended that no further archaeological survey is required, unless Aboriginal or non-Aboriginal sites/relics are uncovered during proposed works activities.

While there were no traces of prior Aboriginal habitation detected during the field assessment, it is necessary to proceed with due care when undertaking works in the project area. In particular, any Aboriginal site/relic identified during the activity must be reported to the Santos Cultural Heritage Team so appropriate protection measures can be implemented.

It is advisable that a cultural heritage awareness program is provided to all those involved in ground disturbance activities to ensure that should Aboriginal sites and relics be uncovered during earthworks, that workers are trained to recognise the likely cultural heritage items and be aware of their responsibilities for reporting all exposed sites and relics.

If any human skeletal remains are encountered, work must stop immediately, the area secured to prevent unauthorised access, and the Northern Territory police contacted.

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Appendix 1 - Glossary of technical terms

AAPA

The Aboriginal Areas Protection Authority (AAPA) is an independent statutory authority established under the *Northern Territory Aboriginal Sacred Sites Act*. The Authority is responsible for overseeing the protection of Aboriginal sacred sites on land and sea across Australia's Northern Territory.

Background scatter

Generally, a very low density, more or less continuous distribution of artefacts over the land surface. Although these artefacts do not constitute a 'site' they are given location details for research purposes and to fulfil legislative requirements.

Bifacial point

Flakes or blades retouched along both ventral and dorsal surfaces of a flake to enhance or give the artefact its pointed shape. They often have the flake's initiation surface (striking platform) platform removed by retouch and this proximal end of the point rounded.

Grinding stone

Top and bottom grindstones, pestles and mortars characterised by at least one use-work and abraded surface.

Hammerstone

A stone that have use-wear on the surface in the form of abrasion and pitting characteristic of hammer usage.

Hatchet head (Edge ground hatchet head)

have been shaped by the process of flaking, pecking and grinding (polishing). They generally have only one cutting edge that has been ground to a straight or moderately convex plan shape.

Knapping (of stone)

Flaking stone to make stone implements. This is done by striking a piece of stone with a stone hammer (dynamic load in freehand percussion), or by more delicately applying pressure with a small stone or a piece of wood or bone.

Lag

A lag deposit is the deposition of stones winnowed by physical action. Fluvial processes (as occurs in the Santos project area), aeolian processes, and tidal processes can remove the finer portion of a sedimentary deposit leaving the coarser stones behind.

Manuport

A stone or fragment of stone that does not occur naturally in an area and must have been carried in by humans. Natural occurrences of locally-exotic stones include emu gastroliths and Permian age ice-rafted ‘dropstones’.

NLC

Northern Land Council.

Northern Territory Archaeological Site Database

A database of sites recorded in the Northern Territory including location and description details. Sites are protected by Northern Territory *Heritage Act, 2011*.

Sacred Site

Areas of significance for sacred sites is considered through the process of securing a sacred site clearance certificate (SSCC) from the Northern Land Council (NLC) and an Authority Certificate from the Aboriginal Areas Protection Authority (AAPA). This process aims to prevent damage to, and interference with sacred sites, by identifying and setting out the conditions for entering and working on the land.

Site

An archaeological site is defined for this survey as having more than one archaeological object within am area of two square metres, or a concentration of artefacts with an average density five times greater than the average density of the background scatter. A site will have an identifiable boundary where either artefact densities decrease to the extent as to be classified as background scatter or environmental features determine the boundary.

Siliceous stone

Rock or stone that is predominantly comprised of silica, usually in the form of quartz crypto-, micro- or macro-crystals. Examples are vein and macro-crystal quartz, quartzite, sandstone, silcrete, chert and chalcedony. These are the stone types commonly used by Aborigine people for making into stone tools.

Stone artefact scatter

An area of stone artefacts scattered on the ground, usually within an area of ground surface erosion. These artefacts are very predominantly the debris from knapping stone to make stone tools. Not uncommonly the scatter is associated with stone artefacts that occur below ground surface, unless scattered across a bare rock surface.

Subject land

The land area that is the subject of proposed work activities or development.

Transect (survey transect)

A straight line or narrow section through an object or natural feature or across the earth’s surface, along which observations are made or measurements taken.

Unifacial point

Flakes or blades that have been retouched along the margins from one surface, either ventral or dorsal to give or enhance its pointed shape. They can be symmetrical or leaf shaped.

Appendix 2 – Aboriginal site types likely to occur in this region

Probably more than 200 million people have lived on the Australian continent since it was first settled more than 40,000 years ago. The material evidence of this human presence and activity is abundant and widespread. Because stone is a highly durable material, stone artefacts are found widely distributed across the continent and sometimes are highly concentrated in certain land units, and in particular areas within these land units.

An Aboriginal archaeological site is defined as any material evidence of past Aboriginal activity in a context or place where the activity occurred (Officer and Navin 1998). Thus, significant Aboriginal sites or places such as 'Dreaming or Story site' do not necessarily have associated cultural remains. However, the vast majority of Aboriginal sites are open-air camps, indicated only by stone flaking debris and discarded stone implements, or sometimes an intact hearth with burnt remains.

The range of Australian Aboriginal sites likely to occur in the subject area can be categorised as:

1. Isolated artefact (usually stone).
2. Isolated hearth.
3. Stone artefact scatter (sometimes associated with Potential Archaeological Deposit (PAD) comprising subsurface artefacts and other objects or features).
4. Aboriginal historical site (camp, residence, mission, etc).
5. Stone procurement place and stone quarry.
6. Shell midden.
7. Cave and rock shelter with cultural sediment
8. Ceremonial ground (sometimes with earth or rock constructions).
9. Scarred tree.
10. Hatchet head grinding locality
11. Aboriginal burial (Aboriginal Ancestral Remains).
12. Rock art site.

These generally recognised site types are described below.

1. Isolated find

An isolated find, usually a single artefact or other cultural object, is defined by the absence of associated artefacts, cultural deposits or archaeological features. These finds may be indicative of random loss or deliberate discard of a single artefact, the remnant of a now dispersed artefact scatter, or a subsurface sedimentary horizon containing artefacts. They may occur anywhere within the landscape but are more frequently encountered in landscape units containing stone artefact scatters.

A conservative approach to artefact identification is required for isolated finds, especially when the find is a piece of fractured quartz. When artefact-size pieces of quartz, particularly relatively unweathered fragments of vein quartz, occur naturally in the sediment an identification of quartz items as artefactual must be based on definite evidence of knapping.

A proportion of the artefacts deemed isolated finds are part of the background scatter or count of artefacts within a land unit. Background scatter or count refers to the widespread occurrence of artefacts that cannot be related to a focus of past activity involving stone discard. The ‘background’ is an accumulation of stone artefact loss and discards events occurring since first human settlement of that region, though erosion in a local area may only reveal artefacts from any recent prehistoric activity.

The type and frequency of isolated artefacts in a landscape unit will depend on a number of factors. These include the nature of past human settlement and exploitation in the region, the proximity and nature of the stone used for toolmaking, and a range of environmental factors such as the nature of sediments, degree of erosion and degree of ground surface visibility. Generally, there are no reliable estimates of background scatter for land units within different regions of Australia.

Isolated finds may indicate:

- loss or discard of an artefact while away from a camp (while travelling);
- an isolated tool-making or resharpening event away from camp, where a group of artefacts is discarded on the ground;
- an encampment area, where artefacts occur within the sediment (and present-day erosion is minimal).

2. Isolated hearth

Aboriginal hearths (fireplaces) are an important archaeological feature of encampments and provide a range of archaeological evidence about prehistoric settlement and subsistence. These features often provide material for chronometric dating of the occupation event (Mitchell 1996) and some isolated hearths are extremely ancient.

Identifying hearths or anthropogenic hearths generally from the remains of natural occurring fire is often problematic There is a range of anthropogenic hearth types, including cooking pits, heat-treatment pits, work and sleeping fires, and ash dumps. Natural fire, such as a slowly burning tree stump, can bake clay sediment and leave a feature comprising a discrete area of burnt clay with charcoal and ash. This same polythetic set of features occurs after European forest clearance and burning of dried timber.

One way of distinguishing human-caused or archaeological fire is by its shape and size. Archaeological fires tend to be roughly circular in shape on the upper surface and basin-shaped in cross-section. Hearths diameter ranges between 20 to 30 cm and about 5 to 10 cm in depth (Mitchell 1996). Archaeological fire features may also appear as lenses of concentrated charcoal, blackened or reddened rocks and clay heat retainers (baked clay lump), and may also contain stone artefacts, cobble manuports and less commonly charred bone and shell. The shape of clay nodules in such a feature can be used to distinguish archaeological fire mounds from a burnt tree feature. Clay heat retainers are rounded nodules while natural baked clay sediment tends to be blocky or irregular in shape. Not uncommonly stone artefacts are flaked beside a fireplace and discarded flaking debris may show evidence of heating.

Mitchell (1996) has identified a number of methods by which anthropogenic can be differentiated from natural fire. However, some of these methods have failed to produce a convincing or reliable result.

Magnetic susceptibility analysis of clay nodules fired at a temperature lower than 500ºC has failed to distinguish between natural and human caused fires (Mitchell 1996). However, other analytical methods that show promise are spatial analysis, macroscopic examination, microscopic analysis, particle size analysis and chemical analysis. For instance, spatial analysis may show clustering of charcoal patches, while macroscopic analyses can help identify rounded orange-red clay nodules as well as identify charcoal size range for analysis of particle size distribution. Experimentally, fire pits produced charcoal size larger than 3 mm. Microscopic analyses allow for identification of flaking microdebitage, fragments of charred bones and identification of species of wood that was burnt. In ideal circumstances, chemical analysis of baked clays can be used to identify organic residues such as exudates from tuber roasting.

3. Stone artefact scatter

When artefacts occur in sufficient concentration on a land surface unprotected by rock overhang the area is described as a stone artefact scatter. Other labels that have been used are: lithic scatter, artefact scatter, surface scatter, open site, open-air site, ‘open camp site, and ‘campsite’.

The stone artefact scatter is the most commonly reported Aboriginal prehistoric site type in Australia. In some regions devoid of rock shelters or caves, open sites (or stone artefact scatters) may be virtually the only type recorded in archaeological surveys. Stone artefact scatters are most likely to occur on level or low gradient land surfaces, along the crests of elevated flats on hills, ridgelines and spurs, in coastal sand dunes, and on slightly elevated flattish ground fringing watercourses and wetlands. Larger stone artefact scatters with subsurface artefact horizons tend to occur in the vicinity of major and/or reliable water sources.

Stone artefact scatters represent a range of different human activities or site uses. However, most are former open-air campsites, ranging in nature from a day camp by an individual or small group during a hunting and gathering trip, to a large, semi-sedentary base camp located at a reliable water source. Some important camping areas were reoccupied on a regular basis over hundreds or even thousands of years.

Often, a scatter of stone artefacts and manuports (such as pebbles and burnt clays heat retainers) lying on the ground are the remains of an uppermost horizon of soil stripped of all but its heaviest items by wind and water erosion. In many instances, the artefact horizon is not removed entirely and there is still a horizon of artefacts (sometimes disturbed) and associated cultural features such as hearths in various spatial concentrations of habitation debris. Where a stone artefact scatter has an identifiable or inferred subsurface cultural horizon as well as artefacts on ground surface, the two kinds of archaeological deposit (surface and subsurface) comprise a single ‘site’.

Usually a visual inspection of the artefacts on ground surface is not sufficient to accurately determine the extent of the subsurface concentration of artefacts. Commonly, the boundary of the subsurface cultural horizon is not well defined, and the count of artefacts gradually decreases with distance from a main concentration until it merges with the average background count for a land unit.

The stone artefacts and manuports in stone artefact scatters represents stone flaking and discard activities associated with manufacture and maintenance of tools, weapons and other items of material culture, or for processing plant food. The remains of hearths, and other cultural features, also may be present within the general area of the site. Artefact density can vary considerably across a site and between different sites in the same land unit.

Stone artefact scatters normally cannot be dated with any precision (within the last few thousand years is common) and they are often difficult to interpret from the small sample of material remains. While the site’s size and its ‘density’ of artefacts are often taken as reflecting more intensive use of the site by people, a wide range of factors bears upon artefact density and site size, sufficient to limit any interpretation in the absence of professional excavation.

3.1. Bioturbation impact on site integrity

Determining the original positions and sequence in which artefacts were deposited at an open-air site often is complicated by a number of disturbance processes, such as downward soil creep on slopes, cracking of topsoil, tree growth, burrowing animals (in particular invertebrates), and human activity. Bioturbation of the soil horizon by ants, worms and termites is a significant cause of artefact sinking and mixing in soil layers (Cahen & Moeyerson 1977; Dean-Jones & Mitchell 1993:43, 46; Mitchell 1988:52; Moeyersons 1978; O’Connell *et. al.* 2018). Kamminga provided the first demonstration of invertebrate bioturbation of an open-air prehistoric site in southeast Australia (Kamminga *et al.* 1989:32-33), and there are a few other documented examples.

Tree growth and tree fall also cause bioturbation of cultural sediments (e.g. Photo 7). Gollan (1992:44) has estimated that in forested land of at least 100 trees per hectare tree growth would have would have caused extensive disturbance of sediments over a period of approximately 2,500 years. Dean-Jones and Mitchell (1993:43-44) have reported that tree fall tends to cause mixing of cultural objects (usually stone artefacts) out of stratigraphic order when sediment is washed from the tree roots by rain. There are specific instances where this has been observed in action (Kamminga *et al.* 1989:27, 32-33). It should be noted however that most trees species in Australia do not significantly disturb the soil when falling, because the trunk breaks after weakened by fire, fungi and termites, and tends to remain in the ground.

In general, it is difficult to assess the effects of plant and animal bioturbation within open-air sites without first undertaking test excavations. in the first identification of invertebrate bioturbation of an open-air site in south-eastern Australia, Kamminga found by plotting artefacts weight distributions that there was a marked vertical dispersal of the lighter fraction (less than a gram) above and below a well-defined horizon of the heavier Aboriginal objects (Kamminga *et al.* 1989:32). This pattern could only be accounted for primarily by earthworm bioturbation. However, the effects are not always so clear. Bioturbation impacts are often relatively small-scale vertical and lateral movement of artefacts. In particular, invertebrate burrowing can result in different sizes and shapes of stone fragments sinking into the soil at different rates and eventually settling at the same level which is normally the lower limit of invertebrate activity (see review in Kuskie and Kamminga 2000).

3.2. Effects of ploughing on subsurface artefact horizons

Human activity at a site in prehistoric times may disturb original material patterns of former occupation. Manuports and artefacts may be moved around a camp during subsequent visits, re-used or even removed. In circumstances where site integrity is high, this subsequent activity may be inferred from the character and pattern of the preserved archaeological record. However, where bioturbation or pastoral practices have diminished site integrity, practically none of this may be evident.

Ploughing occurred soon after vegetation was cleared, especially on floodplains and lower slopes. Ploughing causes both vertical and horizontal movement of artefacts and manuports and is therefore a major cause of disturbance to artefact horizons within 20-30 centimetres of the ground surface. While the stump-jump plough cut a furrow no more than about six centimetres deep, later designs of ploughs and inevitable loss of some topsoil has meant that open-air sites in cleared land tend to be seriously disturbed. Ploughing causes both vertical and horizontal movement of artefacts and manuports, resulting in disturbance to original patterns of discard, either in their original discard configuration or after already affected to some degree by natural processes. Ploughing can also cause the destruction of archaeological features such as fireplaces. After several decades of ploughing, artefacts may be displaced laterally up to several metres. For all types of ploughing equipment, larger artefacts (more than 40 mm in size) tend to be moved the greatest horizontal distance (Roper 1976, Lewarch 1979:116-122, Lewarch & O'Brien 1981a, b). Smaller cultural objects tend to displace downward (Roper 1976). Ploughing also tends to destroy hearths and other cultural features in open-air sites.

4. Aboriginal historical site (camp site, mission site, etc)

Aboriginal lifestyle and settlement patterns changed significantly as British settlers colonised the continent. Surviving Aboriginal people often lost access to their traditional hunting and foraging territories and a dependant relationship developed with the British settlers and colonial government. Aboriginal people settled in family groups on farms and camps were located at some of the British settlements.

In Australia, ‘contact-period’ base camps with intact old growth forest or woodland surrounding them tend to have a relatively large number of scarred trees in the vicinity. Artefact scatters may contain shells and the remains of hearths with burnt clay, and an assortment of items of British or colonial manufacture, such as buttons, clay pipe fragments, nails and other pieces of iron, and bottle and ceramic fragments. However, for a number of reasons, in northern interior NT scarred trees may not be that common in the vicinity of base camps.

5. Stone procurement place and stone quarry

Throughout Australia various stone and mineral substances were collected and sometimes quarried to make stone implements and pigments of various kinds (Hiscock and Mitchell 1993; Mulvaney and Kamminga 1999:27-31). Sandstone also was quarried in large slabs for use as grindstones in milling seeds for flour. Gravel beds and bars in watercourses were often ideal places to collect suitable stone, because they usually provided a choice of different stone types, and size and shape of pebbles and cobbles that had been water transported and therefore naturally tested for toughness. In areas where waterworn stones were collected from stream beds and relict river gravels the rejected and discarded flaking debris is often scattered about at or near the stone source. Where particularly desirable stone occurs, the discarded flaking debris may comprise thousands of items per square metre. Some larger stone collecting localities in the arid zone were extensive rock formations, where knapping debris is scattered over the ground for many kilometres. Rarely, stone procurement sites have quarry pits and shafts following a seam of high-quality stone or ochre. Around these pits are knapping floors or ‘stone reduction sites’, where the early stages of tool manufacture occurred. However, often prehistoric stone procurement places, and at creek beds in particular, there is little or no archaeological evidence of stone procurement: there are no concentrations of preliminary knapping debris and no quarry depressions or pits.

Certain Aboriginal quarries and mines possessed significance that transcended material needs. People did not always prefer the closest source but exchanged valuable goods or travelled through arid country to a more distant source for stone they believed was imbued with spiritual power.

6. Shell midden

Coastal and freshwater shell middens comprise mostly the remains of women’s shellfish collecting activities.

Many of the larger coastal middens along the seaboard of south-eastern Australia have been quarried to obtain shells for lime burning and land fill. Typically, middens are located in coastal estuaries and on headlands and sand dunes along the coast, and inland within riparian zones of watercourses and the margins of lakes with relatively permanent water. Middens and shelly lenses may occur out in the open or in rock shelters. Sometimes a midden deposit is minimal, comprising only a thin shelly layer or lens, as is common for inland lakes or riverside spreads of mussel shells. In other instances, middens are massive in size.

6.1. Types of middens

Ethnoarchaeological research in Arnhem Land has identified two kinds of Aboriginal shell middens – 'base camps' which were occupied continuously for long periods, and 'dinnertime camps', representing ephemeral campsites (Meehan 1982). These ethnographic categories are often used as a rule-of-thumb guide for interpreting prehistoric middens elsewhere in Australia.

Despite the importance of middens for archaeology and the impressive size of many of them, shellfish usually provided only a small part of the Aboriginal subsistence base. While shellfish are a staple food resource, they contributed probably no more than one tenth of dietary needs in most coastal regions. Of course, they were a more significant resource during lean times. Other littoral and marine resources were important to coastal people, as were the plant foods and game obtained from wetlands and adjacent forest or woodland environments both on the coast and inland.

6.2. Antiquity of middens

Accumulations of shell tend to preserve well over a long time because they generate their own alkaline sedimentary environment even in surrounding acidic sediment. Thus, middens and their carbonaceous content of shells, animal and human bones may survive for millennia. Because they fringe the present-day seashore the majority of coastal middens are less then 6,000 years old. Some inland middens are more than 20,000 years old but, like coastal middens, most of those located belong within recent millennia.

6.3. Midden identification criteria

Occasionally there is difficulty in distinguishing midden deposit from natural features such as shelly storm beach deposits and scrub fowl mounds. Sometimes a midden cannot be a natural formation because of its particular location. Commonly agreed criteria for the identification of Aboriginal midden deposits include the range of species (preference for edible, mature shellfish), usually restricted to one or two species such as oyster, *Anadara*, whelk and turbo shells, or freshwater mussel. This concentration of edible sized shells usually produces positively skewed size-frequency distributions. Natural shell accumulations by wave action are likely to contain random species and size samples. Other criteria for midden deposit are layers indicating cultural rather than natural deposition, the presence of stone and bone artefacts, and manuports (natural stone brought by humans, often as cooking stones), and the presence of various crustacean, fish, bird and mammal remains that are not likely to occur naturally.

7. Cave and rock shelter site with cultural sediment

True caves, created by water action and dissolution, are commonly found in limestone country. Large caves occur along the southern coast from Victoria to southwest Western Australia and others in Cape York Peninsula and southern Tasmania. Rock shelters are far more numerous and widespread than true caves. These shelters are formed by cavernous weathering by wind and water, usually of sedimentary rock such sandstone or quartzite, or by the inclination of large boulders.

While caves and rock shelters are of particular interest to archaeologists they were not necessarily commonly used as campsites in prehistoric times. In general, Aborigines did not inhabit the deep and dark recesses of caves, but camped at their entrances, venturing deep into their passages only for special purposes. In some desert areas, rock shelters were normally inhabited only during heavy rain or dust storms and over a period of thousands of years may have been visited only occasionally.

The reason archaeologists concentrate on such places is that the accumulation of stratified and datable sedimentary deposits containing stone artefacts and other occupation debris are concentrated within a very limited area; in some case the cultural material in the deposit is sparse, in other cases it is abundant. The alkaline sediment in limestone caves and shelters preserves bone and shell much better than in other depositional contexts; in very dry cave deposits a wide range of organic materials may be preserved, including dried plant matter such as wood and resin. While most caves and shelters contain shallow deposits, excavations may penetrate many metres of cultural horizons containing food debris of animal bones and shells, plant materials and microscopic pollen and phytoliths (plant silica), ash and charcoal from campfires, debris from knapping stone, and discarded stone implements. These cultural materials provide the basis for reconstructing prehistory.

8. Ceremonial ground

Ceremonial rock arrangements and earthworks are found in many parts of Australia (Mulvaney and Kamminga 1999) and historical records and field surveys indicate that they occur commonly in parts of eastern Australia. Over a thousand are known from NSW and Queensland alone. Many former ceremonial grounds had no features or constructions, and their existence and location are evident only from historical records.

Ceremonial constructions such as rock arrangements and earthworks are always low features in the landscape and usually less than a metre high. There are however a range of different designs. Some were personifications of totemic beings who participated in creation dramas; others demarcated areas for particular ceremonial activities. The latter function possibly explains the many linear or circular arrangements of stones enclosing a clear area ranging from a few square metres to hectares in area. Many earth or piled stone features in Australia are identified as bora ring because of historical accounts of ‘bora’ ceremonies (initiation of boys) at such sites.

Construction of stone lined paths and concentric rings of earth or stones involved considerable labour to construct. Linear earthworks or pathways may link pairs of circles, one larger than the other.

There are also many examples of cairns, or large, single standing stones, some of which have religious associations.

The simpler the construction or feature the more difficulty it is to identify it as an Aboriginal relic. Some constructions have no distinctive cultural attributes and without confirmation from informants, they would be unrecognised as Aboriginal or even cultural features. The location and survey of stone arrangements, ranging from simple cairns to elaborate ground designs are a continuing challenge for archaeologists.

9. Scarred tree

Scarred trees are conspicuous markers of Aboriginal inhabitation of country that is now substantially different from its original state. As Long (2002:5) has noted, there are few agricultural regions in the world where the native living plants display in their fabric pre-modern human activity.

Scarred trees occur within the remnant forestlands and woodlands, and generally more frequently along the sea coast and close to reliable water sources such rivers, billabongs and swamps. However, they may occur almost anywhere. Following widespread clearance of forest and woodland, the number of mature trees suitable for bark removal would have been dramatically reduced. Culturally scarred trees are more likely to survive in state forests and reserves of various kinds (including road reserves). Thus, the few identified scarred trees have been found within remnant areas of native woodland and in narrow road reserves (c.f. Edmonds 1998:47; Kamminga and Grist 2000:78-80, 95-100; Paton 1993:17-18, 23, 25-26; Long 2002, 2005).

The wide range of uses to which bark was put is reflected in the size range of the scars, which for making canoe hulls can be up to six metres in length and two metres in width. ‘Canoe trees’ are concentrated along rivers and other suitable water bodies. Rectangular sheets also were used as roofing and walls of huts and shelters in regions in Australia with suitable tree species. Andrew Long postulates that large mature trees with straight trunks were chosen for construction sheets, and that commonly the width of the bark sheet was 50-75% of the tree’s circumference (Long 2002, 2005).

Smaller sheets cut from a curved trunk or thick limb and from burls were made into containers (carrying vessels) such as bowls and dishes. Other small sheets were used as supports for drying and scraping animal skins (mostly possum), at least in northern Victoria and the Hunter Valley in NSW where they have been documented, but probably more widely, and for bark shields in parts of south-eastern Australia. While bark artefacts of these kinds are widely documented in Australia, less conspicuous or minor uses of bark were for grave pit lining, carved bark sculpture used in corroborees, and cord and rope (the bark was stripped off the tree for making fishing lines, nets, string, climbing rope, etc). Other types of Aboriginal scarring include toeholds cut into the trunk or branches for climbing in pursuit of possums and other small arboreal animals or collecting eggs, nuts and honey, and resource extraction holes (Kamminga and Grist 2000:57; Long 2002, 2005). These features sometimes occur in association with bark procurement scars, and most often exhibit cut marks from a steel axe or hatchet.

Bark was procured from a range of tree species, some of which, such as River Red Gum, and species of box, stringybark and paperbark, were particularly useful for making constructions and artefacts. Inevitably, due to natural death of trees, insect attack, bushfires and agricultural clearing, the number of scarred trees has diminished rapidly, and often they are now only encountered along wooded watercourses, and on the margins of lakes and swamps. Despite this dramatic reduction in numbers these relics are still being recorded in large numbers during archaeological field surveys.

Reliable identification of scars as Aboriginal is notoriously difficult Kamminga and Lance 2016), with considerable consequence for assessment of site significance and potential environmental impacts from development. It is often very difficult to distinguish Aboriginal culturally scarred trees from those made by or for settlers, who used bark most as cladding and roofing material (Kamminga and Grist 2000; Long 2002:3). Scars from the effects of fire, lightening, limb fall, faunal activity and modern human activity often have been wrongly interpreted as Aboriginal. Also, the bark around cultural scars regrow as 'callous tissue', especially around the sides of the scar – this regrowth often obscures the original shape of the scar and hatchet cut marks in the underlying wood. Over time the wood within Aboriginal scar degrades by weathering, bushfire or insect infestation, so that the essential for identification is lost. Finally, there are considerable difficulties in determining the age of living or dead scarred trees. Little information has been compiled on the maximum life spans of the tree species Aborigines exploited for bark, and in particular box and gum trees. Aboriginal Affairs Victoria advised in mid-2007 that only definite Aboriginal scarred trees should be registered. The manuals by Andrew Long, 'Scarred trees: a field identification manual', and 'Aboriginal scarred trees in New South Wales' are essentials guide to identifying and evaluating Aboriginal scarred trees (see also Kamminga and Grist 2000:56-65; Officer and Navin 1998:14; Officer 1992).

10. Hatchet-head grinding locality

One of the most important Aboriginal implements was the ground-stone hatchet, which is more commonly but less correctly known as the 'edge-ground axe' (Mulvaney and Kamminga 1999:32-34, 91-93). On current evidence, this implement first appeared in south-eastern Australia about 4500 years ago. The processes of fashioning and resharpening the hatchet head included the grinding of a cutting edge on an abrasive stone, usually found near water and close to campsites. At these places grinding grooves are worn into bedrock, which often is sandstone.

11. Aboriginal burials (Aboriginal Ancestral Remains)

In general, Aboriginal people regard burials as an extremely significant and sensitive site types (Mulvaney and Kamminga 1999:35-38) and removal of Aboriginal remains for reburial are undertaken only with guidance or supervision from the relevant Aboriginal community. There are also strict legal obligations relating to the recovery of Aboriginal and non-Aboriginal human remains.

Historical evidence indicates great diversity in Aboriginal mortuary practice throughout the continent during early historical times (Hiatt 1969). Burial practices included cremation bodies wrapped in soft bark, skin or matting and buried in a shallow grave, or cached within a hollow tree trunk or ossuary in rock crevices.

Ordinarily such remains are not encountered in archaeological excavations. However, development work and erosion continue to expose prehistoric human remains. Human burials are generally only visible where sub-surface sediments have been disturbed or where an erosional process has exposed them. Most often, they are found in rock shelter deposits and in sand bodies and in sandy or silty sediments. In valleys and plains, burials may occur in locally elevated topographies rather than poorly drained sediments. Burials rarely occur on rocky hilltops.

While the majority of recorded burials date to within the last few thousand years some are much more ancient. Large cemeteries occur along the Murray River, many of which had been established for millennia. A small number of Aboriginal cemeteries have been located in other regions and it is expected that in future years more will become apparent.

Study of such remains provides information about prehistoric nutrition, diseases, injuries, and long-term biological changes. Such studies also provide information about the nature of material culture, and cultural practices and belief systems of past generations. Fibre, animal skin and wood usually disintegrate rapidly after burial, and most graves lack surviving material relics. However, stone, animal bones, bone fishhooks, shells, pellet and powdered ochre, teeth necklaces, and bone pins and points have been recovered from some burials (Mulvaney and Kamminga 1999:35-38). The kinds of information gained about prehistoric culture and society are of importance not only to Aboriginal people but the wider Australian community.

12. Rock art site

Aboriginal rock art is the pictorial record of Australia's human past, and as such is a unique component of the archaeological record (Mulvaney and Kamminga 1999:369-82). This artistic expression provides insight into aesthetics and other social practices and beliefs. Innumerable rock art motifs survive throughout Australia as paintings, drawings, and pecked and abraded 'engravings', on open and sheltered rock surfaces. In most areas of Australia, paintings and engravings are intimately tied to contemporary Aboriginal beliefs and rituals of group or self-identity, sometimes requiring the periodic rejuvenation of motifs. Most surviving rock art in Australia dates within the last 3,000 years. Recent dating of thin encrustations on paintings demonstrates an antiquity of at least 25,000 years for some art in Cape York.

Much of the current research on Aboriginal rock art concerns the discovery, preservation and recording of the art. While many thousands of sites are on State site registers, only a fraction is individually recorded or described, while their conservation raises great problems. More than any other site type, Aboriginal rock art is part of the tourism industry in Australia and is widely recognised for its Aboriginal, aesthetic, scientific, historical and educational values.

The preservation of rock art is dependent on a combination of environmental factors including weather, surrounding plant communities, insect and animal activity, and the geological structure and durability of rock surfaces. Some art is preserved beneath a natural hard coating of silica that has built up on the rock surface. However, rock art usually deteriorates, sometimes at an alarming.

Images were made on rock surfaces by two basic methods – the application of substances such as pigment or beeswax, and the physical removal of the rock surface by pecking or pounding. Pigment was mixed and applied as a liquid medium to form paint, or else drawn using a dry crayon or charcoal. Paint was also blown from the mouth around an object to create a stencilled negative. Almost all the red, yellow and brown pigments are derived from iron-rich minerals, like hematite (Fe^22O^3), commonly known as 'red ochre', siderite, a yellow-coloured iron carbonate, and goethite, a yellow to brown mineral which forms naturally as a weathering product from the other iron minerals. An impure version of goethite, the mineral limonite, which has a vitreous lustre, was also used. The colour of hematite paint ranges from various shades of red to mulberry, and even to blackish when the pigment has aged on a rock surface. Hematite is chemically stable and is durable on rock surfaces because its microscopically platy structure provides strong adherence properties. Charcoal, which normally provides black colouring, was ground and mixed as paint or applied from a charred stick. White mostly comes from kaolin clay. Some carbonate minerals have been identified, such as huntite, dolomite and calcite, which were ground to powder and mixed with water. All these white paints have poor preservation and poor adhesion, so they tend to flake off surfaces. Consequently, white pigment usually indicates that motifs are relatively recent.

Rock engraving involves pounding or 'pecking' the rock surface to expose lighter-coloured unweathered rock. The most common engraving technique was to pound a narrow groove as an outline of the motif. Intaglio, or the pecking of an area of stone to form a negative impression of the image, was also practiced. Engravings are found commonly on stone softer than quartzite (sandstone, limestone, various indurated sediments, fine-grained granite and dolerite) and where the sub-surface is much lighter in colour than the weathered 'skin', so that the visual effect is dramatic. Sometimes a rock pavement that was particularly favoured or ritually significant is densely engraved for over hundreds of square metres.

Stencils are a specialised technique for creating an image of a real object, distinct from most other forms of art which rely on the free-hand interpretation of the artist. Most stencils are of hands; others are of animals, plants and artefacts. Hand stencils probably represent a pictorial signature, and ones of hematite may last for many thousands of years. The most elaborate use of stencil motifs in a narrative or artistic composition occurs in the sandstone country around the Carnarvon Range in southern Queensland.

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Appendix G: Wastewater Management Plan

Santos

Wastewater Management Plan: McArthur Basin 2019 Drilling Program

NT Exploration Permit (EP) 161

Date	Rev	Reason for Issue	Author	Checked	Approved
08/03/2019	0	For Review	DG	PW	DC
27/06/2019	1	Updates on waste disposal location	DG	PW	DC
27/06/2019	2	Updates to align with final CoP	DG	PW	DC

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Tables

Figures

No table of figures entries found.

Appendices

Abbreviations and Units

Acronym / Abbreviation	Description
ALARP	As low as reasonably practicable
ALRA	Aboriginal Land Rights Act
AAPA	Aboriginal Areas Protection Authority
APPEA	Australian Petroleum Production and Exploration Association
CLA	Cambrian Limestone Aquifer
Code	Code of Practice
CPESC	Certified Professional in Erosion and Sediment Control
DENR	Department of Environment and Natural Resources
DoEE	Department of Environment and Energy
DFIT	Diagnostic Fracture Injection Test
DPIR	Department of Primary Industry and Resources
D&C	Drilling and Completions
EC	Electrical Conductivity
EMP	Environmental Management Plan
EP	Exploration Permit
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPS	Environmental Performance Standards
ERA	Environmental Risk Assessment
ESD	Ecologically Sustainable Development
ha	Hectares
GISERA	Gas Industry Social and Environmental Research Alliance
km	Kilometre
LACA	Land Access Compensation Agreement
LWD	Logging While Drilling
NLC	Northern Land Council
m	Metres
MD	Measured Depth
MoC	Management of Change
NRM	Natural Resource Management
NT	Northern Territory
NT EPA	Northern Territory Environmental Protection Authority
NVIS	National Vegetation Information System
Panel	Independent Scientific Panel
PL	Petroleum Lease
PMST	Commonwealth Protected Matters Search Tool
PPL	Petroleum Pipeline Licence

Acronym / Abbreviation	Description
SEAAOC	South East Asia Australia Onshore Conference
SMS	Santos Management System
SSCC	Sacred Site Clearance Certificate
TOC	Total Organic Content
TPWC Act	Territory Parks and Wildlife Conservation Act 2014
TVD	True Vertical Depth
TVDSS	True Vertical Depth referenced to sea-level (Australian Height Datum)
WOMP	Well Operations Management Plan
WoNS	Weed of National Significance

1.0 Introduction

1.1 Background

Santos proposes to undertake exploration and appraisal activities in EP 161 in 2019, 2020 and beyond. The purpose of exploration and appraisal activity is to increase our understanding of the prospectivity or potential of the permit area. Our objective whenever undertaking such activity is to minimise our impact on the environment, including any activities of Traditional Owners and pastoral lessees. To meet this purpose, exploration activities in 2019 include:

- Civil engineering activity – upgrading and creation of new access tracks, lease pads, water bore installation and water extraction as required
- 2D seismic acquisition
- Exploration drilling – both vertical and horizontal drilling
- Well evaluation – including mud logging, wireline logging, logging while drilling formation testing, core acquisition, fluid sampling, open-hole formation integrity testing (i.e. Diagnostic Fracture Injection Testing (DFITs)) and other standard evaluation techniques as appropriate
- Cased hole DFIT
- Hydraulic fracture stimulation
- Flow-back and production testing
- Environmental monitoring
- Well suspension and/or well decommissioning
- Ongoing site and well maintenance and monitoring, work-over and re-entry, and evaluation as required

Under the Petroleum (Environment) Regulations (the Regulations), interest holders in petroleum titles must prepare and submit an Environment Management Plan (EMP). Approval of an EMP is necessary for all activities that have an environmental impact or risk and is only one of several approvals required for the activity to proceed. An approved EMP is a statutory document that is enforceable. The Code of Practice for Petroleum Activities in the Northern Territory sets out the mandatory requirements for management plans for wastewater and spills. The Code states that an EMP for a petroleum activity must include a Wastewater Management Plan (WWMP).

1.2 Scope

Santos proposes to undertake a Drilling Program in 2019 at the Tanumbirini-1/2H and Inacumba-1/1H locations. This WWMP is to be included in the EMP for the Drilling Program.

This WWMP assesses all water and wastewater management activities which are proposed including:

- Water that has been used in, or produced from petroleum wells, whether it be re-used, recycled, treated or disposed of, and includes drilling fluids, completion fluids (excluding hydraulic stimulation fluids) and well suspension fluids.

- "waste material" and material containing "contaminants" as defined in s 117AAB of the *Petroleum Act 1984* (NT)

- Wastewater meeting the definition of waste under the *Waste Management and Pollution Control Act 1998* (NT)

- Water that has been acquired or used in petroleum activities that is being disposed of
- Residual drilling waste, e.g. muds and cuttings (which may be more or less in a solid state) in addition to fluids

No produced water or flow back fluid are to be produced as part of the proposed activities.

No non-aqueous drilling fluids are to be used as part of the proposed activities.

This WWMP is for the Drilling Program at the Tanumbirini-1/2H and Inacumba-1/1H locations. This program does not include hydraulic fracture stimulation activities. Santos does intend to conduct hydraulic fracture stimulation in these wells, but this will be the subject of a separate EMP.

1.3 Wastewater management framework

This WWMP comprises a component of a wastewater management framework.

1. Estimate the quantities and quality of water and wastewater from the petroleum activity
2. Define the methods and approaches that will be used to store, treat, and reuse water and ultimately dispose of wastewater, including what activities will be undertaken at the site of the approved petroleum activity
3. Estimate the quantities and quality of wastewater, or wastewater derived solids, that will be removed from the petroleum site
4. Provide for the relevant activities and the environmental risks and environmental impacts they involve in a wastewater management plan (WWMP)

1.4 Waste management hierarchy

This WWMP has been developed in consideration of the waste management hierarchy outlined in the National Waste Policy, 2018. Where practical, waste and wastewater management activities are designed to sequentially and preferentially avoid, reduce, reuse, recycle and treat before disposing of waste and wastewater. This is described in Section 2.5.

2.0 Management

2.1 Activity description

This section contains a description of the activities that will generate waste and wastewater, including any activities that may generate drilling materials and any other waste that is proposed to be handled, stored or transported away from the area in which the activity is approved to be carried out

Activities that will generate waste are summarised in Table 2-1 and described in the following sections.

Table 2-1 Waste generating activities

Activity – waste source	Waste Type
Domestic activity (camp and offices)	Putrescible and municipal waste
	Recyclables (glass and cans)
	Grey water (laundry, showers, sink wastes, etc.)
	Treated sewage effluent
	Toilet waste (port-a-loos)
Ancillary activities to drilling	Chemical bags and cardboard packaging materials
	Scrap metals
	Used chemical containers and fuel drums
	Chemical wastes
	Timber pallets (skids)
	Vehicle tyres
	Oily rags, filters
Well drilling	Drilling fluids
	Drilling cuttings

2.1.1 Domestic activities

Sewage management practices at all camps will consist of the use of port-a-loos and a fully self-contained sewage treatment plant (STP). Sewage from port-a-loos will be transported offsite by a waste management contractor.

The STP will be furnished with an irrigation sprinkler system to manage sewage and grey water wastes. All waste water will be disposed of in accordance with the Public and Environmental Health Regulation 2018. Discharge from the camp will be treated to achieve the specifications provided in the Northern Territory's Code of Practice for On-site Wastewater Management. Treated effluent will be sprayed 50-100m away from the camp location to the surrounding environment, at a location will be well away from any place from which it is reasonably likely to enter any waters, and to minimise spray drift and ponding. Fencing will be installed around the irrigation area.

Wastepaper, cardboard and food scraps are disposed of into sealed bins set up adjacent to the camp area. The sealed bins will be transported for disposal of waste to a licensed landfill. Recyclable materials will be managed on site and transported to an approved local waste depot facility (likely in Katherine or Darwin).

2.1.2 Ancillary activities to drilling

All waste streams from ancillary activities will be collected and stored on site. Waste will be transported for disposal or recycling as described in Section 2.4.

2.1.3 Well drilling

Drilling fluids

There are various drilling fluid systems used in the oil and gas industry. The term 'mud' is frequently used interchangeably with the term 'fluid'. The term 'mud' is used because of the thick consistency of the fluid system.

In general, drilling muds are used during the drilling of oil or gas wells to:

- Carry cuttings from the hole
- Cool and clean the drill bit
- Reduce friction
- Maintain the stability of the bore
- Maintain down-hole hydrostatic pressure to prevent formation flow while drilling
- Prevent damage to the formation.

The drilling fluid system will be a contained system and consist of engineered fluid storage tanks. Drilling fluids are recirculated through the mud system on the drill rig during drilling operation. Drilling muds will be formulated in-situ by mixing the different additives with water in a dedicated above-ground storage tank.

Drill cuttings

Drill cuttings are lifted out of the hole by the drilling fluid which is pumped down the inside of the drill pipe and circulated back to surface via the annulus of the drilling pipe. During an overbalanced operation, drilling fluid is utilised to mitigate subsurface drilling hazards.

Drilling fluids will be separated from drill cuttings. The returned drilling fluid flows over shale shakers to separate the drill cuttings from the drilling mud, with cuttings ejected into a skip for transferal into the cuttings pit and the drill fluid flows through the sieves and is cycled back to the mud tanks. The cuttings are sampled as they drop off the shale shakers at specified intervals for processing and analysis by the mudlogging team and wellsite geologist.

2.2 Waste characteristics

This section characterises the anticipated wastewater streams that will be generated, including chemical characteristics and volumes of each.

Table 2-2 provides a summary of the anticipated waste characteristics. Further detail is provided for drilling fluid and drilling cuttings.

Table 2-2 Anticipated waste characteristics

Waste	Estimated volume	Chemical characteristic	Management method
Domestic waste – putrescible, municipal and recyclable	Less than 200m^3	Potentially hazardous to non-hazardous	Designated collection bins with transport off-site by licensed contractor
Domestic wastewater – grey water and treated sewage effluent	Less than 720m^3	Non-hazardous	Reticulated collection, on-site treatment and disposal via irrigation
Domestic wastewater – port-a-loo toilets	Less than 100m^3	Potentially hazardous	Collection and storage on-site, disposal off-site by licensed contractor
Ancillary activities to drilling	Less than 100m^3	Hazardous to non-hazardous	Collection and storage on-site, and transport off-site by licensed contractor
Drilling fluid	See Section 2.2.1		Reticulated containment and storage in monitored, lined and bunded tanks and lined pits
Drilling cuttings	See Section 2.2.2		Containment and storage in monitored, lined and bunded tanks, and lined pits

2.2.1 Drill fluids

Volumes

The proposed drilling mud is predominantly comprises water with the remainder made up of salts and fluid additives. It is anticipated that approximately 4-5 ML will be required.

Chemical characteristics

Drilling fluids used are a water based, homogenous blend of water, clays and other minor chemical additives. Additives used have various purposes such as:

- Treating bacteria
- Adjusting pH
- Controlling viscosity
- Reducing fluid loss to the formation
- Inhibiting equipment corrosion.

It is not necessary to use all of these chemicals for every well. Specific chemicals are selected during drilling, depending upon the particular requirements or any difficulties encountered. Of the total volume used, only small volumes have the potential to move beyond the well bore to the formations due to the filter cake properties of the mud and their design.

All chemicals used in Australia must be approved for use by the Commonwealth Government, Department of Health and listed on the Australian Inventory of Chemical Substances which is maintained under the National Industrial Chemicals Notification and Assessment Scheme.

No drilling fluid additives that are used in the process contain benzene, toluene, ethylbenzene or xylene.

The Material Safety Data Sheets for all the chemicals will be provided as part of the Drilling Project Applications to the DENR and DPIR.

2.2.2 Drill cuttings

Volumes

The exact amount of drill cuttings produced is dependent upon a number of factors, including the depth and diameter of the hole being drilled, however, up to 500 m^3 is anticipated per well.

Chemical characteristics

Drill cuttings are expected to primarily comprise siliciclastic rocks (mudstones and sandstones) containing predominantly quartz grains, feldspars, and clays that are benign in terms of environmental hazard. The drill cuttings will be inert, and appear as gravelly sandy or silty material.

It is expected that naturally occurring radiogenic materials (NORMs) will increase above background levels in the cuttings from the organic rich intervals in the Kyalla Formation and Velkerri Formation. This is because uranium has a natural affinity for concentration in similar geological settings to the preservation of organic material. The NORMs activity levels are not expected to approach reportable levels however. This assumption is based on data from other wells drilled across the Beetaloo Sub-basin.

Monitoring of drill cuttings is proposed in Section 2.7.4. The results of the sampling and analysis of the cuttings will inform disposal and rehabilitation measures.

2.3 Rainfall characteristics

This section contains estimates for the 1 in 1000 average recurrence interval (ARI) for rainfall for the duration of activities, along with the means used for their estimation.

Appendix A provides the methodology which was used to determine the 1 in 1000 year annual recurrence interval (ARI) for rainfall over a 3-month period in the wet and the dry season at the location of the proposed petroleum activities. Annual recurrence interval (ARI) is assumed to be equivalent to annual exceedance probability (AEP). Table 2-3 below summarises the findings.

Table 2-3 The 1 in 1000 (0.1%) year AEP for rainfall (in mm) at the location of the proposed petroleum activities

0.1% AEP Rainfall	Wet season (mm)	Dry season (mm)
7-day	682	-
90-day	1,448	321

All drilling operations will occur outside the wet season, including the removal and transfer of all residual drilling fluids, if required. No residual drilling fluids will be stored in open pits or tanks during the wet season.

A minimum of 1m freeboard will be maintained in all pits that contain drilling fluid throughout the dry season. This is conservative, given the 90-day AEP is 0.321 m. This adequately considers the potential overtopping risk due to potential wind and wave action.

The available freeboard will be monitored as referenced in Section 2.7

2.4 Waste management methods and locations

This section contains a proposed method and location of water and wastewater storage, transportation, treatment disposal and re-use as part of the proposed activity, with reference to any requirements mandated by the COP.

2.4.1 Proposed methods

A broad overview of the waste management methods are described in Section 2.1. Disposal options have taken into account the results of a risk assessment (see Section 2.6).

Control measures will be implemented to minimise interactions of all stored waste with wildlife, stock and human receptors. Controls measures will comprise fencing, signage and fauna-proof containment as necessary.

Table 2-4 Waste generating activities and management methods

Activity – waste source	Waste type	Management and disposal method
Domestic activity (camp and offices)	Putrescible and municipal waste	Collected at campsite for disposal to licenced landfill
	Recyclables (glass and cans)	Collected at campsite for deposit at licenced recycling facilities
	Grey water (laundry, showers, sink wastes, etc.) and treated sewage effluent	Grey water captured and piped to a treatment system that meet the NT Code of Practice for Small On-site Sewage, then piped to an irrigation area.
	Toilet waste (port-a-loos)	Toilet waste will be captured and transported offsite for recycling or disposal.
Ancillary activities to drilling	Chemical bags and cardboard packaging materials	Compacted and collected at rig site for disposal to licenced landfill
	Scrap metals	Collected in designated skip for transport to licenced recycling facility
	Used chemical and fuel drums	Collected in designated skip for recycling and re-use
	Chemical wastes	Collected in approved containers for disposal at licenced landfill
	Timber pallets (skids)	Collected at site and recycled or disposed of at licenced landfill
	Vehicle tyres	Shredded and disposed to licenced landfill
	Oily rags, filters	Collected in suitable containers for disposal at licenced landfill

Activity – waste source	Waste type	Management and disposal method
Well drilling	Drilling fluids	Initially recycled. Volume reduced further via evaporation. May be transferred to the cuttings pit for temporary storage and to encourage evaporation of water. Any residual drilling fluids will be removed from the drill pit and transported for disposal off site prior to the onset of the wet season. Residual solid waste (from evaporated drill fluids) will be mixed in with drill cuttings.
	Drilling cuttings	Cuttings and solid drilling residue initially stored in a lined pit. Subject to sampling and testing results drill cuttings will be buried and disposed in-situ. Certification will be sought from a suitably qualified third party that the material is of acceptable quality for disposal to land by the proposed method, and that environmental harm will not result from the proposed disposal. Approval of the certified method must be provided by DPIR/DENR. If approval cannot be granted, then waste may be disposed of to a licenced facility.

Drill cuttings storage

Design of the drill cuttings pit will comprise:

- engineered pits, lined with an impermeable membrane with coefficient of permeability of less than 10-9 m/s tested in accordance with AS 1289.6.7.2 and with resistance to tearing >0.5kN (ASTM D 4073); static puncture >0.5kN (ASTM D 4833) and tensile strength >20 kN/m (ASTM D 7275); or
- above ground storage tanks with secondary containment measures as detailed in section B.4.16.2 (h) of the code.

Drill fluids storage

Drill fluids will be stored in above ground engineered tanks located on the well lease pad. Multiple tanks may be used, comprising operational tanks and contingency fluid storage tanks. Additional storage may be provided by the drill cuttings storage pit.

Spill containment will be installed that comprises a secondary barrier that sits under the above ground tanks and prevents leaks and spills from contacting natural ground surface and facilitates spill collection and clean-up.

Fluid levels in the tanks will be monitored and alarmed in operational tanks to prevent overtopping. If needed, fluid will be transferred from operational tanks to contingency storage tanks and or the drill cuttings pit.

Disposal of residual drilling materials

Residual drill fluid will initially be stored on site and the fluid allowed to evaporate, leaving behind only solid material that can be mixed in with residual drilling cuttings. All residual drilling fluids will be removed from the pit prior to the onset of the wet season.

Results from the monitoring of drill fluid and drill cuttings (refer to Section 2.7) will be used to validate if on-site disposal of solid residual drilling material stored in the pit is feasible. Certification will be sought from a suitably qualified third party that the material is of acceptable quality for disposal to land by the proposed method, and that environmental harm will not result from the proposed disposal. The suitably qualified third party means a person who meets the criteria defined Section C.4.1.2(f) of the code. DENR/DPIR must approve of the disposal method which is certified by the suitably qualified third party.

Should the proposed and certified disposal method not be approved by DENR/DPIR, then it may be disposed of at a licenced facility (see Table 2-5).

Fauna interaction

Control measures to prevent the interactions of wildlife, stock, and human receptors with wastewater are detailed in Table 6-1 of the EMP and include, amongst other things:

- Fauna ladders will be installed at all open pits
- Pits and dams will be fenced
- Daily checks of pits and dams throughout the drilling program

2.4.2 Proposed locations

The EMP for the proposed activities provides a layout of the proposed Infrastructure for each well site (refer to Figure 3-2 and Figure 3-3 of the EMP). These layouts show waste storage locations as follows:

- Dam – correspond to a lined earth-bund structure that will be used to store abstracted groundwater
- Rig campsite – which will be the area that the grey water is reticulated and all other camp wastes are stored
- Laydown area – which will be the area that waste from activities ancillary to drilling will be stored
- Cuttings pit – which will be the pit used to store the residual drill cuttings, drilling fluid and solid drilling residue (from evaporated drilling fluid).
- Well lease area – area in which above-ground tanks will be located and used to store drilling fluid.
- Water tank pads – these are engineered pads that have been constructed to support above ground fluid storage tanks. However the construction and operation of these tanks is not included as part of the proposed petroleum activity related to this WWMP.

Proposed waste disposal locations are provided in Table 2-5.

Table 2-5 Waste Types and Waste Disposal Locations

Type of Waste	Disposal Location
General and food	Katherine or Darwin, NT
Empty IBCs	Katherine or Darwin, NT
Metal and plastic drums	Katherine or Darwin, NT
Waste material	Katherine or Darwin, NT
Batteries and tyres	Katherine or Darwin, NT
Residual drill fluids	Mt Isa
Drill cuttings and solid drilling residue	In-situ disposal, if proven feasible. Otherwise Mt Isa
Listed Waste	Any waste prescribed wastes under the Waste Management and Pollution Control Act as specified as a listed waste by the NT EPA as found at https://ntepa.nt.gov.au/waste-pollution/approvals-licences/listed-waste, will be disposed of in accordance with the regulations and by a company licensed to handle and dispose of this waste.

2.5 Waste minimisation strategies

This section contains strategies to minimise or reduce the volume of wastewater that will be disposed of off-site, and the expected quality and quantity of water and wastewater that will be treated and re-used within the petroleum activity

Table 2-6 summarises the methods that will be used to minimise waste in accordance with the waste management hierarchy.

Table 2-6 Drilling waste streams – waste management hierarchy considerations

Waste Stream	Avoid	Reduce	Reuse	Recycle	Treat	Dispose
Drilling Fluids	Only water based drilling mud planned. Non-aqueous drilling mud will not be used.	Recycle fluids as much as possible - reduces consumption of additives and production of waste.	Transfer recycled fluids between wells where applicable. Treat fluid to avoid bacteria and prolong operational lifespan.	Recycle fluids as much as feasible with available solids control equipment.	Treat with drilling chemicals to facilitate recycling where feasible	At the end of the campaign, drilling fluids with be evaporated as much as possible, pending the weather window and freeboard requirements (minimum 1m during wet season). Remaining fluid will be transferred to a 3rd party process facility for disposal/reuse.

Waste Stream	Avoid	Reduce	Reuse	Recycle	Treat	Dispose
Drilling Cuttings	Cannot avoid.	Mud weights designed for gauge wellbore. This will minimise excess cuttings. Mud chemicals used for shale inhabitation to minimise wellbore instability resulting in excess cuttings.	Not proposed.	Not proposed.	Separate fluids from cuttings as much as possible to maximise recycling of fluid.	Cuttings burial or removal subject to sampling results. The decision on disposal of the pit contents will be made in consultation with, and on the advice of, a suitably qualified independent environmental consultant and approval by DPIR/DENR.

2.6 Risk assessment

This section contains a risk assessment in relation to the potential impact to the environment from water and wastewater management activities proposed as part of the petroleum activity

An assessment of environmental impacts, environmental risks, performnace standards and measurement criteria posed by the drill cuttings and residual drilling fluids, incuding the transferring of recycled/reused fluids, has been carried out. For completeness and consistency, this is presented in Section 6 and Section 8 of the EMP. All risks associated with wastewater have been assessed to a level that is ALARP and acceptable.

2.7 Monitoring plan

This section contains a monitoring plan that:

- *Outlines the sampling locations, frequency, proposed analytical methods and analytical detection limits, and any quality assurance and quality control measures that will be implemented*
- *Reflects all monitoring requirements mandated by the COP and the EMP, as well as any monitoring that is determined to be necessary as part of the risk assessment*
- *Requires all field measurements and sampling to be undertaken by suitably qualified personnel and to utilise equipment that is suitably maintained, laboratory checked and calibrated*
- *Requires all laboratory analyses to be conducted at a National Association of Testing Authorities (NATA) accredited lab, where possible.*

2.7.1 Baseline monitoring of soils

An assessment of physical properties of representative baseline soils at each well site will be conducted.

Three samples will be taken at equidistant depth intervals in a 0.6 metre deep soil core from three locations across the well site, adjacent to:

- the proposed well
- the proposed location for drill fluid storage tanks (i.e. on the well pad)
- cuttings pit location.

Soil tests for each sample will include:

- A permeability test, such as falling head permeability testing on a sample or triaxial constant head permeability testing.
- A sample tested for:
  - Particle size distribution
  - Total chlorides (mg/kg)
  - Exchangeable sodium (%)
  - Emmerson aggregate test

2.7.2 Monitoring of stored water

The quality and quantity of all water stored will be monitored as per the below.

Quantity

Volume of water that is abstracted from the water bore will be measured using flowmeter. This will by recorded weekly during bore operations.

Fluid levels in storages containing abstracted groundwater will be monitored daily during well site operations. This provides a measure of the stored quantity of water.

Quality

Water quality of abstracted groundwater stored in tanks will be sampled monthly. The suite will be tested as per Table 2-7.   Testing will comprise grab samples from the tank, or a sample of water pumped from the storage tank.

2.7.3 Monitoring of drill fluid

The quality and quantity of drill fluid will be recorded while within the area of the approved petroleum activity.

Quantity

The fluid levels in tanks containing drilling fluids will be monitored daily throughout drilling operations. Fluid level will be used to calculate the stored volume of drilling fluid in tanks.

The volume of each load of residual drill fluid that is removed for treatment and/or disposal by third-party waste management contractors will be recorded and tracked.

Quality

A representative sample of stored drill fluids will be taken each month. The sample will be tested for the suite shown in Table 2-8. Sampling and testing will occur at least once each month throughout drilling operations.

The composition of residual drill fluids will be analysed to determine whether it is consistent with the assumptions used for the assessment of environmental hazards and the design of proposed disposal methods.

2.7.4 Monitoring of drill cuttings

The quality and quantity of drill cuttings will be recorded while within the area of the approved petroleum activity.

Quantity

The volume of drill cuttings that will be stored in the pits will be estimated based on drilling data. An estimate of the total volume of drill cuttings stored in the pit will be estimated prior to disposal.

If removed from site, the volume of each load of drill cuttings that is removed for treatment and/or disposal by third-party waste management contractors will be recorded and tracked.

Quality

Continuous X-ray fluorescence (XRF) monitoring used during drilling to characterise the composition of the cuttings will be undertaken to verify that cuttings do not pose a safety or environment hazard, including the NORM activity levels. XRF monitoring will occur continuously during drilling, at every major source rock interval (e.g. every 10m of drilling) and provide a major elemental composition. The results provide a basis for determining if the NORM activity levels are reportable. This testing satisfies the need to test for radioactivity from NORMs to determine if the waste is classified under the Radiation Protection Act 2004 (NT).

At the end of the drilling operations, representative samples will be taken of stored drill cuttings. Samples will be tested for the suite shown in Table 2-9 and Table 2-10.

Leachability testing of drill cuttings will be undertaken in accordance with the Australian Standard Leachate Procedure (Australian Standard AS4439.2 and 44396.3) by a NATA accredited laoratory.

Further samples may be taken to verify that the quality of the material has been adequately characterised for the purpose of determining that the proposed disposal option is suitable, in accordance with any requirements to classify the waste as is required under the EMPC Act 1989 (NT).

The composition of residual drill cuttings will be analysed to determine whether it is consistent with the assumptions used for the assessment of environmental hazards and the design of proposed disposal methods.

2.7.5 Quality assurance and quality control measures

All field measurements and environmental sampling will be undertaken by suitably qualified personnel.

All monitoring equipment will be suitably maintained and calibrated prior to use, as per manufacturer's instructions.

All samples shall be collected using suitable sample containers, preservation methods and chains of custody prior to receipt by analytical laboratories. Holding times will be met, where practical.

All laboratory analyses will be conducted at a National Association of Testing Authorities (NATA) accredited lab, where possible.

Santos

Table 2-7 Suite of analysis for testing of stored groundwater

Analyte	ALS Method Code	Limit of reporting	Units
Electrical Conductivity (EC) (measured in field)	EA010-P	1	µS/cm
Total Dissolved Solids (TDS)	EA015H	10	mg/L
Total Suspended Solids (TSS)	EA025H	5	mg/L
pH (measured in field, and in lab)	EA05-P	0.01	pH Units
Sulfate (SO_4^{-2})	NT-2A	1	mg/L
Chloride (Cl^-)	NT-2A	1	mg/L
Carbonate (CO_3^{-2})	NT-2A	1	mg/L
Bicarbonate (HCO_3^-) (as CaCO3 equivalent)	NT-2A	1	mg/L
Bicarbonate Alkalinity (as CaCO3 equivalent)	NT-2A	1	mg/L
Hydroxide Alkalinity (as CaCO3 equivalent)	NT-2A	1	mg/L
Total Alkalinity (as CaCO3 equivalent)	NT-2A	1	mg/L
Nitrite (NO_2^-)	NT-8A	0.01	mg/L
Nitrate (NO_3^-)		0.01	mg/L
Fluoride (F^-)	NT-2A	0.1	mg/L
Sodium (Na^+)	NT-1B	1	mg/L
Magnesium (Mg^{2+})		1	mg/L
Potassium (K^+)		1	mg/L
Calcium (Ca^{2+})		1	mg/L
Arsenic	W-3, W-3T, EG020F, EG020T	0.001	mg/L
Barium		0.001	mg/L
Boron		0.001	mg/L
Cadmium		0.0001	mg/L
Chromium		0.001	mg/L
Lithium		0.001	mg/L
Copper		0.001	mg/L
Iron		0.05	mg/L
Lead		0.001	mg/L
Manganese		0.001	mg/L
Mercury		0.0001	mg/L
Selenium		0.001	mg/L
Silica		0.1	mg/L
Silver		0.001	mg/L
Strontium		0.001	mg/L
Zinc		0.001	mg/L

Table 2-8 Suite of analyses for testing of residual drill fluid

Analyte	ALS Method Code	Limit of reporting	Units
Dissolved oxygen (DO) measured in situ	EP025	0.1	mg/L
Electrical Conductivity (EC) measured in situ and lab	EA010-P	1	µS/cm
Total Dissolved Solids (TDS)	EA015H	10	mg/L
Total Suspended Solids (TSS)	EA025H	5	mg/L
pH measured in situ and in lab	EA05-P	0.01	
Temperature measured in situ	-	0.1	°C
Nitrate	NT-6	0.01	% saturation and mg/L
Nitrite	NT-6	0.01	
Total Nitrogen	NT-8A	0.1	
Total Kjeldahl Nitrogen	NT-8A	0.1	
Ammonia	NT-8A	0.01	
Reactive Phosphorus	NT-8A	0.01	
Total Phosphorus	NT-8A	0.01	
Sulfate (SO_4^{-2})	NT-2A	1	mg/L
Chloride (Cl^-)	NT-2A	1	mg/L
Carbonate (CO_3^{-2})	NT-2A	1	mg/L
Bicarbonate (HCO_3^-) as CaCO3 equivalent	NT-2A	1	mg/L
Bicarbonate Alkalinity as CaCO3 equivalent	NT-2A	1	mg/L
Hydroxide Alkalinity as CaCO3 equivalent	NT-2A	1	mg/L
Total Alkalinity as CaCO3 equivalent	NT-2A	1	mg/L
Nitrite (NO_2^-)	NT-8A	0.01	mg/L
Nitrate (NO_3^-)	NT-8A	0.01	mg/L
Fluoride (F^-)	NT-2A	0.1	mg/L
Bromide (Br^-)	ED009X	0.01	mg/L
Total Cyanide	EK026SF	0.004	mg/L
Sodium (Na^+)	NT-1B	1	mg/L
Magnesium (Mg^{2+})	NT-1B	1	mg/L
Potassium (K^+)	NT-1B	1	mg/L
Calcium (Ca^{2+})	NT-1B	1	mg/L
Aluminium	W-3, W-3T, EG020F, EG020T	0.01	mg/L
Antimony	W-3, W-3T, EG020F, EG020T	0.001	mg/L
Arsenic	W-3, W-3T, EG020F, EG020T	0.001	mg/L
Barium	W-3, W-3T, EG020F, EG020T	0.001	mg/L
Beryllium	W-3, W-3T, EG020F, EG020T	0.001	mg/L
Boron	W-3, W-3T, EG020F, EG020T	0.001	mg/L
Cadmium	W-3, W-3T, EG020F, EG020T	0.0001	mg/L
Chromium	W-3, W-3T, EG020F, EG020T	0.001	mg/L
Cobalt	W-3, W-3T, EG020F, EG020T	0.001	mg/L
Copper	W-3, W-3T, EG020F, EG020T	0.001	mg/L
Iron	W-3, W-3T, EG020F, EG020T	0.05	mg/L
Lead	W-3, W-3T, EG020F, EG020T	0.001	mg/L

Analyte	ALS Method Code	Limit of reporting	Units
Manganese		0.001	mg/L
Mercury		0.0001	mg/L
Molybdenum		0.001	mg/L
Nickel		0.001	mg/L
Selenium		0.001	mg/L
Silica		0.1	mg/L
Silver		0.001	mg/L
Strontium		0.001	mg/L
Thorium		0.001	mg/L
Tin		0.001	mg/L
Uranium		0.001	mg/L
Vanadium		0.05	mg/L
Zinc		0.001	mg/L
Other radionuclides and gross alpha, beta, and gamma radiation	EA250-LSC	0.05-0.1	Bq/L
Benzene	W-24	0.001	mg/L
Toluene		0.001	mg/L
Ethylbenzene		0.001	mg/L
M and p Xylene		0.001	mg/L
o Xylene		0.001	mg/L
Total Xylenes		0.002	mg/L
TRH C_6 - C_{10}	W-24	0.02	mg/L
TRH C_6 - C_{10} less BTEX		0.02	mg/L
TRH >C_{10} - C_{16}		0.02	mg/L
TRH >C_{10} - C_{16} less Naphthalene		0.02	mg/L
TRH >C_{16} - C_{34}		0.01	mg/L
TRH >C_{34} - C_{40}		0.01	mg/L
Total TRH C_6 - C_{40}		0.01	mg/L
3-Methylcholanthrene	W-24, EP074 A to H and EP033	0.001	mg/L
7, 12- Dimethylbenz(a)anthracene		0.001	mg/L
Acenaphthene		0.001	mg/L
Acenaphthylene		0.001	mg/L
Anthracene		0.001	mg/L
Benzo (a) pyrene		0.001	mg/L
Benzo (b) fluoranthene		0.001	mg/L
Benzo (ghi) perylene		0.001	mg/L
Benzo (k) fluoranthene		0.001	mg/L
Benzo (a) anthracene		0.001	mg/L
Chrysene		0.001	mg/L
Dibenz (ah) anthracene		0.001	mg/L
Fluoranthene		0.001	mg/L
Fluorene		0.001	mg/L
Indeno (1,2,3-cd) pyrene		0.001	mg/L
Naphthalene		0.001	mg/L

Analyte	ALS Method Code	Limit of reporting	Units
Phenanthrene		0.001	mg/L
Pyrene		0.001	mg/L
Carcinogenic PAHs (benzo[a}pyrene equivalents			
Total PAH		0.001	mg/L
2,3,4,6-Tetrachlorophenol	W-24, EP074 A to H and EP033	0.005	mg/L
2,4,5-Trichlorophenol		0.005	mg/L
2,4,6-Trichlorophenol		0.005	mg/L
2,4-Dichlorophenol		0.005	mg/L
2,4-Dimethylphenol		0.005	mg/L
2,4-Dinitrophenol		0.005	mg/L
2,6-Dichlorophenol		0.005	mg/L
2-Chlorophenol		0.005	mg/L
2-Methyl-4,6-dinitrophenol		0.005	mg/L
2-Nitrophenol		0.005	mg/L
4-Chloro-3-methylphenol		0.005	mg/L
4-Nitrophenol		0.005	mg/L
Dinoseb		0.005	mg/L
Hexachlorophene		0.005	mg/L
m- and p-Cresol		0.005	mg/L
Pentachlorophenol		0.005	mg/L
Phenol		0.005	mg/L
Dissolved Organic Carbon (DOC)	EP002	1	mg/L
Total Organic Carbon (TOC)	EP005	1	mg/L
Bromide	ED009X	0.01	mg/L
Chlorine/Chloride	NT-2A	1	mg/L
Formaldehyde	EP010		mg/L

Table 2-9 Suite of analyses for testing of drill cuttings (solid samples)

Analyte	Method Code	Limit of Reporting	Units
Ag	iMET2SAICP	0.5	mg/kg
Al	iMET2SAICP	10	mg/kg
As	iMET2SAICP	1	mg/kg
B	iMET2SAICP	5	mg/kg
Ba	iMET2SAICP	0.1	mg/kg
Be	iMET2SAICP	0.05	mg/kg
C	(combs)	0.05	%
CO_3	(combs)	0.25	%
Cd	iMET2SAICP	0.05	mg/kg
Cl	iCO1SEDA	5	mg/kg
Co	iMET2SAICP	0.1	mg/kg
Cr	iMET2SAICP	0.05	mg/kg
Cu	iMET2SAICP	0.1	mg/kg
Electrical conductivity at 25˚C	iEC1SASE	0.2	ms/m
F	eF1ST	50	mg/kg
H_2O_105C	iMOIS1SAGR	0.1	%
Hg	iMET2SAMS	0.02	mg/kg
Mn	iMET2SAICP	0.2	mg/kg
Mo	iMET2SAICP	0.5	mg/kg
N	(total)	0.005	%
Ni	iMET2SAICP	1	mg/kg
P	(totals)	10	mg/kg
Pb	iMET2SAICP	0.5	mg/kg
Se	iMET2SAICP	2	mg/kg
Sr	iMET2SAICP	0.2	mg/kg
TIC	(combs)	0.05	%
TOC	(combs)	0.05	%
V	iMET2SAICP	0.2	mg/kg
Zn	iMET2SAICP	5	mg/kg
pH	iPH1SASE	0.1	-
Benzene	eBTEXSoil	0.5	mg/kg
Toluene	eBTEXSoil	0.5	mg/kg
Ethylbenzene	eBTEXSoil	0.5	mg/kg
Xylene	eBTEXSoil	1	mg/kg
Total BTEX	eBTEXSoil	2.5	mg/kg
TPH C6-C9	eTPHSoils	25	mg/kg
TPH C10-C14	eTPHSoils	50	mg/kg
TPH C15-C28	eTPHSoils	100	mg/kg
TPH C29-C36	eTPHSoils	100	mg/kg
Total TPHs	eTPHSoils	275	mg/kg
Acenaphthene	ePAH1SOIL	1	mg/kg

Analyte	Method Code	Limit of Reporting	Units
Acenaphthylene	ePAH1SOIL	1	mg/kg
Anthracene	ePAH1SOIL	1	mg/kg
Benz(a)anthracene	ePAH1SOIL	1	mg/kg
Benzo(a)pyrene	ePAH1SOIL	1	mg/kg
Benzo(b+k)fluoranthene	ePAH1SOIL	1	mg/kg
Benzo(g,h,i)perylene	ePAH1SOIL	1	mg/kg
Chrysene	ePAH1SOIL	1	mg/kg
Dibenzo(a,h)anthracene	ePAH1SOIL	1	mg/kg
Fluoranthene	ePAH1SOIL	1	mg/kg
Fluorene	ePAH1SOIL	1	mg/kg
Indeno(1,2,3-cd)pyrene	ePAH1SOIL	1	mg/kg
Naphthalene	ePAH1SOIL	1	mg/kg
Phenanthrene	ePAH1SOIL	1	mg/kg
Pyrene	ePAH1SOIL	1	mg/kg
Total PAHs	ePAH1SOIL	16	mg/kg

Table 2-10 Suite of analyses for testing of drill cuttings (Australian Standard Leaching Procure Extract From Solid)

Analyte	Method Code	Limit of Reporting	Units
Ag	iMET1WCMS	0.0001	mg/L
Al	iMET1WCICP	0.005	mg/L
As	iMET1WCMS	0.001	mg/L
B	iMET1WCICP	0.02	mg/L
Ba	iMET1WCICP	0.002	mg/L
Be	iMET1WCICP	0.001	mg/L
Cd	iMET1WCMS	0.0001	mg/L
Cl	iCO1WCDA	1	mg/L
Co	iMET1WCICP	0.005	mg/L
Cr	iMET1WCICP	0.001	mg/L
Cu	iMET1WCMS	0.0001	mg/L
Hg	iHG1WCVG	0.0001	mg/L
Hg	iMET1WCMS	0.0001	mg/L
Mn	iMET1WCICP	0.001	mg/L
Mo	iMET1WCMS	0.001	mg/L
Ni	iMET1WCMS	0.001	mg/L
Pb	iMET1WCMS	0.0001	mg/L
Se	iMET1WCMS	0.001	mg/L
Sr	iMET1WCICP	0.002	mg/L
V	iMET1WCICP	0.005	mg/L
Zn	iMET1WCICP	0.005	mg/L
pH_ASLP	iASLP	0.1	-

Appendices

Santos

Appendix A: Storage tank water balance investigation Northern Territory climate analysis

Memorandum

Date	1 February 2019	Pages	18
Attention	Philippa Kassianos		
Company	Santos Ltd		
Job No.	1413-10-B		
Subject	Storage tank water balance investigation Northern Territory climate analysis		

Background and study objectives

WRM was engaged by Santos to undertake a simple water balance analysis of water storage tanks proposed for Northern Territory petroleum operations.

The storage tanks will be used to temporarily contain wastewater (e.g. unused hydraulic fracture fluids, drilling fluids, raw water or produced formation water) for up to 3 months. The tanks may be open-topped and will therefore be subject to climatic influences.

Santos requested analysis of the two areas shown in Figure 1, which experience very different climate conditions:

- Beetaloo Basin (Dukas 1 well);
- Amadeus Basin (Inacumba North well).

Santos wish to better understand how the tanks would need to be designed and operated to minimise the likelihood of rainfall-driven wastewater overflow. The design standard currently under consideration is containment of rainfall inflows to an annual exceedance probability (AEP) of 1 in 1,000 (0.1%) over the duration of the activity.

The key objectives of this study are therefore to understand 3-month 0.1% AEP rainfall depths, and given the temporal distribution of rainfall and evaporation experienced in these areas, how stored water levels could be expected to respond over periods of up to a year.

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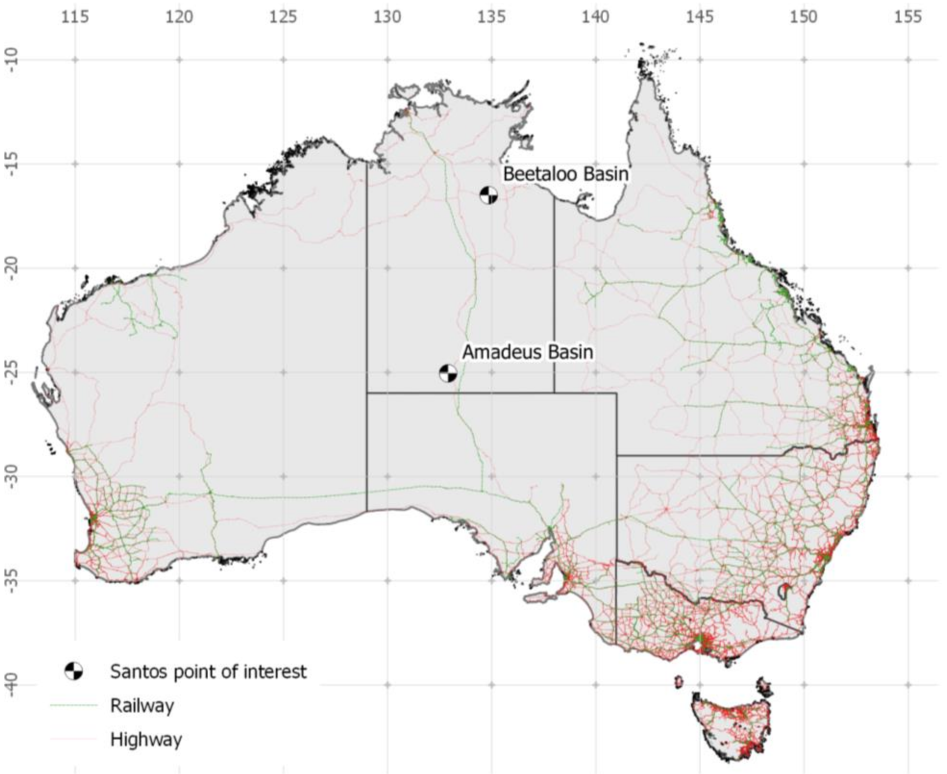


Figure 1 – Location of the assessment locations

Climate characteristics

Rainfall and evaporation data for the Amadeus and Beetaloo Basin sites were obtained from the Queensland Climate Change Centre of Excellence (QCCCE) SILO Data Drill Service. The rainfall and evaporation datasets span from January 1889 to January 2019.

As shown in Figure 2 to Figure 5, rainfall in the Amadeus Basin (average annual rainfall 210 mm) is significantly less than in the Beetaloo Basin (average annual rainfall 684 mm). Rainfall in the Beetaloo Basin is strongly seasonal, with most rain falling between November and April, whereas Amadeus Basin rainfall is evenly distributed throughout the year.

Figure 2 to Figure 5 also show evaporation is higher in the Amadeus Basin (average annual pan evaporation 2,928 mm) than in the Beetaloo Basin (average annual pan evaporation 2,671 mm). Evaporation in the Amadeus Basin is strongly seasonal, with evaporation rates being significantly reduced between April and September.

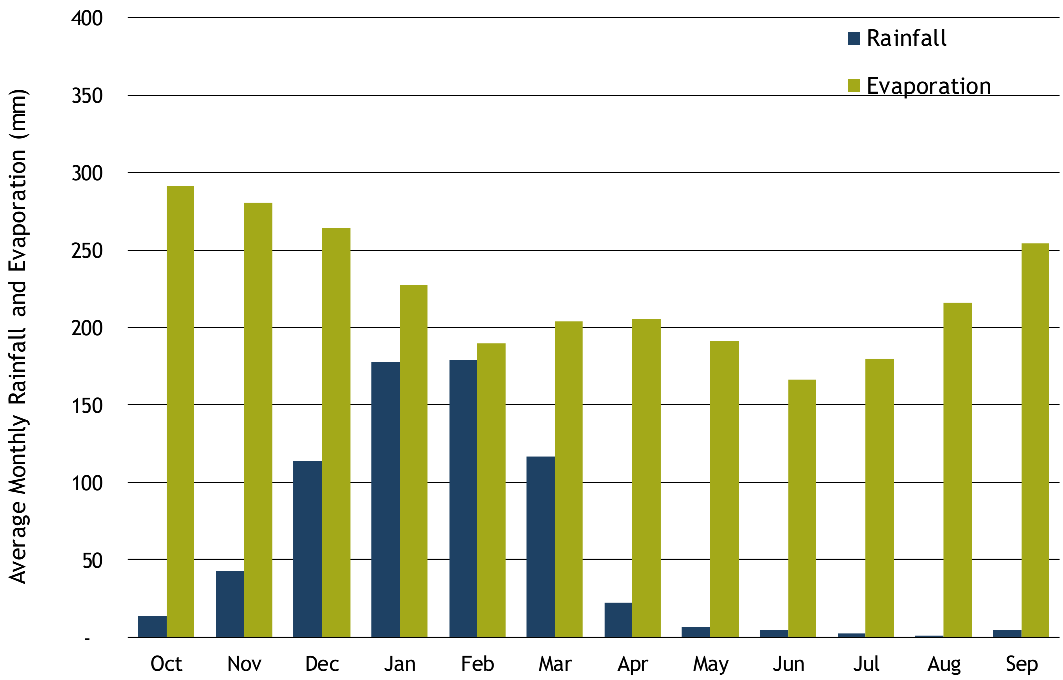


Figure 2 - Average monthly rainfall and pan evaporation - Beetaloo Basin

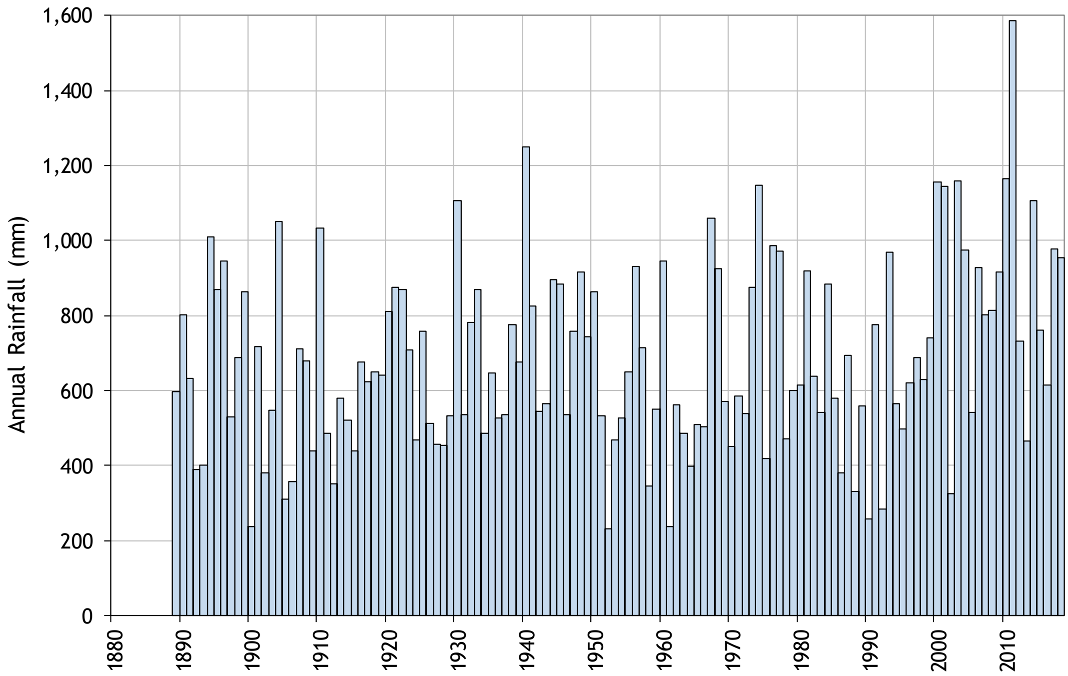


Figure 3 - Annual rainfall - Beetaloo Basin

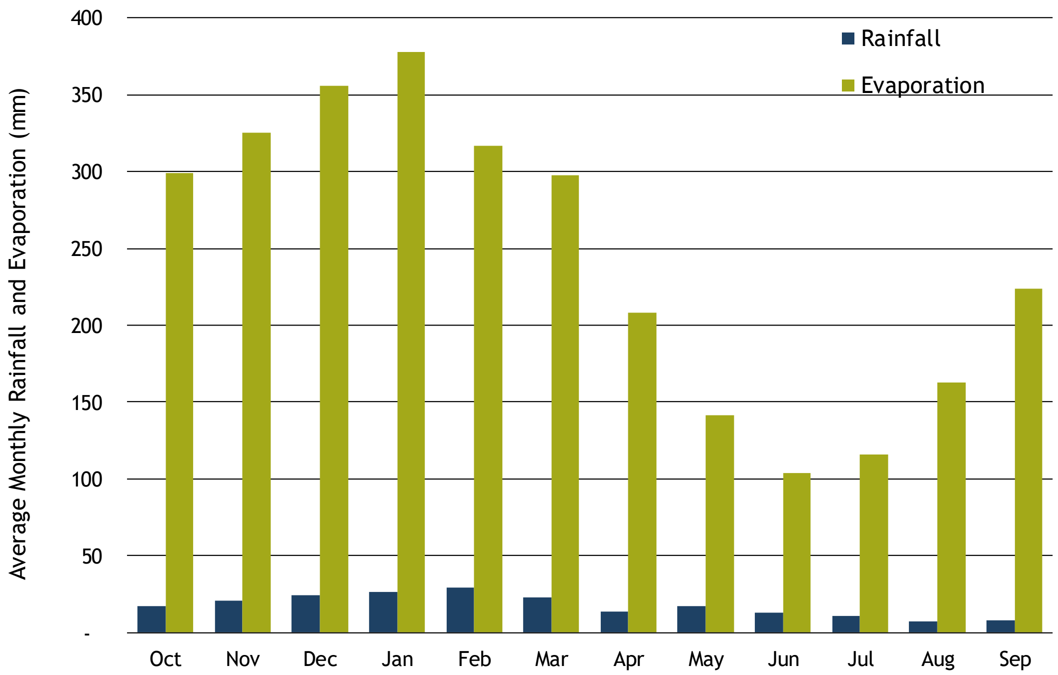


Figure 4 - Average monthly rainfall and pan evaporation - Amadeus Basin

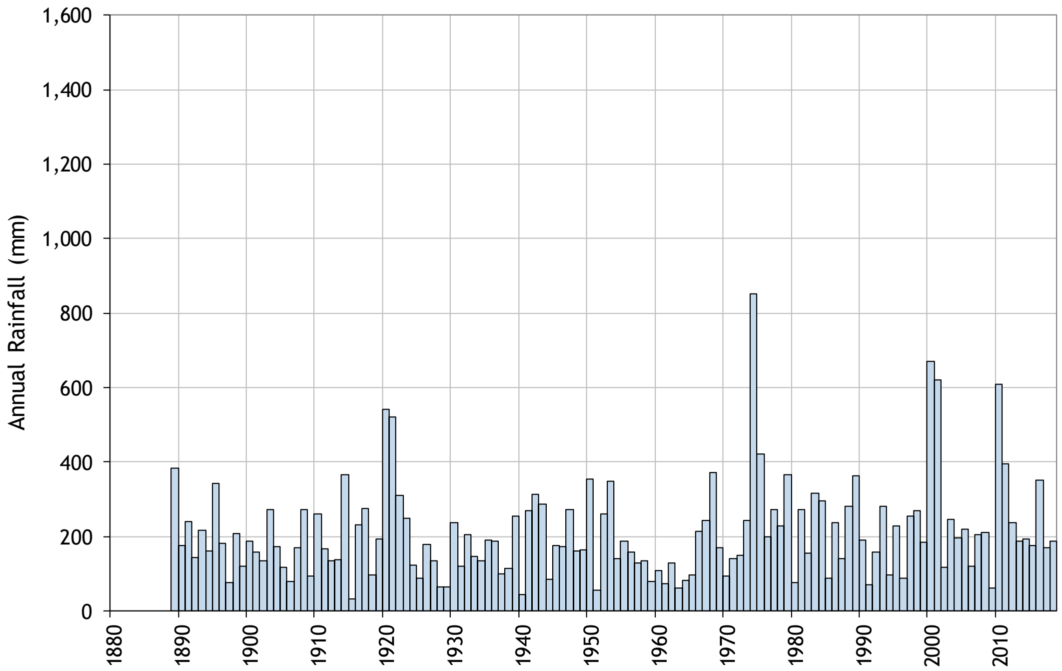


Figure 5 - Annual rainfall - Amadeus Basin

Methodology and Results

Estimation of 3-month (90 day) 0.1% AEP rainfall depth

The following methodology was used to estimate the 0.1% AEP rainfall depth.

1. For each day in the climate dataset, sum the rainfall and evaporation over the preceding 90 day period;
2. Identify the highest 90 day rainfall total in each calendar year to create an annual time series of 90 day maxima (130 annual maxima);
3. Identify the highest 90 day rainfall in the dry season months of each calendar year to create an annual time series of dry season 90 day maxima (130 annual maxima);

   For the purpose of this analysis, a 90 day period is considered "dry season" if it ends between July and November (as illustrated in the figure below - i.e. it relates to tanks operating between May and November only)

J	F	M	A	M	J	J	A	S	O	N	D

4. Rank the 90 day maxima and fit a Log Pearson Type III (LPIII) distribution – repeat for the dry season time series;
5. Extrapolate the LPIII distribution to estimate the 0.1% AEP rainfall depth.

Note that the potential effects of climate change have not been incorporated into this analysis.

The LPIII distributions to the annual series of 90 day rainfall maxima are shown in Figure 6 to Figure 9[1]. The 3-month, 0.1% AEP rainfall totals are estimated to be:

- Beetaloo Basin – all months: 1,448 mm;
- Beetaloo Basin – dry season: 321 mm;
- Amadeus Basin - all months 593 mm;
- Amadeus Basin - dry season: 342 mm.

For context, 0.1% AEP 7-day design rainfall depths sourced from the Bureau of Meteorology have been listed below:

- Beetaloo Basin – 682 mm
- Amadeus Basin - 492 mm

[1] Note the horizontal scale in the LPIII figures follows the terminology specified in the 2016 version of Australian Rainfall and Runoff (Book 1, Chapter 2.2.5). EY denotes events per year, and is the inverse of 'average recurrence interval' (ARI).

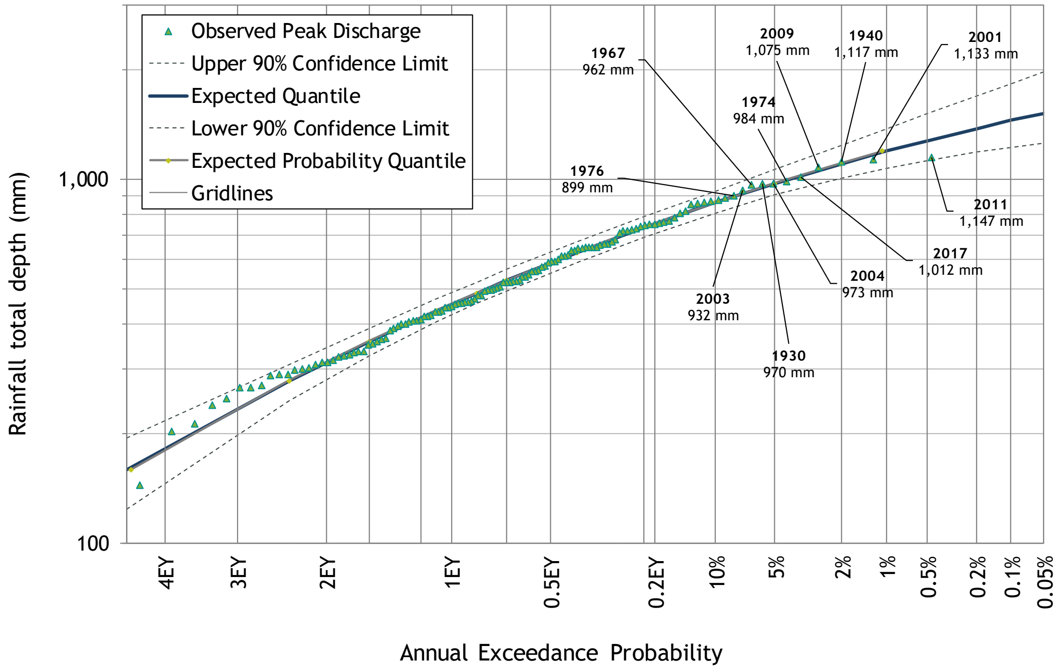


Figure 6 - Fit of LPIII Distribution to annual series of 90 day rainfall depths - Beetaloo Basin

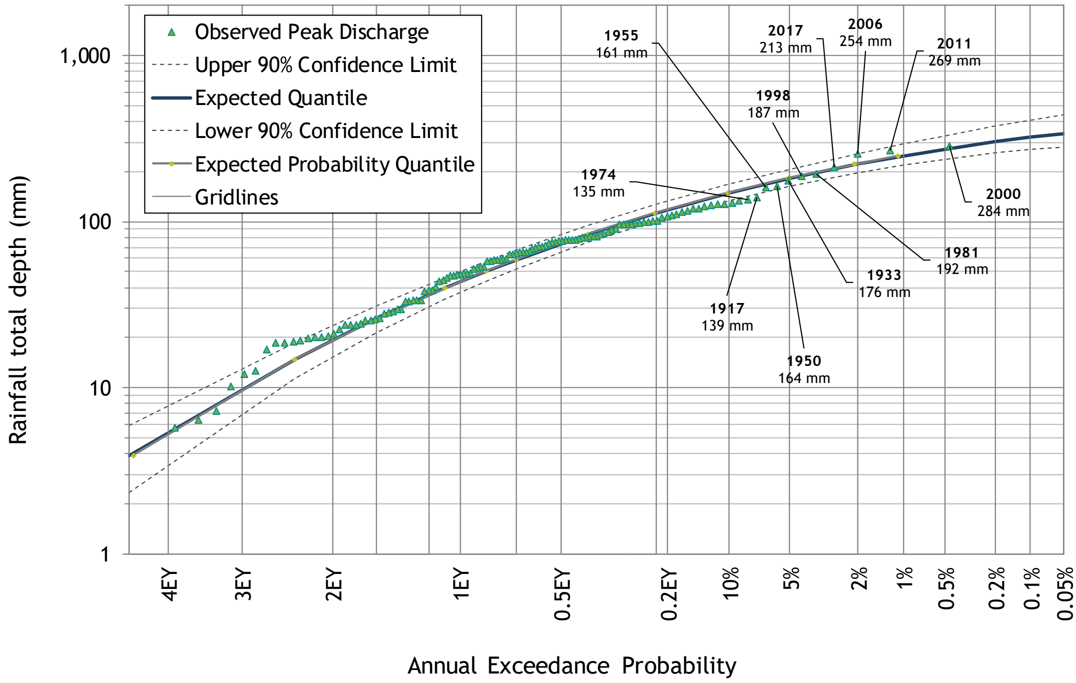


Figure 7 - Fit of LPIII Distribution to annual series of 90 day dry season rainfall depths - Beetaloo Basin

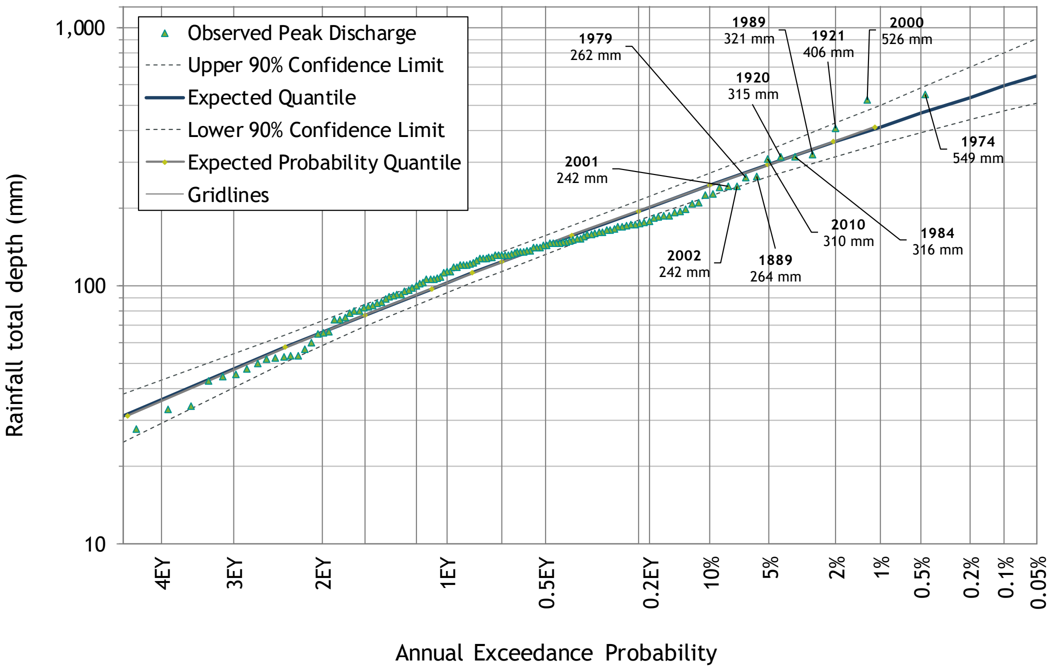


Figure 8 - Fit of LPIII Distribution to annual series of 90 day rainfall depths - Amadeus Basin

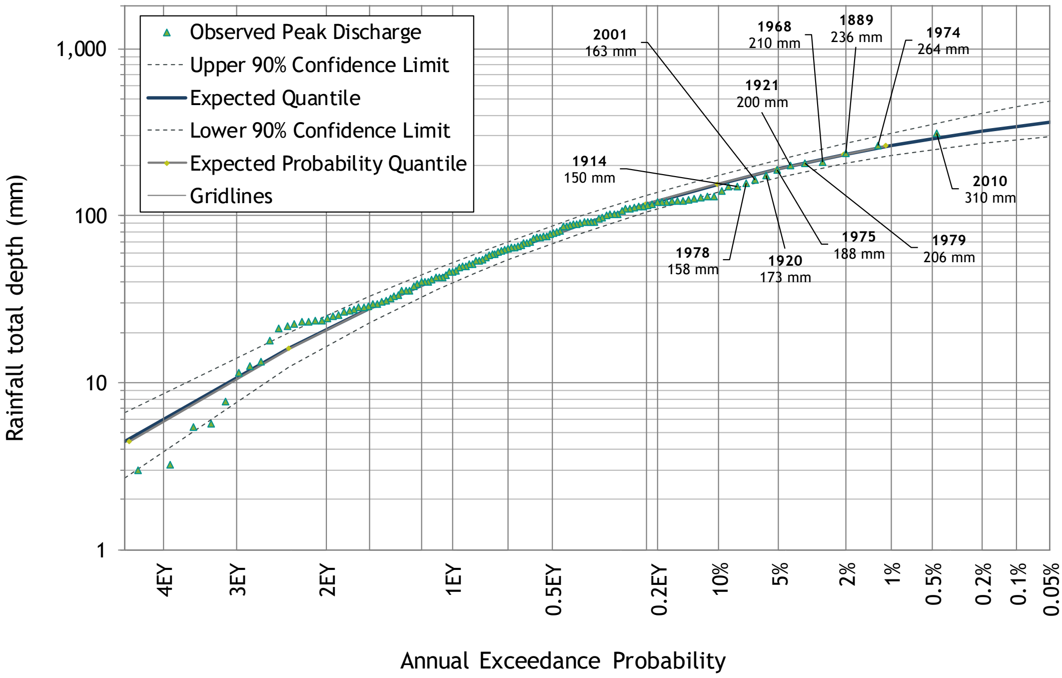


Figure 9 - Fit of LPIII Distribution to annual series of 90 day dry season rainfall depths - Amadeus Basin

Estimation of total 90 day evaporation coinciding with 0.1% AEP 90 day rainfall

The Data Drill estimates of Morton's lake evaporation were adopted for estimating evaporative losses from the tank water surface.

As shown in Figure 10, in the Beetaloo basin, elevated 90 day rainfall totals are associated with reduced evaporation. For the purpose of this investigation, a linear regression line was applied to this relationship, and extrapolated to estimate the evaporation associated with the 0.1% AEP. In the dry seasons, and the Amadeus Basin, the correlation between rainfall and evaporation is less clear. The figures show the evaporation rates adopted for this.

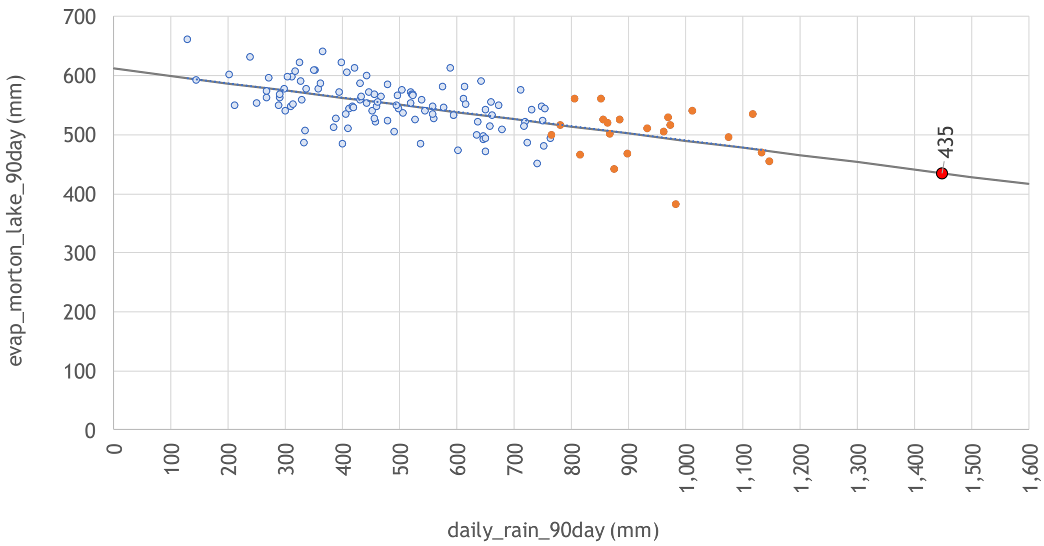


Figure 10 - Relationship between 90 day rainfall depth and evaporation - Beetaloo Basin

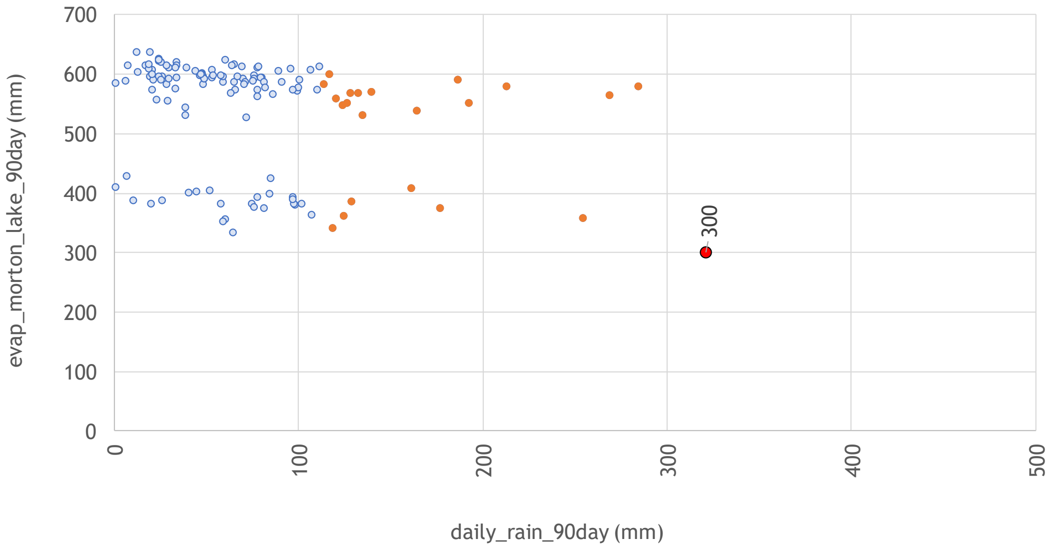


Figure 11 - Relationship between 90 day rainfall depth and evaporation - Amadeus Basin

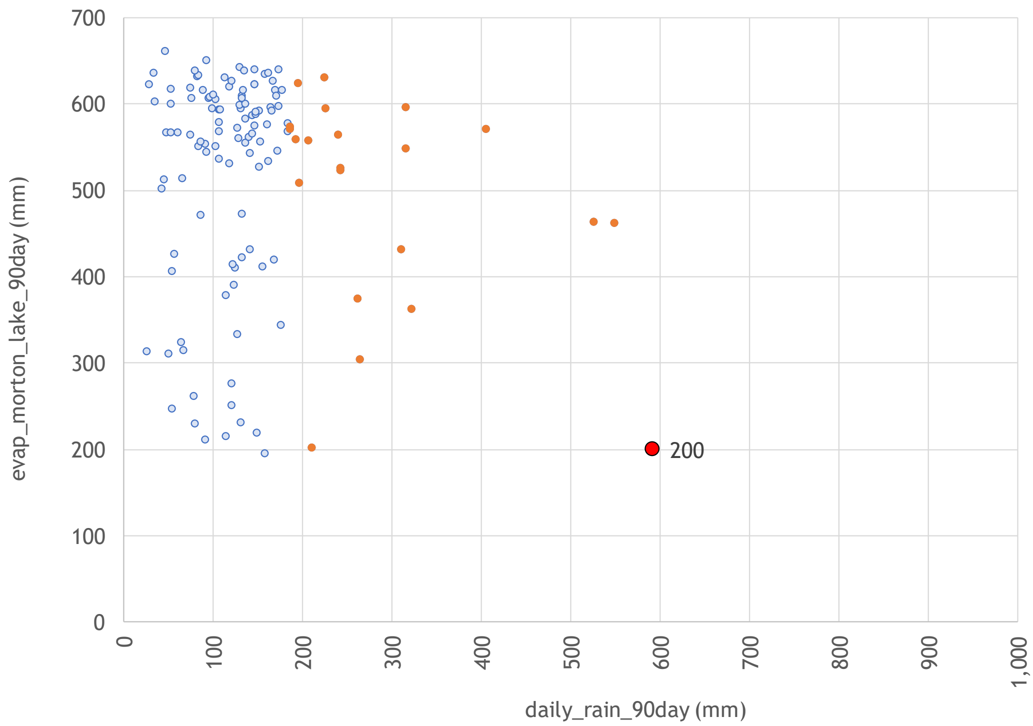


Figure 12 - Relationship between 90 day rainfall depth and evaporation (dry season) - Beetaloo Basin

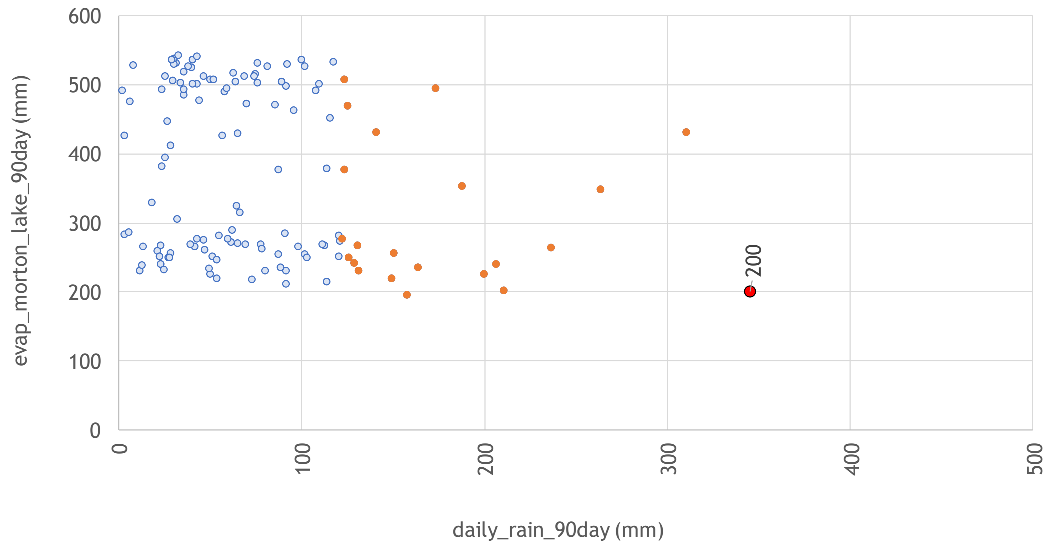


Figure 13 - Relationship between 90 day rainfall depth and evaporation (dry season) - Amadeus Basin

Derivation of 0.1% AEP daily timestep climate datasets for water balance model

The climate dataset was sampled 20 times - each sample commencing at the start of one of the 20 largest 90 day rainfall events.

The resultant ensemble of 20 – 366-day long rainfall and evaporation temporal patterns was used for the analysis. The first 90 days of each cumulative rainfall temporal pattern are shown in the figures below.

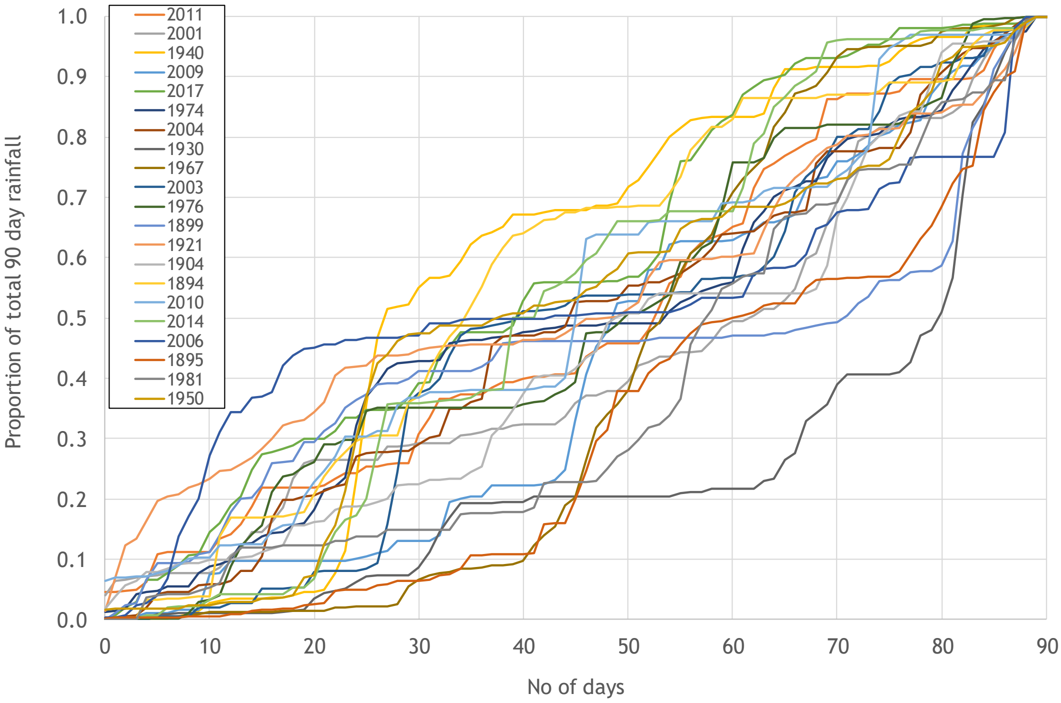


Figure 14 – Ensemble of 20 rainfall temporal patterns (all months) – Beetaloo Basin

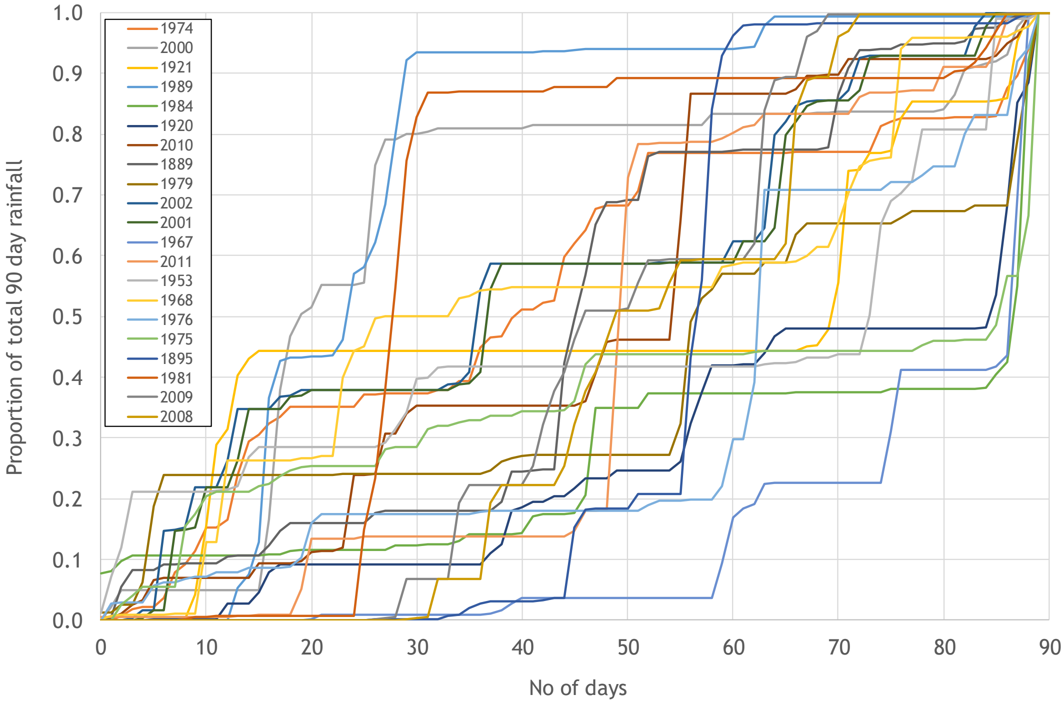


Figure 15 – Ensemble of 20 rainfall temporal patterns (all months) – Amadeus Basin

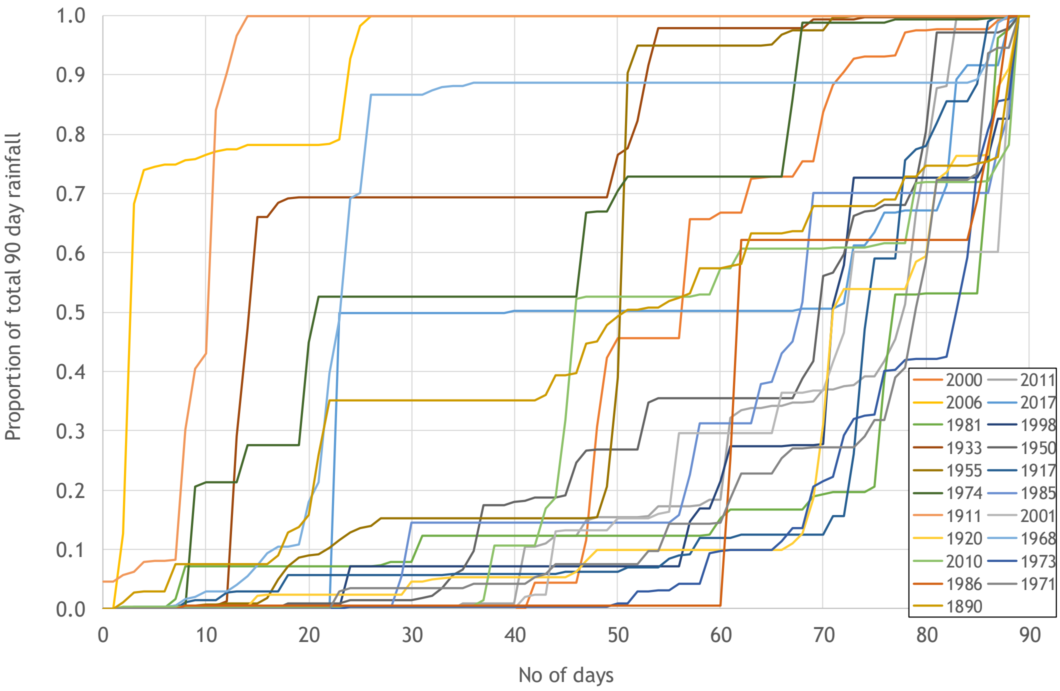


Figure 16 – Ensemble of 20 rainfall temporal patterns (dry season) – Beetaloo Basin

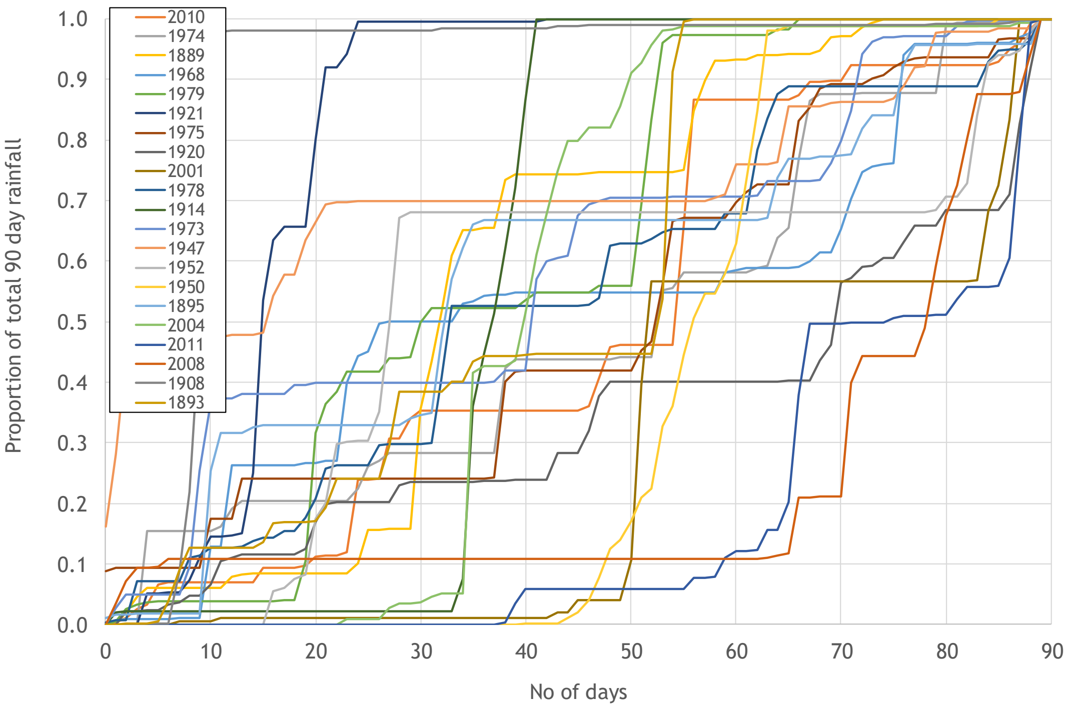


Figure 17 – Ensemble of 20 rainfall temporal patterns (dry season) – Amadeus Basin

The first 90 days of each rainfall temporal pattern was scaled up by the ratio of the 0.1% AEP 90 day rainfall to the 90 day total for that event.

The first 90 days of each evaporation temporal pattern was scaled up by the ratio of the 90 day evaporation estimate from the previous step to the 90 day total for that event.

Model Results

The adopted climate data was input to a very simple water balance model in which daily tank water level on each day is estimated as:

Tank WL_n = Tank W_{n-1} + Rainfall – (M_{lake} to Tank Evap Factor) *(M_{lake} Evap)

Where (M_{lake} to Tank Evap Factor) = 1.0

The results of the model are summarised in the table below and in the following figures. When reviewing the figures, please note the following:

- The starting condition has been adjusted to ensure that no temporal patterns result in negative water levels;
- Extended outlook figures show 0.1% AEP rainfall conditions for the first 90 days of the simulation, and historical climate for the remainder of the simulation period. The intent of these figures is to give an indication as to how the water levels in the tank may recover (or otherwise) after a 0.1% AEP rainfall sequence, if the tank were left in place for longer than three months.

Table 1 - Summary of tank water balance model results (all units: mm)

Item	Beetaloo Basin		Amadeus Basin	
	Wet Season[A]	Dry Season	Wet Season[A]	Dry Season
0.1% 90-day AEP rainfall	1,448[C]	321[C]	593[D]	342[D]
Co-incident evaporation	-435	-300	-200	-200
Net 90-day water level increase	1,013	21	393	142
Max water level increase during the 90-day period[B]	1,168	278	522	328

[A] Based on all months (not wet season only)

[B] The largest difference between minimum and maximum water level occurring during the 90d simulation period, out of the 20 temporal patterns.

[C] Note that BOM IFD 0.1% AEP 7d design rainfall is 682 mm for Beetaloo Basin location. This rainfall can notionally occur at any time throughout the year.

[D] Note that BOM IFD 0.1% AEP 7d design rainfall is 492 mm for Amadeus Basin location. This rainfall can notionally occur at any time throughout the year.

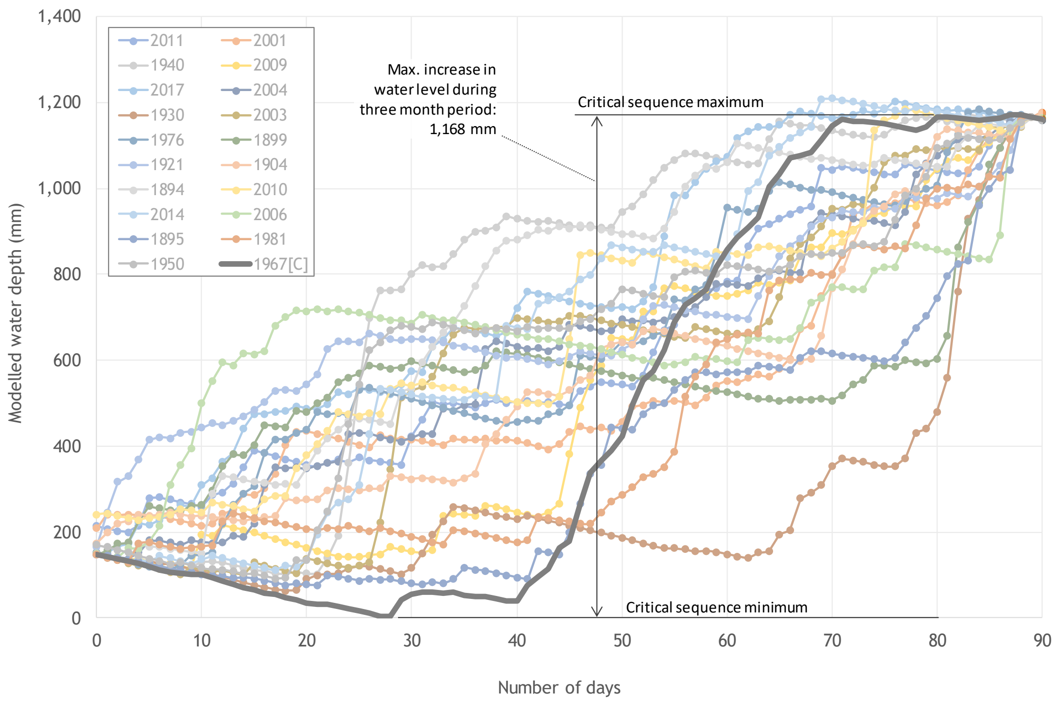


Figure 18 - Water balance model results - all months - 90 days - Beetaloo Basin

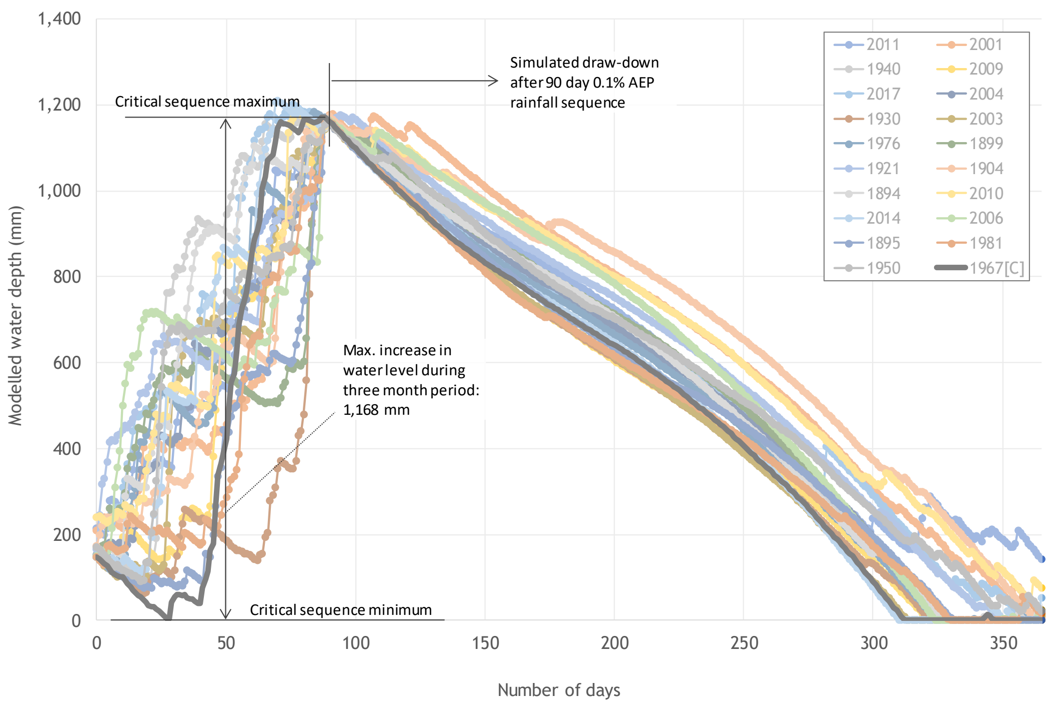


Figure 19 - Water balance model results - all months - 366 days - Beetaloo Basin

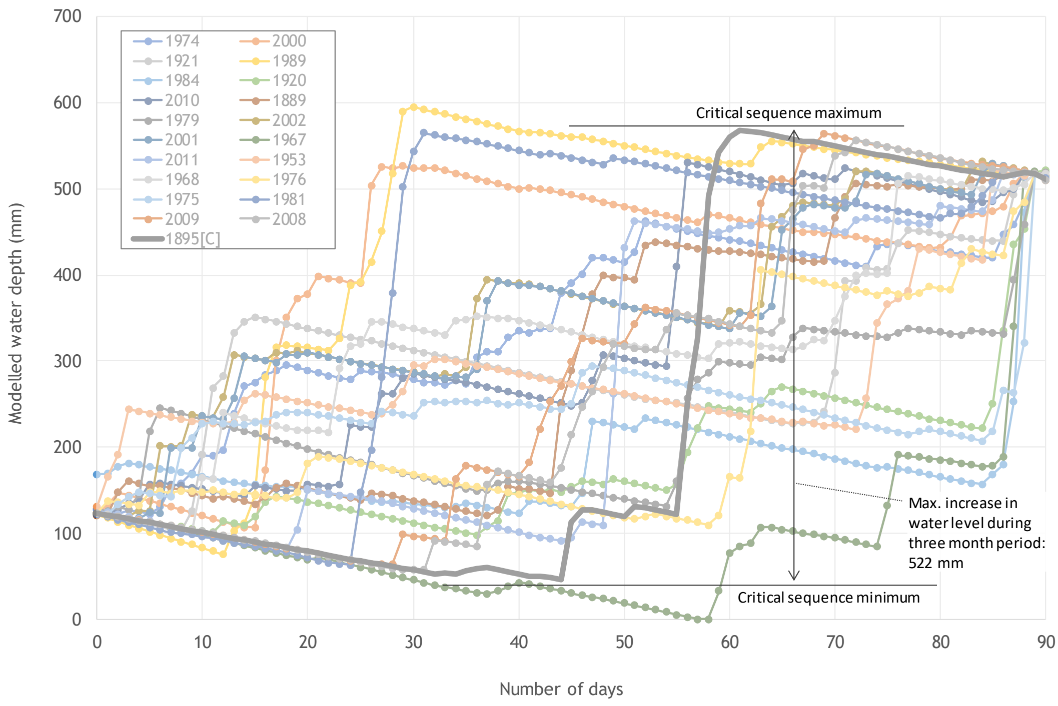


Figure 20 - Water balance model results - all months - 90 days - Amadeus Basin

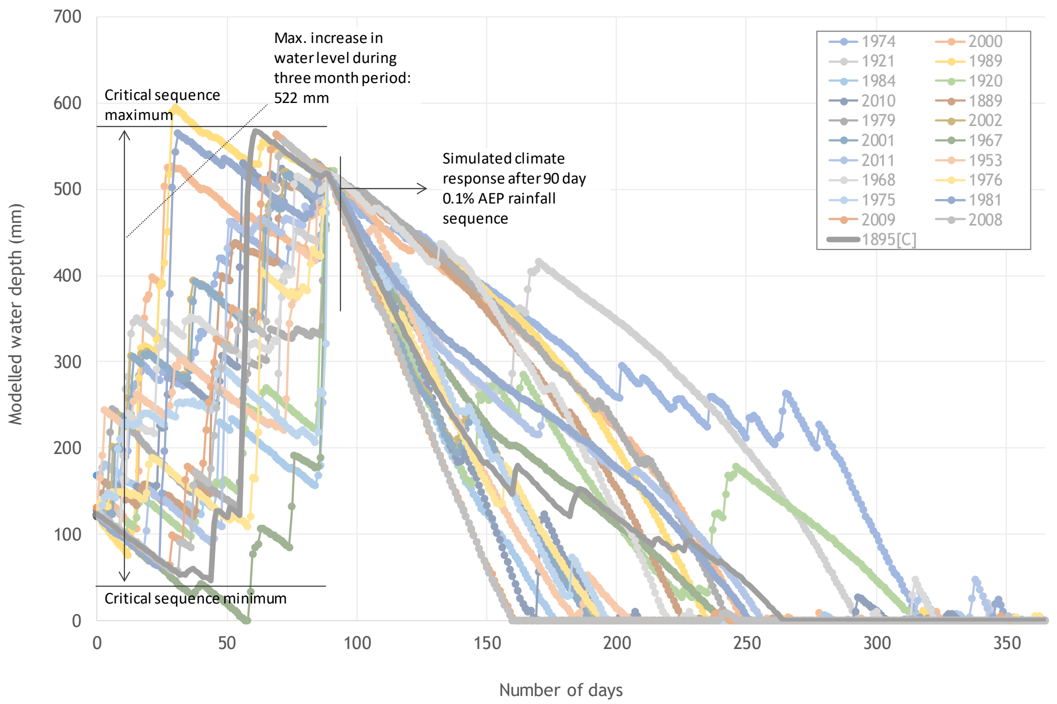


Figure 21 - Water balance model results - all months - 366 days - Amadeus Basin

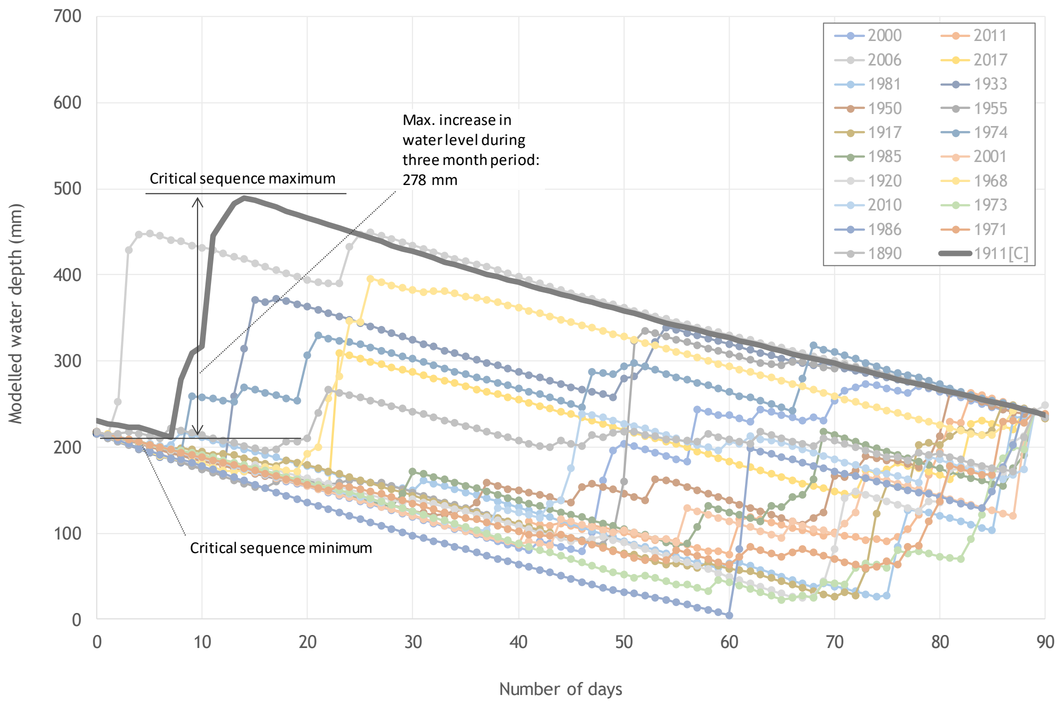


Figure 22 – Water balance model results – dry season – 90 days – Beetaloo Basin

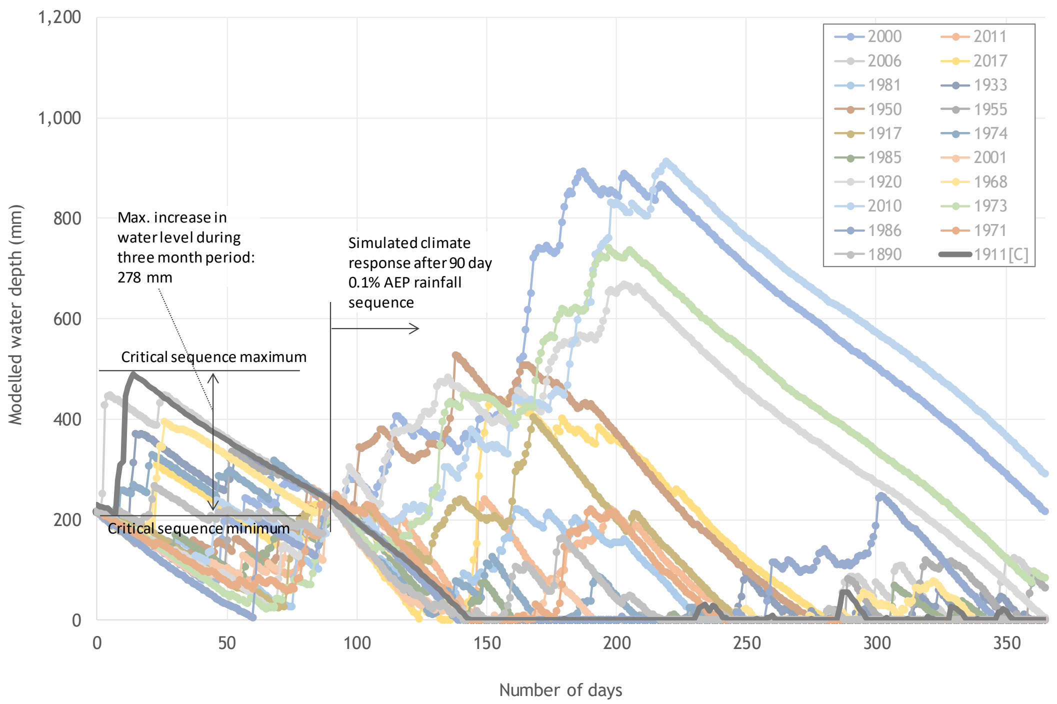


Figure 23 – Water balance model results – dry season – 366 days – Beetaloo Basin

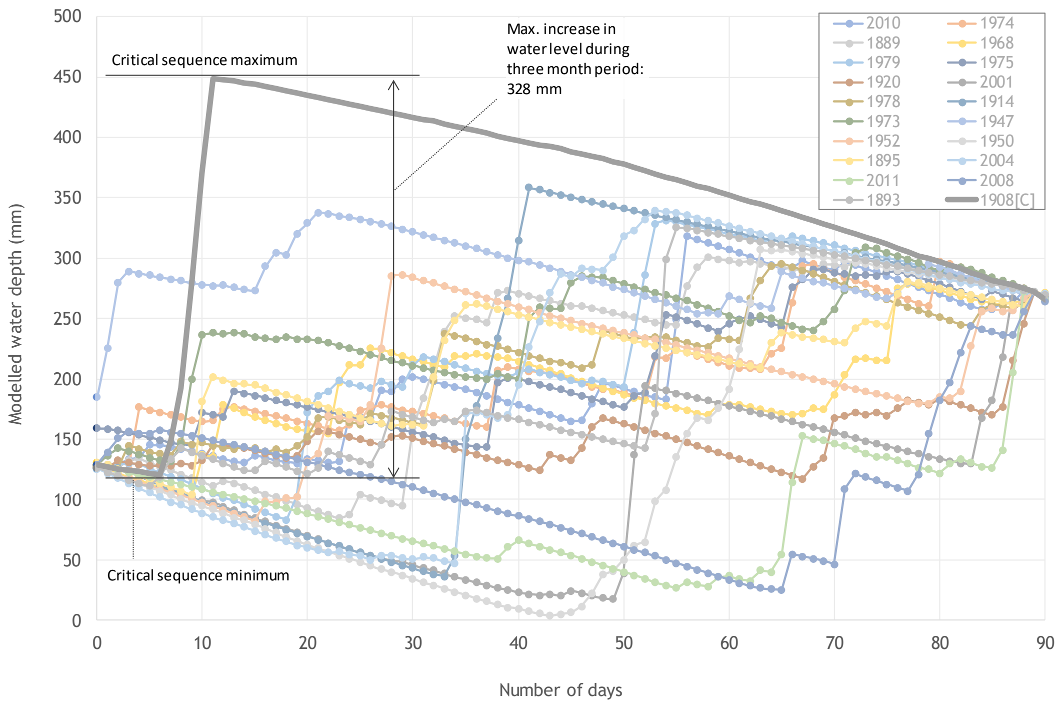


Figure 24 – Water balance model results – dry season – 90 days – Amadeus Basin

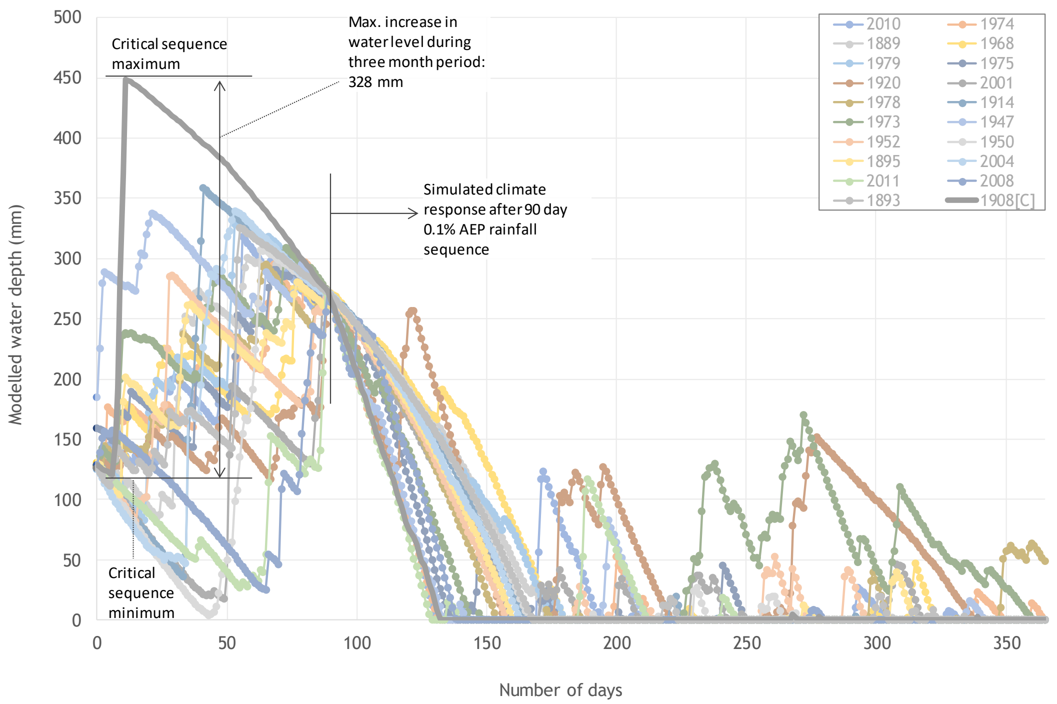


Figure 25 – Water balance model results – dry season – 366 days – Amadeus Basin

Maximum operating level considerations

The values in the bottom row of Table 1 may be used by Santos when selecting where to set the maximum operating levels in the proposed ponds. The maximum operating level (MOL) should be set some distance below the overflow level of the tank. The distance between the MOL and overflow level is defined as the freeboard. The freeboard depth will correspond to either the design 0.1% AEP rainfall inflow (i.e. Table 1 values), or a 0.1% AEP wave allowance estimated using a recognised engineering method, whichever of the two is greater. Figure 26 shows an example tank control level configuration.

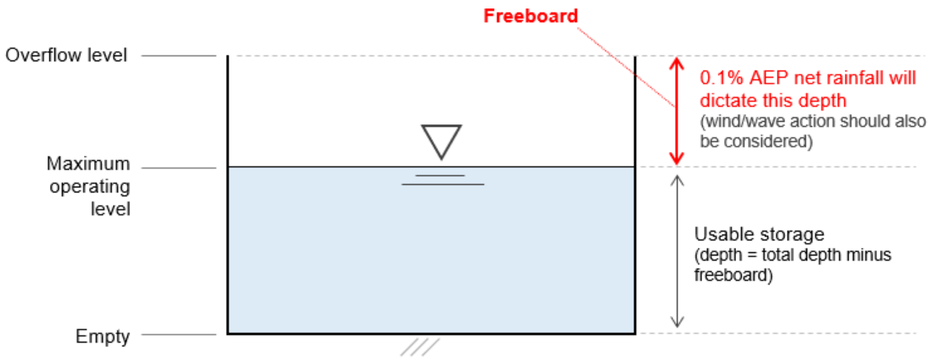


Figure 26 - Conceptual tank configuration - maximum operating level setting

As an example, for a tank located in the Betaloo Basin that will be in service for three months during the wet-season, the design rainfall inflow is 1,168 mm from Table 1. Assuming this will dominate over any wave action, the MOL would be set at 1.2m (rounded to 1 decimal place) below the overflow level of the tank. For a hypothetical total tank depth of 3m, the MOL would be set at a depth of 1.8m. Figure 19 gives an indication as to how such a tank would perform if it were left in place beyond its design life of three months.

The last sentence in the paragraph above ties into an important factor that should be considered when setting an MOL, particularly for the Betaloo Basin site. Review of Figure 23 shows that setting MOLs based on the assumption that a tank will only be in place during the dry season (i.e. using Beetaloo 0.1% AEP rainfall of 278mm), could lead to an increased containment risk in the following wet-season, if for some reason the tank were to be left in place longer than originally anticipated. More intense storm events within the dry-season could also produce greater tank water level increases than those shown in Table 1 (i.e. Beetaloo 0.1% AEP design 7-day rainfall from BOM IFD is 682 mm vs 278 mm critical dry-season rainfall in table 1).

Estimation of inflow volumes

The outcomes of the water balance analysis (Table 1) have been equated to volumes in Table 2, for a range of tank sizes. Tank specifications have been calculated based on information (diameter versus tank capacity) available on the CONCEPT tank vendor website[2].

[2] https://www.conceptservices.com.au/concept-tanks/

Table 2 - Design wet-season depths and volumes for a range of tank sizes

Item	Units	Tank Size 12ML	15.5ML	25ML	40ML
Tank specifications					
Diameter	m	70	80	110	130
Area	m2	3,850	5,025	9,505	13,275
Depth	m	3.1	3.1	2.6	3.0
Capacity	ML	12.0	15.5	25.0	40.0
Betaloo Basin (wet-season)					
Depths					
0.1% AEP 90d rainfall	mm	1,448	1,448	1,448	1,448
Co-incident evaporation	mm	435	435	435	435
Net increase over 90d	mm	1,013	1,013	1,013	1,013
Max incr. within 90d	mm	1,168	1,168	1,168	1,168
Volumes					
0.1% AEP 90d rainfall	ML	5.6	7.3	13.8	19.2
Co-incident evaporation	ML	-1.7	-2.2	-4.1	-5.8
Net increase over 90d	ML	3.9	5.1	9.6	13.4
Max incr. within 90d	ML	4.5	5.9	11.1	15.5
Amadeus Basin (wet-season)					
Depths					
0.1% AEP 90d rainfall	mm	593	593	593	593
Co-incident evaporation	mm	200	200	200	200
Net increase over 90d	mm	393	393	393	393
Max incr. within 90d	mm	522	522	522	522
Volumes					
0.1% AEP 90d rainfall	ML	2.3	3.0	5.6	7.9
Co-incident evaporation	ML	-0.8	-1.0	-1.9	-2.7
Net increase over 90d	ML	1.5	2.0	3.7	5.2
Max incr. within 90d	ML	2.0	2.6	5.0	6.9

Closing

We trust this information satisfies your immediate requirements. If you have any queries or require any additional information in relation to the contents of this document, please do not hesitate to contact our offices.

For and on behalf of

WRM Water & Environment Pty Ltd

Gavin Rootsey

Principal Engineer

Appendix H: Spill Management Plan

Santos

Spill Management Plan: MacArthur Basin 2019 Drilling Program

NT Exploration Permit (EP) 161

Date	Rev	Reason for Issue	Author	Checked	Approved
05/04/2019	0	For Review	MB	PW	DC
23/05/2019	1	For Review	MB	PW	DC
24/06/2019	3	Reviewed to fix typographical error	MB	PW	DC

Table of Contents

Tables

Figures

Appendices

Abbreviations and Units

Acronym / Abbreviation	Description
ALARP	As low as reasonably practicable
ALRA	Aboriginal Land Rights Act
AAPA	Aboriginal Areas Protection Authority
APPEA	Australian Petroleum Production and Exploration Association
CLA	Cambrian Limestone Aquifer
Code	Code of Practice
CPESC	Certified Professional in Erosion and Sediment Control
DENR	Department of Environment and Natural Resources
DoEE	Department of Environment and Energy
DFIT	Diagnostic Fracture Injection Test
DPIR	Department of Primary Industry and Resources
D&C	Drilling and Completions
EC	Electrical Conductivity
EMP	Environmental Management Plan
EP	Exploration Permit
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPS	Environmental Performance Standards
ERA	Environmental Risk Assessment
ESD	Ecologically Sustainable Development
ha	Hectares
GISERA	Gas Industry Social and Environmental Research Alliance
km	Kilometre
LACA	Land Access Compensation Agreement
LWD	Logging While Drilling
NLC	Northern Land Council
m	Metres
MD	Measured Depth
MoC	Management of Change
NRM	Natural Resource Management
NT	Northern Territory
NT EPA	Northern Territory Environmental Protection Authority
NVIS	National Vegetation Information System
Panel	Independent Scientific Panel
PL	Petroleum Lease
PMST	Commonwealth Protected Matters Search Tool
PPL	Petroleum Pipeline Licence

Acronym / Abbreviation	Description
SEAAOC	South East Asia Australia Onshore Conference
SMS	Santos Management System
SSCC	Sacred Site Clearance Certificate
TOC	Total Organic Content
TPWC Act	Territory Parks and Wildlife Conservation Act 2014
TVD	True Vertical Depth
TVDSS	True Vertical Depth referenced to sea-level (Australian Height Datum)
WOMP	Well Operations Management Plan
WoNS	Weed of National Significance

1.0 Introduction

1.1 Background

Santos proposes to undertake exploration activities in 2019, this Spill Management Plan is in support of the Drilling Program Environmental Management Plan. The primary activities considered in the Drilling EMP include:

- Exploration drilling – both vertical and horizontal drilling
- Well evaluation – including wireline logging, logging while drilling formation testing, core acquisition, fluid sampling, open-hole formation integrity testing (i.e. Diagnostic Fracture Injection Testing (DFITs)) and other standard evaluation techniques as appropriate
- Cased hole DFIT
- Well suspension and/or well decommissioning
- Ongoing site and well maintenance and monitoring, work-over and re-entry, and evaluation as required

Under the Petroleum (Environment) Regulations (the Regulations), interest holders in petroleum titles must prepare and submit an Environment Management Plan (EMP). Approval of an EMP is necessary for all activities that have an environmental impact or risk and is only one of several approvals required for the activity to proceed. An approved EMP is a statutory document that is enforceable. The Code of Practice for Petroleum Activities in the Northern Territory sets out the mandatory requirements for management plans for wastewater and spills. The Code states that an EMP for a petroleum activity must include a Spill Management Plan (SMP).

1.2 Scope

Santos proposes to undertake a Drilling Program in 2019 at the Tanumbirini-1/2H and Inacumba-1/1H locations. This Spill Management Plan (SMP) is to be included in the EMP for the Drilling Program.

This spill management plan assesses and manages the risks posed by potential spills of waste, wastewater, fluids and any chemicals used or stored as part of the Drilling Program at the Tanumbirini-1/2H and Inacumba-1/1H locations. The Drilling Program EMP at the Tanumbirini-1/2H and Inacumba-1/1H locations does not cover any hydraulic fracture stimulation scope of work, accordingly this SMP is specific to the Drilling Program scope of work and a further SMP will be developed to support an EMP for any proposed hydraulic fracture stimulation activity.

2.0 Potential Spill Materials

A list of chemicals, water and wastewater and the way that they will be stored, transported and transferred as part of activity is provided below

2.1 Chemicals used in the Activity

2.1.1 Grey water and Sewage

Camp wastewater from laundry, showers and kitchen is proposed to be piped to an irrigation area. For treated sewage is sewage that has passed through a sewage treatment system, the liquid component of the sewage treatment is either disposed of using an irrigation system or transported with the solid waste to an approved disposal facility. Macerated sewage is not treated sewage.

2.1.2 Hydraulic fluids and Fuel

Hydraulic fluid and fuel drums are stored within portable bunding and bulk fuel is stored within tankers equipped with safety features such as double-skins (or temporary bunding), safety cut-off valves, top accessing etc. Spill leak and drip trays will be used to address the risk of minor drips and spills associated with re-fuelling operations. The estimated volumes and storage of fuels and oils used in the Drilling Program is provided in Table 2-1 below.

Table 2-1: Estimated Volumes and Storage of Fuels and Oils

Description	Stored on Site (m^3)	Storage Location	Containment
Diesel Fuel	100	Rig Fuel Storage Tanks (Double Skinned)	Secondary Containment
Hydraulic Oil	3.8	Storage Tanks and Drums	Secondary Containment (Double Skinned Tank or Bunded Containment Area or Bunded Pallet Storage)
Other Chemicals (excluding drilling additives)	10	Oil Storage Skids or Mechanics Shack	Secondary Containment (Double Skinned Tank or Bunded Containment Area or Bunded Pallet Storage)

2.1.3 Drilling Fluid

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

The proposed drilling fluid is comprised of predominantly water with the remaining made up of salts and fluid additives. The anticipated that approximately 4-5 ML will be required. A list of fluid additives potentially used in the activity are provided in Table 2-2.

Testing of the residual drilling fluid will be undertaken in accordance with an approved Wastewater Management Plan (submitted in support of the Drilling Program EMP).

Table 2-2: Proposed Drilling Chemicals

Trade name	Supplier name	Purpose of use	Component name	Maximum ingredient concentration	Maximum ingredient concentration in total fluid used
Potassium Chloride	Potassium Chloride	Inhibitor / Weighting Agent	Potassium Chloride	22 lb/bbl	17.4 lb/bbl
Soda Ash	Soda Ash	pH Controller	Soda Ash	0.3 lb/bbl	0.2 lb/bbl
Bentonite	Bentonite	Viscosifier	Sodium montmorillonite clay	15 lb/bbl	10 lb/bbl
Biocide	ALDACIDE G	Biocide	Biocide	0.3 lb/bbl	0.2 lb/bbl
Xantham Gum	BARAZAN D PLUS	Rheology Modifier	BARAZAN D PLUS	2 lb/bbl	1.6 lb/bbl
Polyanionic cellulose, low viscosity	PAC-L	Fluid Loss Additive	PAC-L	5 lb.bbl	3 lb/bbl
Cross-linked Starch	N-DRILL HT PLUS	HTHP Filtration Control Additive	N-DRILL HT PLUS	8 lb/bbl	5 lb/bbl
Sodium Bicarbonate	Sodium Bicarbonate	pH Controller	Sodium Bicarbonate	N/A – contingent only	N/A – contingent only
Citric Acid	Citric Acid	pH Controller	Citric Acid	N/A – contingent only	N/A – contingent only
Barite	Barite	Weighting Agent	Barium sulphate	500 lb/bbl	120 lb/bbl
Sodium Chloride	Sodium Chloride	Inhibitor / Weighting Agent	Sodium Chloride	50 lb/bbl	N/A
LCM	KWIKSEAL BAROFIBRE STOPPIT	Lost Circulation Material	LCM	N/A – contingent only	N/A – contingent only
Lubricant	DRIL-N-SLIDE	Lubricant	Lubricant	N/A – contingent only	N/A – contingent only
Oxygen Scavenger	OXYGON	Oxygen Scavenger	Oxygen Scavenger	N/A – contingent only	N/A – contingent only
Caustic Soda	Caustic Soda	pH Control	Caustic Soda (Sodium Hydroxide)	0.6 lb/bbl	0.2 lb/bbl

Trade name	Supplier name	Purpose of use	Component name	Maximum ingredient concentration	Maximum ingredient concentration in total fluid used
BARABUF	BARABUF	pH Stabilizer	pH Buffer	N/A – contingent only	N/A – contingent only
Foaming Agent	ULTRAFOAM	Foaming Agent	Foaming Agent	N/A – contingent only	N/A – contingent only
Defoamer	BARA-DEFOAM HP	Defoamer	Defoamer	N/A – contingent only	N/A – contingent only
Corrosion Inhibitor	BARACOR 100	Corrosion Inhibitor	Filming Amine	N/A – contingent only	N/A – contingent only
Calcium Carbonate	BARACARB	Weighting/Bridging Agent	Calcium Carbonate	N/A – contingent only	N/A – contingent only
Anti-Balling surfactant	CON-DET	Anti-Balling surfactant	CON-DET	N/A – contingent only	N/A – contingent only
SAPP	SAPP	Thinner/Dispersant	SAPP	N/A – contingent only	N/A – contingent only
Modified Starch	DEXTRID LTE	Filtration Control Agent	Modified Starch	8 lb/bbl	6 lb/bbl
H2S Scavenger	SOURSCAV	H2S Scavenger	H2S Scavenger	N/A – contingent only	N/A – contingent only
Polyglycol	GEM CP/GP	Shale Stabilizer	glycol	N/A – contingent only	N/A – contingent only
Non-amine inhibitor	BORE-HIB	Shale Stabilizer	Non-amine inhibitor	N/A – contingent only	N/A – contingent only
Non-amine inhibitor	PERFORMATROL	Shale Stabilizer	Non-amine inhibitor	N/A – contingent only	N/A – contingent only
Low toxicity spotting fluid/lubricant	QUIK-FREE	Stuck Pipe Spotting Fluid	Low toxicity spotting fluid/lubricant	N/A – contingent only	N/A – contingent only
PHPA	EZ-MUD DP EZ MUD	Shale Stabilizer	PHPA	N/A – contingent only	N/A – contingent only

Trade name	Supplier name	Purpose of use	Component name	Maximum ingredient concentration	Maximum ingredient concentration in total fluid used
PHPA	EZ-MUD DP EZ MUD	Shale Stabilizer	PHPA	N/A – contingent only	N/A – contingent only
PHPA	EZ-MUD DP EZ MUD	Shale Stabilizer	PHPA	N/A – contingent only	N/A – contingent only

3.0 Spill Risk Assessment

3.1 Potential Spill Scenarios

A number of chemicals and hydrocarbons will be handled, stored and transported for the project. The potential impact of a spill or leak is dependent on the type and volume of material released. Due to the remote location of the project, chemicals will be transported by road and stored on site prior to use.

Potential sources of spills during drilling activities are shown in Table 3-1. Well blow-out is not included in Table 3-1 as both wells in the proposed 2019 drilling program avoid conventional structural closures and are targeting a Proterozoic (i.e. very old) basin setting where there is insufficient permeability to support the potential for a well blow-out.

Table 3-1 Quality and quantity of spill scenarios

Potential spill scenario	Quantity of spill	Quality of spill	Design controls
Loss of containment of liquid drilling additives from storage area.	Less than $1m^3$	Potentially hazardous	Secondary containment
Loss of containment of dry drilling additives from storage area.	Less than $1m^3$	Potentially hazardous	Spill containment
Poor refuelling or fuel transfer practices	Less than $1m^3$	Hazardous fluids	Secondary containment
Overflow of pits	Less than $1m^3$	Non-hazardous	Spill containment
Drill fluid leaching from below pit	Less than $20m^3$	Non-hazardous	Pit liner design and integrity and monitoring
Drill fluid leaking from above ground storage tank	Less than $20m^3$	Non-hazardous	Spill containment and monitoring

The mitigation measures to reduce the risks associated with these spill scenarios are discussed in Section 5.0.

3.2 Potential Impact to the Environment

Potential impacts to the environment as a result of a spill event include reduction in quality of groundwater, surface water or soils. These are discussed in more detail below.

<u>Groundwater</u>

Chemicals and fuels used during the drilling program have the potential to leak to surface and infiltrate the ground, migrating to shallow or perched aquifers. This may effect groundwater quality, however the Technical Memorandum for Three Spill Scenarios (Appendix A) demonstrated that impacts to groundwater are extremely unlikely.

Surface Water

Spills to surface have the potential to migrate to surface waters such as ephemeral watercourses. This has the potential to effect surface water quality and ecological values of that habitat.

Soil

For smaller spills and leaks (<1m^3), migration is likely to be contained within the surface soils and would be readily removed or remediated. If a larger spill were to occur, such as that from a bulk tanker, there is the potential that product could infiltrate.

Shallow lithology obtained from exploration well Tanumbirini-1 (See Appendix 1) reveals two main hydrogeological units; a relatively impermeable siltstone/claystone followed by limestone which has highly variable hydrogeological properties, but the potential for high permeability.

3.3 Risk Assessment Table

An assessment of environmental impacts and environmental risks posed by a spill event has been carried out. For completeness and consistency with the EMP, the environmental risk assessment of all activities is presented in Section 6 of the EMP.

4.0 Procedures and Process

4.1 Site material and fluids management

The well site layout and design has been approved in the Civils and Seismic EMP and has been designed to minimise the potential for harm to others and the environment with considerations of the Land Clearing Guidelines and Part A of the Code.

Through the implementation of the mitigations measures provided in the Table 6-1 of the EMP, the relevant mandatory site material and fluids management requirements will be met. In particular the well will be:

- designed and operated to minimise the risk of causing a fire on the well site or in the surrounding environment
- adequately secured to prevent access by wildlife.
- designed and operated to minimise the potential for releases of contaminants to the environment and the impacts of such a release.
- designed to ensure the use, storage and handling of materials is adequate comply with the code.

4.2 Minimising the Risk of a Spill

4.2.1 Santos SMS

Santos manages the environmental impacts and risks of its activities through the implementation of the Santos Management System (SMS). The SMS provides a formal and consistent framework for all activities of Santos employees and contractors. This SMP and the Project EMPO have been developed in consideration of the Santos SMS, including:

- SMS-MS1 Risk – ST13 Environmental Hazard Controls Procedure
- SMS-MS11 Incident and Crisis Management Standard
- SMS-MS1 Incident and Crisis – ST1 – Emergency and Crisis Management Procedure.

In addition to this the Santos Emergency Response Plan (ERP) and the Contractors ERP provide additional processes and procedures to minimise the risks of a spill.

4.2.2 Emergency Response Plan

The Emergency Response Plan for the activity will be prepared by the drilling contractors and will be provided to DENR and DPIR and made available upon request. If the Emergency Response Plan is updated, a revised version will be provided to DENR and DPIR.

The emergency response arrangements within the Emergency Response Plan will be exercised early in the campaign to ensure that personnel are familiar with the plan and the type of emergencies to which it applies and that there will be a rapid and effective response in the event of a real emergency occurring. Following the exercise, lessons will be captured and the plan updated if required.

Other triggers for revising or updating the Emergency Response Plan may include:

- New information becomes available following an incident, near miss or hazard
- Learnings from an exercise or drill
- Change in contractor undertaking the work
- Organisational changes

- Changes to government agency contact details or portfolios

4.2.3 Well Operations Management Plan

Well Operations Management Plan (WOMP) will be submitted to the regulator for approval prior to spud of the first well activity to which the plan would apply. The WOMP will provide details on:

- Description of the well and well activities
- Well integrity risk management process
- Design, construction, operations and management of wells
- Performance outcomes
- Well lifecycle control measures
- Performance standards for control measures
- Performance objectives measurement criteria
- Monitoring, audit and well integrity assurance
- Well Abandonment and suspension considerations
- Responsibilities and competencies of contractors service providers
- Source control and blowout contingency measures

Fundamentally the risks of spills associated with the activity are managed effectively through the implementation of the mitigation measures described in the EMP. With the application of mitigation and management measures described in this plan and the EMP, the potential for chemical spills and leaks is reduced to an acceptable level. The impacts and risks associated with chemical spills and leaks are well-understood and that are established practices in place to manage these risks. With implementation of the control measures, it is considered that the risks and impacts of physical disturbance have been reduced to ALARP.

4.3 Spill Detection

Spills monitoring measures used to detect spills throughout the Drilling Program include:

- Drill fluids that are contained in engineered fluid storage tanks. These tanks and system as a whole will be monitored throughout the Drilling Program.
- Cuttings and fluid storages will be inspected daily to check integrity throughout drilling operations.
- Daily monitoring of weather and for predicted significant rainfall events will be undertaken
- Completion of the daily monitoring checklist

5.0 Spill Response Strategy

5.1 Response

Small spills will be managed locally at the site using dedicated spill kits; which are readily available and appropriately stocked. For spills that are large and cannot be managed locally, the Operating Company Representative is to notify the Santos D&C Superintendent as shown in the Detailed Emergency Response flowchart to provide incident details and initiate an appropriately response supported (See Figure 1).

All spills will be managed in accordance with:

- Santos Emergency Response Plan
- Contractors ERP
- SMS-MS1 Risk – ST13 Environmental Hazard Controls Procedure
- Incident & Crisis ST2 - Incident Reporting, Investigation and Learning Procedure
- The EMP

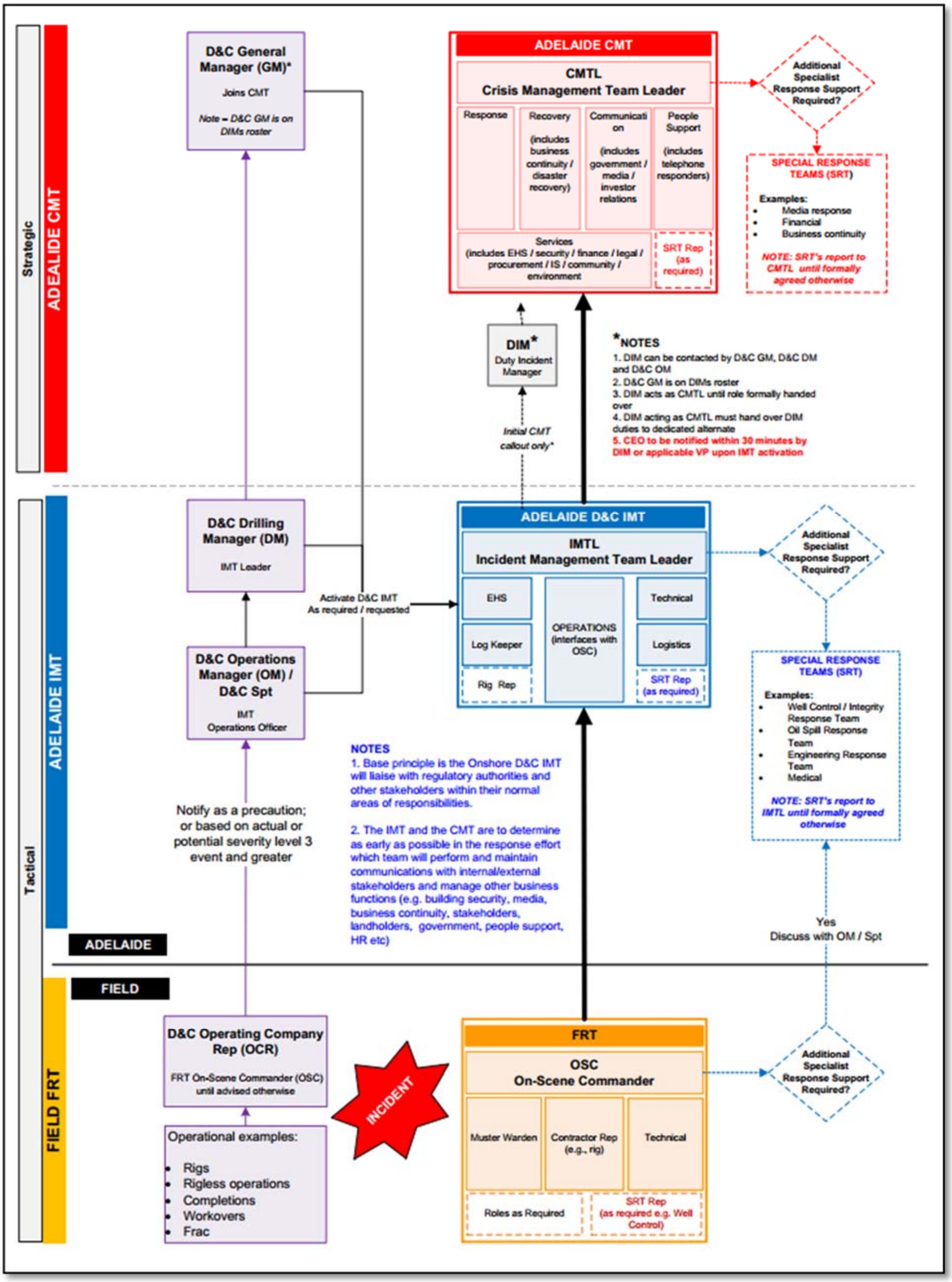


Figure 1: Detailed Emergency Response Arrangements

5.2 Communication Plan

5.2.1 Communication to Personnel

Spill prevention and monitoring strategies will be communicated to personnel working on the 2019 Drilling Program via:

- This Plan
- The EMP
- Site Inductions
- Safety Meetings
- Tool Box Talks
- Daily Meetings

Communications about a spill will be undertaken in accordance with the Emergency Communications section of the Emergency Response Plan. This includes the following steps:

- Incident Management Team Leader (IMTL) informed of incident and establishes contact with affected site to be provided with details of the incident, understanding of severity and response resource requirements
- Assessment of the emergency and severity is made (based on information from the affected site) and an emergency/incident response level determined
- IMT activated to provide support to the affected site or facilities
- D&C Superintendent attends the Incident Management Team (IMT) (where practicable) and liaises with IMTL to provide technical input and guidance
- IMTL maintains open communications with the affected site - On-Scene Commander (OSC)
- Affected site OSC supervises the Field Response Team (FRT)
- Other D&C personnel (roles) may be conscripted into the IMT as required

5.2.1.1 Wellsite Emergency Response Numbers (ERN)

The well site will be clearly identified in a permanent manner with the well name, well number, major hazards and details of the interest holder. The name of the person-in-charge of any active well operations will be displayed in writing where the lease pad meets the well site.

Maintaining key well information and contact details is critical to ensure a timely response to an emergency. The aid in this Wellsite ERNs are provided for and available at each wellsite location include the following details:

- Name of the well
- Wellsite and camp site location coordinates and driving route
- Estimated travel distance to the nearest medical support
- Contact details for contractor personnel (mobile phone and satellite phone)
- Contact details of local Santos base (if relevant) and nearest emergency response support facilities

5.2.2 Incident Reporting and Recording

In the case of any inconsistencies the reporting requirement of the Petroleum (Environment) Regulations and the *Waste Management and Pollution Control Act* (WMPC Act) trump any requirements listed in this plan.

Spills located entirely within EP 161 will be reported to the minister in accordance with Part 3 of the Petroleum (Environment) Regulations. Spills that are located entirely outside of the EP 161 permit area will be reported to the NT Pollution Hotline (1800 064 567) in accordance with Section 14 of the WMPC Act. Where a spill occurs initially within the EP 161 permit area, but discharges out of the permit area, it will be reported to the minister in accordance with Part of the Petroleum (Environment) Regulations and to the NT Pollution Hotline (1800 064 567) in accordance with Section 14 of the WMPC Act.

5.2.2.1 Notice of a reportable incident under the Petroleum (Environment) Regulations

Santos must give the Minister notice of a reportable incident in accordance with this regulation for reportable incidents within the EP 161 area. A reportable incident means an incident, arising from a regulated activity that has caused or has the potential to cause material environmental harm or serious environmental harm. A notice of the reportable incident must be given to the Minister as soon as practicable but not later than 2 hours after the incident first occurred or if the incident was not detected at the time it first occurred – the time the interest holder became aware of the reportable incident.

Report about reportable incident

An initial report about a reportable incident will be given to the Minister as soon as practicable but not later than 3 days after the reportable incident first occurs; and must include comprehensive details about the following:

- the results of any assessment or investigation of the conditions or circumstances that caused or contributed to the occurrence of the reportable incident, including an assessment of the effectiveness of the designs, equipment, procedures and management systems that were in place to prevent the occurrence of an incident of that nature.
- the nature and extent of the material environmental harm or serious environmental harm that the incident caused or had the potential to cause
- any actions taken, or proposed to be taken, to clean up or rehabilitate an area affected by the incident
- any actions taken, or proposed to be taken, to prevent a recurrence of an incident of a similar nature

A report about recordable incidents:

must relate to each reporting period for the regulated activity and must be given as soon as practicable but not later than 15 days after the end of the reporting period. The report must contain:

- a record of all recordable incidents that occurred during the reporting period
- all material facts and circumstances concerning the recordable incidents that the interest holder knows or is able, by reasonable search or enquiry, to find out
- any action taken to avoid or mitigate any environmental impacts and environmental risks of the recordable incidents
- the corrective action that has been taken, or is proposed to be taken, to prevent similar recordable incidents.

Reporting will occur at a period agreed in writing between the interest holder and the Minister or each 90 day period after the day on which the environment management plan is approved.

Recordable incident means an incident arising from a regulated activity that has resulted in an environmental impact or environmental risk not specified in the current plan for the activity; or has resulted in a contravention of an environmental performance standard specified in the current plan for the activity; or is inconsistent with an environmental outcome specified in the current plan for the activity. A recordable incident is not a reportable incident.

5.2.2.2 Duty to notify of incidents causing or threatening to cause pollution under the WMPC Act

Santos must notify the NT EPA on their Pollution Hotline (1800 064 567) as soon as practicable after (and in any case within 24 hours) first becoming aware of a reportable incident or the time they ought reasonable be expected to become aware of a reportable incident. A reportable incident under the WMPC Act includes an incident that causes, or is threatening or may threaten to cause, pollution resulting in material environmental harm or serious environmental harm.

The notification must include the following details:

a) the incident causing or threatening to cause pollution;
b) the place where the incident occurred;
c) the date and time of the incident;
d) how the pollution has occurred, is occurring or may occur;
e) the attempts made to prevent, reduce, control, rectify or clean up the pollution or resultant environmental harm caused or threatening to be caused by the incident; and
f) the identity of the person notifying.

Appendices

Appendix A: Technical Memorandum for Three Spill Scenarios

09 April, 2019

EHS Support Pty Ltd
PO Box 297
Port Melbourne,
Victoria, 3207

Santos Ltd
32 Turbot Street,
Brisbane QLD 4000

Please find attached, EHS Support Pty Ltd technical memorandum for the assessment of potential risk to groundwater associated with hypothetical shale gas activities in the Northern Territory.

Should you have any questions or require additional information, please feel free to contact me at (+61) 400 470 070 or chris.smitt@ehs-support.com.

Sincerely,
EHS Support Pty Ltd

Chris Smitt
Principal Hydrogeologist

Nigel Goulding
Chief Technical Officer

1. INTRODUCTION

The following memorandum provides an assessment of the potential for impacts on groundwater associated with hypothetical shale gas activities in the Northern Territory. For the purpose of this assessment two primary modes of potential impact were identified (releases to the land surface and the strategic burial of drilling mud) and technical assessment and modelling is provided in the sections below.

1.1. OBJECTIVE

The objective of this assessment is to define the potential extent of the area impacted by a release or "spill" of fluids. Specifically, the following questions were addressed:

1. Using three spill scenarios (1,000L; 100,000L and 1ML), determine the maximum pooled area in which a spill would inundate;
2. Over the size of the pooled area, determine infiltration rates to gain an understanding of vertical groundwater movement and associated travel times;
3. Evaluate the potential impacts on groundwater from burial/management of drilling muds at the well sites (where muds are blended and buried with soils); and.
4. Provide a description of what remedial actions could be implemented if impacts to groundwater were observed.

1.2. SCOPE OF WORK

To meet the objectives described above, the following work tasks were undertaken:

1. Establishment of applicable soil/aquifer characteristics within the area of interest based on a literature review and geological log from Santos exploration bore Tanumbirini-1;
2. Assessment of the water pooling area on a flat surface using the formulae proposed by Grimaz et al. (2007);
3. Assessment of the infiltration capacity of surface soils and ponding time using the analytical Green and Ampt infiltration equation;
4. Evaluation of potential migration and attenuation of common drilling fluid constituents if materials were buried below surface as part of the management of drilling muds; and
5. Discuss the remedial technologies that would be employed if impacts to groundwater occurred due to surficial releases and associated infiltration.

2. OVERVIEW OF HYDROGEOLOGY/GEOLOGY

The area of interest where this assessment will occur is within Santos exploration areas of the Beetaloo Sub-Basin (refer **Figure 1**).

The hydrogeological unit of interest is the Cambrian Limestone Aquifer (CLA) defined as the Top Springs Limestone (also commonly referred to as the Tindal Limestone or Gum Ridge Formation) depending on which part of the basin you are in. The unit comprises massive and commonly dolomitised (and often fractured and karstic) limestone beds with minor siliclastic mudstone. Results from Santos exploration bore Tanumbirini-1 (refer **Figure 1** for location and **Figure 2** for stratigraphy), reveal that the Top Springs Limestone can be found at a depth of 52mbgl with a thickness of 150m. For detailed broad scale geological interpretation of the regions geology refer to Fulton, 2009; Kruse et al, 2013.

In the vicinity of exploration bore, Tanumbirini-1, the CLA is confined by Cretaceous siltstones mudstones. The permeability of the CLA is highly dependent on the development of dissolution and fracture features

(Fulton and Knapton, 2015). A review of water bores that intersect cavities or record circulation loss during drilling suggests that the karst development is widespread across the Beetaloo Sub-Basin and that aquifer permeability is generally not spatially correlated. Within the broader basin over 415 operational and abandoned water bores screen the CLA, with bore depths ranging from 34 – 221 m (average 105 m) (*ibid*).

Fulton and Knapton, (2015), reported airlift yields range from 0.3 – 20 l/s (average 3.5 l/s), with the standing water level (SWL) in the Gum Ridge Formation ranging from 23 to 155 metres below ground level (mBGL). Water levels along the Carpentaria Highway on Amungee Mungee and Tanumbirini stations are reported to be (125 mBGL) (*ibid*). Results from 21 pumping tests undertaken by WRD report a Transmissivity (T) range of 3 – 3377 m^2/d. The lowest T values (<50 m^2/d) occur in the northwest of the basin where the CLA has limited saturated thickness and aquifer development is restricted to the unconformity with the underlying Antrim Plateau Volcanics (Yin Foo, 2002).

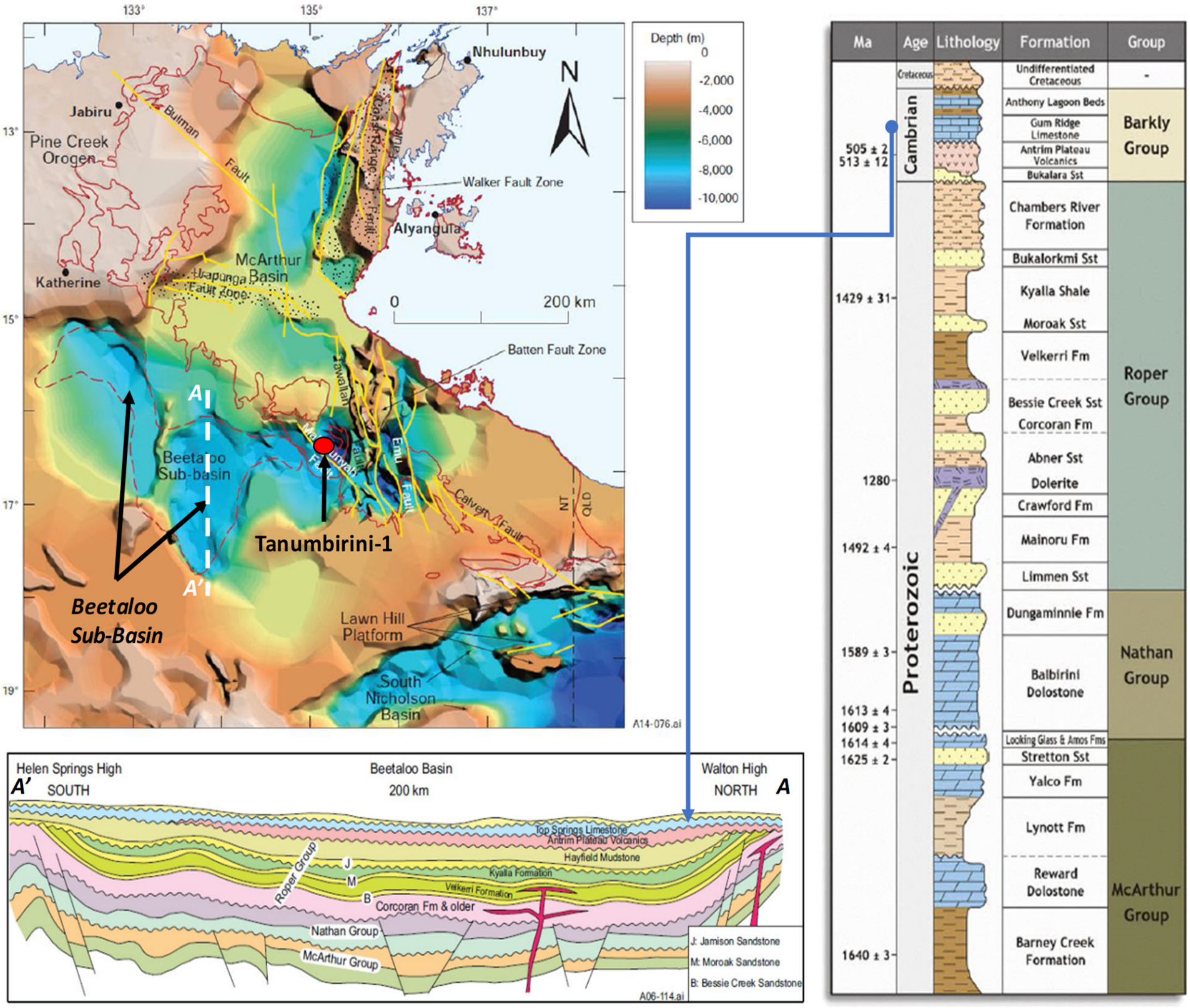


Figure 1. Location of the Beetaloo Basin along with Santos assets, stratigraphy and a north-south section. Reference used to create Figure 1: Silverman et al. (2008) [geological cross-section], and Close et al: 2016 [SEEBASE^{TM} depth-to-basin image & stratigraphic column]

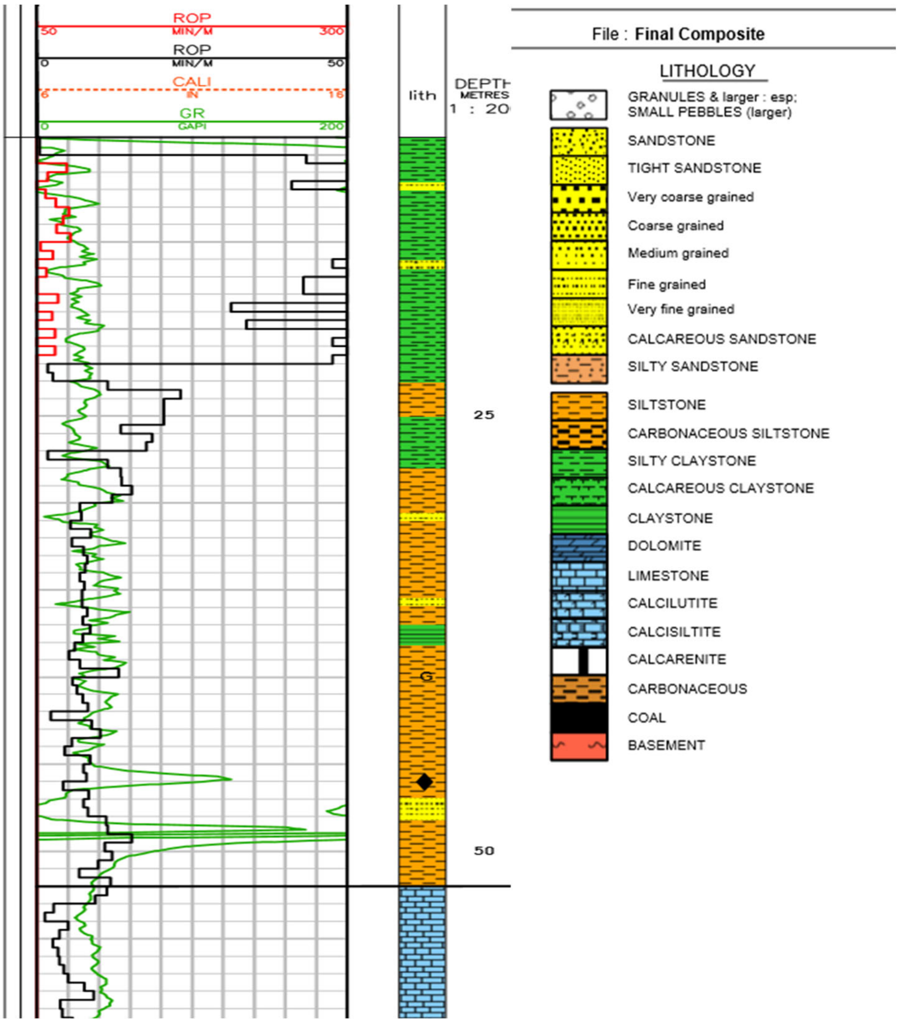


Figure 2 Shallow Lithology from Santos well "Tanumbirini-1

3. ANALYTICAL ASSESSMENT (METHODOLOGY)

3.1. WATER POOLING ON FLAT SURFACES

For instantaneous releases on flat surfaces, the formulae (**Equation 1**) proposed by Grimaz et al. (2007) was used to estimate the area of the pool of liquid on flat ground. This method is used for oil spills but can allow for water by varying the liquid properties (primarily viscosity and permeability).

$$A_{pool} \cong 2.3782 \frac{Q^{4/5}}{(k_i k_r)^{1/5}} \qquad (1)$$

Where: A_{pool} *is the area of the pool of liquid on the surface [m2]; q is the flow rate of release [m3 s-1]; Q is the total amount of liquid released [m3];* ϑ *is the kinematic viscosity of the liquid [m2 s -1]; g is the gravitational acceleration [ms-2]; ki is the intrinsic permeability of soil [m2]; kr, is the relative permeability of the liquid [-]*

3.2. TIME FOR WATER TO REMAIN ON SURFACE

Equation (**2**) taken from Grimaz et al. (2007), can be used to estimate the duration of the pool on the surface t_{ep}. and can be considered equal to the time of complete infiltration of the fluid into the porous medium. The method (**Equation 2**) is based on Darcy's Law and considers a theoretical depth of water pool and the seepage velocity at complete saturation:

$$t_{ep} = \frac{h_{tp}}{v_{p,s}} = \frac{V_{spill}}{A_{pool}} \frac{\theta}{K_w K} \frac{\emptyset_{fluid}}{\emptyset_{water}} \tag{2}$$

where; t_{ep} *is the estimated duration of the liquid pool on the surface [s];* h_{tp} *is the depth of the liquid pool [m];* $v_{p,s}$ *is the velocity of penetration of the liquid into soil in saturated conditions [ms-1];* V_{spill} *is the volume of the liquid spilt [m3]; K is the soil hydraulic conductivity [ms-1];* θ *is the porosity of soil [-],* $\emptyset$ *the kinematic viscosity [m2 s -1]; and* K_w *is the is the relative permeability of the liquid [-].*

Then, in order to estimate the percentage of fluid evaporated from the pool in t_{ep} the daily pan evaporation rate can be applied. (Fulton and Knapton, 2015) report pan evaporation ranges between 5 and 11 mm/d (average about 7-8 mm/d) in the region.

3.3. INFILTRATION INTO UNSATURATED ZONE

The spilt fluid will not only tend to spread out over the surface of the soil and evaporate, but will also penetrate into the ground (unless it is impermeable). Infiltration to the unsaturated zone, and in particular infiltration capacity and time for ponding to occur can determined using the infiltration equation of Green and Ampt (1911).

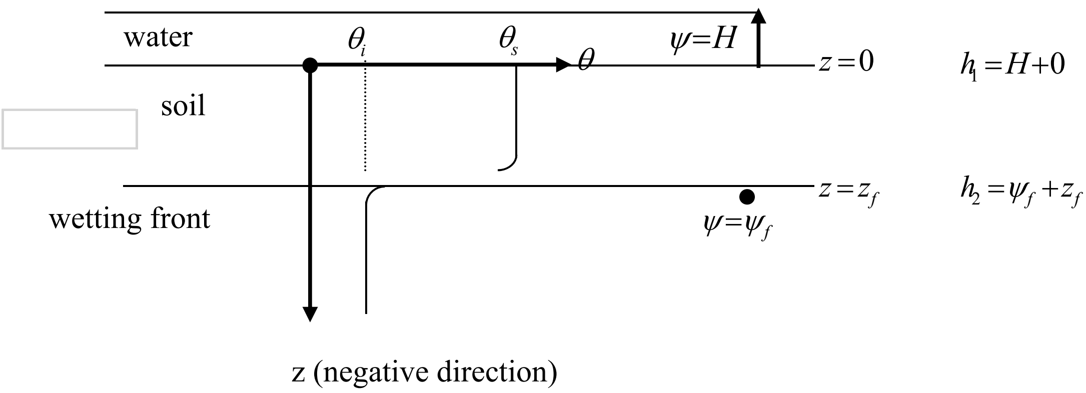
The infiltration rate actually experienced in a given soil depends on the amount and distribution of soil moisture and on the availability of water at the surface with a maximum rate at which the soil in a given condition can absorb water. This upper limit is called the infiltration capacity, f_c and is a limitation on the rate at which water can move into the ground. If surface water input is less than infiltration capacity, the infiltration rate will be equal to the surface water input rate (w). If irrigation (analogous to a release) intensity exceeds the ability of the soil to absorb moisture, infiltration occurs at the infiltration capacity rate until the soil is saturated and ponding and associated runoff occurs. Infiltration capacity declines over time until a steady state is reached.

Several processes combine to reduce the infiltration capacity. The filling of fine pores with water reduces capillary forces drawing water into pores reducing the storage potential of the soil. Clay swells as it becomes wetter and the size of pores is reduced. Coarse-textured soils such as sands have large pores down which water can easily drain, while the fine pores in clays retard drainage. If the soil particles are held together in aggregates by organic matter or a small amount of clay, the soil will have a loose, friable structure that will allow rapid infiltration and drainage.

The calculation of infiltration at a point combines the physical conservation of mass (water) principle expressed through the continuity equation with quantification of unsaturated flow through soils, expressed by Darcy's equation. The downward hydraulic gradient inducing infiltration is from a combination of the effect of gravity, quantified by the elevation head, and capillary surface tension forces, quantified by the pressure head (negative due to suction) being lower at depth due to lower moisture content. If the water input rate is greater than the saturated hydraulic conductivity (i.e. w > Ksat), at some point in time the water content at the surface will reach saturation. At this time, the infiltration capacity drops below the surface water input rate and runoff is generated. This time is referred to as the ponding time. After ponding occurs, water continues to infiltrate and a zone of saturation begins to propagate downward into the soil as the wetting front. After ponding, the infiltration rate is less than the water input rate and the excess water accumulates at the surface and becomes infiltration excess runoff. As time progresses and the depth of the zone of saturation increases, the contribution of the suction head to the gradient inducing infiltration is reduced, so infiltration capacity is reduced. Once the soil profile is completely saturated no further water can infiltrate.

3.3.1. GREEN AND AMPT INFILTRATION MODEL

The Green – Ampt (1911) model (**Equation 3**) is an approximation of the infiltration process described above and was utilised to assess infiltration capacity and time for ponding for various soils.



$$q = -K_s \frac{dh}{dz} = -K_s \frac{h_2 - h_1}{z_2 - z_1} = -K_s \frac{(\psi_f + z_f) - (H + 0)}{z_f - 0} = -K_s \frac{\psi_f + z_f - H}{z_f} \qquad (3)$$

Where: *H = the depth of ponding, cm, Ks = saturated hydraulic conductivity (cm/s), q = flux at the surface (cm/h) and is negative, f = suction at wetting front (negative pressure head),* θ_i *= initial moisture content (dimensionless) and* θ_s *= saturated moisture content (dimensionless).*

The following assumptions are implicit in the Green and Ampt equation:

1. As water infiltrates, the wetting front advances at the same rate with depth, which produces a well-defined wetting front;
2. The volumetric water content remains constant above and below the wetting front as it advances; and
3. The soil-water suction immediately below the wetting front remains constant with both time and location as the wetting front advances.

As described in the results discussion (**Section 4**), the travel times for surface releases to reach groundwater are very long and therefore the potential for impacts to groundwater are low

3.4. ASSESSMENT OF LEACHING TO GROUNDWATER

The potential risk associated with the leaching of constituents from drilling muds over time was evaluated using the VLEACH model. This model determines vertical contaminant transport from materials placed in the unsaturated zone and its response to recharge over time. VLEACH was developed by the United States Geological Service for the United States Environmental Protection Agency (USEPA) and is an industry recognised model. This model allows for very conservative modelling of organic constituents moving through the unsaturated zone towards groundwater systems.

4. ANALYTICAL ASSESSMENT (RESULTS)

4.1. WATER POOLING ON FLAT SURFACES

The “pooled area” for the instantaneous releases of fluid was determined for the following release volumes:

- 1000L ($1m^3$);
- 100,000 L ($100m^3$); and
- 1,000,000 L ($1000m^3$).

Shallow lithology obtained from exploration well Tanumbirini-1 (Figure 2), summarized in Table 1: reveals two main hydrogeological units; a relatively impermeable siltstone/claystone followed by limestone which has been reported to have highly variable hydrogeological properties (see **Section 2**).

As a result, and for the purposes of assessing surface water pooling, soil properties reflective of a clay have been applied to **Equation 1**. These are presented in **Table 2**. Therefore using, **Equation 1,** and the information presented in **Table 2,** the theoretical area of pooled water over Clay is presented in **Table 3**. For the purpose of providing comparison, a more permeable sandier soils is also presented.

Table 1 Shallow lithology at Tanumbirini-1

Depth From (mbgl)	Depth to (mbgl)	Lithology (Figure 2)	Hydrogeological Unit
0	20	Silty Claystone	Anthony Lagoon Beds?
20	52	Siltstone	
52		Limestone	Tops Springs Formation / Tindal - Gum Ridge Limestone

Table 2 Modelling Input Parameters

Parameter	Clay / Claystone / Siltstone	Permeable Sandstone / Limestone	Literature Source
Porosity	0.482*	0.4**	* Dingman, 1994 **Knapton 2009
Saturated Hydraulic Conductivity (Ksat) (cm/s)	0.0007	0.038**	**Knapton 2006 (based on relevant aquifer transmissivity and thickness)
Air-Entry Tension (cm)	40.5	12.1	Dingman, 1994
Saturated Tension (cm)	30.78	9.2	Dingman, 1994
Intrinsic permeability (m^2)	$1x10^{-13}$	$1x10^{-8}$	Dingman, 1994

Table 3 Model Results - Pooled Water Area

	Volume Released (L)	Volume Released (m3)	Area (m2)	Radius (m)
Clay / Claystone / Siltstone	1,000	1	947	17
	100,000	100	37691	110
	1,000,000	1000	237820	275
Permeable Sandstone / Limestone	1	1	95	6
	100,000	100	3770	35
	1,000,000	1000	23782	87

4.2. TIME FOR WATER TO REMAIN ON SURFACE

Using **Equation 2**, the results presented in **Table 3** and assuming the kinematic viscosity of the fluid is 1x10-6 m^2/s and a Kh:Kv of 1:100, the time it will take for a 5cm deep pool over the 1ML spill area is ~6 days. For a smaller spill of 1,000L, infiltration time is less than 1 day (~2 hours).

4.2.1. GREEN AND AMPT INFILTRATION MODEL

The results of the Green and Ampt Infiltration equation are present in **Table 4**.

As there are two distinct hydrogeological units (siltstone to a depth of ~50m followed by karstic limestone). The time it takes for water to infiltrate 50m through the siltstone (to the top of the limestone) and the time to migrate through an additional 50 m (to a depth of 100 m) and 150 m of limestone (to a depth of 200m) has been calculated to enable evaluation of travel times based on the potential variable depth to groundwater within the limestone across the field.

Previous studies have indicated the CLA (limestone) can be highly fractured and karstic (refer **Section 2**), a sensitivity analysis assuming k is 100 times greater in this limestone has been undertaken. This has also been applied to the overlying siltstone.

The results indicate that any spill will take ~690 years to move through the initial 50m before rapidly moving though the more permeable limestone. To provide a comparative / conservative case where permeability of the sub surface is increased by 2 orders of magnitude, travel times to the top of the CLA reduce to ~7 years. Furthermore, under each spill scenario, the release rate exceeds the infiltration capacity of the subsurface, therefore as the area increases with each spill (refer **Table 3**), the driving force on the wetting front remains the same and is constrained by the permeability.

It should be noted that the assessment is highly conservative. Due to CLA aquifer anisotropy, bulk basin scale hydraulic conductivities are likely to be lower than those modelled. Further the higher hydraulic conductivities used in the sensitivity analysis for the siltstone are considered improbable based on literature information for this unit.

Table 4 Green and Ampt Modelling Results

	Time for wetting front to reach 50 mbgs (days)	Time for wetting front to reach 100 mbgs (days)	Time for wetting front to reach 200 mbgs (days)
Siltstone (K = 0.000007 cm/s; 0.01 m/d)			
Run 1	252267 (690 yrs)		
Run 2	252267 (690 yrs)	-	-
Run 3	252267 (690 yrs)		
Karstic Limestone (K = 0.005 cm/s; 4.3 m/d)			
Run 1	-	252271 (~690 yrs)	252275 (~690 yrs)
Run 2		252271 (~690 yrs)	252275 (~690 yrs)
Run 3		252271 (~690 yrs)	252275 (~690 yrs)

Run 1 = 1,000L spill;
Run 2 = 100,000L spill
Run 3 = 1,000,000 L spill

Table 5 Green and Ampt Modelling Results (Sensitivity Analysis K = 100x Increase)

	Time for wetting front to reach 50 mbgs (days)	Time for wetting front to reach 100 mbgs (days)	Time for wetting front to reach 200 mbgs (days)
Clay (K = 0.0007 cm/s; 0.6 m/d)			
Run 1	2522 (~7 yrs)	-	-
Run 2	2522 (~7 yrs)	-	-
Run 3	2522 (~7 yrs)	-	-
Karstic Limestone (K = 0.5 cm/s; 432 m/d)			
Run 1	-	2523 (~7 yrs)	2523 (~ 7yrs)
Run 2	-	2523 (~7 yrs)	2523 (~7 yrs)
Run 3	-	2523 (~7 yrs)	2523 (~7 yrs)

Run 1 = 1,000L spill;
Run 2 = 100,000L spill
Run 3 = 1,000,000 L spill

4.3. ASSESSMENT OF BURIAL/MANAGEMENT OF DRILLING MUDS

Based on the chemistry for example drilling muds (refer **Table 6**), leaching assessments were conducted on a scenario where drilling muds were stabilized (by blending with native soils to manage residual moisture) and compacted and placed below ground surface. The blend of drilling muds and cuttings produces a low permeability material with a high cation exchange capacity (CEC). This typically results in metals and metalloids being strongly bound within the muds and the mud and cuttings exhibiting very low permeabilities. Drilling muds by design typically exhibit permeabilities between 1×10^{-8} m/s and 1×10^{-10} m/s.

For the purposes of this assessment it has been assumed that the hydraulic conductivity of the blended materials it is assumed that the combined material will have a hydraulic conductivity no lower than 1×10^{-6} m/s. Typically the drilling muds are buried 1-2 m below ground surface to ensure the materials are below the rooting depth of crops and plants and the area graded to prevent ponding and preferential infiltration of water.

For the purposes of the modelling, only water soluble organic compounds were assessed (insoluble organic compounds like starch and polymers would have no mobility in the formation) and Sodium from Sodium Chloride was evaluated conservatively by assuming no attenuation (although cation exchange with the dominant calcium ions would impede vertical migration of sodium and potassium). Furthermore, as the lithology is likely to be rich in clay, a sensitivity analysis was undertaken on Sodium to increase its “retardation factor” or Distribution Coefficient by 2 orders of magnitude.

The VLEACH model results for each chemical constituent (BOLDED, in **Table 6)** are presented in **Figure 3**.

The results indicate that the modelled constituents take a very long time to move through the subsurface and contain immeasurable concentrations once below several meters depth even before dilution and without taking into account biodegradation.

Table 6 Drilling Mud Chemistry (BOLD values indicate those subject to VLEACH Modelling)

Chemical Name	**Concentration in Drilling Mud Solids (mg/kg)**
Ethylene oxide/propylene oxide copolymer	24
Polyalkylene	22260
Polypropylene glycol	48
Silicic acid, potassium salt	22200
Sodium Chloride	**45600**
Sodium polyacrylate	1092
Copolymer of acrylamide and sodium acrylate	702
Glutaraldehyde	**300**
Glyoxal	31

Chemical Name	**Concentration in Drilling Mud Solids (mg/kg)**
Methanol	**3**
Potassium Chloride	41520
Sodium Carbonate	78
Sodium carboxymethyl cellulose	3117
Sodium Hydroxide	300
Starch	3058
Xanthan Gum	3060
Methylisothiocyanate (MITC)	30

Table 7 Constituent Properties

	Concentration in drilling (mg/L)	Organic Distribution Coefficient (ml/g)	Henry's Law Constant (atm-m3/mol)	Water Solubility (mg/L)	Free Air Diffusion Coefficient (m2/day)	Source
Methanol	3000	0.014	0.0001937	1000000	1.296	GSI Chemical Properties Database (http://www.gsi-net.com/en/publications/gsi-chemical-database.html)
Glutaraldehyde	300,000	0.07	0.0000108	85500000	0.096	GSI Chemical Properties Database (http://www.gsi-net.com/en/publications/gsi-chemical-database.html)
Sodium Chloride	29,900,000** (converted from **Table 6)**	1930* / 19.3	1E-20	360000**	0	*Bencala (1985) **http://srdata.nist.gov/solubility/index.aspx

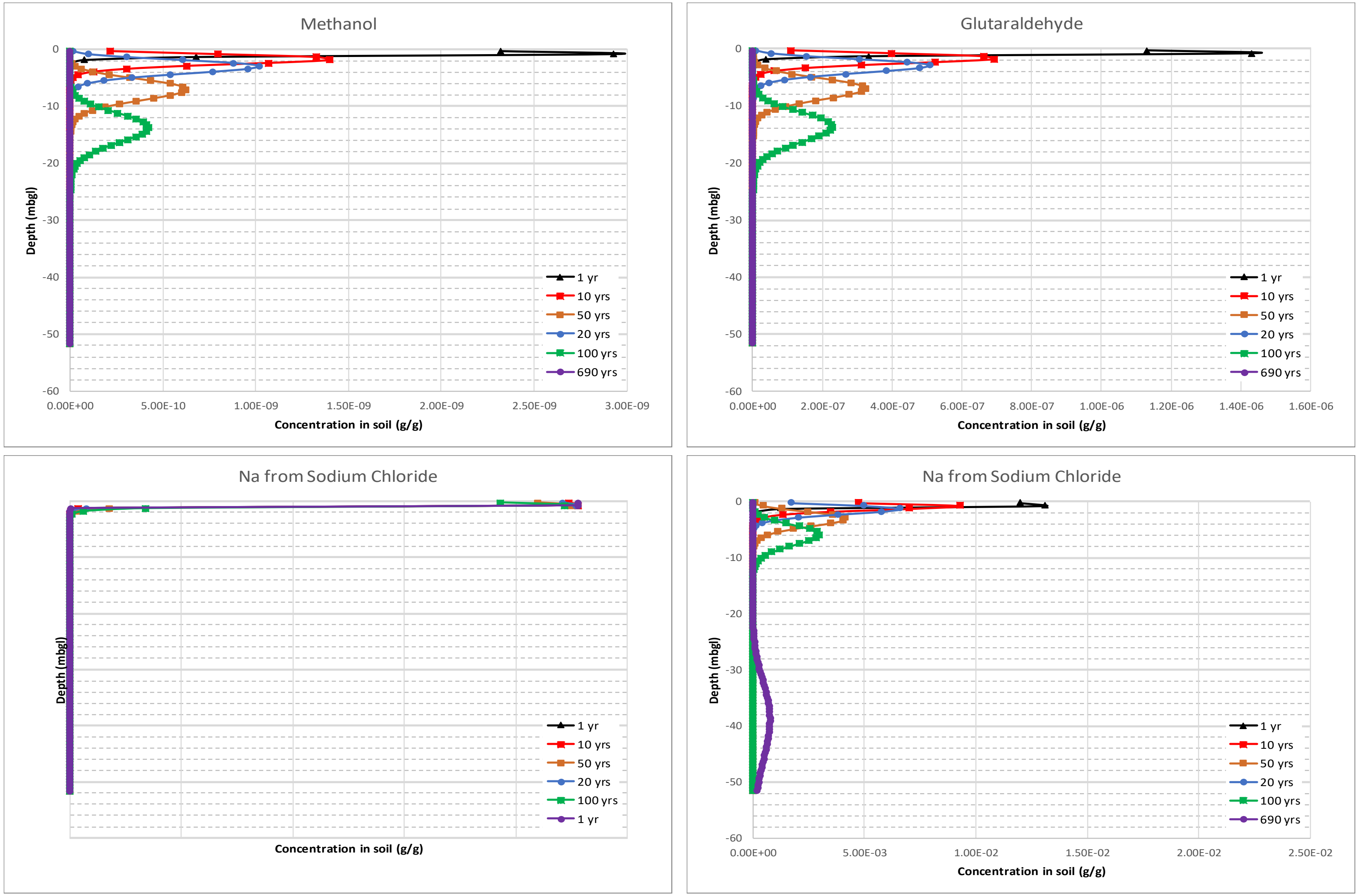


Figure 3 **VLEACH Results. [Note: Bottom left Na assumes a Distribution Coefficient 2 orders of magnitude higher then bottom right results].**

5. REMEDIAL OPTIONS OF GROUNDWATER

Based on the modelling provided above and considering the retardation processes in the formation, only water soluble constituents have the potential to migrate to and impact on groundwater. As demonstrated in the assessment above, the potential for impact on groundwater is considered limited and travel times are sufficient slow (>500 yrs to travel 50m) that management/monitoring and remediation (if required) could be implemented.

In the context of this hydrogeologic system, which has deep and prolific aquifer systems and considering the constituents of potential concern are soluble compounds, groundwater extraction and water treatment provides the best remedial option (if needed).

Based on the drilling fluid constituents that may impact on groundwater a range of treatment options are available including open air storage to facilitate natural dissociation, photodegradation, etc, biological treatment for alcohols, glycols, glutaraldehyde (they biodegrade rapidly in the presence of oxygen), activated carbon absorption (non-polar organics) and ion exchange. All of these technologies are readily available and could be quickly implemented.

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Appendix I: Stakeholder Engagement Records

Table I-1: List of Relevant Stakeholders

Stakeholder	Role/Position	Phone number	Email or other contact
Aboriginal Affairs Protection Authority			
	Chief Executive Officer (CEO) AAPA		
Landholders/Managers			
	Tanumbirini Station Manager		
	Beetaloo / O.T Downs Station Manager		
	Broadmere Station Manager		
Northern Land Council			
	Manager Minerals and Energy		
Northern Territory Government			
	Executive Director – Onshore Gas Reform (DENR)		
	Executive Director (DPIR)		
	DENR		
	Senior Onshore Petroleum Advisor		
	Senior Assessment Officer - Petroleum		
	Regional Weed Officer (Onshore Shale Gas Development) – DENR		

Table I-2: Stakeholder Engagement Records

Stakeholder	Role / Position	Date	Type of Contact	Method of Contact	Matters Raised	Written Responses Received	Santos Response (If required)
	Tanumbirini Station Managers	1-2 Feb 2019	Face to face	Consultation	Accompanying CSIRO crew conducting methane survey	No	None Required
	Thames Pastoral	25 Jan 2019	Email	Consultation	Completed Santos 2018 activities and initiate engagement for Santos plans for 2019 and requirement for LACA	No	None Required
	Tanumbirini Station Managers	24 Jan 2019	Email	Notice of entry	EP 161 CSIRO Methane Survey Activity	No	None Required
	Tanumbirini Station Managers	18-20 Dec 2018	Face to face	Consultation	Close out 2018 Santos activities and face to face conversation about Santos plans for 2019	No	None Required
	Tanumbirini Station Managers	19 Oct 2018	Email	Notice of Entry	2019 Beetaloo Drilling Program Scout EP 161	No	None Required
	Tanumbirini Station Managers	18 Oct 2018	Email	Consultation	Ongoing communication regarding accommodation requirements at Tanumbirini Station	No	None Required
	Tanumbirini Station Managers	15 Oct 2018 /16 Oct 2018	Email	Consultation	Accommodation requirements/availability at Tanumbirini Station	No	None Required
	Tanumbirini Station Managers	15 Oct 2018	Email	Notice of Entry	EP 161 Water Bore Baseline Monitoring	No	None Required

Stakeholder	Role / Position	Date	Type of Contact	Method of Contact	Matters Raised	Written Responses Received	Santos Response (If required)
	Tanumbirini Station Managers	Oct 2018-Jan 2019	Phone calls and text messag es	Consultation	Numerous phone calls and text messages regarding Santos activities – survey, accommodation, contractor camp, civil activities for bore drills	No	None Required
	Tanumbirini Station Managers	24/10/2018 / 23/10/2018 / 22/10/2018	Face to face/ Email / Email	Consultation	Daily contact onsite on Tanumbirini Station regarding requirements to access bores, fuel equipment etc.	No	None Required
	Beetaloo Station Managers	25/10/2018 / 24/10/2018	Face to face/ Email	Consultation	Met onsite on Beetaloo Station regarding requirements to access bores and planned activity.	No	None Required
	Tanumbirini Station Managers	16/10/2018 / 15/10/2018	Email	Communication	Correspondence regarding CSIRO and Santos representatives conducting bore monitoring and accommodation requirements	No	None Required
	Broadmere Station Managers	17/10/2018/ 15/10/2018	Email	Communication	Update on Beetaloo groundwater monitoring program	No	None Required
	Tanumbirini Station Managers	19/10/2018	Email	Notice of Entry	Survey and Scout for 2019 Beetaloo Drilling Program	No	None Required
	Beetaloo / O.T Downs Managers	15/10/2018	Email	Notice of Entry	Beetaloo - Groundwater monitoring EP 161	No	None Required

Stakeholder	Role / Position	Date	Type of Contact	Method of Contact	Matters Raised	Written Responses Received	Santos Response (If required)
	Tanumbirini Station Managers	15/10/2018	Email	Notice of Entry	Tanumbirini - Groundwater monitoring EP 161	No	None Required
	Tanumbirini Station Managers	6/10/2018	Email	Notice of Entry	2018 Work Program Tanumbirini – Survey	No	None Required
	Broadmere Station Managers	29/08/2018	Email	Notice of Entry	Beetaloo groundwater monitoring program	No	None Required
	Tanumbirini Station Managers	12/08/2018 11/08/2018 10/08/2018 09/08/2018 08/08/2018 07/08/2018	Face to face	Consultation	Daily contact onsite on Tanumbirini Station regarding requirements to access bores, fuel, equipment and updates on progress etc.	No	None Required
	Beetaloo / O.T Downs Managers	24/04/2018	Email	Notice of Entry	Beetaloo groundwater monitoring program	No	None Required
	Tanumbirini Station Managers	24/04/2018	Email	Notice of Entry	Beetaloo Groundwater Monitoring Program	No	None Required
	NLC Manager Minerals and Energy	16/01/2019	Email	Work Program	In accordance with clause 5.1(c) of the EP 161 Co-operation and Exploration Agreement Santos provided a Work Program (Northern Scope) and supporting spatial files with respect to areas within EP 161 where it proposes to undertake activities. (Full Program provided Below)	No	None Required

Stakeholder	Role / Position	Date	Type of Contact	Method of Contact	Matters Raised	Written Responses Received	Santos Response (If required)
	NLC Manager Minerals and Energy	26/04/2019	Email	Communication	EP 161 Enabling Activities 2018: Report to AAPA and Summary Report to Operator	No	None Required
	NLC Manager Minerals and Energy	10/05/2019	Email	Communication	Santos - Certificate for Variation to C2014/053 over EP 161 Northern Areas (AAPA ref: 201900379)	No	None Required
	NLC Manager Minerals and Energy	17/06/2019	Email	Communication	Informing NLC of Notice of EMP Approval	No	None Required

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Telephone: 08 8116 5111

WP-19-0002
15 January 2019

CONFIDENTIAL – Commercial in Confidence

Attention: Native Title
Parties Representative
C/o Northern Land Council
45 Mitchell Street
Darwin NT 0800

Mr. Malcolm Hauser
Senior Project Officer
Borroloola - Barkly Region
Minerals and Energy
Northern Land Council
45 Mitchell Street, Darwin NT 0801

Dear Malcolm,

WP-19-0002_EP 161_McArthur_2019_Work Program – Northern Scope

Santos (QNT) Pty Ltd (Santos), in accordance with clause 5.1(c) of the Co-operation and Exploration Agreement, EP 161, provides this Work Program with respect to areas within EP 161 where it proposes to undertake activities. The areas identified in this submission (Tanumbirini North and Inacumba North; or collectively the **Northern Locations**) are identical to those submitted, and subsequently surveyed by the NLC and Traditional Owners, in 2013/14 and resulted in an Anthropological Report being provided to AAPA and the attached AAPA Authority Certificate C2014/053 being issued. These locations were also surveyed more recently in late 2018, although for the purpose of drilling water bores rather than exploration wells; these activities are covered by AAPA Authority Certificate C2018/105.

Many of the activities included in this submission, such as exploration drilling, have therefore, been the subject of previous sacred site surveys. These areas have also been the subject of previous surveying associated with seismic activity undertaken in 2013 (Authority Certificate C2013/142).

This submission includes further activity at the previously surveyed Northern Locations, as outlined in summary below and in detail in the attached tables and annexures. We request the opportunity to inform the host Traditional Owners via a community consultation and for the host Traditional Owners to review the Northern Locations (and their access routes) via a remote mapping exercise given the extensive and recent sacred site surveys. Noting the timeframes to undertake work in 2019 any assistance in expediting the process for the Northern locations would greatly assist the planned 2019 exploration program.

In parallel to this submission, Santos will also submit a work program for identical activity clearances at two locations (Tanumbirini South and Inacumba South; collectively the **Southern Locations**) where water bore installation has recently been approved but approval for exploration drilling has not previously been sought via the work program process. We understand that approvals for the Southern Locations are unlikely to be able to be expedited given that they will likely require sacred site surveys following the 2018-19 wet season along with community consultation.

Scope (Northern Locations)

Approved by and entirely within the areas included in Authority Certificate C2014/053 and Authority Certificate C2018/105:

- Civil engineering activity – upgrading and creation of new access tracks, lease pads, water bore installation and water extraction as required (note that water extraction will require a Water Extraction License)
- 2D seismic acquisition

New activities for approval in the areas included in Authority Certificate C2014/053 and Authority Certificate C2018/105:

- Civil engineering activity – upgrading and creation of new access tracks, lease pads, water bore installation and water extraction as required (note that water extraction will require a Water Extraction License)
- 2D seismic acquisition
- Exploration drilling – both vertical and horizontal drilling (where horizontal wells will be contained entirely within the 5km radius subject area)
- Well evaluation – including wireline logging, formation testing, core acquisition, fluid sampling, open-hole formation integrity testing (i.e. DFITs) and other standard oilfield evaluation techniques as deemed appropriate
- Hydraulic fracture stimulation
- Flow-back and production testing
- Well suspension and/or well decommissioning
- Ongoing site and well maintenance and monitoring, work-over and re-entry, and evaluation as required

Details of the proposed project work activities are included in the attached tables and annexures, and have been identified by undertaking a combination of desktop assessment and information from locations previously scouted.

Purpose

The purpose of exploration and appraisal activity undertaken at the Northern Locations in 2019, 2020 and beyond is to increase our understanding of the prospectivity or potential of the EP161 permit area. Our objective whenever undertaking such activity is to minimise our impact on the environment, including any activities of Traditional Owners and pastoral lessees.

AAPA Authority Certificate

Santos will seek an Authority Certificate from Aboriginal Areas Protection Authority (AAPA). As previously agreed and discussed, the NLC will undertake the on ground assessment remote assessment and provide the report findings to AAPA in the AAPA template which has been previously provided.

Work Program Meeting

Santos is available to attend work program meetings on country or, in the absence of a work program meeting, resource the NLC accordingly to meet any community requirements. Santos is willing to fund and resource interpreters or any other specific requirements to meet community requirements.

Well Locations and Coordinates

Refer to the attached maps, spatial data and the table below for the coordinates of the proposed project works, including access.

Attachments
Please refer to the attachments which contain maps, spatial data, tables and descriptions of the proposed activities proposed at each location with approximate coordinates of the proposed well locations under application:

1. Attachment 1: Summary table, maps, tables of proposed work activities and locations.
2. Attachment 2: Annexures describing industry work activities
3. Attachment 3: GIS data and supporting imagery

Santos is seeking your approval to proceed on this basis and look forward to meeting at an agreed date to discuss in detail and progress this work program.

Santos also notes the importance of the community consultation requirements to ensure the host traditional owners are adequately consulted and informed of project activities. We look forward to working with the NLC to ensure the community consultations fully inform the host traditional owners.

Please contact Che Cockatoo Collins on the details below if you require any further information or clarification of the proposed works.

Kind regards,

** Names Redacted **

Attachment 1 – EP 161

1. Summary of proposed activities

All of the activities included in Table 1 and annexures are subject to extensive regulatory approvals or review by the Department of Primary Infrastructure and Resources, the Department of Environment and Natural Resources, the Environmental Protection Authority, and other regulatory agencies. Moreover, substantial baseline data acquisition (including water monitoring bores installed at least six months prior to drilling hydraulic fracture stimulation activity) is required under the Petroleum Act and associated Petroleum Environment Regulations. Further details regarding these approvals and or approval submissions can be provided on request.

Table 1. Summary of the Proposed Work Program

(A) The nature, scope and objectives of proposed activities;	Please refer to Annexures for detailed descriptions of the exploration activities summarised in this table, which include 2D seismic, exploration drilling, hydraulic fracture stimulation, flow-back and production testing, well monitoring and site maintenance, and associated civils works. The annexures detail the following activities that could potentially be proposed at both the Tanumbirini North and Inacumba North locations: • 2D seismic acquisition (Annexure 1) • Wellsite civils works, access and camps (Annexure 2) • Diagnostic Fracture Injectivity Testing (DFIT) (Annexure 3) • Exploration drilling and evaluation (Annexure 3) • Microseismic and tiltmeter monitoring (Annexure 3) • Fracture stimulation (Annexure 3) • Flow or production testing (Annexure 3) • Completion including suspension and/or well decommissioning (Annexure 3) • Ongoing well and site monitoring, maintenance, work-over and evaluation Refer to the provided maps and spatial data for proposed locations, access, and approximate areas of disturbance. All proposed work activities will be located within the boundaries of the AAPA Authority Certificates C2014/053 and C2018/105.
(B) The estimated time and period for the performance of such activities;	It is proposed that seismic and civils activity could commence as early as Q2 2019 and that drilling activities could commence in late Q2 2019. However, activity commencement will require substantial approvals and it is possible some or all activity will be deferred until 2020. Activity could be repeated in future years at these locations pending appropriate notification and discussion by Traditional Owners through On Country Work Program meetings. **The following summarises typical time-frames for discrete work packages or activities and reflects the planned 2019 or 2020 (pending approvals) work program plan. In future years, timings could vary and activity**

could reduce. It is unlikely that 2D seismic acquisition will be repeated and, once access and a well lease is constructed, these activities will not be repeated (although maintenance will be required).

4-12 weeks – Lease and Access Track Preparations:
Access track preparation, well pad construction and associated works will be undertaken in preparation for drilling operations. Where possible existing access tracks will be upgraded; however, new access tracks will be created (within the surveyed areas only) if it achieves the objective to minimise the overall impact of the operations. Temporary camps will be used to support these activities.

2-8 weeks – Seismic Acquisition (well focused not regional surveying):
Line preparation and surveying typically takes 1-2 weeks depending on the extent of the survey. The seismic recording crew then typically commence 1-2 weeks after line preparation and surveying crews and will typically take a further 1-2 weeks to complete the seismic survey. The extent of any surveying that could be considered under this clearance request is relatively limited as it will be contained within the 5km radius buffer around the well lease.

60-90 days (per well) – Drilling Phase:
Following completion of lease and access track preparations, the drilling phase is anticipated to take approximately 60-90 days per well.

15-40 days (per well) – Fracture Stimulation Phase:
Following completion of drilling and well completion, the fracture stimulation phase is anticipated to take approximately 15-25 days per well.

3-5 days (per well) – Completion Phase:
Pending the initial gas flow rates, wells may be completed with a tubing string that is run in the well to improve productivity. The tubing will be installed with a workover rig and is anticipated to take approximately 3-5 days per well.

Flow Testing Phase and Well Suspension:
Subject to a successful reservoir outcome, the well will be put on extended flow test for an initial period of approximately 90 days. We will seek approvals to extend the flow testing period for one or more years from the Northern Territory regulator for early exploration wells to allow key data to be gathered. Flaring will be used to ensure hydrocarbon gases are safely and efficiently handled. Such approvals will be subject to rigorous environmental management plan approvals. Subsequent to any flow testing the well will be suspended. A build-up test may be incorporated into the well suspension to aid in the evaluation of the well results. Following the build-up test a successful test well will likely be suspended until a development project is sanctioned or a well is decommissioned at the end of the project life.

	Further on-going well integrity monitoring, well-head maintenance, site maintenance, in-hole evaluation and work-over will be performed as required. If required, Santos will provide further details prior to the field work and as planning progresses
(C) The techniques, infrastructure and major items of equipment to be used;	**Civils Surveying:** Surveying of proposed access tracks, leases, gravel/borrow pits, camp sites and associated facilities will be carried out using 4WD vehicles and GPS units utilising existing roads and station tracks where possible. **Road Construction:** Existing access roads and tracks will be upgraded and widened (within approved subject land area only) to accommodate larger vehicles and the drilling rig mobilisation to well site. New access roads or tracks will be created where necessary to access the lease pad or minimise our overall environmental impact or impact on pastoral lessee infrastructure or activities. The attached maps (Attachment 1) and spatial data show the locations of the proposed access tracks based on previous scouting and authority certificate subject lands. All proposed access tracks are within the clearance area of the C2014/053 Authority Certificate and/or the C2018/105 Authority Certificate. Changes to these proposed routes may occur to minimise overall impact; however, at no times will the surveyed area previously approved by Traditional Owners (via the NLC) and AAPA (under C2015/053 and C2018/105) be exceeded. **2D Seismic Acquisition:** Refer to Annexure 1 for details of the 2D seismic survey process **Well Pad / Lease Construction:** Well lease construction will include clearing and stockpiling, grading and capping with clay/suitable material if deemed required based on ground condition. Construction of turkey's nests and above ground storage tanks will occur if required. Stockpiled vegetation and top soil will be respread as part of the rehabilitation process, following well decommissioning (which may be some or many years in the future depending on exploration and appraisal activities and project success). **Drilling Activities:** The wells will be drilled using either drilling mud or air hammer as required to suit formation properties. Wells will be either vertical only (i.e. a vertical well), or initially vertical with a subsequent inclined section leading to a lateral or horizontal section (i.e. a deviated or horizontal well). Vertical well sections could vary between approximately 1000m and 4500m and horizontal sections could vary from less than approximately 250m to in excess of 3000m (where the absolute limit of any horizontal well

	would be the area surveyed and cleared for sacred sites (i.e. the clearance area). Where possible, drill core and/or cutting samples and/or fluid samples will be obtained for geological assessment and analyses as per Santos and regulatory requirements. **Evaluation Activities:** Open-hole wireline logs will be acquired over the open-hole sections as per Santos and Northern Territory Government requirements. In addition to wireline logging Santos may undertake formation testing, open-hole formation integrity testing (i.e. DFITs) and other standard oilfield evaluation techniques as deemed appropriate. Vertical seismic profiling may also be completed, this activity combines surface seismic activities (Annexure 1) with down-hole wireline evaluation tools (geophones). **Diagnostic Fracture Injection Test (DFIT):** A DFIT refers to the act of injecting small volumes of a clear fluid, typically water (usually with a small percentage of Potassium Chloride e.g. 2 to 3% KCl) at low pumping rates to create a fracture before the wellhead is shut-in and the pressure allowed to fall-off naturally. The fluid contains no proppant so that the fracture can relax and close naturally when pressure is released. The pressure changes are measured with high-accuracy gauges that are either placed deep in the wellbore or at surface on the wellhead. The analyses of fracturing pressure, during injection and after shut-in, provide information data for understanding and improving the fracturing process. The DFIT process differs from fracture stimulation in a number of key ways, primarily it is of a much smaller scale, does not involve pumping proppant, and is not intended to induce hydrocarbon production. **Well Completion Activities:** The wells will have casing set in the well to meet the design objectives of the well and the meet the standards from the NT Well Operations Code of Practice and the Santos Drilling and Completions Management Process (DCMP). Casing will be set in order to isolate shallow aquifers present, isolate any geohazards that may present like significant formation losses or tight hole, as well as being designed to withstand the expected forces during hydraulic fracturing. Each casing string will be cemented in place to ensure aquifer isolation and overall wellbore integrity is maintained. Once each casing is cemented in place, it is pressure tested to ensure the cement and casing meet and/or exceed their design specifications. The final casing string, the production string, is tested to above the maximum anticipated pressure to stimulate and confirm the integrity of the designed well envelope. **Hydraulic Fracture Stimulation Activities:** Prior to the hydraulic fracture stimulation (or frac) “spread” (the term used to describe the various trucks and equipment needed to frac) arriving on location, the well will be logged to confirm the cement bond and ensure isolation between the fracture stimulation target intervals and shallow aquifers. A number of valves are

	installed on the wellhead known as the "Christmas Tree" which are rated to above the maximum designed surface pressure, and allow for the transfer of fluid and proppant/sand into the wellbore. The complete system is then pressure tested again to simulate hydraulic fracturing conditions. Intervals to be fracture stimulated will be perforated using a shaped charge which creates small holes in the casing providing a conduit between the wellbore and the formation. The combination of water, proppant and chemicals (generally <2% of total mix) known as the slurry are mixed together at surface using a "blender" – see Annexure 4 for summaries of the chemical composition of potential frac fluids and solids that could be included, and note that they are typically used at low concentrations (the final fluid composition must be provided to the NT Government as part of the environmental approval process). The slurry is transferred to pumps that convert it from low pressure to high pressure, and allow it to be injected through the wellhead into the well, and ultimately into the formation that is being hydraulically fracture stimulated. After each frac stage, a plug is pumped down on wireline and the next frac stage is perforated, and the process starts again. At the completion of hydraulic fracturing, Coiled Tubing is used, which is run in hole with a motor and mill on the end to remove the isolation plugs in place. After reaching the bottom of the well with the coiled tubing and establishing a flow path to the surface for all frac stages, the well flowback commences in order to recover the frac fluids pumped into the well. Fracture Diagnostics are often used to determine the fracture effectiveness and allow for future optimisation. Chemicals Tracers may be pumped with the slurry at a known concentration. Their concentration during flowback can be measured to determine the relative contribution from each stage. Microseismic geophones may be used either at surface or in a neighbouring well, to listen for the very small seismic events that are created during fracture stimulation. Triangulation is used from the geophone array to determine the location of the event and hence gain a picture for fracture dimension (height and length) and direction. Tiltmeters may be used to gain an understanding of the micro deformation that takes place during a frac. These small changes can be used to determine the verticality of the frac and also indicate the direction in which the fracture has propagated. The installation of either surface geophones or tiltmeters is low-impact, and down-hole geophones have no impact on the environment. **Flow-back and Well Testing Activities:** Some flow testing may be conducted with the drilling rig on location prior or post open hole logging activities. Subject to a successful reservoir outcome, wells will be flow tested for an initial period of approximately 90 days.

	We will seek approvals to extend the flow testing period for one or more years from the Northern Territory regulator for early exploration wells to allow key data to be gathered. Flaring will be used to ensure hydrocarbon gases are safely and efficiently handled. Such approvals will be subject to rigorous environmental management plan approvals. **Well Status:** Exploration wells in the McArthur/Beetaloo area are exploration wells with relatively high uncertainty on reservoir outcome. The following activities may occur post logging evaluation: 1. The well will be suspended with steel casing cemented in place for future re-entry; or 2. The well will be decommissioned. As part of the well suspension process, wellbore barriers will be put in place as per Santos and Northern Territory regulatory requirements. A well integrity monitoring plan will be put in place for any suspended well for monitoring of wellbore barriers. As part of well decommissioning process, cement plugs will be permanently placed in the well as per Northern Territory regulatory requirements. The wellhead will be removed; leases and roads rehabilitated and signed properly as per Northern Territory regulatory requirements. **Site Rehabilitation Activities:** For any decommissioned well, the well pad and associated camp sites, etc. will be rehabilitated to ensure minimal disturbance. For any suspended well, the wellhead area will be fenced off and the well pad site rehabilitated as much as practical to ensure re-entry for well integrity monitoring and intervention activities can be maintained. Further technical details can be provided on request. **Camps** Camps may be constructed within the approved subject lands to support the above activities. These camps may be capped with suitable clay material if required based on ground conditions. Preference will be given to utilising previously disturbed areas. All camps will be covered by a valid Environmental Management Plan and comply with all conditions of that plan to minimise environmental impacts.
(D) The likely Environmental Impact of such activities and proposals to minimise the Environmental Impact, in particular, the disturbance to Native Title Parties;	Where possible, access roads, borrow/gravel pits, leases, camp sites and associated works will be planned so as to use existing station roads and/or access roads or resources to minimise any new disturbance. Access tracks planned to be utilised have been identified from initial scouting activities. Where it is not possible to use existing

	tracks and access roads, due to the requirements of heavy vehicle access (where upgrading of the existing track is not feasible), some new access tracks will need to be constructed. New access tracks will not exceed the approved subject lands in the authority certificates referenced above. Roads/access tracks could extend up to 10m either side of centre line (i.e. up to 20m in width). Where possible and practical new access tracks will be oriented to minimise or avoid disturbance to land systems and native flora. Santos will construct stock proof fencing around specific work areas such as drilling sumps and pits, to minimise potential impacts on native fauna and livestock. Where possible, consideration of the use of above ground tanks/water storage facilities will be included in the project scope of works to reduce the disturbance footprint and minimise environmental impact. Following completion of drilling activities, remnant fluids will be left in-situ (lined sumps or lined ponds) to evaporate with the ability to transfer to covered above-ground pond as per the NT Well Operations Code of Practice. Where the volume of remnant fluid poses a risk of overflow during the wetter part of the year, fluids may be removed from site or stored (on-site) temporarily in purpose built containers. Chemicals will be stored in appropriately bunded and designated areas for the duration of the drilling operations. No surplus chemicals will be left on site after the well is decommissioned or suspended. In shale hydraulic stimulation treatments, water accounts for more than 90% of the mixture and sand accounts for about 5-9%. Chemicals generally account for less than 1% of the mixture and assist in carrying and dispersing the sand in the low permeability rock. In accordance with regulatory requirements, the chemicals additives are subject to full disclosure. The chemical additives are not specific to the hydraulic fracture stimulation process, having many common household uses such as in swimming pools, toothpaste, baked goods, ice cream, food additives, detergents, cosmetics and soap. An above ground water storage tank provides temporary water storage for use in the hydraulic stimulation process. Source water can either be trucked from a nearby water source or piped along a temporary network. Small dosages of biocide are added to control algal growth particularly under warm and stagnant conditions. Following completion of works, temporary water storage infrastructure is removed from site. The equipment and machinery required to carry out a hydraulic stimulation operation is highly mobile and able to be installed and removed relatively quickly (generally within a couple days). They are designed to comply with state and federal regulations for road transport, and are fitted with safeguards such as an in-vehicle monitoring

	system (IVMS) to ensure compliance of the individual contractors. For any decommissioned well, the well pad and associated camp sites, etc. will be rehabilitated to ensure minimal disturbance. For any suspended well, the wellhead area will be fenced off and well pad site rehabilitated as much as practical to ensure that re-entry for well integrity monitoring and intervention activities can be maintained. Further technical details can be provided on request.
(E) The proposed means of access and access routes for personnel and equipment, both into and within the Permit Area, including particulars of the amount of vehicular and airborne access and any proposals to construct or upgrade roads, landing strips, or other access facilities;	Please refer to Attachment 1 for details of the proposed access routes for personnel and equipment and proposals to construct or upgrade roads. Please note that multiple access options have been included; however, these will not all be required for the final scope. The amount of vehicular access will be variable during the scope of proposed activities, but Santos will aim to design proposed infrastructure that does not adversely impact Traditional Owners, pastoral lessees, nearby industry or the general public. **Initial Access Roads** Planned earthworks are required to provide a safe and practical work area and access to drill exploration wells, water wells, campsites, airstrips and for other operational needs. The access roads for the Northern Locations already exist, but may need upgrading in some sections to meet Santos standards, which are designed to accommodate heavy vehicle usage. Regular watering may occur to reduce dust and additional capping may be added to the surface to reduce maintenance or closure following periods of rain. **Landing Strip** Airstrips and Helipads are commonly used to bring the workforce from a main centre closer to worksites with the aim of reducing fatigue and exposure to land transportation risks. Existing landowner airstrips will be utilised and upgraded under agreement to a condition where charter operator (for crew change), or RFDS or Careflight Air Ambulance (emergency evacuation) aircraft can be accommodated. Helipads may be constructed at each wellsite to provide additional direct access to remote wellsites. **Initial Mobilisation and Final Demobilisation:** Initial mobilisation of drilling rig requires approximately 80-120 loads/trailers mobilised to the nominated Wellsite. A combination of standard trailer loads and oversize loads (for which the required permits for transport will be in place with the NT government) will be used. Demobilisation will involve moving all equipment out from location via the proposed access routes. **During drilling activities:**

	A small number of trailer loads to the wellsite will be required, with some mobilisation of equipment to lay down areas via a combination of trailerised loads (singles, doubles, road trains). A daily commute will occur by 4WD vehicle for crew changes between campsite and rig site. Road maintenance will include the application of imported capping to repair creeks or holes, the addition of water to the road surface to restore compaction or reduce dust generation, and grading to restore drainage by reshaping the road profile or removing rutting. Rollers will be used where necessary to aid compaction. **Fracture stimulation** Initial mobilisation of the frac spread and associated services like coiled tubing and wireline will require approximately 40-60 loads/trailers mobilised to the nominated wellsite. There will also be 50-100 loads to the wellsite required to transport frac materials like proppant to the location. Demobilisation will involve moving all equipment out from location via the proposed access routes. There will be a daily commute by 4WD to mobilise and demobilise crews from the camp to the frac spread and vice versa. **Flow testing:** Minimal personnel, some trailerised equipment haulage to site for initial set up of equipment and then 4WD transport as required for monitoring during flow testing activities. **Well Integrity Monitoring** Scheduled visits for well integrity monitoring one or two personnel as required.
(F) Any fly-camps or other camp sites of less than five days duration proposed to be used;	When and where feasible, temporary local accommodation (i.e. Tanumbirini Station) will be considered to minimise environmental impact. Camps may be constructed within the subject areas. These camps may be capped with suitable clay material if required based on ground conditions. Preference will be given to utilising previously disturbed areas.
(G) Any water, timber or other resources proposed to be obtained from within the Permit Area and surrounding areas;	**Water bores:** Drilling of new water bores and use of existing water monitoring bores are the preferred water supply sources; followed by use of existing station water bores. Water bores have been previously constructed by Santos proximal to the Tanumbirini North and Inacumba North locations, so it may not be necessary to install more. However, further water bores may be installed if needed and will always be located within the subject land. The water taken from water bores is limited by the conditions of the NT Government Water Act provisions and/or appropriate water extraction licence(s) In addition, earthen water holding pond(s) and loadout facilities may be constructed and fenced as required.

	Water will be used for drilling and fracture stimulation purposes and for road maintenance as required. **Construction materials (soils and gravels):** Where in-situ materials are unsuitable, additional fill/clay/rubble for capping of roads, flood-ways, landowner pipeline crossings and leases will be sourced from approved areas; wherever possible this will be done by extending existing quarries or borrow pits. **Borrow/gravel pits:** Borrow pits may be required as a source for extraction of construction materials. The presence of suitable borrow/gravel pits within the subject land approved areas has been confirmed through initial scouting. Management practices include stockpiling cleared vegetation and topsoil in separate piles for respreading over progressively reclaimed areas, and areas to be restored will have battered edges. Maximum excavation depth will be based on the available soil types and volume; however, excavations will not typically extend beyond 3m depth. Where possible, materials stockpiled for construction will be stored within the cleared area and transferred to site as required. Mixing of water with materials to create a cohesive mix may be undertaken at the pit or at the construction site – e.g. lease pad or roadway.
(H) The estimated costs of implementing such activities;	$80m to $100m 2019 budget estimate only. Future activities beyond 2019 will be budgeted separately.
(I) Any proposals concerning employment, training and business opportunities;	To be determined. Santos will provide further details as logistical and program requirements are finalised. Refer to section J below.
(J) If known, the identity of any proposed contractors and sub-contractors engaged or likely to be engaged and the minimum and maximum number of personnel likely to be on the Permit Area from time to time and their roles in undertaking such activities;	**2D seismic acquisition** The contractor is unknown at this point in time as the procurement process is ongoing. At any one time, the seismic crew may consist of approximately 15 personnel, including: ▪ Line preparation (4 personnel); ▪ Surveying (2 personnel); and ▪ Seismic recording (15 personnel). The crew will consist of plant operators, surveyors, line labourers, truck drivers, technical personnel, camp support personnel, paramedics and field management personnel. **Civil Works Wellsite & Access Road Construction** *(Includes Water Bore Construction)* At this point in time the procurement process is ongoing. Santos has been in discussion with several contractors who have good indigenous engagement and local

	experience. It is expected that the following companies will be invited to tender for the 2019/20 scopes of work. • Cairns Industries • Crowhurst / Goodline • Intract • MS Contracting • Rusca Bros • Yindwati At any one time, the civil works crew may consist of approximately 20 personnel, including: ▪ Site management (3 personnel); ▪ Water Bore Drillers (4) ▪ Earthmoving Construction Crew (9) and ▪ Support Crew (4) The crew will consist of plant operators, water bore specialists, truck drivers, camp support, and field management personnel. **Drilling** Primary drilling contractor is proposed to be Ensign Australia Pty Limited for the 2019 program. Future programs could use other, equally qualified, drilling services providers. For other services, Santos will initiate preliminary discussions with contractors to ascertain availability and operational capacity. Further information can be provided once these arrangements are finalised. **Fracture stimulation** The most common contractors for hydraulic fracture stimulation scopes of work are Halliburton, Schlumberger and Condor. We anticipate that one, or a combination, of these companies will undertake the frac works. Each company is highly experienced and qualified for the activities in scope. The workforce associated with this phase of activity will vary from approximately 10 to 40 depending on the specific daily activities undertaken.
(K) The chemical composition of any fluids and solids proposed for use in Hydraulic Fracturing of potential Hydrocarbon producing formations;	Refer to Annexure 4 for a list of chemicals used by Halliburton, Schlumberger and Condor in Fracture Stimulation operations. If chemicals other than those listed are proposed for use, these will be provided to the NLC and disclosed to Traditional Owners at On Country Work Program meetings.
(L) The area, or where appropriate, line distance the subject of such activities (in square or, where appropriate (for example, seismic lines and roads), line kilometres); and	The proposed 2019 work program includes an approximately 10km 2D seismic line around the Tanumbirini North location (see maps below), which is entirely within the previously surveyed area of Authority Certificate C2014/053. The line will not interact with any sacred sites or 'cleared with constraints' areas and will be planned to minimise environmental impact. Any future seismic survey is likely to be of a similar scope, or would require separate cultural heritage and sacred site clearances. Please refer to the below maps and the spatial data provided.

(M) Any other aspect of such activities that is likely to have any Environmental Impact, or in particular, any impact upon Native Title Parties.	Santos has procedures and extensive experience in operating in arid environments. Santos will ensure that any risk of long term impact is minimised and that there is no risk or impact to sacred sites and cultural heritage as a result of the work. To ensure there is no risk or impact to sacred sites and cultural heritage as a result of the proposed work, it is suggested that representative/s of the Traditional Owner group/s accompany the team where possible for any sampling, survey, or construction activities. Santos also welcomes the involvement of local Traditional Owner groups to provide cultural awareness training, welcome to country, and to visit the operations during our activities.

2. Areas of proposed work activities

The proposed work activity falls within previously approved NLC reviewed & AAPA authorised areas approved under AAPA Authority Certificates C2014/053 and C2018/105 that were granted in April 2014 and December 2018 respectively (Figure 2.1.1). This application provides a refreshed work program detailing proposed activities within the approved areas and ensuring that no activity will occur within the identified restricted work areas (RWAs). Pending authority, council and state approvals Santos would propose to commence seismic & civil activities as early as Q2 2019. Access track preparation, well pad construction and associated works will be undertaken in preparation for seismic and drilling operations. Where possible existing access tracks will be upgraded; however, new access tracks will be created (within the surveyed areas only) if it achieves the objective to minimise the overall impact of the operations. Temporary camps will be used to support these activities and will remain with the current cultural heritage authorised areas.

2.1 Inacumba North Lease Pad and Access

Civils work at Inacumba North is proposed to facilitate access and prepare the area for the exploration of the Inacumba well. The approximate coordinates of the proposed location are presented in Table 2.1.1. GIS files are attached to this application that complement the scope of work described Table 1. Figure 2.1.1 is a location map showing the Inacumba North Area.

Projection	GDA94 Zone 53, CM 135°
Latitude	16˚ 30’ 58.92” S
Longitude	134˚ 50’ 33.11” E
Easting	483196
Northing	8173939

Table 2.1.1: Approximate wellhead coordinates of proposed 2019 Inacumba North well.

2.2 Tanumbirini North Wellsite Infrastructure & Access

Civils work at Tanumbirini North is proposed to access and prepare the area for the exploration and appraisal of the Tanumbirini wells. Tanumbirini-1 well coordinates and the approximate coordinates of the proposed Tanumbirini-2H location are presented in Table 2.2.1. GIS files are attached to this application that complement the work-scope briefly described in Table 2.2.2. Images have been provided in figures 2.2.1 to 2.2.4 as a guide of the approximate location of each zone proposed in the lease pad area and access to the lease.

Location	Projection	GDA94 Zone 53, CM 135°
Tanumbirini-1 (drilled in 2014)	Latitude	16° 23' 56.59" S
	Longitude	134˚ 42’ 13.76” E
	Easting	468375
	Northing	8186900
Proposed Tanumbirini-2H well (2019 program)	Latitude	16° 23’ 58.01”S
	Longitude	134° 42’ 12.71”E
	Easting	468344
	Northing	8186856

Table 2.2.1: Approximate wellhead coordinates of proposed 2019 Tanumbirini North well

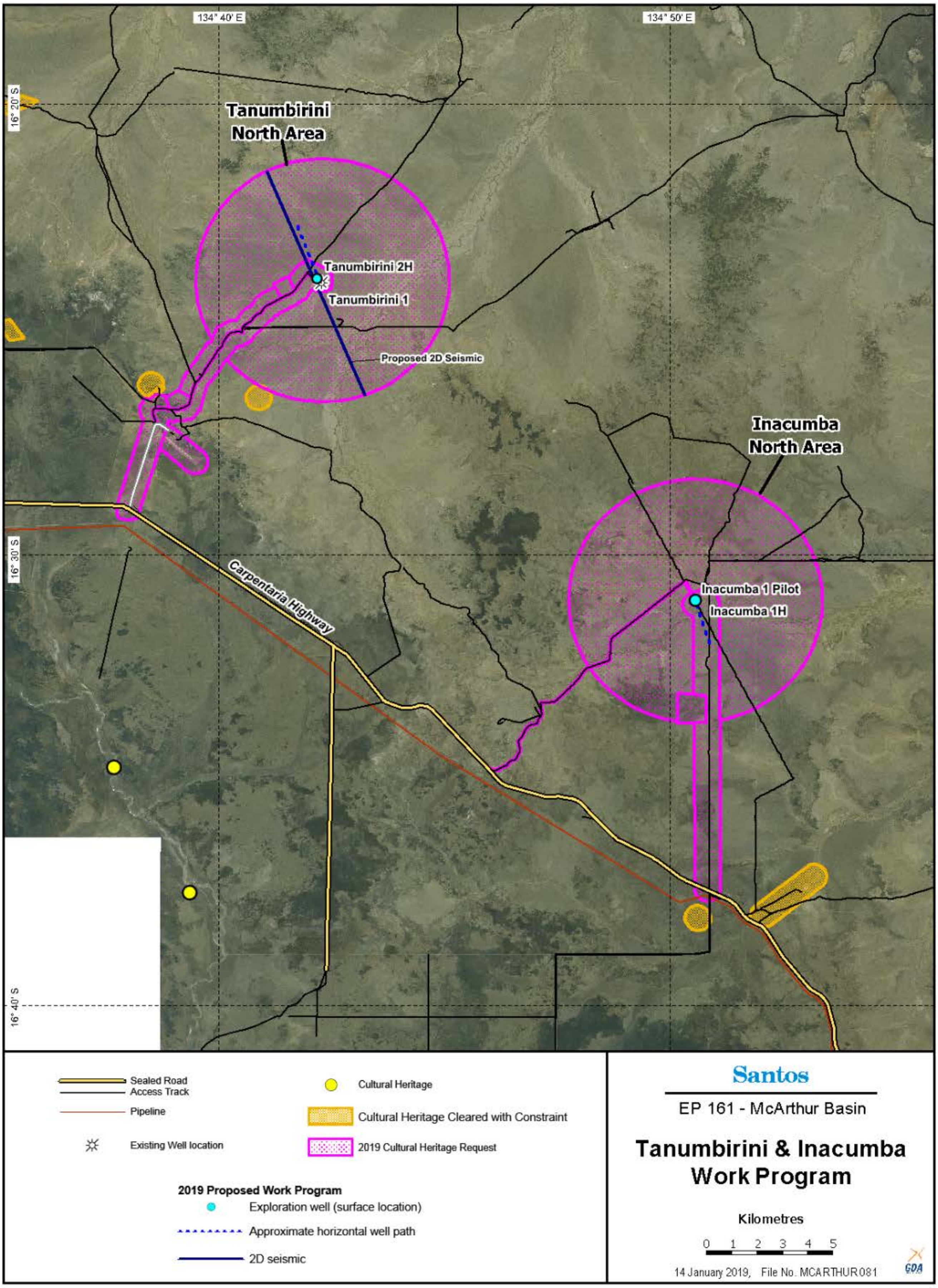


Figure 2.1.1: Overview of the Northern Area showing the Inacumba North Area and Tanumbirini North Area.

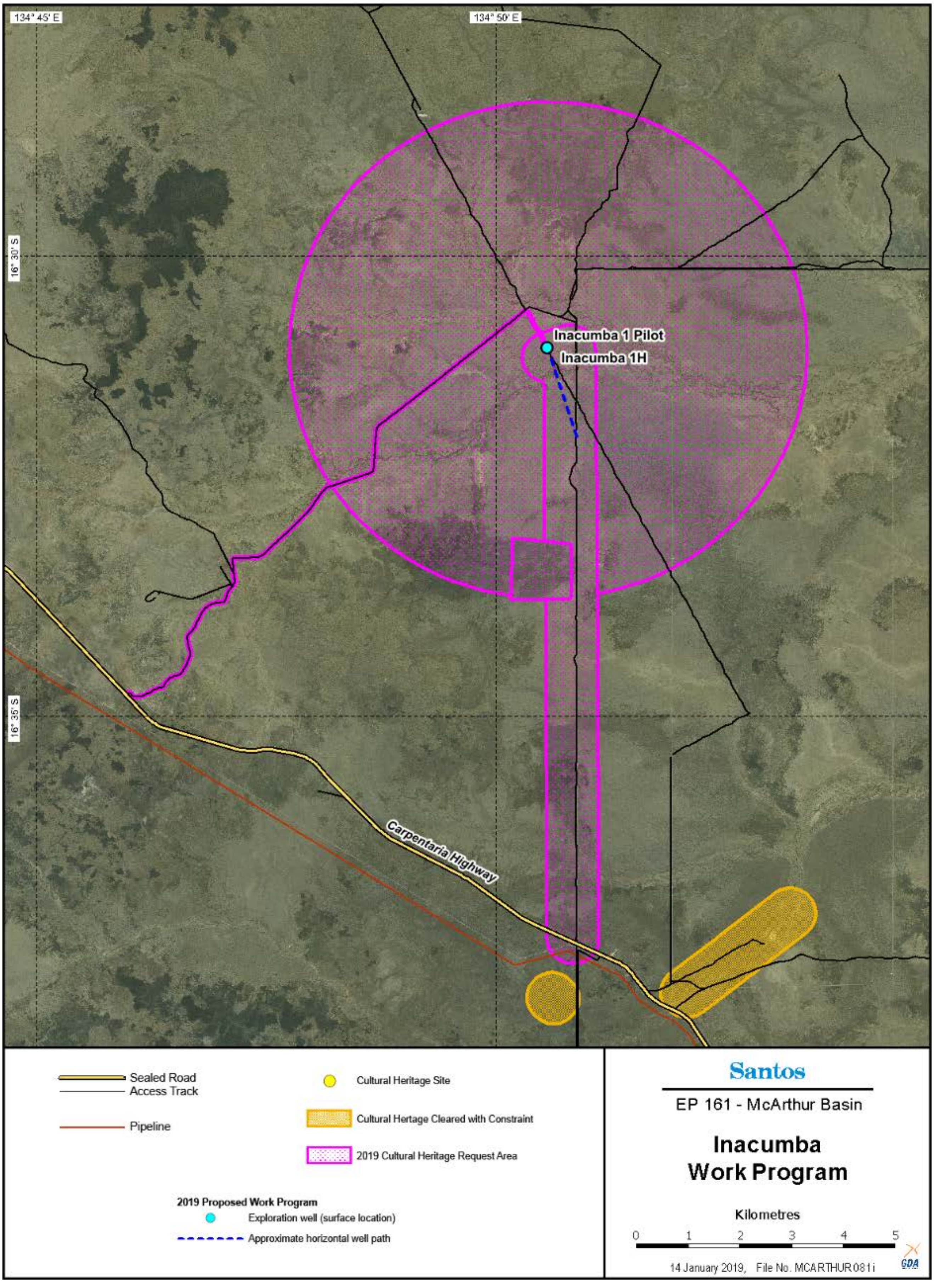


Figure 2.1.2: Map showing the Inacumba North Area

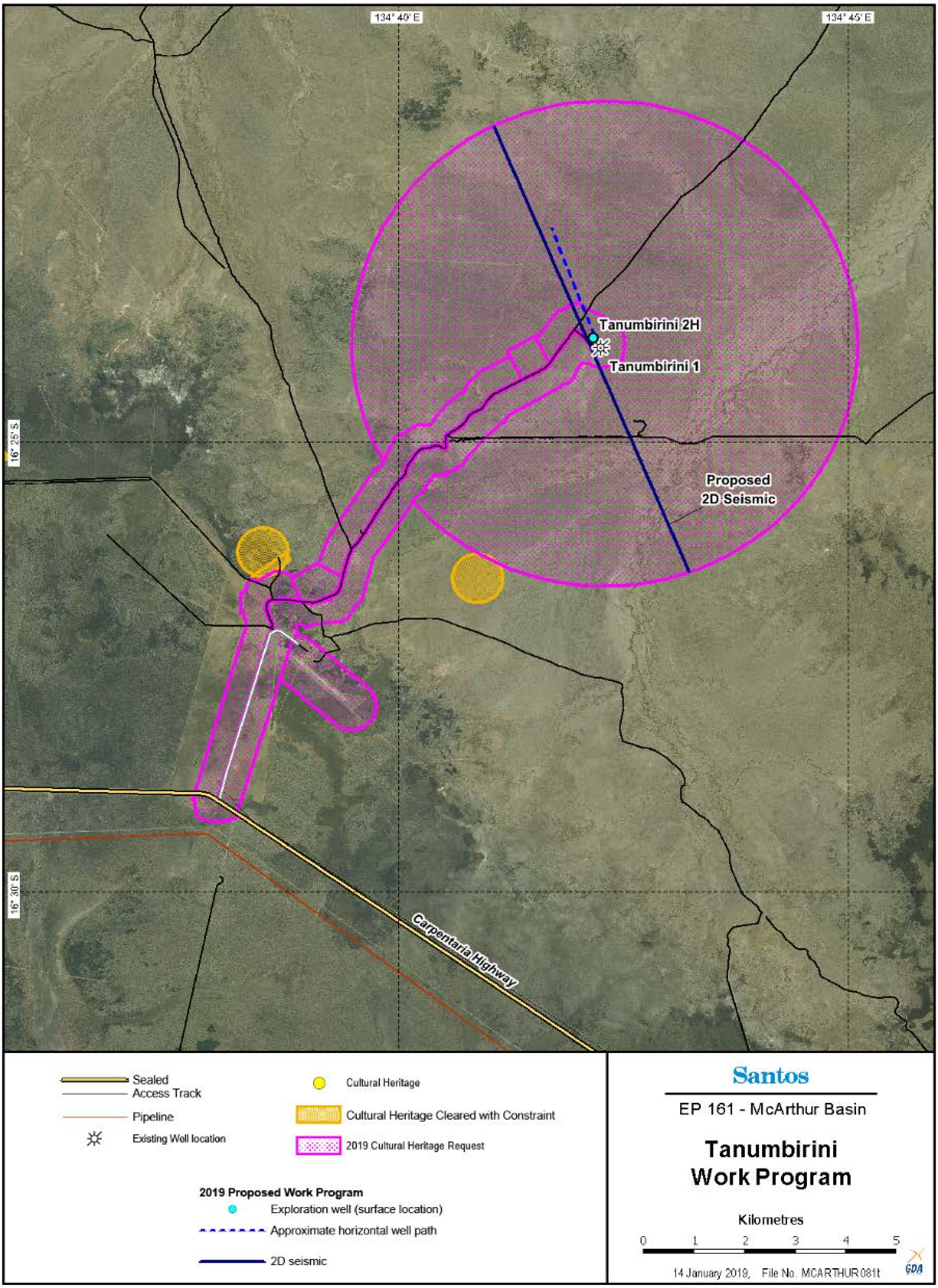


Figure 2.2.1: Tanumbirini North Area

__Attachment 2 – ANNEXURES__

Annexure 1 – Description of 2D Seismic Operations

The seismic method

Seismic acquisition allows the explorer to 'image' below the surface and identifies areas where oil and gas may have accumulated. The seismic method uses energy sources such as vibrator trucks (or equivalent) to generate sound waves that travel into the earth and are then reflected from subsurface geological structures. The returning reflections are recorded in a digital format and sent to a seismic data processing centre to produce a 'cross-section' of the layers of the earth's crust. The following sections explain the field procedures for recording seismic data.

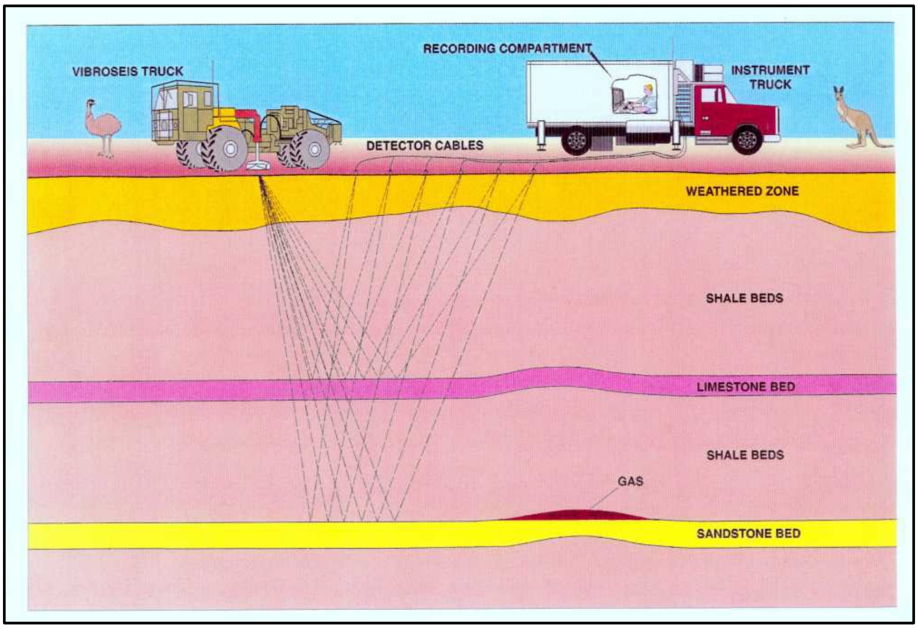


Figure: Schematic of typical seismic acquisition operation

Planning

Once the exploration team have proposed a seismic program, the line layout is plotted onto detailed topographic maps and aerial images to begin planning the survey.

Seismic surveys can be of a regional nature covering a very large area including the first look at an area or an infill type survey that is infilling other seismic surveys. Typically infill surveys are a tighter density of lines covering a smaller area than a regional survey.

Regardless of their regional or infill nature, a seismic survey can be as small as a single line or up to dozens of lines totalling hundreds of linear kilometres. In the case of an infill type survey, the lines will usually be set out in a rough grid with line spacing ranging between 0.5 – 5km.

2D Seismic lines are used to layout the seismic detectors that pick up the reflected sound waves and are also travelled by the vibrator trucks that provide the sound waves recorded on the seismic detectors.

Seismic lines are usually prepared tracks that are 4-5 m wide. The energy source for conventional 2D seismic lines typically moves along the line as recording progresses. The seismic lines are carefully laid out to avoid sensitive environmental sites as well as cultural features such as buildings, dams, water wells and known cultural heritage sites. The key aspect of field acquisition is to get equipment (usually vehicular based) and personnel along the planned seismic lines and acquire sufficient data to adequately 'image' the subsurface.

The safety of field personnel is a key aspect of any seismic operation. This involves compromise between what is logistically, environmentally and economically possible.

Cultural heritage clearance

A cultural heritage clearance is usually the first field activity to occur on a 2D seismic survey. Clearance logistics vary from project to project. The appropriate method for the project is decided during early discussions between representatives of the explorer and the Native Title Claimants/Traditional Owners.

Depending on the method used, Santos may employ a field liaison officer who will be the link between the field clearance operation and Santos. He/she will work closely with Traditional Owners and will provide survey support to the group if required.

In the case of the McArthur, all requests for Cultural Heritage Clearance are directed to the Northern Land Council who will then in turn consult with Traditional Owners and their own technical specialists to facilitate approval to proceed with the survey. Typically this approval will come with a number of conditions that must be abided by for the survey to proceed.

No work will commence on the ground by Santos or any of its contractors until this approval (whatever its form) is obtained.

Seismic Line and Access track preparation

Once the line positions for a project have been cleared by the cultural heritage group(s), the line preparation crew can commence work.

The line preparation crew usually operates simultaneously on different lines using D6 bulldozers (or equivalent) for the initial pass and then a grader may be utilised for tidy up work if required. Daily production of prepared line varies greatly and is primarily dependent on the terrain. It may vary from 5-20km per day per machine. In areas of low or sparse vegetation, the bulldozer will be utilised to simply walk with the blade up in easily traversable terrain, with the marks of the tracks being sufficient for the grader (if required) and the surveyors to follow. Where required for safety reasons, the blade may be used for minor clearing of topsoil or sand dune access. Blade work is kept to a minimum and generally restricted to skimming the top off rough ground to provide safe access for subsequent operations.

The grader that follows the dozer simply tidies up the resultant line. If any windrows are left behind the grader will knock them down to prevent any channelling of rain water and thereby prevent future erosion. In many areas, the dozer will simply walk and there will be no work required by the grader.

All machine operators are given detailed project inductions at the start of each survey with project specific issues discussed in great detail such as Cultural Heritage, Environmental, Safety and infrastructure requirements.

The line positions are pre-programmed into GPS units mounted in the dozers. These GPS units allow the dozer operators to get real time position updates. These are plotted on a display that also indicates the Cultural Heritage cleared corridor for the dozer operators.

The dozers weave around vegetation stands and on open ground the machines weave every 75-100m to reduce the visual impact. Other items such as roads, infrastructure, detours plus any exclusion zones or restricted work areas are also displayed on the dozer GPS units so the operator has a detailed project map shown in relation to their position at all times.

Figure: Example seismic line (Mereenie) after line Preparation

The line preparation personnel typically operate out of a small mobile self-contained camp that moves with operations regularly. The project surveyors are also normally accommodated in the same camp along with a paramedic and Santos supervisor.

The line preparation phase may last anywhere from a couple of days to a couple of months dependent on the size of the survey.

Seismic Line Surveying

Surveying commences within a day or two of the commencement of line preparation.

A survey team is typically made up of a Senior Surveyor and a number of GPS operators. The senior surveyor is typically responsible for all office work plus doubles as the dozer pointer to assist the dozer operators if they are working in a highly constrained area. The GPS operators are responsible for surveying each seismic line and placing the required survey markers.

The GPS operators use real time kinematic GPS receivers to position receiver/source points. Surveyors generally insert numbered wooden pegs and plastic tipped “pin flags” to indicate the points; however, a seismic line can be “stakeless” in special circumstances such as when working on properties with a certified organic status. Markers protrude about 30cm above ground level and may be placed as deep as 100mm in soft sandy terrain. All of these markers are removed on completion of the recording phase. Line detours are often marked with biodegradable flagging, which is also removed. Each survey team (one surveyor in a light 4WD vehicle) generally makes only one pass over any given section of line.

Figure: Light 4WD vehicles used to pass along proposed seismic lines.

Back packing of the survey effort occurs in areas where line preparation and vehicle access routes have deviated from the true line position and markers have to be inserted on foot. This could be due to a variety of reasons, the more common being Cultural Heritage restrictions, environmental restrictions or infrastructure concerns. In these situations, the following recording crew will position cables and geophones by foot and no vehicles would traverse the area.

Figure: Surveyor pegging on newly prepared seismic line

Surveying operations are normally run in conjunction with the line preparation operation and therefore have about the same duration.

Seismic Data Recording

Approximately 1-2 weeks after the line preparation and surveying are completed in an area, the recording operation will commence. This operation is the largest part of the seismic operation in terms of personnel and vehicles. Depending on the size of the program, a 2D recording crew would normally number up to 35 personnel and up to 15 light vehicles. It should be noted that the bulk of the on ground equipment is transported to site in heavy vehicles. These heavy vehicles will only be used on existing tracks/roads and will not travel along the seismic lines.

Work commences with the deployment of small seismic detectors (geophones) that contain the geophone element, a GPS receiver, hard disk storage and a battery. These are deployed along the line at a pre-determined interval, dependent on geophysical target, which can be between 2.5m and 25m increments.

Figure: Seismic line crew deploying geophones

Recording would normally commence when a sufficient number of geophones have been deployed. This layout is termed “the spread” and it picks up the acoustic energy transmitted from subsurface layers during the seismic surveying process, converts it to electrical energy and stores that information on a hard drive within the unit. Surveys may have up to 12km or more of spread live at any one time.

Recording consists of the vibrator trucks travelling along the line and stopping at regular increments, generally between every 10m and 20m, to “shake” the ground. After shaking in one spot for around 12-15 seconds, the trucks will move onto the next point along the line and shake again. During this, the trucks are centrally located in the line spread, resulting in around 6km of spread behind the trucks and 6km in front of the trucks. The seismic labourers (or “juggies”) rotate the redundant spread from behind the vibrator trucks to in front of the vibrator trucks continuously throughout the day to ensure the vibrators can continue without delay.

Figure: Seismic line crew planting geophones

Figure: Geophone planted in the ground

Once the vibrators are finished on a line, the final spread behind the vibrators is picked up and the line is complete.

Figure: Seismic Recording Truck

All operational vehicles stay on the prepared line with the exception of parked vehicles that have to park off line to avoid causing noise on the spread and interference with line traffic. While parked off the prepared line, vehicles remain within the corridor cleared by the cultural heritage teams.

Along any single line the following vehicle passes can be expected to occur during normal operations.

Bulldozer: 1 pass
Grader: 1 o r 2 passes
Light vehicles: Multiple passes during surveying and recording operations.

Seismic Line/Access Track and Campsite Restoration
Once a seismic line is completed, restoration work may commence if required. The majority of seismic lines and access tracks do not require restoration work, as one of the main objectives is to prepare and utilise them in a way that will facilitate rapid natural recovery. However, instances that can give rise to restoration are:

- It is a requirement of the project Environment Plan for all lines to be restored
- Wheel ruts have been created after wet periods or bulldust
- Windrows have not been fully removed by the grader
- Windrows need to be removed at intersection of lines and public tracks
- Public access tracks need to be reshouldered where necessary
- Access tracks have sustained damage due to extensive seismic traffic.

Normally a single grader is all that is required to carry out the restoration work. Methods used for rehabilitation include;

- Ripping of compacted areas with rear tynes
- Windrow material and vegetation pushed onto the line
- Public road windrows reinstated.
- Wheel rut material used to infill affected areas.
- Affected water course channels and creek banks reinstated to pre-survey profile.

Environmental Monitoring

During the above activities the maintenance of environmental standards are monitored closely by the Santos field representatives and Contractor section heads. All crew personnel are environmentally inducted prior to start up. Environmental monitoring points (EMP's) are set up close to easy vehicle access and the natural rehabilitation is monitored photographically over a period of years until rehabilitation is complete.

Annexure 2 – Description of wellsite civils works and access

Various earthworks are required to provide a safe and practical work area and access to drill gas wells, water wells, campsites, airstrips and other operational needs. The construction designs will be determined by a framework that supports users, landowner and regulatory needs.

All civil work activities will be fit for purpose and will be undertaken to minimise impacts on Traditional Owners, pastoral lessees, nearby industry or the general public. Design and construction will be appropriate for:

a. The types of vehicles that need to use the road.
b. The type of road planned and the surface material – e.g. high clay (Black Soil), dunefields or fine bulldust soils require differing construction and maintenance requirements.
c. Expected weather conditions – i.e. all weather access and mobility can be improved by formation design, adequate drainage, plus capping with rock, rubble, or "Durabase Matting".
d. The conditions of the approved Environmental management plan, which requires a civil solution to manage erosion, wildlife impact, bushfire, and flood risks.

Optimally designed, planning and execution of civil works are critical to ensure that:

1. **Wellsites** are constructed to create safe, fit for purpose work areas that include several distinct zones:
   i. Drill hardstand is level and compacted using selected fill that supports the loads and pressures of drilling rig equipment operations.
   ii. Drill pad work area is level and surrounds the drill hardstand – this area needs to be compacted and support ancillary equipment like generators, fluid treatment systems, piperacks and forklifts.
   iii. Wellsite work areas that surround the drill hardstand and cuttings pits have a level tolerance of <2% and must be compacted to support the movement of trucks and forklifts and bunded areas created for the storage of chemicals, racks and shelving supporting casings and other consumables.
   iv. Cuttings pits should be located in an area accessible directly from the fluid treatment systems (Mud Tanks) or loaders (in the case of "sumpless drilling"), usually on multi well pad sites. Pits can be unlined, lined with a bentonite and clay mix to create an impermeable layer, or lined with a synthetic membrane to retain drilling fluids during drilling and subsequent dehydration process prior to backfill.
   v. Flarepits should be located in a position down-wind from the prevailing wind direction and ideally >35m from hole centre or any other sensitive zones.
   vi. Mini camps, crib/first aid rooms and site management offices, are located outside the wellsite work/hardstand areas; offices will have a clear view of the rig floor. This area will be level, compacted and accessible to supplies and emergency vehicles, and usually include emergency muster points and vehicle parking.

2. **Access Roads** are designed and constructed so that road trains can deliver equipment and supplies to the sites, and personnel can be safely moved around or delivered to site. Roads may be watered to reduce dust, and/or capped to reduce maintenance and/or closed following rain.
3. **Laydown yards** are constructed so that materials can be offloaded and stored for use as and when required. Materials include, casings, tools and mud chemicals. Laydown yards must provide enough room for the safe movement of trucks and forklifts.
4. **Campsites** for workers' accommodation, and refuge during severe weather, illness or injury, are located in positions that provide isolation from fire and flood dangers. Campsites must be reliably resupplied and provide workers with good comfort and recreation facilities. The location of campsites should reduce travel and fatigue exposure to acceptable levels.
5. **Water Bores** for the supply of water to aid compaction and reduce dust; support drilling, completion and hydraulic fracture stimulation operations; and supply water to the campsite for amenity needs. It is preferable to have a low salinity water supply close to site. However, saline aquifers are suitable for some operations, reducing road maintenance costs and the quantity of imported potable water.
6. **Water Storage Pads**, are required so that water tanks can be erected, providing sufficient volume and delivery of water at a rate required to support the works. Typically larger storage is required where water bore flow to surface is low.
7. **Airstrips and Helipads** are used to transport the workforce from a main centre to the worksite. Air transport reduces fatigue and exposure to land transportation risks. Existing landowner airstrips will be utilised and upgraded under agreement to a condition where charter operators (for crew change),

or RFDS or Careflight Air Ambulance (emergency evacuation) aircraft can be used. Helipads may be constructed at each wellsite to provide additional direct access to remote wellsites.

Annexure 3 – Description of drilling, evaluation, fracture stimulation, completion and flow testing activities

3.1 Drilling

Oil and gas wells are typically drilled by rotating a drill bit on the end of drill pipe while exerting downward force on the drill pipe. During drilling, fluid is pumped through the inside of the drill pipe or “string” to the drill bit and back up the outside of the drill string to lift drill cuttings out of the hole. The drilling fluid / drill cuttings are then channelled into tanks or bentonite and local clay lined pits and the drill cuttings are separated from the drilling fluid; drilling fluid is then recycled down hole in a continuous process. The well is drilled deeper by adding a length of drill pipe to the drill string; this is repeated until the well, or a section of well, reaches the target depth. Once the target depth is reached, casing composed of concentric steel pipe is installed into the well and cemented in place to provide the structural integrity and well integrity barriers for the designed life of the well.

The figure below illustrates a typical drilling rig layout and lease and access roads required for a Cooper Basin drilling operation. The drilling rig along with specialised wellsite support services and camp are mobilised to the well location, comprising 100-150 truckloads. The drilling rig camp is either located adjacent to the wellsite or in a location central to multiple wellsites. It is designed to accommodate the crew working at the wellsite, and will expand and contract as required to meet personnel requirements.

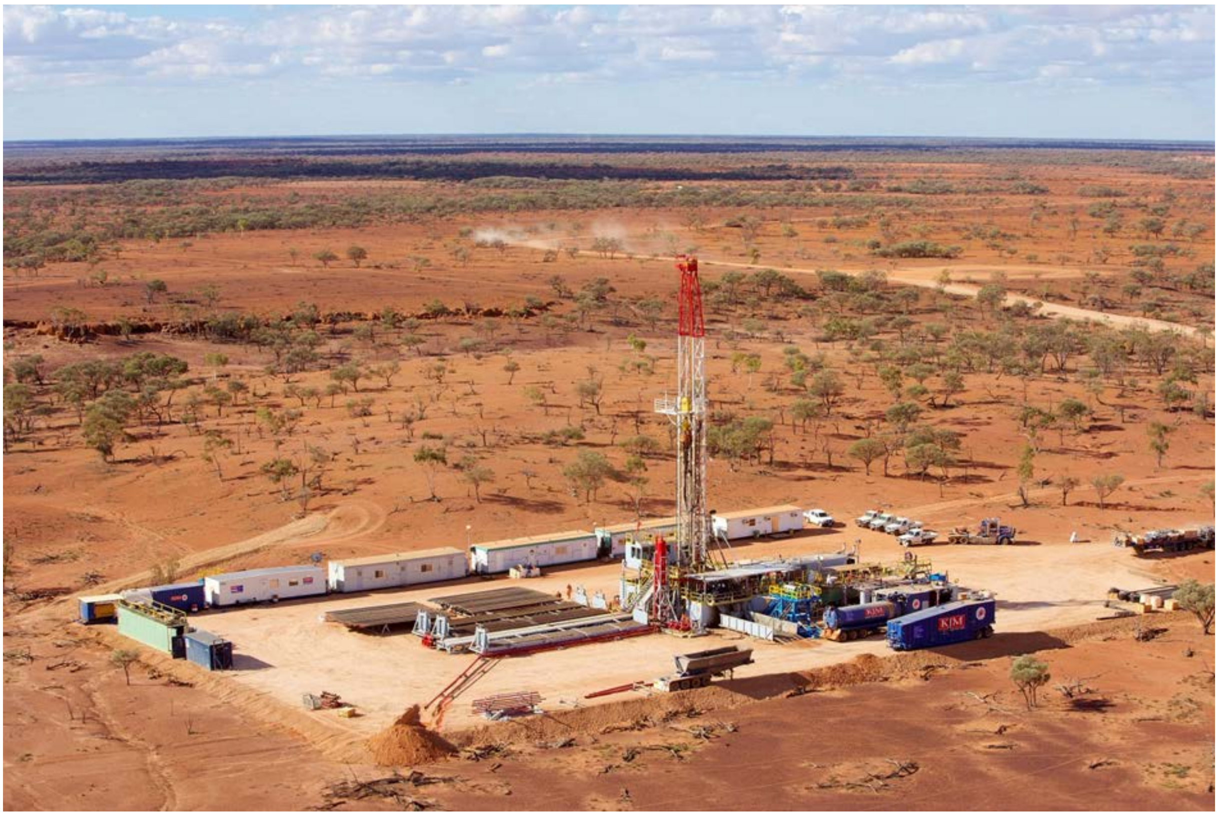


Figure: Drilling rig in the Cooper Basin. (Source: Santos 2016)

Wells are drilled to reach the gas formation targets through a series of hole sections. While drilling, mud logging samples are captured in order to characterise the formations that are being drilled through and to calibrate the geological model. It is expected that 2-3 ML of water will be required to drill each well, with the water being supplied from water bores installed at or near the drill location. Each hole section serves a specific purpose for well construction and well integrity as outlined below:

1. The Conductor Hole Section is drilled and cased to stabilise the surface sediments from the drilling of subsequent drilling phases (i.e. it prevents loose soils from caving into the borehole), and is cemented into place to ensure an appropriately robust seal (up to ground level). The conductor casing also serves to isolate aquifers near surface, if present.

2. The Surface Hole Section is drilled and cased to isolate shallow aquifer systems and to stabilise the well for subsequent hole sections. The hole section will be drilled with drilling fluid that exerts a higher hydrostatic pressure on the rock face than is present naturally in the rock pore space, ensuring formation fluids do not enter the wellbore. Other techniques such as underbalanced or managed pressure drilling may be applied dependant on the downhole environment. The surface casing is cemented in place from bottom to top to ensure effective pressure isolation of shallow aquifers from deeper hydrocarbon bearing zones encountered in subsequent hole sections. Finally, the casing is pressure tested to simulate well life design specifications.

3. After the surface casing is installed, a Blowout Preventer (BOP) is installed onto the well at surface to provide a second barrier along with the drilling fluid. At the commencement of drilling the next hole section (i.e. only 2-3m of new hole drilled), a Leak Off Test (LOT) or Formation Integrity Test (FIT) is conducted to determine the rock strength. This will ensure the well is drilled without risk of the rock failing due to exerted pressure and will ensure the fluid used for drilling the well has the appropriate kick tolerance.

4. The Intermediate Hole Section(s) may be drilled and cased to isolate deeper aquifer systems (if present), to contain pressure that may occur during the subsequent hole section, or to isolate a geohazard, like a salt formation prior to drilling deeper. The hole section is drilled with drilling fluid that exerts a higher hydrostatic pressure on the rock face than is present naturally in the rock pore space, ensuring formation fluids do not enter the wellbore. Other techniques such as underbalanced or managed pressure drilling may be applied dependant on the downhole environment. As with the surface casing, the intermediate casing is cemented in place to ensure appropriate well integrity. Finally, it is pressure tested to simulate well life design specifications.

5. The Production Hole Section is drilled to intersect formation targets containing oil and/or gas and is drilled to a depth below the lowest hydrocarbon bearing target. The hole section is typically drilled with drilling fluid that exerts a higher hydrostatic pressure on the rock face than is present naturally in the rock pore space, ensuring formation fluids do not enter the wellbore. Other techniques such as underbalanced or managed pressure drilling may be applied dependant on the downhole environment. Logging while Drilling (LWD) can be used to gather data in real time to gain an understanding of the petrophysical environment.

6. If well trajectory allows, openhole wireline logging is generally performed after the production hole section has been drilled and prior to the production casing being run. Wireline operations for Santos are undertaken by a number of different industry recognised specialist service companies. Different energy sources are lowered into the well via wireline including density, neutron, acoustic and electrical logging tools. Calculations based on the received signals are undertaken to evaluate the different parameters of the formation such as porosity, permeability, rock type and hydrocarbon saturation. This information is used to ascertain whether the well is economical to run production casing for future production. If the well is not currently economic, a decision not to run production casing may be made requiring the well to be plugged and decommissioned or plugged and suspend for future operation.

7. The wireline logging evaluation program may include a vertical seismic profile (VSP) or checkshot survey, or a 'walk-away' VSP. These geophysical techniques are similar to surface seismic exploration, except the detectors (geophones) are located in the well bore, rather than at the surface, and the surface source is stationed at specific locations around the well. The geophone array comprises one to several geophones on wireline. The surface seismic energy source is either an airgun (in a water filled drum and pit) or a small vibrator truck located as close as is safe and practical to the well bore. The geophone array is run to the bottom of the hole on the wireline, and is then moved up the hole at regular intervals (e.g. 15m) and the stationary surface source is triggered. The geophones record the time it takes for the seismic energy from the surface source to arrive downhole at the geophone. The data recorded provides accurate velocity information and is processed to produce a seismic wavelet well-tie, such that the well can be "tied" to the 2D seismic line on which it is located.

8. After the production hole is drilled and logged, production casing is installed to the total depth of the wellbore and cemented in place. It is pressure tested to simulate well life design specifications. The purpose of the production casing is to provide isolation between the hydrocarbon reservoirs and all other overlying formations, to contain the pressurised fluid used to hydraulically stimulate the target zones, and to provide effective wellbore integrity for well production. High quality steel casing is designed specifically for each well. If the well does not require hydraulic stimulation, a lower grade of steel casing may be used that meets the design requirements for the life of the well.

Casing design scenarios are modelled using well-established and reviewed techniques to simulate the design loads for collapse, burst and tensile failures that could conceivably be observed during the operational and production phases. The results of these analyses direct the selection of casing grade and weight. All casing is tested by Santos and the contractor using specific Quality Assessment and Quality Control (QA / QC) procedures prior to installation to ensure compliance with the Santos engineering and regulatory specifications.

After each hole section is drilled, the steel casing is cemented in place. The correct composition, volume and placement of cement is critical for well integrity. The cement serves two purposes – it provides protection and structural support to the casing while also providing zonal isolation between different formations, including groundwater and aquifers. The cement and required additives are high quality materials produced specifically for oil and gas operations with the materials selected designed to address the specific conditions of a particular well.

Santos and the cementing contractor ensure the cementing material and equipment is adequate to achieve the well design objectives and ensure effective isolation. Prior to pumping the cement, it will be laboratory tested against the engineering design and actual downhole conditions such as temperature. The cement is tested using specific QA / QC procedures and includes the following:

1. slurry density
2. thickening time
3. fluid loss control
4. free fluid
5. compressive strength development
6. fluid compatibility (cement, mix fluid, mud)
7. sedimentation control
8. expansion or shrinkage characteristics of the set cement
9. static gel strength development
10. mechanical properties (e.g. Young's Modulus, Poisson's Ratio, elastic / compressibility characteristics)

Cased hole logs can be run inside the cemented casing to validate the quality and integrity of the cement sheath bond to the casing and to the formation. Typically, these logs include:

1. gamma ray - measures naturally occurring gamma radiation to characterise the rock or sediment in a borehole
2. casing collar locator - a magnetic device that detects the casing collars
3. cement bond log - an acoustic device used to measure the properties of the cement sheath and the quality of the cement bond between the casing and the formation

The cement bond log is an acoustic device that can detect cemented or non-cemented casing. It works by transmitting a sound or vibration signal into the casing, and then recording the amplitude of the arrival signal. Casing that has no or poor quality cement surrounding it (i.e. free pipe) will have large amplitude acoustic signal because the energy remains in the pipe and isn't transmitted to the formation. Casing that has a good cement sheath (fills the annular space between the casing and the formation and effectively couples the two) will have a much smaller acoustic amplitude signal as the energy is absorbed by the formation due to effective acoustic coupling. Santos uses experienced contractors to identify the key features of the cement quality to ensure the integrity of the cement seal for each casing pipe sheath.

3.2 DFIT

A Diagnostic Fracture Injection Test (DFIT) goes by many names: mini-frac, mini fall-off, datafrac, etc.; but all refer to the act of injecting small volumes of a clear fluid (usually with a small percentage of Potassium Chloride e.g. 2 to 3% KCl) at low pumping rates to create a fracture before the wellhead is shut-in and the pressure allowed to fall-off naturally. The fluid contains no proppant so that the fracture can relax and close naturally when pressure is released. The pressure changes are measured with high-accuracy gauges that are either placed deep in the wellbore or at surface on the wellhead. The analyses of fracturing pressure, during injection and after shut-in, provide powerful tools for understanding and improving the fracturing process. The importance of this DFIT analysis of fracture pressure was recognized in 1958 by Godbey, J.K. and Hodges, H.D. and pioneered by Nolte in 1979 who introduced the G-Function based on material balance and the Carter leak-off model. Barre et al. in 1996 recommended using the G-Function and its diagnostic derivatives to identify fracture closure and signatures of non-ideal leak-off behaviours such as tip extension, pressure dependant leak-off (PDL) and storage height recession signatures. These signatures help operators recognise fracture behaviours and design fracture stimulation programs accordingly to ensure that the targeted reservoirs are stimulated optimally. Below are examples of the signature behaviours that are commonly used in the industry to observe fracture injectivity responses:

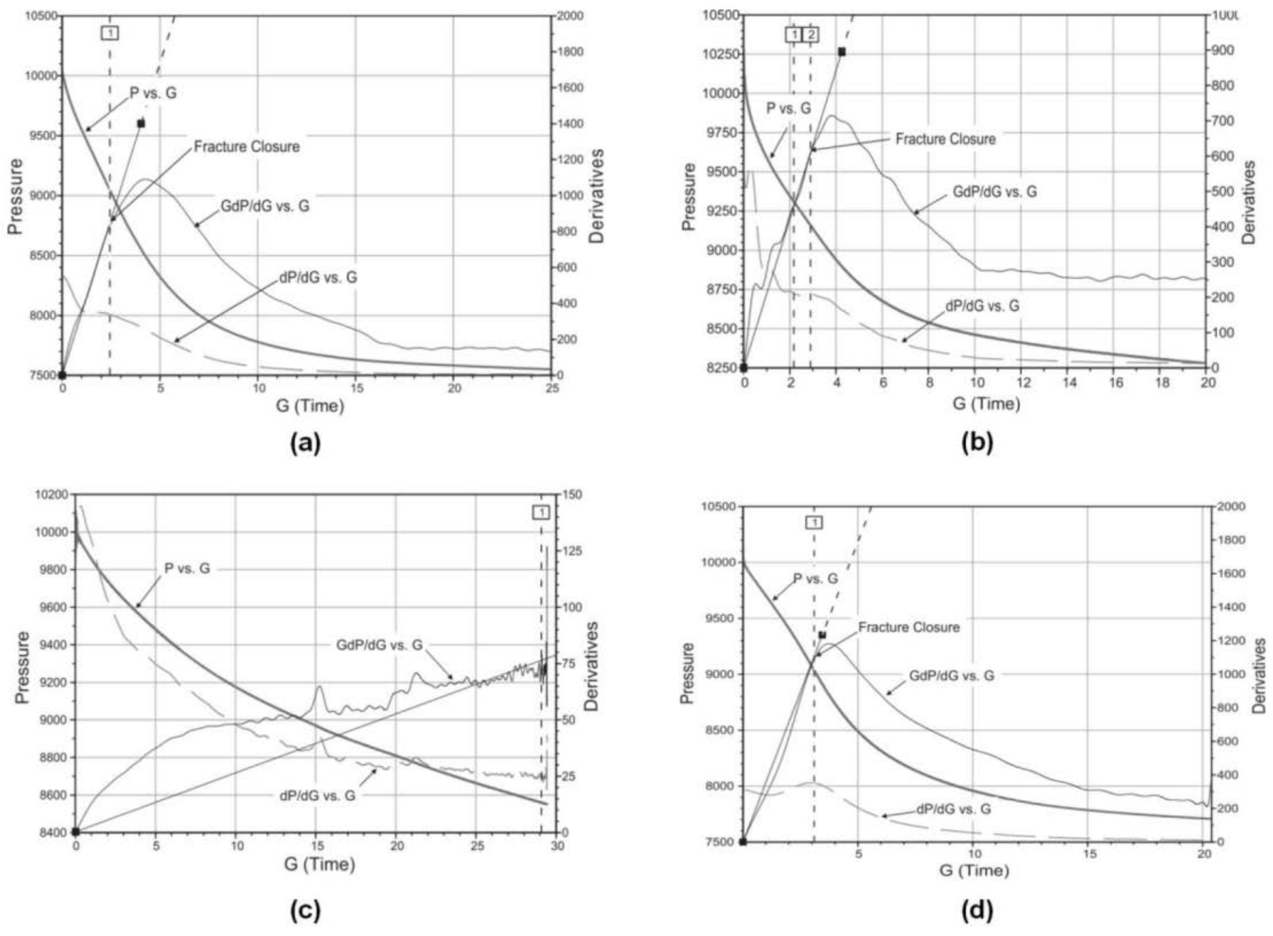


Figure: (a) Normal leak-off; (b) pressure dependant leak-off (PDL); (c) tip extension; (d) storage/height recession signatures on G-function plots (Barree et al. 2009).

Models have also been built to predict the fall-off pressure of an ideal normal leak-off DFIT using standard pressure transient analysis (PTA) log-log diagnostic plots. The figure below presents a log-log diagnostic plot of the basic fall-off response shape of a normal leak-off, which is interpreted as a 3/2 slope on the Bourdet-derivative (with respect to superposition time).

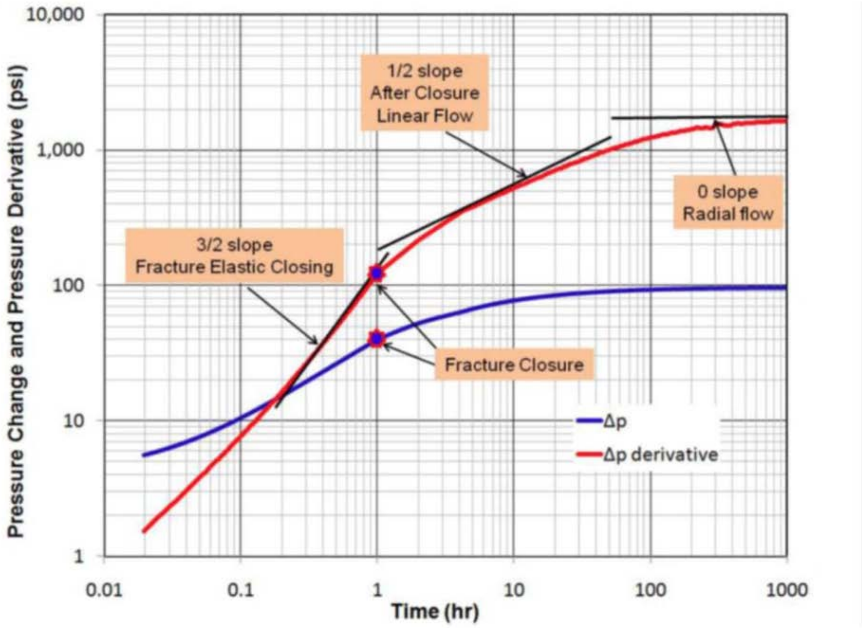


Figure: Log-log diagnostic plot of an idealised fracture-injection/fall-off test (Marongiu-Porcu et al. 2011).

3.3 Fracture Stimulation Evaluation

Pressure Monitoring

During a fracture stimulation treatment, computer assisted live monitoring allows for potential problems (surface or down-hole) to be identified and corrected quickly. An example of live monitoring applied to downhole conditions is if pressure communication between the annulus of the well and inside of the well is identified. Where communication is identified, it may be an indication that the first barrier control (as part of the well's integrity management) has been compromised and the treatment will be stopped immediately.

The figure below depicts information presented during real time stimulation operation monitoring. Key parameters such as surface, bottom-hole and annular treatment pressures, proppant concentrations, volume of injected fluid and fluid additives are monitored. The modelled pressures are compared with the actual pressures and can provide useful information in evaluating the overall fracture growth and fracture geometry achieved. This calibration process is used to refine and improve subsequent designs as part of the design optimisation process.

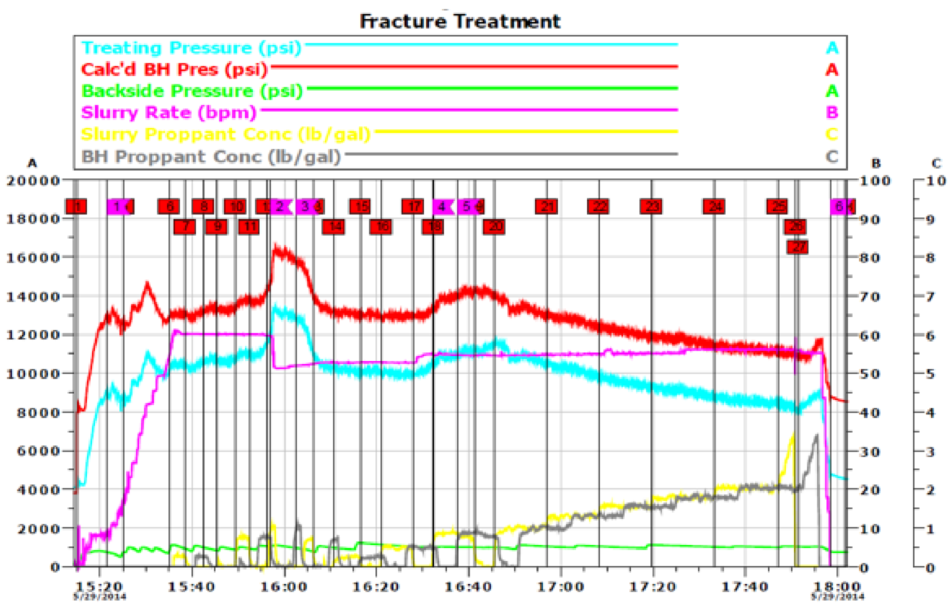


Figure: Real time monitoring of hydraulic fracture parameters (pressure, rate etc.) on a shale gas frac in the Cooper Basin (Santos 2014)

Tracers

Chemical tracers are used to determine the relative contribution from each fracture stimulation stage. The low dosage chemical are designed to be unique in composition and able to be absorbed into the water or gas phase. This enables the operator to determine the performance of each frac stage and incorporate optimisation learnings into future campaigns.

Microseismic

Advanced stimulation monitoring techniques such as microseismic monitoring, may be used to evaluate fracture azimuth, fracture height and fracture half length. This information can be further used to calibrate the hydraulic stimulation model predictions. Microseismic monitoring involves the use of sensitive receivers ("geophones") at the surface or within one or more nearby wells to detect and locate in 3D space the releases of energy associated with the propagation of the stimulated fractures. The figure below shows an example of a side-view of the locatable microseismic events that were detected during the multi-stage hydraulic stimulation of a Cooper Basin horizontal shale well, with the positions of the events colour-coded by stimulation stage. The modelling and field results show good agreement.

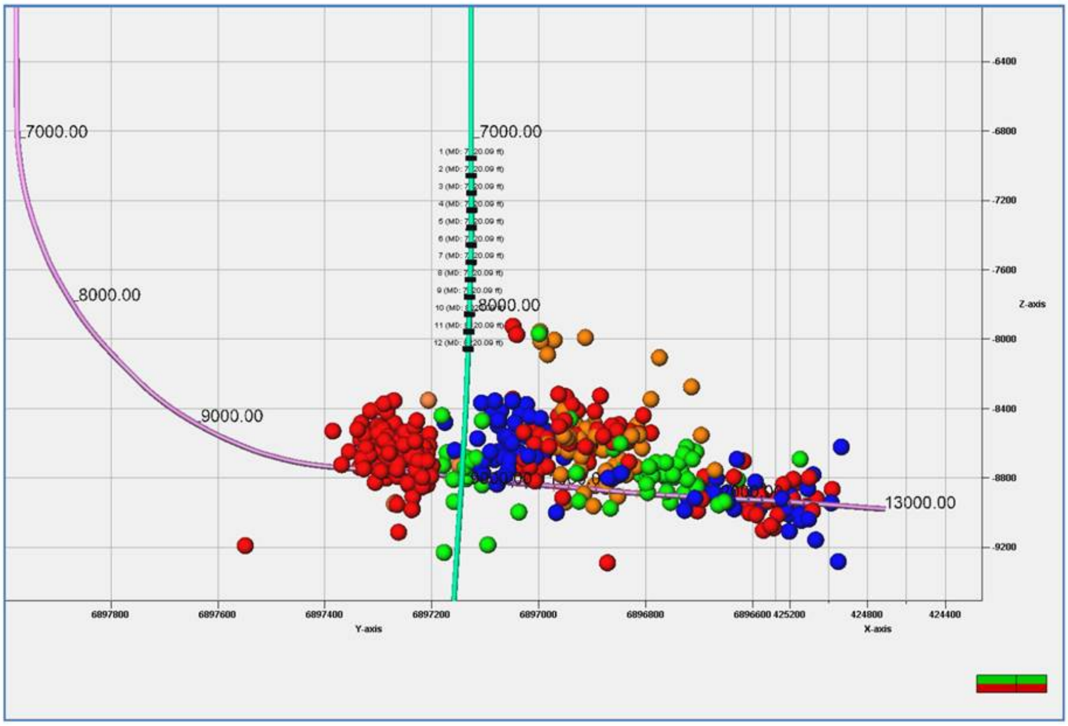


Figure: Microseismic events mapped during the 10 stage shale hydraulic fracture treatments pumped in the Cooper Basin. The different colours represent the different frac stages (Santos 2014).

The microseismic results are supported by detailed studies such as by Fisher and Warpinski (2012) which have reviewed height growth data from unconventional (shale) plays in the US including the Barnett, Marcellus and Woodford shales. These studies have indicated that maximum height growth is typically far less than 300m when contained within a relatively homogeneous layer.

Tiltmeter installation

Tiltmeters are very sensitive surface tools for measuring very minor displacement or movement in the subsurface. They are used in hydraulic fracture stimulation operations to provide insight into the spatial extent and orientation of induced fractures.

Tiltmeters are typically installed into pre-drilled and cased holes drilled with an 8" or 10" diameter bit to a depth of around 12 metres.

Once the drilling is completed a 4" PVC pipe is then cemented in place within the hole. The cement secures the 4" PVC pipe to the ground around it to ensure good coupling for the tiltmeter. The cement ends around

1.2m below ground. To further minimize unwanted noise a larger 8 – 10” pipe around 1.8m in length is then placed around the smaller pipe to a depth of about 1.2m below the surface. The tiltmeter tools are then lowered into the inner 4” string of PVC. A small amount of sand is poured around the tools to give positive coupling to the surrounding ground. An end cap is then placed over the 8” PVC pipe to make the entire setup weatherproof.

Drilling of the tiltmeter holes will be performed by a small truck mounted rig as pictured below. There will also be an additional vehicle and trailer for transporting extra equipment and consumables such as concrete and sand. As the vehicles are light vehicles only minimal (if any) line preparation will be needed for access. It is expected that most hole / tiltmeter sites will be accessible with no access track preparation at all.

Drill cuttings will be stacked adjacent the hole to be re-used to backfill the holes upon completion of the project.

Installation would typically be completed in a 2 week period.

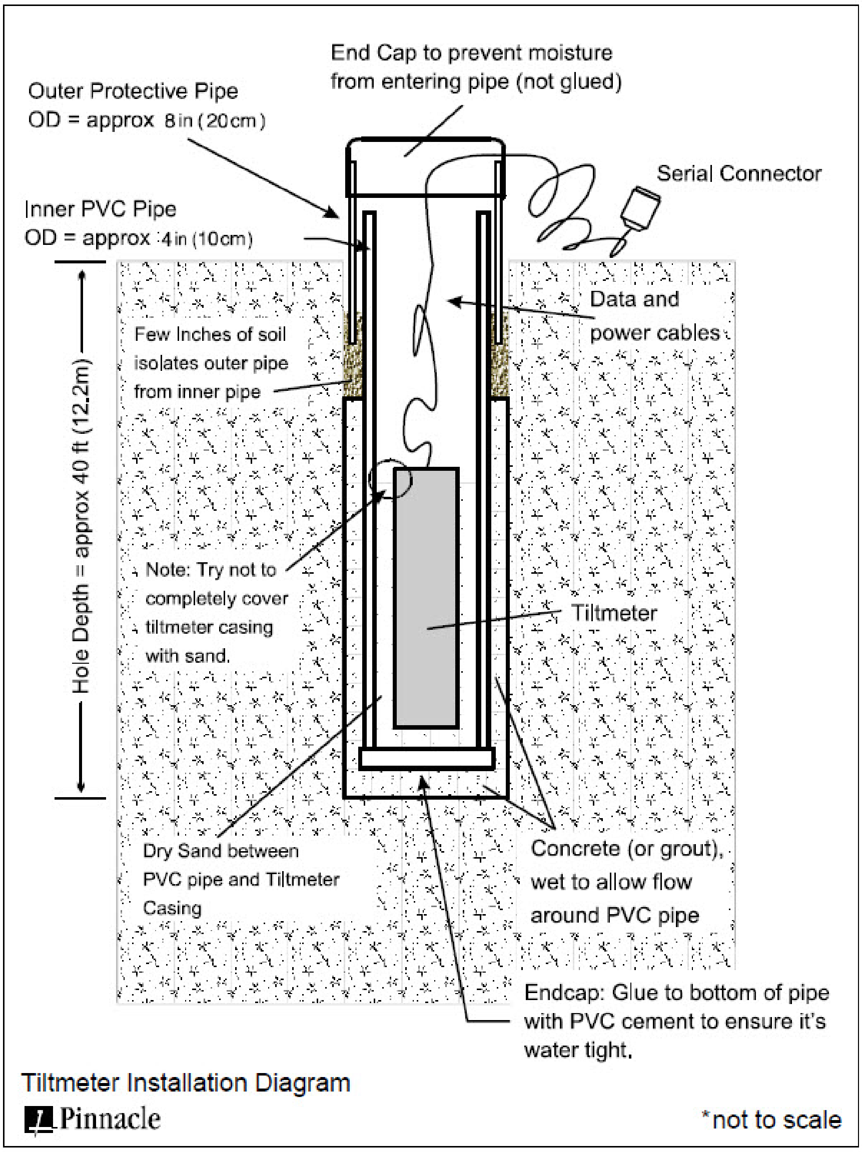


Figure: Schematic of typical tiltmeter installation

Figure: Truck mounted rig preparing shallow hole to install tiltmeter.

Access track preparation

The proposed locations have not yet been finalised but, wherever possible, they will be located close to existing roads or tracks for ease of access. These should all be accessible with no access track preparation. A small number of holes may be required that are remote to existing roads and will need longer cross country travel to reach.

Each hole is likely to only have 2 or 3 light vehicles access it during the installation process.

Should access line preparation be required, the lines will be prepared to the standard of seismic lines and access line preparation will be a conventional approach using a dozer and possibly a grader.

Tiltmeter recording

Once the tiltmeter installation is complete, the meters themselves are basically maintenance free and do not require any revisits until the project is complete and the meters are removed. The tiltmeters are expected to remain in-situ for 2 – 3 months.

Tiltmeter recovery and restoration

Once the tiltmeter survey is complete, the tiltmeters are removed and the location restored. To do this, each site is once again visited by a couple of light vehicles and the meter is manually removed. The outer 8” PVC casing is also removed. The remaining 4” PVC casing is then broken off around 1.2m below ground and the resultant hole is backfilled to ground level using the drill cuttings form the initial drilling if possible.

If any access tracks were prepared, they will be inspected at the time of tiltmeter removal and if required a grader will be brought in to restore the access tracks.

3.4 Fracture Stimulation

Objective

After determining that a well has the required design and well integrity to undergo stimulation and completions, the well is handed over to 'complete' the well and set it up for production. Hydraulic fracture stimulation is not part of the drilling process but is a completion technique applied after the well is drilled. The intent of hydraulic stimulation is to place a highly conductive channel into the reservoir to increase the flow capacity of the well. Typically used in low permeability reservoirs that cannot sustain economic production such as shale. It is a process that has been used in the oil and gas industry since 1947. The Society of Petroleum Engineers (SPE) estimates that over 2.5 million hydraulic stimulation treatments have been undertaken in oil and gas wells worldwide. It has been successfully used on wells in the Cooper Basin for nearly 50 years without a primary barrier breach and is currently performed in many basins around Australia, including the Amadeus Basin in the Northern Territory.

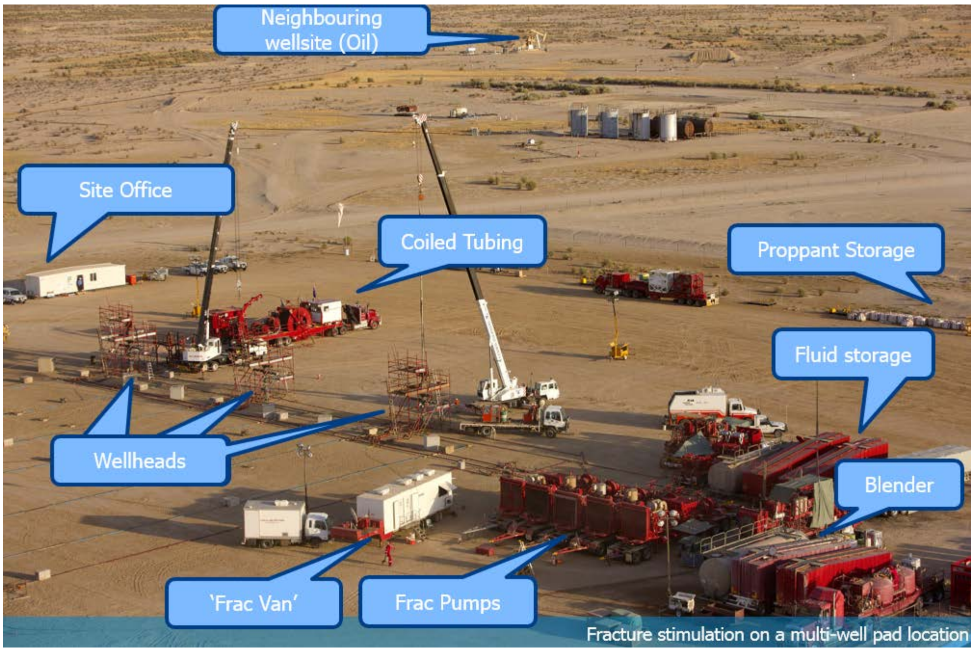
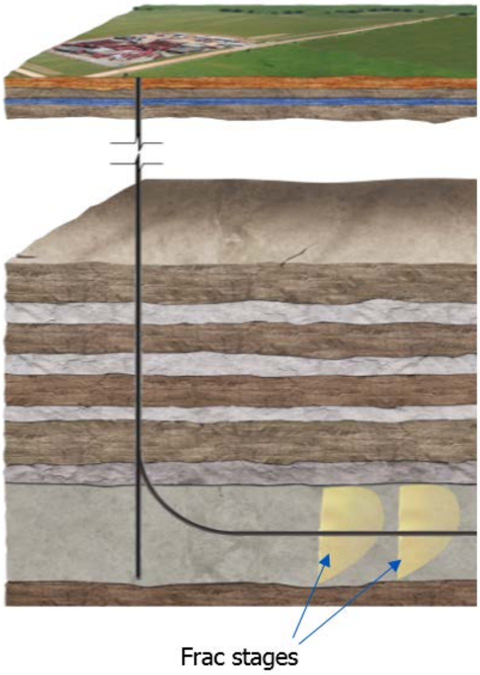


Figure: Fracture Stimulation spread rigged up on a 3-well pad in the Cooper Basin. (Source: Santos 2016)



Vertical depth to proppant placement in hydraulically opened fractures will likely range between 1500m and 4000m below surface.

Figure: Multi stage fracture stimulation operations in a horizontal well.

The stimulation process involves pumping water, a specific blend of chemical additives and a propping agent such as sand or ceramic beads down the well at sufficient pressure to create a fracture in the target formation. Proppant keeps the fractures open once the pump pressure is released which thereby improves the productive potential of the well. A fracture created in deep shale reservoirs, will propagate laterally from the well in a vertical plane. Common dimensional terminology for the created fracture includes fracture half length (xf), fracture height (hf) and propped width (wf), as depicted in the figure below. An unconventional shale gas well typically takes 10 to 15 days to complete hydraulic stimulation operations, with a hydraulic stimulation fluid flowback period of 3 to 90 days, depending on the reservoir and clean up profile, which is typically followed by ongoing flaring and production testing. Production tests may be short if it is possible to put hydrocarbons into existing infrastructure (e.g. Cooper Basin, Surat Basin); however, for exploration wells in frontier basins extended periods (>1 year) of flaring and production testing will be required to establish whether a well or field has the potential to be developed economically

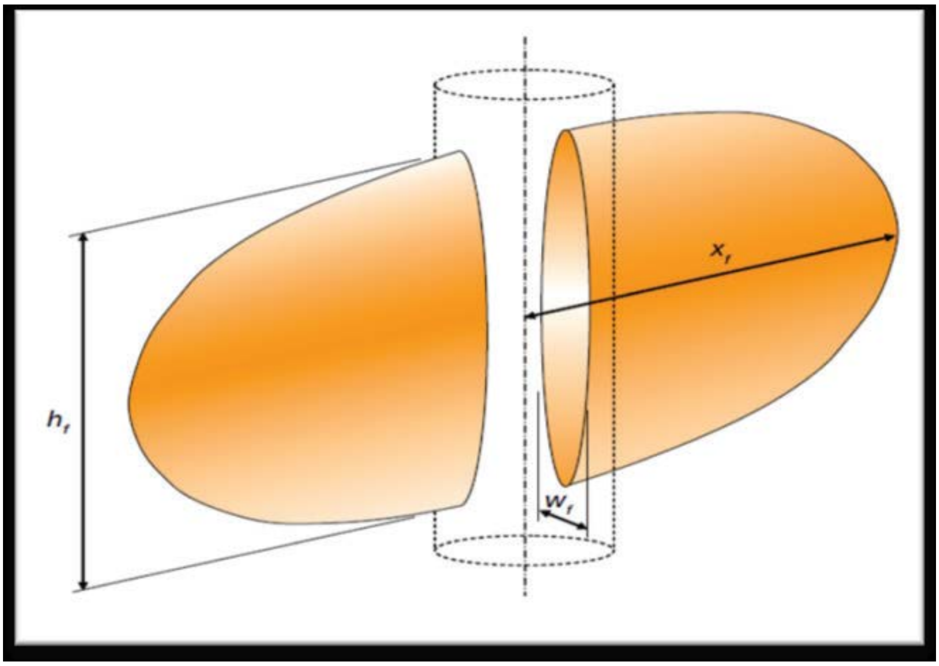


Figure: Conceptualised Shape of Hydraulic Stimulation Zone of Influence. (Source: Economides and Martin, 2007)

Santos has a long history of demonstrated well integrity during hydraulic fracturing operations. In nearly 50 years of hydraulic fracturing operations on over 1,150 wells, there has never been a loss of the primary barrier during the fracture treatment. The primary barrier during the stimulation phase is generally the production casing, with the secondary barrier being the surface well pressure control. Should the primary barrier fail, a pressure relief valve (PRV) installed to monitor pressure between the primary barrier and surface casing, is triggered to open at a pressure well below the failure point of the surface casing. This ensures that the surface casing is not exposed to pressure above its design specification, and as a result prevents the risk of failure. Also, programmable pressure triggers (kickouts) on each of the high pressure pumps will physically shutdown each pump (and associated pressure) if a certain trigger pressure is reached. This trigger is below the design of the well. If the primary barrier did fail during hydraulic fracturing operations, operations would cease and it would be repaired to meet the design requirements before going forward with completing the well again.

Engineering Design

Open hole and cased hole logging provides information required for the hydraulic stimulation design process, including rock stress and lithological parameters. This data is processed using industry-accredited stimulation software to develop an optimal design. The basis of well specific hydraulic fracture design is to create a fracture within the target formation that will produce hydrocarbon through the number of required fractures. This is achieved by modelling fracture length, fracture conductivity, and fracture height for each created fracture as depicted in the figure below. A number of considerations influence the final design for each treatment, including:

- depth and thickness of the formation target
- lithology of formation target and bounding layers
- minimum and maximum horizontal stress across all layers (target and bounding)
- thickness of the seals above and below the target reservoir formation
- porosity and permeability of the formation
- pore fluid saturations (percentage of formation pore volume occupied by oil, gas or water)
- pore fluid properties (e.g. density, water salinity)
- well performance data, including flow rates, formation pressure and produced fluid properties
- formation boundaries (as identified from offset wells, log data, cuttings data, and/or seismic data)
- bulk rock density, elastic properties and compressibility
- natural fracture networks
- stress field analysis to determine the maximum principle stress direction and the minimum principle stress direction

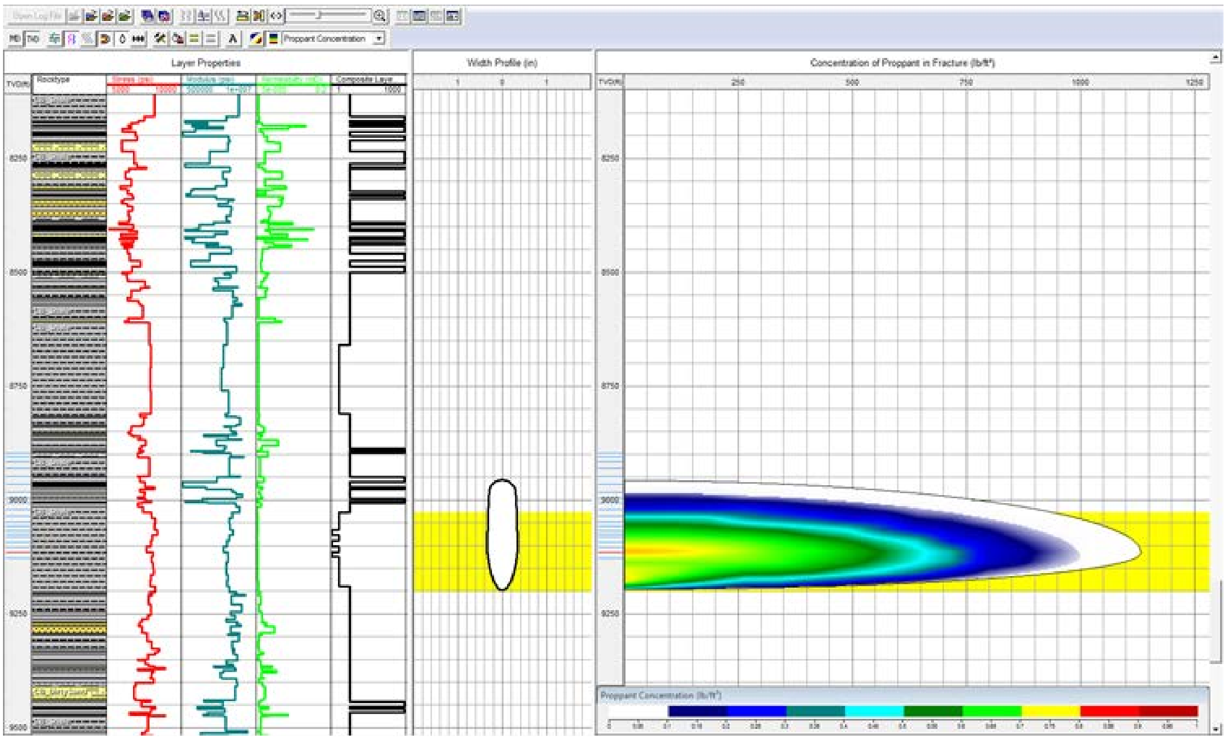


Figure: Modelled side view output from industry accredited stimulation software for a Cooper Basin horizontal well shale hydraulic fracture (Source: Santos 2014)

Proppant and Chemicals

In shale hydraulic stimulation treatments, water accounts for more than 90% of the mixture and sand accounts for about 5-9%. Chemicals generally account for less than 1% of the mixture and assist in carrying and dispersing the sand in the low permeability rock, and ensuring the fluids and formation are compatible and will have the desired physical properties. In accordance with regulatory requirements, chemical additives are subject to full disclosure. The chemical additives are not specific to the hydraulic fracture stimulation process, having many common household uses such as in swimming pools, toothpaste, baked goods, ice cream, food additives, detergents, cosmetics and soap. The chemicals used provide the following functions:

- Viscosity – gelling agents (natural plant based) are added to the water to provide viscosity to enable the proppant material to be transported down the well and into the created fractures.
- Friction reduction – to reduce the force required to pump the fluid, making the fluid more slippery and easier to pump at high pressures and high rates required to create the fracture network.
- Biocide – added to ensure that there are no microbes or organisms present in the water that will affect the gelling agents and to ensure they will not enter and affect the reservoir.
- Scale and corrosion – scale and corrosion inhibitors are added to prevent deposition of mineral scales and to prevent corrosion of the primary wellbore barrier (i.e. the steel casing).

- Surface tension – surfactants or surface tension modifiers are added to assist the flowback of fluids from the formation.

The process is initiated by pumping a pre-designed volume of the stimulation fluid without proppant, referred to as the “pad volume”. The purpose of the pad volume is to create the fracture geometry required to receive the designed proppant volume. Prior to and during pumping the pad into the well, the base gel is prepared and tested using specific QA/QC procedures. Programmed and automated control systems are used to maintain the fluid properties during the pumping of the treatment process. The viscosity of the fluid is typically in the region of 10 to 40 centipoise (cp), depending on the specific fluid design. This may require the use of a base gel or cross-linked gel, both made from guar. In shale fracture stimulation, it is generally possible to use only Friction Reduced (FR) water (instead of a base or cross linked gel), by the addition of a friction reducing agent. This fluid system has the effect of making the fluid slippery to minimise friction pressure lost to the casing.

Figure: Example of a typical slurry gum constituent, guar gum – illustrating its native form, seed form, splits and powder.
*** Note: Guar gum is a vegetable product which is ground into a powder and used to create a viscous liquid for hydraulic fracturing. (Source: Economides and Martin, 2007)*

Once the pad volume has been pumped, the injection of the “slurry stages” begins. Proppant is added to the blender and proportioned into the stimulation fluid. The concentration of proppant generally increases through the slurry stages as designed within the fracture treatment simulator. Previously mentioned chemical additives are incorporated to provide a suitable fluid for transporting proppant into the already created fracture.

In a cross-linked gel fluid system, breaker compounds are added at progressively increasing concentrations throughout the pad and slurry stages. The breaker comprises an oxidizing compound or enzyme that breaks the crosslink sites, as well as the long chain polymers. The end result is a fluid with significantly lower viscosity that can be easily flowed back from the formation to assist with fracture clean-up. The “break time” is designed to coincide with the known pump time at reservoir conditions plus some additional time to ensure the treatment is pumped to completion. This enables the fluid to be more easily recovered from the formation.

Proppant addition begins at low concentrations and is staged up to the final designed concentration which is specific to the formation being hydraulically stimulated. Typical proppant concentrations will range from 0.5 lb/gal (60 kg/m^3) to 8 lb/gal (1000 kg/m^3) for conventional reservoir stimulation, and typically range from 0.5 lb/gal (60 kg/m^3) to 2.0 lb/gal (240 kg/m^3) for shale reservoir stimulation. Proppant used in hydraulic stimulation range from graded quartz sand to higher strength ceramic proppants. The strength of this inert material varies, with ceramic proppant being much stronger than quartz sand. Ceramic proppant is used in formations with higher effective stresses, to prevent it from crushing and losing the created fractures conductive properties.

Figure: Typical sand - guar gum fluid mix. (Source Economides and Martin, 2007)

Once the final slurry stage is pumped on surface, the flush stage is pumped. The flush stage is a friction reduced fluid (non cross-linked) that is used simply to displace the last stage of slurry down to the perforations. This leaves the wellbore volume free of proppant and ensures that the proppant is placed within the fracture. Once this flush volume has been pumped, the high pressure pumps are shut down and the fracture treatment is considered complete. The duration of the treatment is dependent on the specified volumes to be pumped and the rate at which the treatment is pumped, but is typically around 2 hours for a single shale stage treatment.

Perforating

When the formations requiring hydraulic stimulation are identified, the casing needs to be perforated to provide communication between the wellbore and the formation target zone. The type of charge used depends on the type of hole, size and penetration depth required. The three primary types of perforating used are:

- Wireline Conveyed Perforating (WCP) – the most widely used perforating technique in the Cooper Basin. As the name suggests, WCP uses wireline to deploy the perforating charge.
- Tubing Conveyed Perforating (TCP) – uses the same technology as conventional wireline perforating but is run using a coiled tubing unit or jointed tubing (not wireline). TCP is the preferred perforating method when operating in underbalance or overbalanced conditions.
- Hydro-jetting – uses sand and water jetted through small holes in the bottom hole assembly to create holes in the casing across the target formation – there is no perforating charge. Hydro-jetting allows for targeted or pinpoint perforating, creating between 3 and 4 holes per event.

Process

A number of steps are involved in the hydraulic stimulation process to pump the designed fracture treatment:

1. Diagnostic Fracture Injection Test (DFIT) to validate and update the proposed stimulation design. This involves injecting a small volume of water, shutting down the surface pumps and monitoring pressure decline to evaluate near wellbore entry friction, fracture gradient, fluid leak off, and minimum horizontal stress. This stage is optional and typically only performed in the exploratory or appraisal stages of development, or until localised fracture characteristics are defined.
2. Main stimulation treatment consisting of pad volume, slurry stages with increasing proppant concentrations, and flush stage to displace last slurry stage through the perforations and into the fracture.
3. Isolation of the completed fracture stimulation stage using a mechanical plug installed at a pre-designed depth.

4. Perforation of the next stage to be hydraulically stimulated and repetition of the process in steps 2 to 4 above until the final fracture stimulation stage is completed.
5. Removal of all mechanical isolation devices by milling out the mechanical isolations.
6. Flowback well to clean up fracture stimulation fluids and monitor hydrocarbon production. This step may also be combined with an Extended Production Test (EPT) to help define the field reserves and expected production life. The flowback of stimulation fluid is conducted through a separator, which separates and captures liquids, and flares produced gas through a vertical ‘flare stack’.

The above method describes the “plug and perf” technique for fracture stimulation. Another technique is to use coiled tubing assisted annular stimulation which is used to provide a conduit for “pin-point fracturing”. Coiled tubing is run into the well to the deepest target. The bottom-hole assembly run on the end of the coiled tubing incorporates a jetting assembly that allows low concentration sand slurry to cut holes or slots into the casing and cement. The hydraulic stimulation treatment is then pumped into the coiled tubing / casing annulus to initiate and propagate the fracture.

Equipment

The equipment and machinery required to carry out a hydraulic stimulation operation is highly mobile and able to be installed and removed relatively quickly (generally within a couple days). The equipment is designed to comply with state and federal regulations for road transport, and are fitted with safeguards such as an in-vehicle monitoring system (IVMS) to ensure compliance of the individual contractors.

The Wellhead – is used to inject into and control the well, during hydraulic stimulation operations. The stimulation fluids, which are injected from the surface via the wellhead, are injected through the perforations in the well casing under high pressures in order to physically fracture the reservoir rock. The wellhead provides the primary surface barriers for well control.

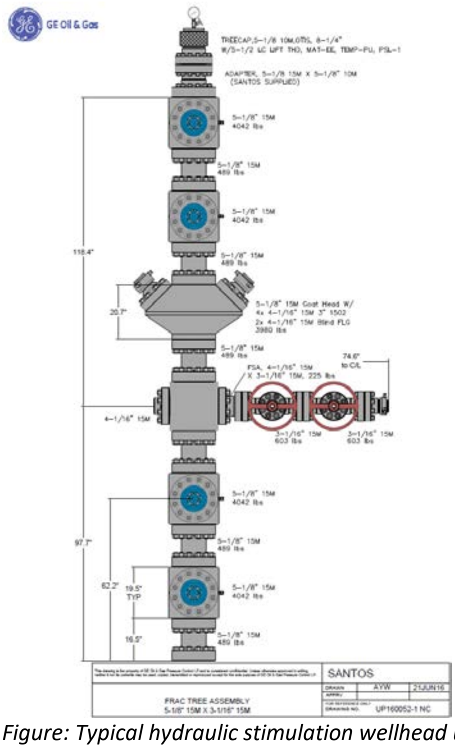


Figure: Typical hydraulic stimulation wellhead used for shale stimulation operations

Above ground storage tanks – on site, above ground water storage tanks provide temporary water storage for use in the hydraulic stimulation process. Source water can either be trucked from a nearby water source or piped along a temporary network. Small dosages of biocide are added to control algal growth particularly under warm and stagnant conditions. Following completion of works, temporary water storage infrastructure is removed from site.

Figure: Above ground storage ponds used for frac make up water storage and frac flowback water storage in the Cooper Basin, (Santos 2013)

Sand Trailer Unit – a large, multi-compartment trailer that holds proppant (sand or ceramic material) required for the treatment. When proppant is required, a conveyor system distributes proppant from the compartments to the blender unit.

Figure: Sand trailer unit. (Halliburton 2012)

Blender Units – In general, two different blending units are used: A pre-gel blender; and a down-hole blender. The pre-gel blender combines the source water with additives required for the base stimulation fluid and proportions of required additives to provide the final hydraulic stimulation fluid. The down-hole blender unit then proportions proppant to the stimulation fluid to provide the proppant concentrations specified in the treatment design. The final hydraulic stimulation fluid, without proppant, is referred to as the “clean fluid”. The final hydraulic stimulation fluid, with proppant added, is referred to as “slurry”. Chemical additives are precisely measured, controlled and recorded by the blender throughout the stimulation treatment process.

Figure: Blender unit. (Halliburton 2012)

High Pressure Pumps – Reciprocating triplex or quintaplex pumps that receive low pressure hydraulic stimulation fluid from the down-hole blender and inject these fluids at the required higher pressure into the well during the hydraulic stimulation process. 6-20 units are typically used on shale hydraulic fracture stimulation treatments. The pumps contain programmable pressure triggers (kick outs) to prevent pressure from exceeding the wellbore design limits. High pressure treating iron (pipes, manifolds, connectors, etc.) connecting the stimulation pumps and the wellhead also contain pressure safety valves (PSVs) that are set to open at a pre-set pressure to ensure the well components are protected.

Figure: High pressure pump. (Halliburton 2012)

Control or Data Acquisition Unit – telemetry from all units connects to a central control room during hydraulic stimulation treatments. Treatment parameter data, including surface and bottom-hole pressure, pumping rate, chemical rate and fluid density, are monitored, recorded and plotted. Treatment supervisors monitor and control the treatment to ensure that the treatment is pumped according to design. Satellite communication facilities allow further 'remote' oversight by technical experts.

Figure: Control unit. (Halliburton 2012)

Coiled Tubing Unit – a Coiled Tubing Unit (CTU) has many uses within oil and gas operations but is not always required as part of hydraulic stimulation operations. On some occasions the stimulation treatments are placed using coiled tubing assisted annular fracturing, as opposed to "perf and plug" completions (as described above). Coiled tubing can be used in place of wireline jet perforating by jetting holes through the casing and cement using abrasive jetting. Once perforations are jetted, the coiled tubing is left inside the well and the hydraulic stimulation treatment is pumped down the coiled tubing / casing annulus.

In Plug and Perf operations, the Coiled Tubing Unit is generally used at the completion of hydraulic fracturing operations and prior to flowing back into the well, in order to remove or “mill out” the bridge plugs set in the well to hydraulically isolate each stage.

Figure 3.19: Coiled tubing unit. (Halliburton 2012)

Flowback Ponds and/or Tanks – are used to receive fluids produced during stimulation operations and during the initial clean-up phase (following stimulation activities), and potentially during the early weeks and/or months (or possibly longer) of production testing operations. Typically the returning fluid decreases over time until it ceases and a hydrocarbon stream is solely produced. Ponds are typically double lined with UV stabilised synthetic liners to prevent leaks. Typically, after the initial clean-up phase, the produced fluids are allowed to evaporate or treated for disposal or re-use.

3.5 Completion

At the end of the clean-up phase, a workover rig may be used to install production tubing and associated completion equipment such as packers, nipple profiles, tubing hanger, and the production tree. Production tubing which has a smaller internal diameter than casing, is generally required to ensure the well can continue to ‘clean up’ and there is sufficient vertical lift performance to enable fluid to be removed from the well under natural lift from the well. After the well has been “completed” it is ready for longer term production via an inline production network.

3.6 Flow Testing

Once the injection process is complete, the internal pressure of the rock formation causes fluid to return or “flowback” to the surface through the shale gas well. This fluid, often referred to as flowback, contains the dissociation or breakdown products of the injected fluids plus naturally occurring geogenic compounds (i.e. material or substances that are mobilised through the process that must also be considered for any potential health or environmental impact).

A considerable volume of the injected fluids are recovered as flowback. Studies performed by the US EPA (US Environment Protection Agency (EPA), 2004) indicated that approximately 60% of the fluids are recovered in the first three weeks, and total recovery back to surface was estimated to be from 68–82%; however, this is variable across different fields and can be less than 20% in some instances. The flowback water is typically temporarily stored tanks or lined pits before treatment for reuse or disposal.

Initial flowback is typically performed with a mobile separator on location during exploration and appraisal when there are no or limited surface processing facilities. The separator is normally located on the well-pad and connected via relatively short flowlines that include debris catchers and choke manifolds to the wellhead in order to optimise the flowing conditions and frac clean-up. Separators are generally 3-phase which have the ability to effectively segregate gas, oil and water. The gas is sent through to a flare stack where it is flared on location (unless a gas network is already in place), while the liquid hydrocarbon (oil/condensate) is stored in onsite storage tanks, and the water or flowback is stored as described above

Figure 3.20: Flow testing separator rig up on a pad location. (Farley Riggs 2014)

The recovered fluids produced during the initial clean-up phase (following stimulation activities), are stored in Flowback Ponds or Tanks, which are double lined with UV stabilised synthetic liners to prevent leaks. The fluid is allowed to evaporate or it is treated for disposal or reuse in the next hydraulic fracturing event. Waste treatment and management facilities are modular, factory fabricated and transported to site for assembly and connected to piping, electrical controls and instrumentation. By-products from wastewater treatment are contained in fully engineered, purpose built structures for further treatment and disposal. Strategic opportunities for further treatment and beneficial use will be reassessed once composition and technology is assessed. The NT Government will mandate a number of conditions through a Code of Practice that Santos will be required to comply with as a condition of its authorisation to undertake exploration activity.

Fluid samples are taken during the flowback period. The analysed samples are used to determine flow contribution from each of the fracture stimulation stages. Gas sampling is also performed in order to determine the composition of the gas (methane, ethane, butane, carbon dioxide, hydrogen sulphide [not expected], etc.). This will define the value of the product as well as optimising the casing and wellhead material specifications for future campaigns.

Annexure 4 – List of Chemicals Proposed for use in Hydraulic Fracturing of Potential Hydrocarbon Producing Formations

Below is a list of chemicals used by Halliburton, Schlumberger and Condor in Fracture Stimulation operations. If chemicals other than those listed are proposed for use, these will be provided to the NLC and disclosed to Traditional Owners at On Country Work Program meetings.

Chemical Name
1,6-Hexanediol
2-Ethoxy-naphthalene
2-hydroxy-N,N,N-trimethylethanaminium chloride
2-Mercaptoethyl Alcohol
2-methyl-2h-isothiazol-3-one
2-Propenamid (impurity)
2-Propenoic acid, homopolymer, ammonium salt
5-chloro-2-methyl-2h-isothiazolol-3-one
Acetic acid
Acrylamide acrylate copolymer
"Acrylamide, 2-acrylamido-2-methylpropanesulfonic acid, sodium
salt polymer"
Acrylamide, sodium acrylate polymer
Acrylonitrile
Alcohols, C10-16, ethoxylated propoxylated
Alcohols, C11-14-iso-, C13-rich, ethoxylated
Alcohols, C12-15, ethoxylated
Alcohols, C12-16, ethoxylated
Alcohols, C6-12, ethoxylated propoxylated
Alcohols, C9-11, ethoxylated
Alkyl Alcohol
Amides, tall-oil fatty, N,N-bis(hydroxyethyl)
Amine oxides, cocoalkyldimethyl
Ammonium Chloride
Ammonium Persulphate
Ammonium Sulphate
Amylase, Alpha
Benzaldehyde
but-2-enedioic acid
Butyl alcohol
Calcium magnesium sodium phosphate frit
Carbolite (proppant)
Castor Oil
Ceramic (proppant)
Chlorous acid, sodium salt
Choline Chloride
Cinnamaldehyde
Citric acid
Copper(II) sulfate
Cristobalite
Crystalline silica, quartz
Decamethyl cyclopentasiloxane
D-Gluconic acid, monosodium salt
Diammonium peroxodisulphate
Diatomaceous earth, calcined
Dicoco dimethyl quaternary ammonium chloride
Diethanolamine
Diethylene glycol

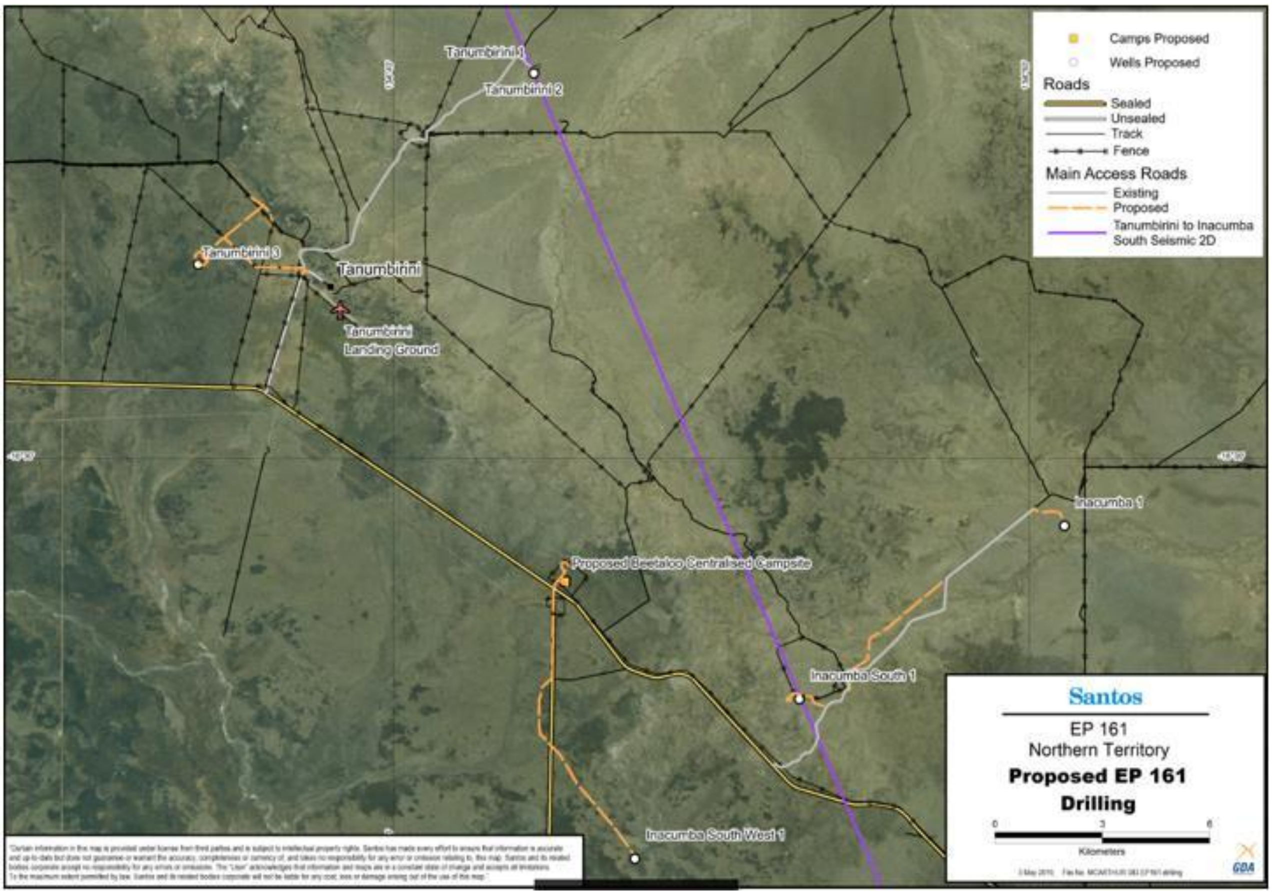
Diethylene Glycol
Dimethyl siloxanes and silicones
Disodium octaborate tetrahydrate
Distillates, Hydrotreated Light
Diutan
Diutan gum
Dodecamethylcyclohexasiloxane
EGMBE
Ethanol
Ethoxylated branched C13 alcohol
Ethoxylated C11 Alcohol
Ethylene Glycol
Fatty acids, tall-oil, ethoxylated
Formic Acid
Glutaraldehyde
Guar Gum
Hemicellulase
Hydrochloric acid
Hydrotreated light petroleum distillate
Inorganic Salt
Isopropanol
ISP (proppant)
Magnesium chloride
Magnesium nitrate
Magnesium silicate hydrate (talc)
Methanol
N-Benzyl-Alkylpyridinium Chloride
Non-crystalline silica (impurity)
Octamethylcyclotetrasiloxane
Partially neutralized polycarboxylic acid polymer
Pine Oil
Poly(oxy-1,2-ethanediyl), alphahexyl-omega-hydroxy-
poly(tetrafluoroethylene)
Polyacrylamide
Polyethylene glycol
"Polymer of 2-acrylamido-2-methylpropanesulfonic acid sodium
salt and methyl acrylate"
Polyoxyethylene nonylphenol ether
Polyoxyethylene-polyoxypropylene Block Copolymer
Potassium Chloride
Potassium Hydroxide
Potassium persulfate
Pottasium Sorbate
Propan-2-ol
Quartz, Crystalline silica
Quaternary ammonium compounds, bis(hydrogenated tallow alkyl) dimethyl, salts with bentonite
Sand (proppant)
Siloxanes and silicones, dimethyl, reaction products with silica
Sobitan, mono-9-octadecenoate, (Z)
Sodium acrylate, polymer with acrylamide and sodium AMPS
Sodium Benzoate
Sodium bisulfite
Sodium Bromate
Sodium calcium pentaborate octahydrate
Sodium Chloride
Sodium diacetate
Sodium erythorbate

Sodium hydroxide
Sodium iodide
Sodium perborate tetrahydrate
Sodium persulfate
Sodium polyacrylate
Sodium Sulfate
sodium sulphite
Sodium Tetraborate Decahydrate
sodium thiosulphate
Sorbitan monooleate polyoxyethylene derivative
Sorbitan, mono-(9Z)-9-octadecenoate
Sorbitan, monooleate, polyoxyethylene derivs.
Tar Bases, Quinoline Derivatives, Benzyl Chloride-Quat
Tetrasodium ethylenediaminetetraacetate
Tributyl tetradecyl phosphonium chloride
Triethanol amine
Ulexite
Urea

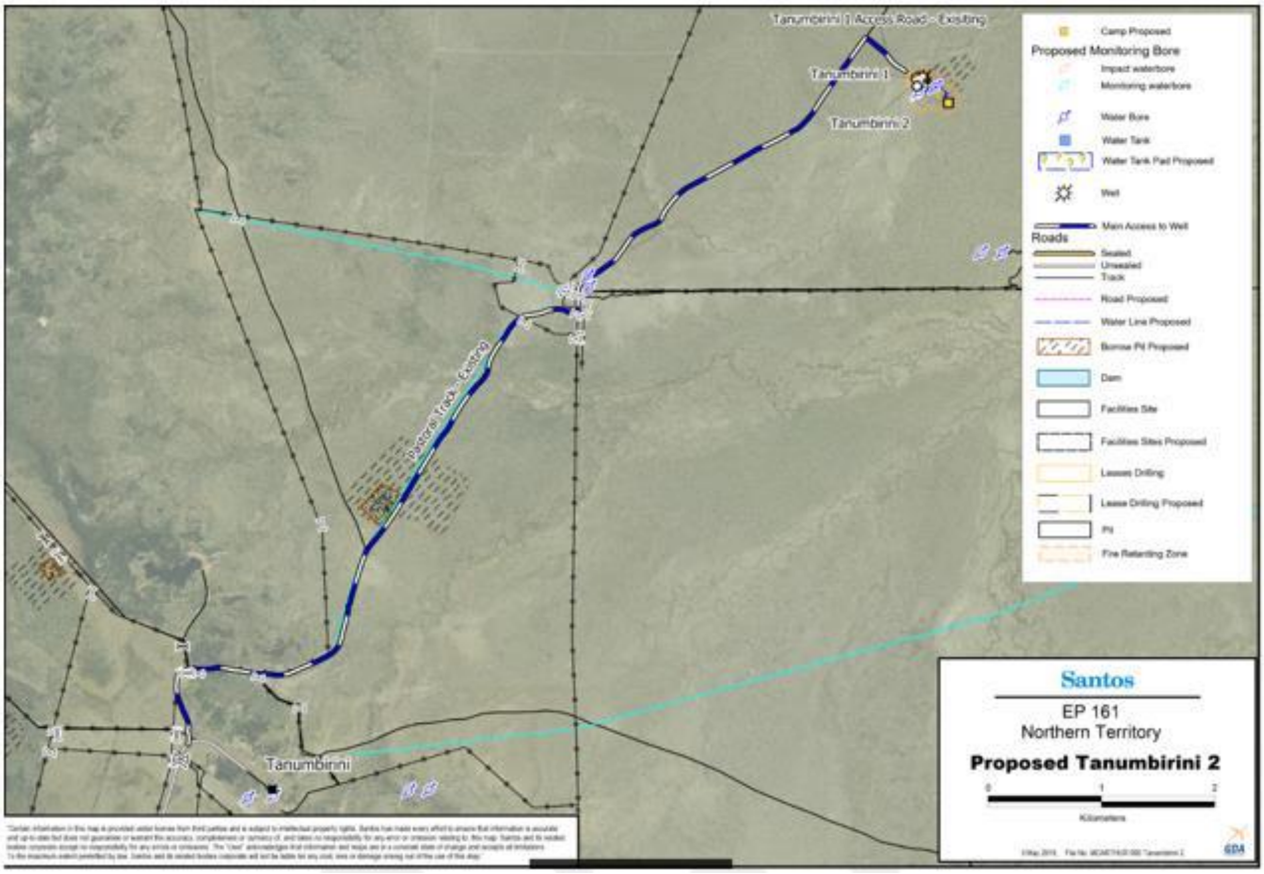
Pastoral Land Access and Compensation Agreement – Annexure D Plans

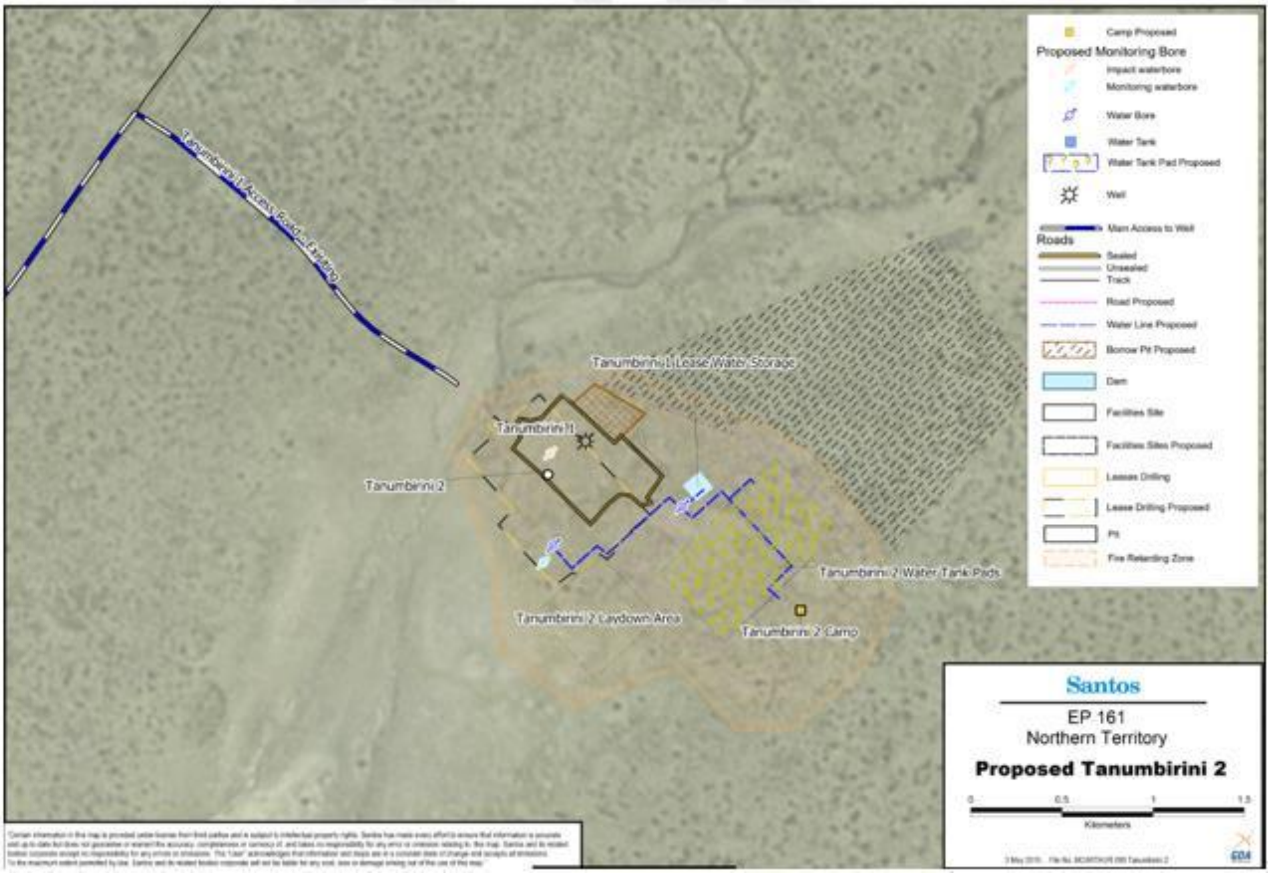
Annexure D Plans

Existing and Proposed Access Roads for 5 x wellsites

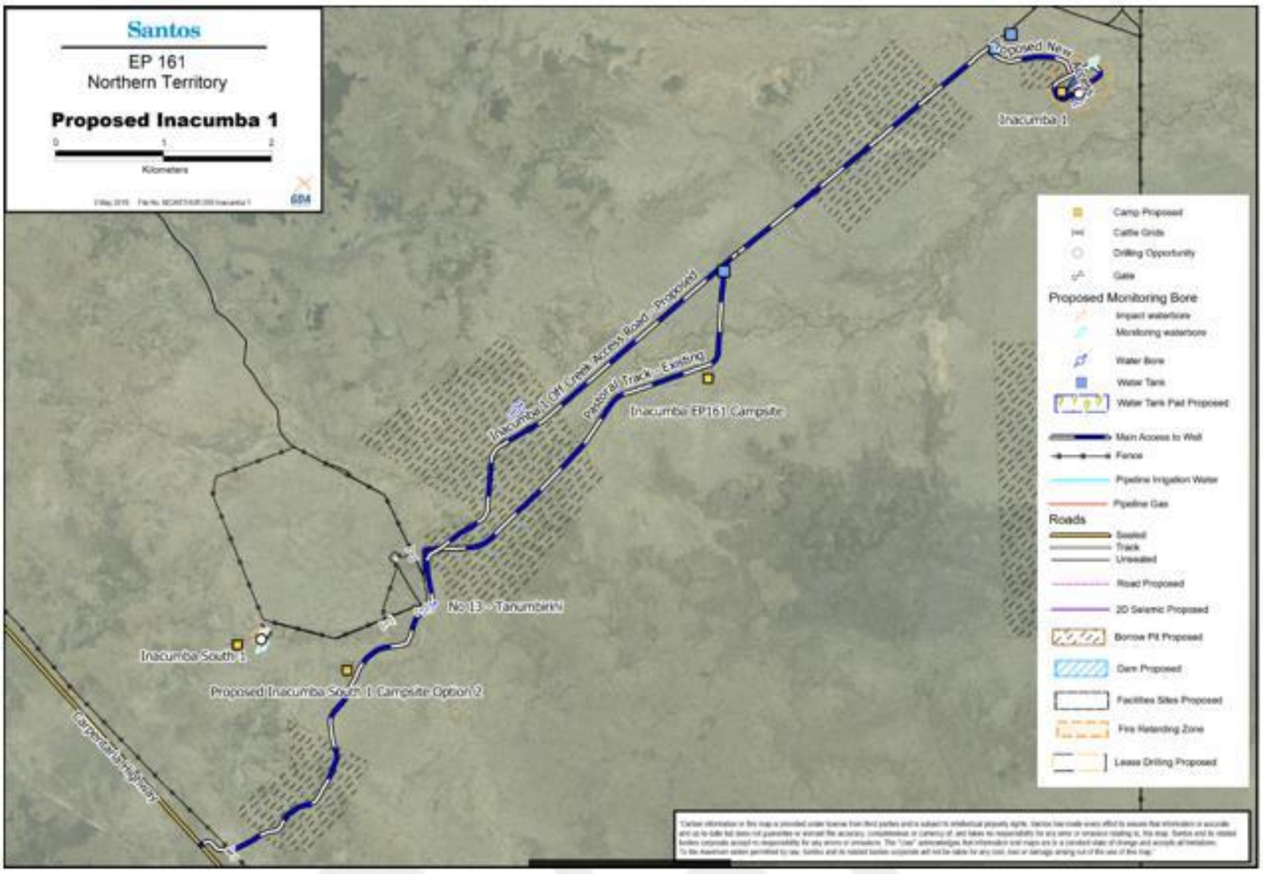


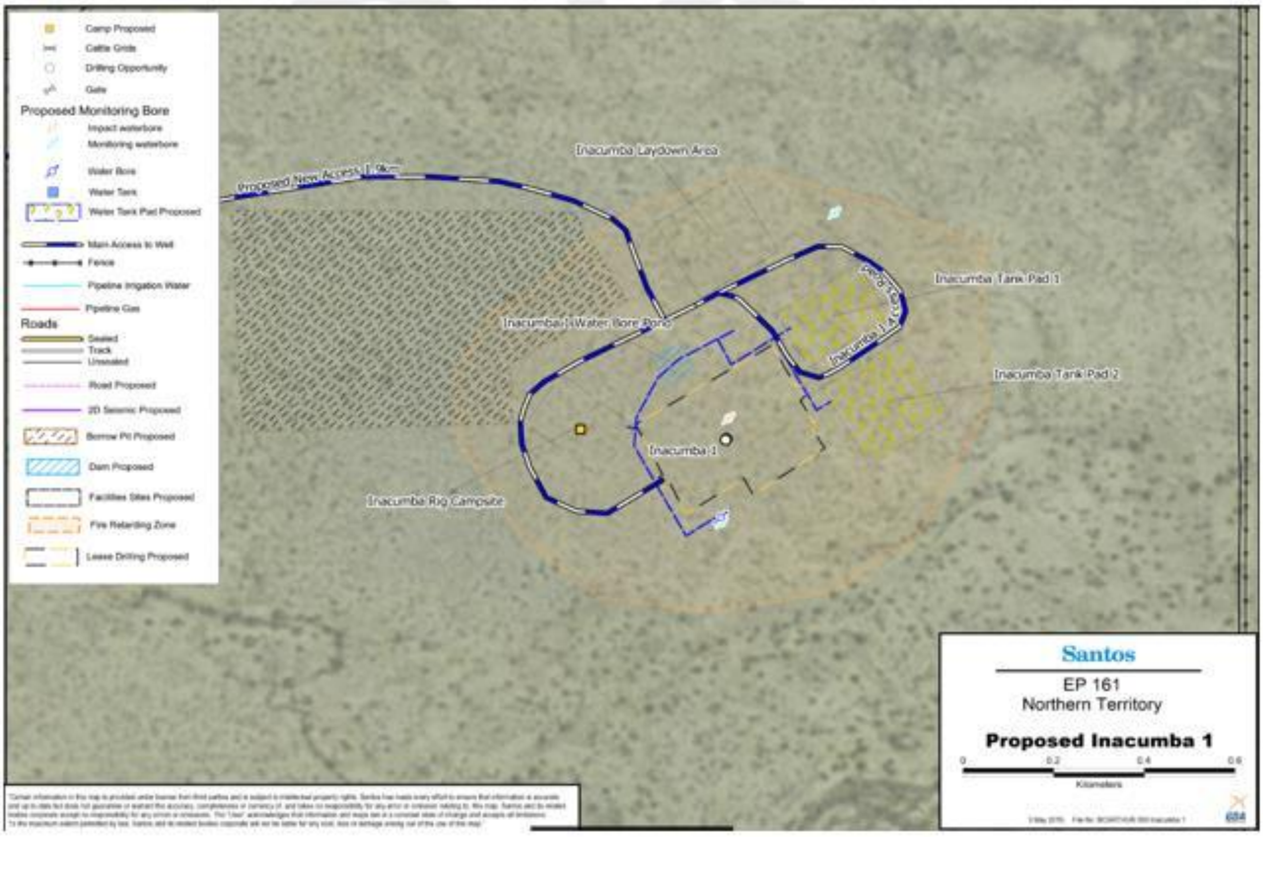
Tanumbirini #2 access road and wellsite maps



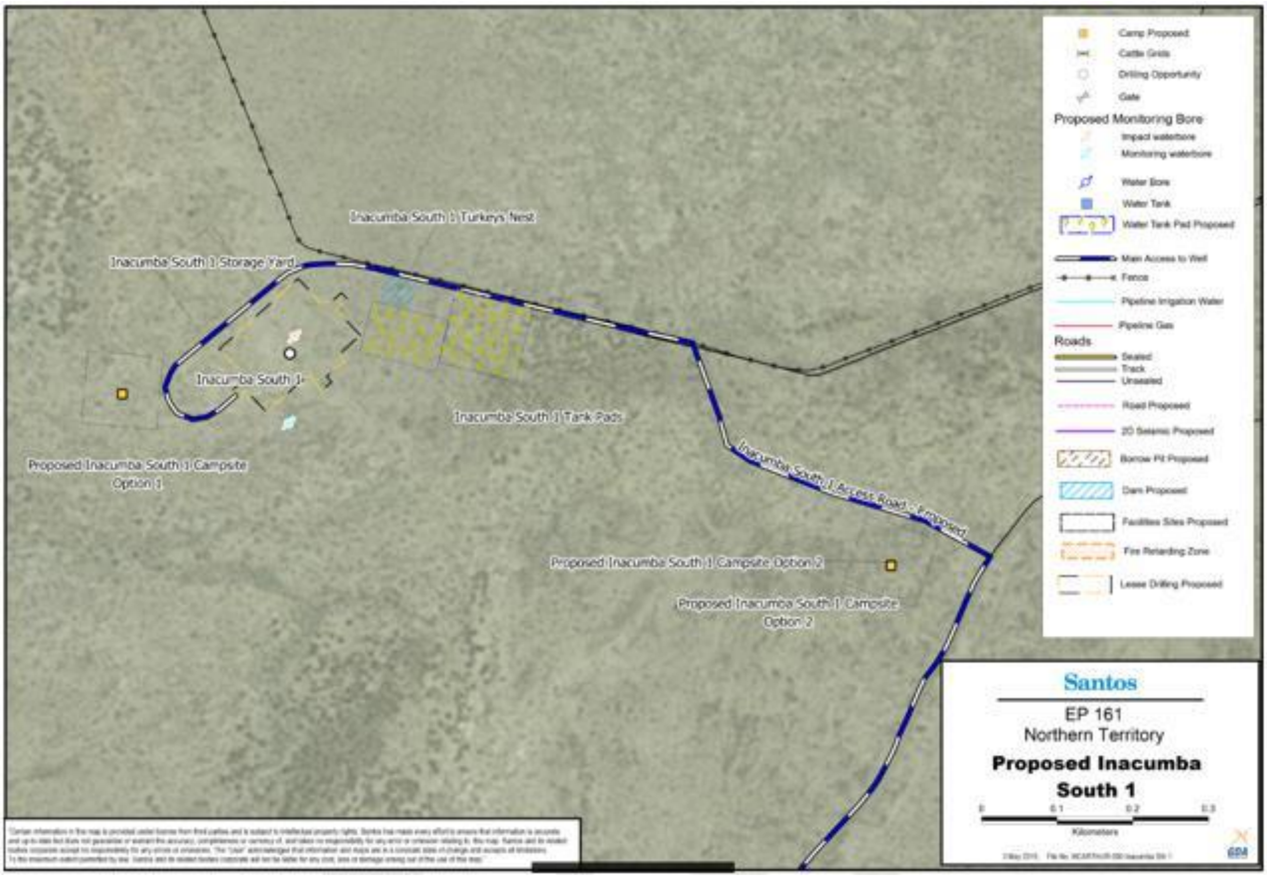


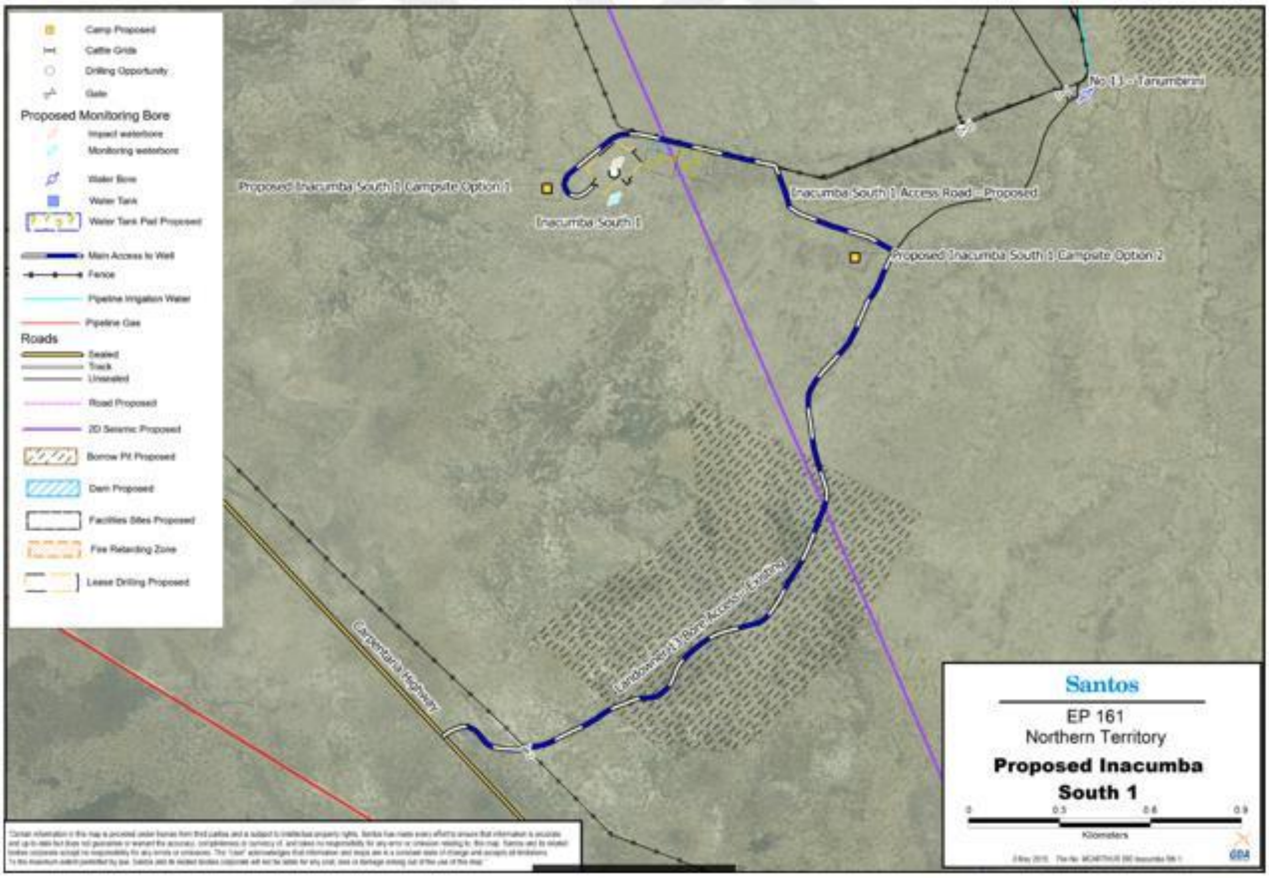
Inacumba #1 access road and wellsite maps



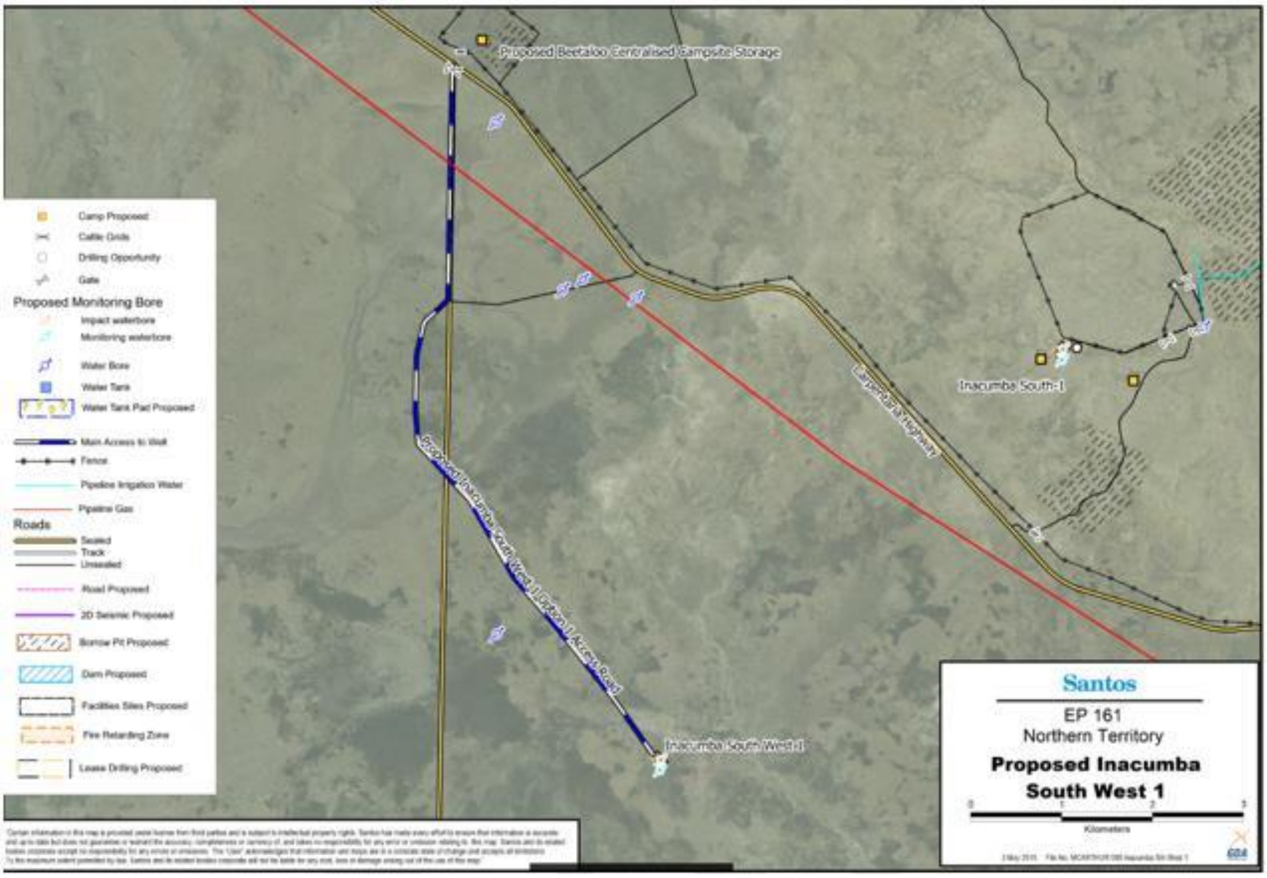


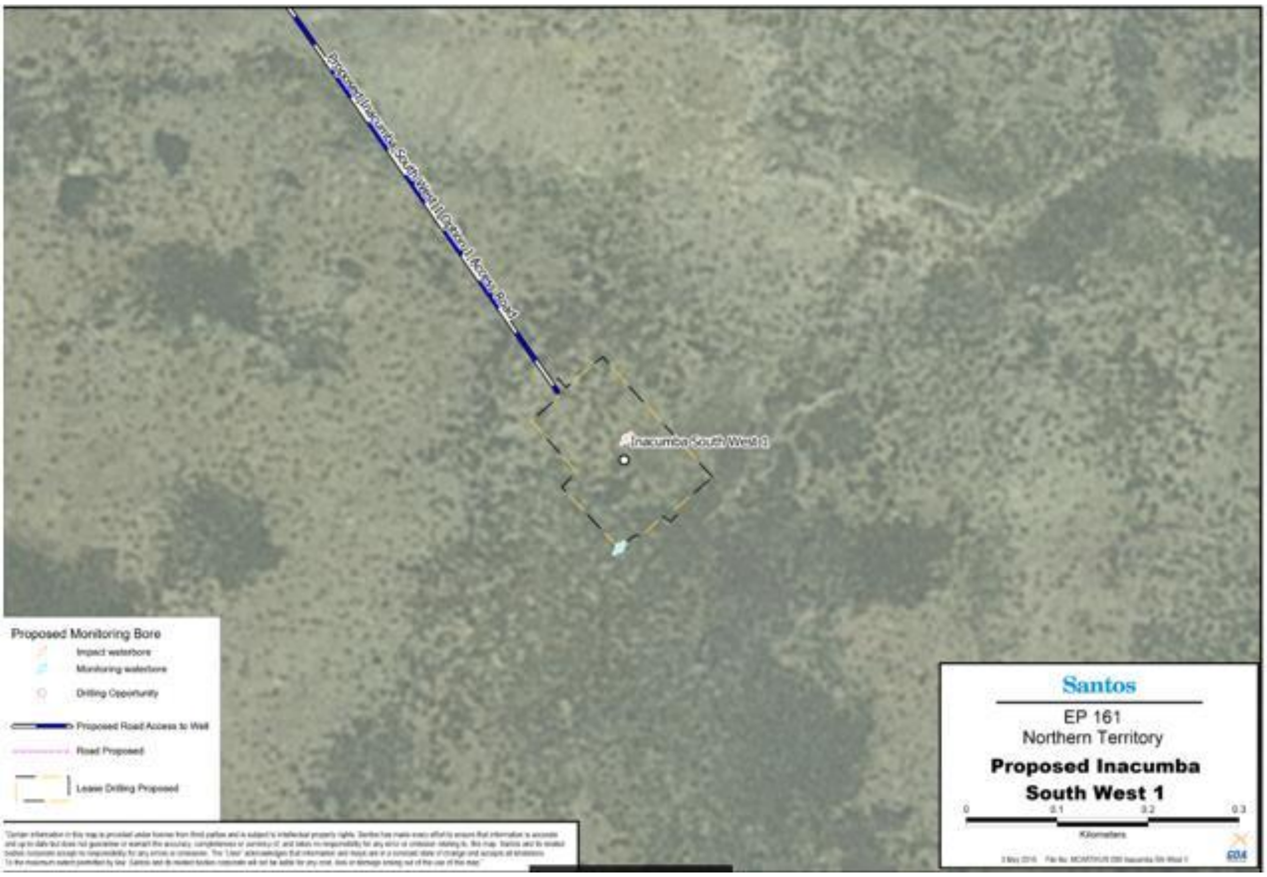
Inacumba South #1 access road and wellsite maps



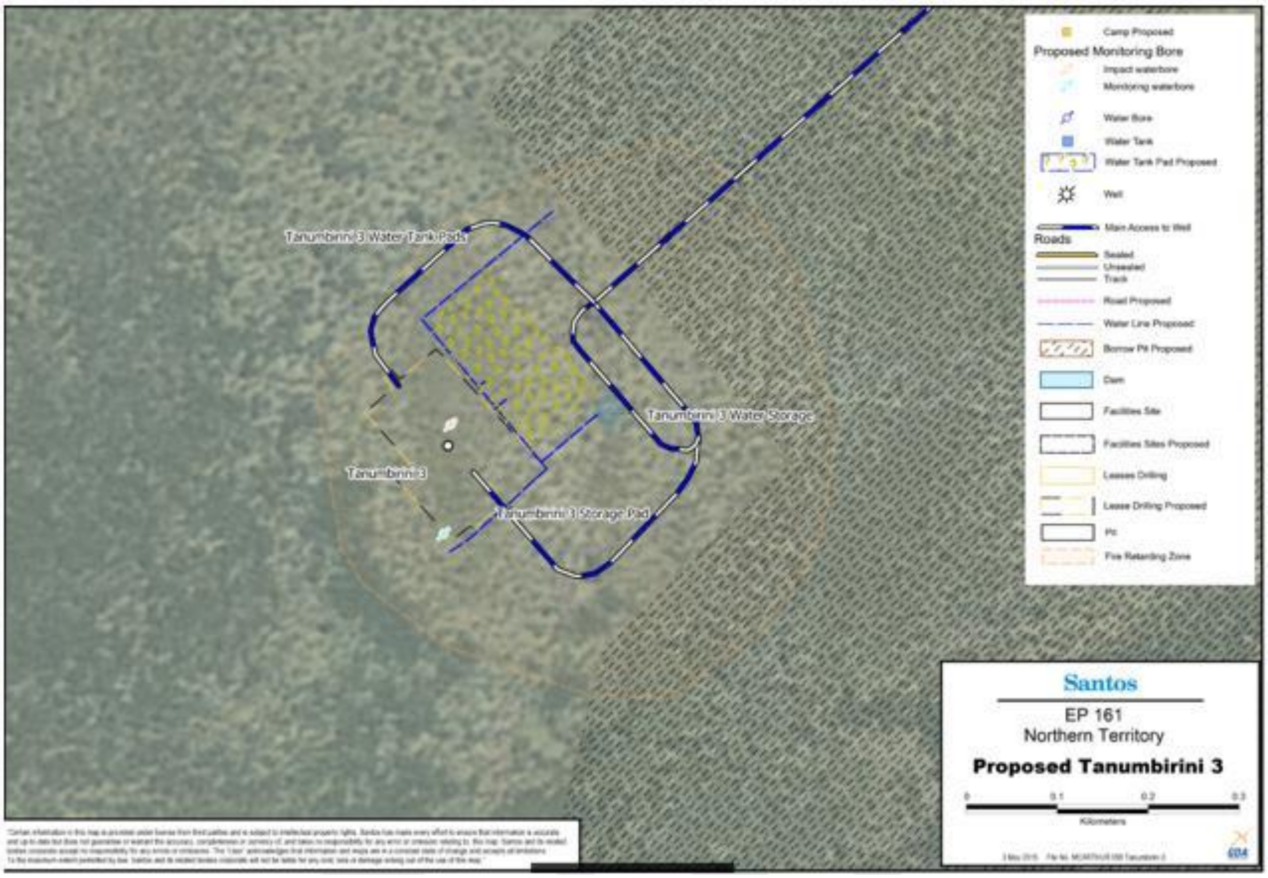


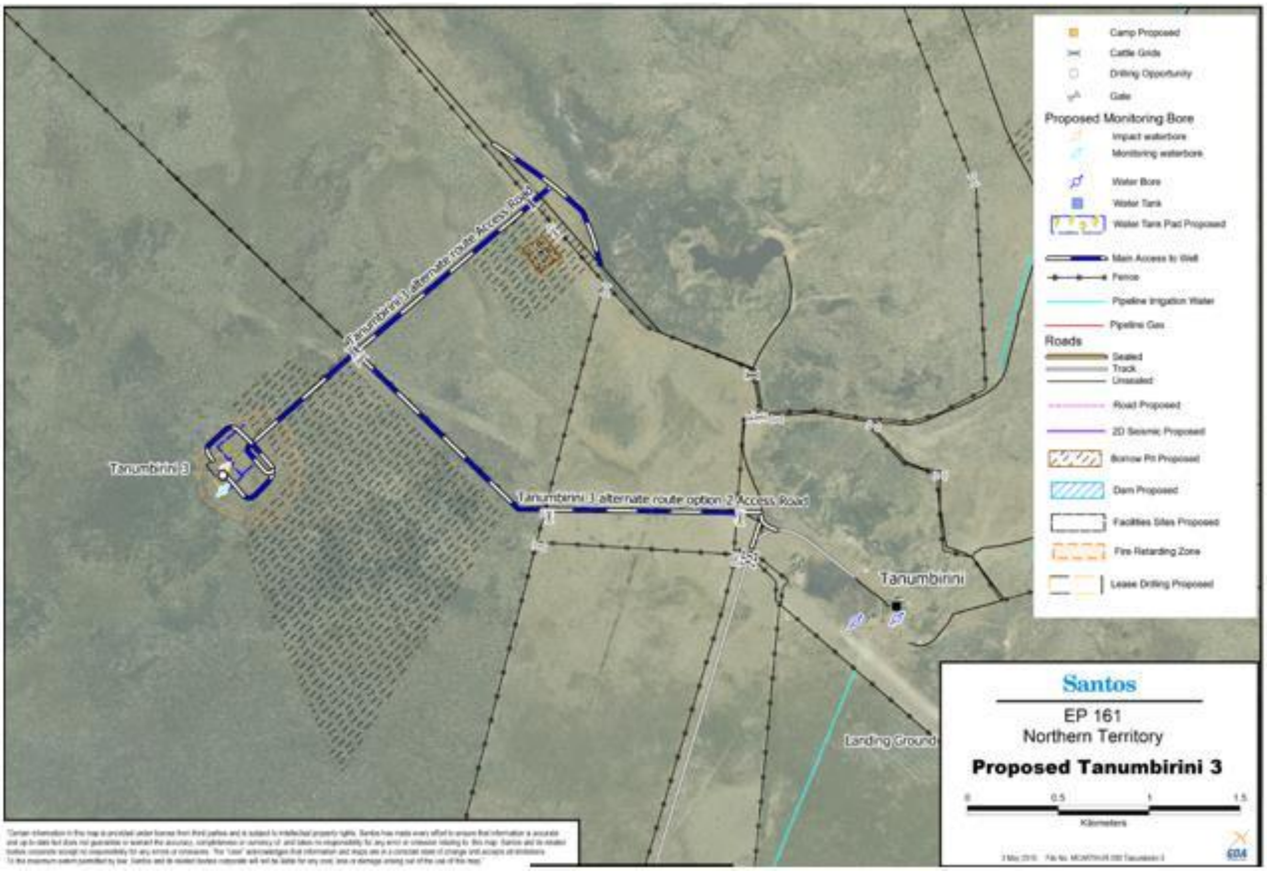
Inacumba South West #1 access road and wellsite maps





Tanumbirini #3 access road and wellsite maps





2D seismic line between Tanumbirini #2 and Inacumba South #1