# M

# Biodiversity – Flora and Vegetation Report

# Arafura Resources Limited

## Nolans Project Environmental Impact Statement

## Appendix M: Biodiversity - Flora and Vegetation Assessment

May 2016

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# Abbreviations

| | |
|---|---|
| BRT | Burt Plain bioregion |
| EMP | Environment Management Plan |
| DD | Data deficient |
| DotE | Department of the Environment |
| DLPE | Department of Lands, Planning and the Environment |
| DLRM | Department of Land Resource Management (formally NRETAS) |
| DMP | Dust Management Plan |
| EIS | Environmental Impact Statement |
| EPBC Act | *Environment Protection and Biodiversity Conservation Act 1999* |
| FMP | Fire Management Plan |
| MNES | Matters of National Environmental Significance |
| NRETAS | Department of Natural Resources and Environment, the Arts and Sport (now DLRM) |
| NT | Near Threatened |
| NT EPA | Northern Territory Environment Protection Authority |
| NVIS | National Vegetation Information System |
| PMST | Protected Matters Search Tool |
| s.l. | *sensu lato*, in the broad sense |
| subsp. | subspecies |
| TEC | Threatened Ecological Community |
| TOR | Terms of reference |
| TPWC Act | *Territory Parks and Wildlife Conservation Act 2000* |
| var. | variety |
| VT | Vegetation type |
| WM Act | *Weed Management Act 2001* |
| WMP | Weed Management Plan |

# 1. Introduction

## 1.1 Project description

Arafura Resources Limited (Arafura) proposes to develop the Nolans Rare Earths Project (the project), located approximately 135 km north west of Alice Springs, Northern Territory. Arafura plans to mine, concentrate and chemically process rare earths at the Nolans site Figure 1.1 Nolans site, then transport a rare earth intermediate product to an offshore refinery for final processing into high-value rare earth products.

The general arrangement of the proposed operation includes the three key sites - the mine site, the processing site and the borefield; in addition to the workers accommodation village, utilities corridors and access roads (Figure 1.1).

Project activities include construction, mining, processing, rehabilitation and decommissioning of an open-cut, rare earth mine, and associated infrastructure. Mining operations would be undertaken using conventional open pit methods (drill, blast, load and haul) to recover up to 900,000 tonnes of ore per annum.

Ore will be beneficiated onsite before a rare earth concentrate slurry is pumped approximately 8 km south to an intermediate processing plant. A total 20,000 tpa rare earth oxide will be transported by road then rail to East Arm Port (Darwin) for export to an offshore rare earths separation plant in an established chemical precinct.

The Nolans Bore deposit contains thorium and uranium, which will be removed and stored in a waste disposal facility during processing. The operational life of the Project is expected to be 43 years.

## 1.2 Purpose of this report

GHD was engaged by Arafura Resources Limited (Arafura) to undertake a flora and vegetation assessment of the Study area. This included assessment of the proposed mine site, processing site, accommodation village, access roads, potable water pipeline, water supply pipeline and borefields area (as shown in Figure 1.1).

Ecological assessments for the Project have been completed over a period of eight years.

This report includes the findings of flora and vegetation surveys of the mine site that were completed by GHD in 2010/11, and those completed for the processing site, accommodation village, access roads, potable water pipeline, water supply pipeline and borefields area undertaken by GHD in 2015. Earlier work by Low Ecological Services (2007) was incorporated where relevant.

The purpose of this assessment was to satisfy the requirements of the Northern Territory Environment Protection Authority (NT EPA) Terms of Reference (TOR) for the Project with regards to flora and vegetation.

In particular, the objectives of this report are to:

- Describe and map vegetation communities occurring within the Study area
- Identify threatened vegetation communities and/or flora species, listed under *Environment Protection and Biodiversity Conservation Act 1999 (*EPBCAct) and/or *Territory Parks and Wildlife Conservation Act 2009* (TPWC Act) present or considered likely to occur within the Study area

- Provide a map of the project footprint overlain with vegetation mapping that is sufficient to identify areas that have already been subject to clearing activities or disturbance previously (if any) and identify areas of vegetation that are proposed to be cleared
- Evaluate vegetation condition with regard to anthropogenic disturbance such as the presence of introduced flora, evidence of clearing or heavy livestock impact
- Map the extent of exotic (weed) species listed under the *Weeds Management* (WM) *Act 2001* and/or other significant weed infestations within the Study area
- Assess the regional and national significance of the vegetation and flora species within the Study area
- Determine ways in which the proposed Project might impact on ecological values including threatened flora species
- Identify additional risks to local ecological values associated with the clearing of vegetation, edge effects and invasive species
- Identify measures to avoid, minimise, mitigate and offset potential impacts on ecological values within the Study area
- Determining any residual risks to vegetation and flora species.

## 1.3 Scope and limitations

This report: has been prepared by GHD for Arafura Resources Limited and may only be used and relied on by Arafura Resources Limited for the purpose agreed between GHD and the Arafura Resources Limited as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Arafura Resources Limited arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on limitations made by GHD described in this report (refer Section 3.9 of this report). GHD disclaims liability arising from any of the limitations being incorrect.

GHD has prepared this report on the basis of information provided by Arafura Resources Limited and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of services, vegetation, access and sacred sites. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

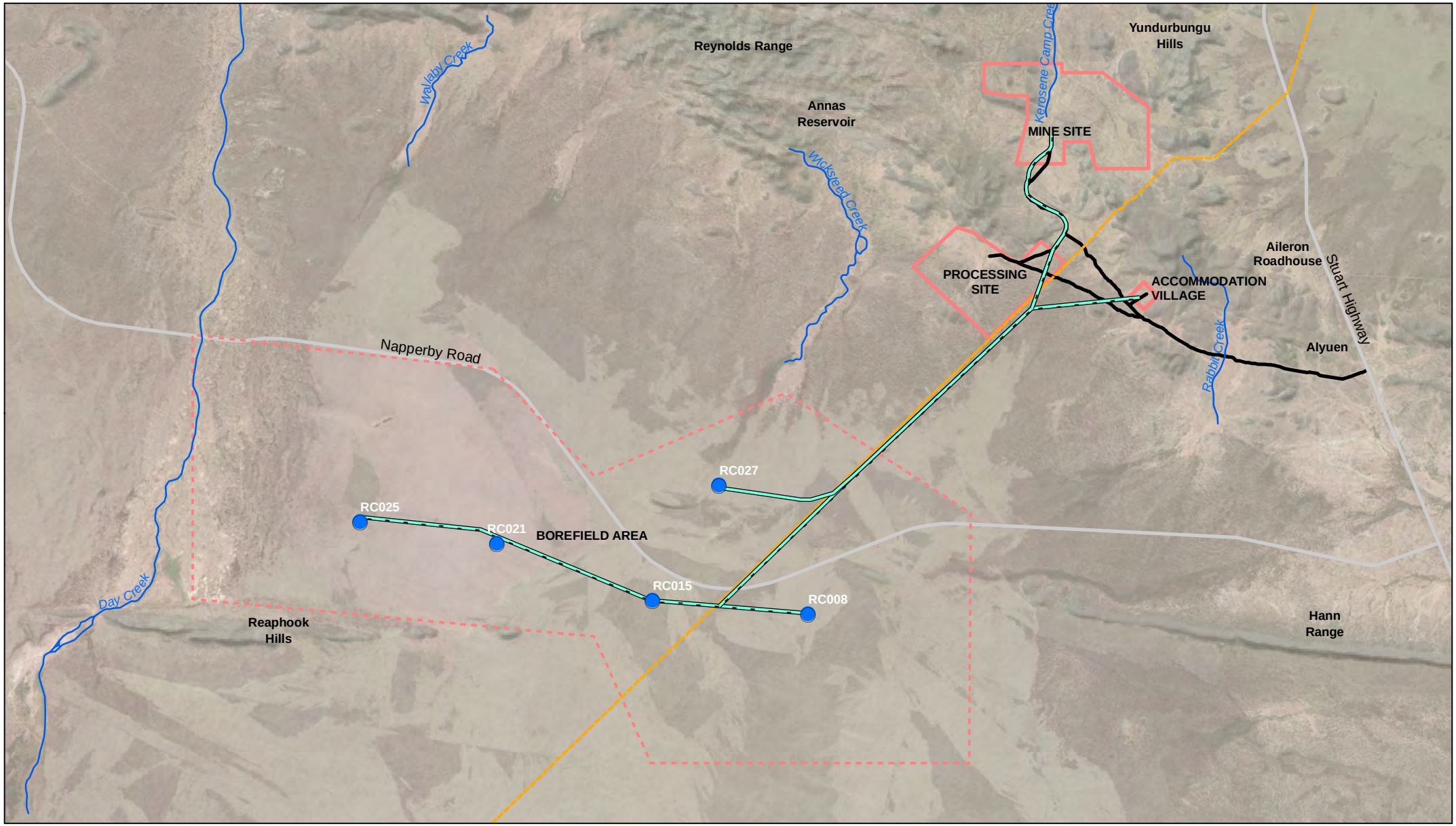
## 1.4 Definitions

For the purposes of this assessment, the following definitions are employed:

**Nolans Site** – refers to the mine site, processing site, accommodation village, access roads, potable water pipeline, water supply pipeline, and borefields area as shown in Figure 1.1.

**Study area** – refers to the area that was surveyed for this assessment. It included the mine site, processing site the accommodation village as well as a 200 m wide corridor along the proposed access roads and 100 m corridor along the potable water pipeline and water supply pipeline. The total area is approximately 5692 ha (Figure 1.2).

**Locality** – the area within a 20 km radius of the Study area.

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0 2 4 6 8

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Water Bores
- Proposed Powerline
- Proposed Pipelines and Easement
- Existing Gas Pipeline and Easement
- Waterways
- Existing Roads
- Existing Access Track
- Borefield Area
- Site Boundaries

Arafura Resources Limited
Nolans Project

| | |
|---|---|
| Job Number | 4322301 |
| Revision | 0 |
| Date | 18 Mar 2016 |

Nolans site

Figure 1.1

G:\43\22301\GIS\Maps\4322301_303_SiteAndSurrounds.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: GA - Imagery (2008), Roads, Waterways, Placenames (2015). ESRI - Shaded Relief (2009). ARL - Water Bores, Proposed Pipelines, Borefield Area, Proposed Mine Site, Treatment Plant and Accommodation Village (2015). Created by: CW, CM


1:225,000 @ A4

0 2 4 6 8

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Water Bores
- Existing Roads
- Existing Access Track
- Waterways
- Study Area
- Borefield Area

Arafura Resources Limited
Nolans Project

| | |
|---|---|
| Job Number | 4322301 |
| Revision | 0 |
| Date | 18 Mar 2016 |

# Study area

Figure 1.2

G:\43\22301\GIS\Maps\4322301_302_StudyArea.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: GA - Imagery (2008), Roads, Waterways, Placenames (2015). ESRI - Shaded Relief (2009). ARL - Water Bores, Proposed Pipelines, Borefield Area, Proposed Mine Site, Treatment Plant and Accommodation Village (2015). Created by: CW, CM

# 2. Existing environment

## 2.1 Location

The Nolans site is located approximately 135 km north-west of Alice Springs, Northern Territory (NT), within Exploration Lease 28473, 28498, 29509. Arafura Resources Limited has lodged an application for a Mineral Lease (ML 26659) and is preparing additional applications to accommodate an expanded Project footprint to include the mine site, processing site and an accommodation village. Background land tenure to the site is the Aileron Perpetual Pastoral Lease (PPL 1097) held by Waite River Holdings Pty Ltd.

The predominant land use in the area is cattle grazing on pastoral tenure, with stocking rates tending to vary according to rainfall patterns.

The Nolans site is located approximately 10 km west of the Stuart Highway and 65 km from the Darwin-Adelaide railway. The Amadeus Basin to Darwin natural gas pipeline runs directly adjacent to the processing site and within five km of the mine site.

The town of Alice Springs, south-southeast of the Nolans site along the Stuart Highway, is well served by modern air, road, rail and telecommunications infrastructure.

## 2.2 The Study area

The Study area is situated in central Northern Territory within the Burt Plain bioregion. It is located on the Aileron and Napperby pastoral stations. These stations have been used for grazing since the early 1880's.

The Study area contains a wide variety of landforms including rocky outcrops consisting of granitic orthogneiss and granite, alluvial plains and fans and drainage channels (watercourses). The outcrops extend up to 150 m from the surrounding plain.

The proposed borefield area consists of gently undulating sandplains with limited surface drainage. Dominant vegetation types within the Study area include *Acacia* shrublands, hummock grasslands, and grassy eucalypt woodlands.

## 2.3 Climate

The Study area is located within the southern extent of the Australian monsoonal belt, with a semi-arid climate characterised by significantly higher evaporation potential than annual rainfall.

The closest weather station to the site is located at the Territory Grape Farm which is located approximately 40 km north of the Study area. The hottest months are November to March, with the monthly mean of daily maximum temperatures ranging from 36.2 to 34.3 degrees Celsius, and monthly mean daily minimum temperatures ranging from 19.5 to 18.8 degrees Celsius. The coolest months are May to August, with the monthly mean daily maximum temperatures remaining at or below 25.3 degrees Celsius, and monthly mean daily minimum temperatures not rising above 9.5 degrees Celsius.

The mean annual rainfall is approximately 319.1 mm, with a reasonably strong seasonal pattern of more summer rainfall than winter rainfall. Average monthly rainfall totals range from 4.7 mm in August to 68.0 mm in February (Table 2.1). Average three-monthly rainfall totals range from 18.8 mm in June/July/August to 171.8 mm in December/January/February. However, any month can receive relatively large rainfall totals, or little or no rain at all.

The distinct seasonality of rainfall in the region is distinctly correlated with temporal and spatial fluctuations in species richness and abundance, with many ephemeral flora species only emerging for short periods following rain.

Table 2.1 Rainfall and temperature statistics (BoM 2015; Territory Grape Farm NT 1987-2014)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Rainfall (mm)** | | | | | | | | | | | | |
| Highest | 280.4 | 342.2 | 109.2 | 151.7 | 136.3 | 53.8 | 34.2 | 39.4 | 96.6 | 56.8 | 119.2 | 119.2 |
| 95th %ile | 159.0 | 244.2 | 96.9 | 89.9 | 100.1 | 48.7 | 21.3 | 26.9 | 41.7 | 51.3 | 81.4 | 109.9 |
| Mean | 62.4 | 65.8 | 21.9 | 18.0 | 23.3 | 8.7 | 4.9 | 4.7 | 10.3 | 15.3 | 30.9 | 50.5 |
| 5th %ile | 3.8 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.9 | 8.9 |
| Lowest | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 |
| **Temp (°C)** | | | | | | | | | | | | |
| Maximum[1] | 37.3 | 36.2 | 34.3 | 30.5 | 25.5 | 22.2 | 22.5 | 25.3 | 30.5 | 33.3 | 35.6 | 36.3 |
| Minimum[2] | 21.9 | 21.6 | 19.5 | 14.6 | 9.5 | 6.2 | 5.2 | 7.1 | 12.1 | 15.6 | 18.8 | 21.1 |

Notes: [1] Monthly mean maximum temperature is the average of the available daily maxima for that month.

[2] Monthly mean minimum temperature is the average of the available daily minima for that month.

## 2.4 Bioregion

A bioregion represents a large area of land with generally consistent biophysical characteristics (i.e. the climate, landform, geology, soils, vegetation and animals).

The Study area occurs entirely within the Burt Plain bioregion, which is characterised by plains and low rocky ranges with extensive areas of mulga and other acacia woodlands. The bioregion covers an area of 73 605 km$^2$ which represents approximately 5% of the Northern Territory (NRETAS 2005).

The bioregion includes some of Australia's best established and most extensive mulga (*Acacia aneura*) woodlands. Less than 0.3% of the bioregion is reserved in National Parks or other conservation reserves, and most ecosystems are not well represented in the reserve network – particularly mulga woodlands (NRETAS 2005).

Pastoralism represents the major industry in the Burt Plain, with 37 pastoral leases within or intersecting the boundary of the bioregion, occupying approximately 82% of the land area (Neave *et al.* 2006).

Geologically the bioregion lies over the Arunta Province, Tennant Inlier, and small areas of Georgina, Wiso and Ngalia Basins, with metamorphic, plutonic, and sedimentary rocks of Precambrian age. Soils are generally comprised of shallow sands and massive earths. Landforms range from undulating plains to rocky ranges, with elevations of 350 to 1100 m respectively. The bioregion is dominated by undulating plains which are interrupted by major drainage lines associated with terraces and levees, and sporadic hills and rocky ranges (DNREA 2006). Several ephemeral rivers drain the rocky ranges and flow through the bioregion in a northerly direction into the Tanami Desert.

There are five broad vegetation types that have been mapped within the bioregion (Wilson *et al.* 1990), the most abundant being Acacia Woodland. Other broad vegetation types recorded

within the bioregion include Eucalyptus low woodland with tussock grass understory, Eucalyptus woodland with hummock grass understory, Hummock Grassland and Tussock Grassland (NRETAS 2005).

The bioregion is known to contain more than 1100 flora species of which three species are listed as vulnerable under the TPWC Act, with one also listed as vulnerable under the EPBC Act. Additionally, 64 species listed as data deficient, 41 listed as near threatened in the Northern Territory and seven listed as endemic to the bioregion have been recorded (Neave *et al.* 2006). There are 16 sites of botanical significance within the Burt Plain bioregion, none of these occur within or near to the Study area (Neave *et al.* 2006).

Wetlands occur within the Burt Plain bioregion, but none is listed in the 'Directory of Important Wetlands in Australia' (DIWA) or under the 'Convention on Wetlands of International Importance' (Ramsar Convention). There are no potentially significant wetlands that occur within the Burt Plain bioregion that are directly associated with the Study area or immediate surrounds (i.e. Stirling Swamp, and the springs and waterholes of the Dulcie Ranges).

The Burt Plain bioregion is recognised as a national priority bioregion for conservation planning. This is primarily due to the fact that it is one of the most poorly documented bioregions in the Northern Territory in terms of its biodiversity values (Neave *et al.* 2006).

Potential and existing threats to biodiversity that have been identified within the bioregion include exotic flora, introduced animals, fire, erosion, land clearing, pastoralism and mining (Neave *et al.* 2006). Exotic predators are widespread and there are fifteen declared weed species currently listed under the *Northern Territory Weeds Management Act 2001* (WM Act) known to occur in the bioregion. Other exotic plants species, most notably Buffel and Couch grass, also pose significant threats to some habitats.

The Burt Plain bioregion is comprised of four sub-regions. The Study area occurs mostly within the Burt Pain 1 subregion with a small portion in the south of the Study area located within the Burt Plain 2 subregion. These subregions have been assessed as being in mostly good condition with native vegetation cover exceeding 90%. A high proportion of both subregions however, have been impacted by grazing and exotic flora species (particularly Buffel Grass) (Neave *et al.* 2006).

## 2.5 Geology

Geological mapping completed at a scale of 1:1 000 000 (Geosciences Australia) indicates that there are 15 geology units within the Study area, of which the most dominant are Red earth and Alluvium. Geology types present within the Study area are provided in Table 2.2 and shown in Figure 2.1.

Table 2.2 Geology types mapped within the study area

| Geology | Area (Ha) |
|---|---|
| Aeolian sand | 912 |
| Alluvium | 1933 |
| Calcrete | 224 |
| Coarse porphyritic granitic augen gneiss with mantled feldspars | 65 |
| Cordierite gneiss, quartzofeldspathic gneiss, garnet-biotite gneiss, sillimanite gneiss | 9 |
| Felsic granulite, mafic granulite, amphibolite, garnet-biotite gneiss, sillimanite gneiss, cordierite granulite | 0 |
| Garnet-cordierite-biotite-quartz granofels, tourmaline metaquartzite | 69 |
| Granite, granodiorite | 95 |
| Mafic granulite, felsic granulite, quartzofeldspathic gneiss | 1 |
| Medium even-layered granitic gneiss, minor porphyritic granite | 232 |
| Red earth | 2012 |
| Retrogressively metamorphosed rock in the Arunta Block | 29 |
| Schist, gneiss, quartzite, quartz-rich metasediment | 1 |
| Schist, phyllite, andalusite hornfels, tourmaline-quartz pods | 77 |
| Sillimanite-biotite-cordierite-orthoclase granofels | 34 |
| **Total** | **5694** |

The Nolans Bore deposit is located at the southern end of the Reynolds Range, in the central Aileron Province of the Arunta Region. The Aileron Province comprises greenschist to granulite facies metamorphic rocks with protolith ages in the range 1865-1710 Ma (Geosciences Australia 2015).

Supracrustal rocks in the Reynolds Range are divided into two broad units: The Lander Rock Beds (LRB) and the Reynolds Range Group. The LRB comprise (meta) turbiditic rocks that range in metamorphic grade from greenschist to granulite. In the Nolans Bore region, the LRB include schist, phyllite, andalusite hornfels, garnet-cordierite-biotite-quartz granofels, sillimanite-biotite-cordierite-orthoclase granofels, tourmaline metaquartzite, and tourmaline-quartz pods (Geosciences Australia 2015).

Granite intrusion occurred in the Reynolds Range area between 1810 and 1790 Ma. Granitic rocks which intrude the LRB in the vicinity of Nolans Bore are a southern extension of the Mount Boothby Orthogneiss (MBO). The supracrustal rocks and granites were overprinted by high grade metamorphism to amphibolite and granulite facies during 1590-1560 Ma (Geosciences Australia 2015).

Apatite-hosted REE-P-U (-Th-F) mineralisation at Nolans Bore is distributed over an area of approximately 150 ha within a kilometre radius of the bore. Primary mineralisation occurs predominantly in a series of sub-parallel tabular zones of massive fluorapatite ($Ca_5(PO_4)_3(F,OH)$), or as a stockwork of fluorapatite ± allanite ± carbonate veins and associated calcsilicate alteration. The massive zones dip steeply (65°-90°) to the NNW, are up to about

75 m thick, and extend laterally and at depth over tens to several hundreds of metres. They are hosted primarily by gneissic granite assigned to the MBO, and also by the LRB and pegmatites. (Geosciences Australia 2015).

## 2.6 Land system classification

Land systems have been defined as “a reasonably homogenous part of a land surface, distinct from surrounding terrain with consistent properties in landform, soil and vegetation” (Laily 1971).

The Study area is covered by land system mapping of the Alice Springs area which has been completed at a scale of 1:1,000,000 as part of surveys carried out by the Division of Land Research and Regional Survey between 1956 and 1957 (Perry et al 1962). A total of six land systems have been mapped across the Study area. The majority of the area is covered by two lands systems, the Napperby system which is characterised by sparse shrubs or low trees over forbs and grasses and the Bushy Park system which primarily consist of mulga plains on red earths.

Table 2.3 provides a summary of the land systems that have been mapped within the Study area along with their typical landform, soil descriptions and general vegetation (Perry et al 1962).

Table 2.3 Land systems mapped within the study area

| Code | Land System | Landform | Dominant soil types | Vegetation | Area (ha) |
|---|---|---|---|---|---|
| Sn (78) | Singleton | Parallel, reticulate and irregular sand dunes with stable flanks | Red dune sands and red clayey sands | Spinifex | 946 |
| Bu (67) | Bushy Park | Plains | Red earths over stable alluvia | Acacia aneura (Mulga) in groves over short grass or Eragrostis eriopoda (woollybutt) | 1786 |
| Ha (1) | Harts | Mountain ranges on gneiss, schist and granite; outcrop | Rocky outcrop with pockets of shallow, gritty and stony soils | Acacia kempeana – Senna spp. or sparse shrubs and low trees over sparse forbs and grasses | 19 |
| Na (3) | Napperby | Low hills and hills mostly on granite, gneiss, rhyolite and some schist; common rock outcrop and surface stone | Shallow soils alternating with red earths and other soils | Sparse shrubs or low trees over forbs and grasses | 2169 |
| Ry (19) | Ryan | Gently undulating to undulating plains with rises and low hills on granite, schist, gneiss (deeply weathered in places); coarse grained sandy, earthy and texture contrast soils | Textured – contrast soils | Sparse shrubs and low trees over Triodia spp. Eremophila spp. over short grasses and forbs or Spares low trees or Acacia aneura over short grasses and forbs | 101 |
| Ai (5) | Aileron | Low hills and hills mostly on granite, gneiss, rhyolite and some schist; common rock outcrop and surface stone | Shallow gritty and stony soils alternating with red earths and red clayey sands | Sparse shrubs and low trees over spinifex or short grasses and forbs | 671 |
| | | | | **TOTAL** | **5694** |

## 2.1 Topography

The Study area is located adjacent to the southern Reynolds Range, 135 km north-northwest of Alice Springs.

The Reynolds Range is a narrow (5-10 km wide, 90 km long), west-northwest trending belt of steep hills and mountains and deeply incised drainages which flatten rapidly to both the north and south. The highest peaks in the Range reach over 1,000 m above sea level (e.g. Mt Freeling - 1,005 m; Mt Thomas - 1,116 m) whereas the adjacent lowlands, such as those occurring around the Nolans site, are at about 650 m above sea level.

The Study area is situated on a flat plain area which straddles Kerosene Camp Creek to the west, north and northeast of the mine site. The Nolans Bore cattle yards cover the eastern portion of the deposit. A wide expanse of alluvial sand and silt and calcrete separates the fluorapatite outcrops around the mine site and in the associated holding yards from those adjacent to Kerosene Camp Creek 500 m to the northwest and 800 m to the south west of the Bore (Figure 1.2.

To the east and west of the mine site are extensive areas of flat alluvial floodplains, red earths and sand plains.

## 2.2 Hydrology and hydrogeology

The mine site lies in the headwaters of the Woodforde River drainage system that flows across the south western fringe of the Ti Tree Basin. The mine site occupies less than 0.1% of the basin.

Kerosene Camp Creek is an ephemeral creek that flows through the centre of the mine site before joining the Woodforde River 3 km further to the north. Nolans Creek is a tributary of Kerosene Camp Creek that drains an area of 26 km2 upstream of the mine site and flows adjacent to the eastern boundary of the proposed Flotation Tailings Storage Facility.

Creek beds tend to be mobile with deep sand deposition and banks that show signs of active erosion. Typical channel sections are approximately 1.0 m deep with a base width of up to 5 m.

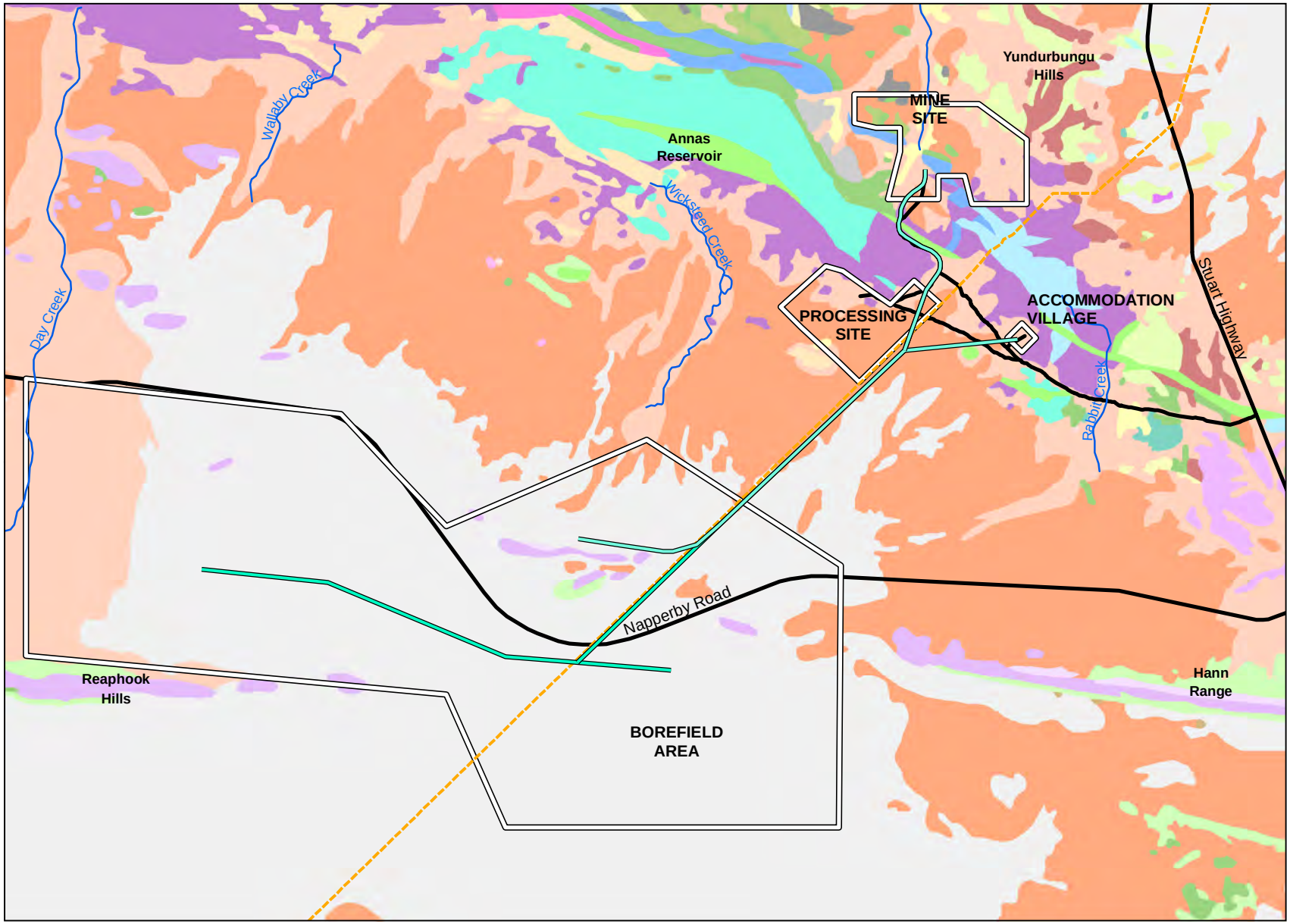
Semi-arid regions such as the area in which the Nolans site is located are typically characterised by conditions in which actual evaporation closely matches rainfall and virtually all rainfall evaporates resulting in almost no surface runoff. Therefore, the occurrence of surface runoff and flows within local creeks is likely to be infrequent and only occur during exceptional rainfall events associated with the occasional southward extension of the monsoon trough or periodic incursion of north-west cloud bands over the interior.

The Processing site occupies a small part of the headwaters of several creeks draining southwards into the Southern Basins catchment. Distinct channels have not formed within these headwaters and runoff from the Processing site is likely to be dispersed in minor rills. The access road from the Stuart Highway will cross the headwaters of numerous unnamed creeks draining southwards into the Southern Basins catchment. More information about surface water in the area is presented in Appendix I of the project EIS.

Local aquifers at the mine site are thought to approximately correspond to the geographical extent of the ore body, surrounded by much lower permeability rocks which act as an aquitard[1]. Due to the porous nature of soils and the surface outcropping of the apatite, the aquifer will be

[1] Environmental Earth Sciences (June 2010) Work progress report for open pit dewatering investigation at Nolan's Bore, via Aileron, NT. Letter report to Arafura Resources Ltd.

recharged directly from surface infiltration during in frequent rainfall events and by leakage through the creek bed when Kerosene Camp Creek is flowing.




**Geology - Napperby**

- Aeolian sand
- Alluvium
- Calc-silicate rock, marble, gneiss, schist
- Calcrete
- Coarse porphyritic granitic augen gneiss with mantled feldspars
- Colluvium
- Cordierite gneiss, mafic granulite
- Cordierite gneiss, quartzofeldspathic gneiss, garnet-biotite gneiss, sillimanite gneiss
- Cordierite granofels, metaquartzite, calc-silicate rock, felsic granulite, garnet-biotite gneiss
- Deeply weathered granite, felsic granulite, felsic gneiss, schist, dolomite
- Dyke or vein; quartz
- Fanglomerate
- Felsic granulite, mafic granulite, amphibolite, garnet-biotite gneiss, sillimanite gneiss, cordierite granulite
- Ferricrete
- Garnet-biotite gneiss, cordierite gneiss, sillimanite gneiss, calc-silicate rock, mafic granulite
- Garnet-cordierite-biotite... granofels, tourmaline metaquartzite
- Granite, granodiorite
- Mafic granulite, felsic granulite, quartzofeldspathic gneiss
- Marble, calc-silicate rock, para-amphibolite, chlorite schist, quartzite, sillimanite schist
- Medium even-layered granitic gneiss, minor porphyritic granite
- Mica-quartz sandstone, siltstone, shale, slate
- Quartz-rich metasediment, cordierite gneiss, mafic granulite
- Quartzofeldspathic gneiss,biotite gneiss, sillimanite gneiss, cordierite granulite, garnet-biotite gneiss
- Red earth
- Retrogressively metamorphosed rock in the Arunta Block
- Schist, gneiss, quartzite, quartz-rich metasediment
- Schist, phyllite, andalusite hornfels, tourmaline-quartz pods
- Sillimanite gneiss, amphibolite, garnet amphibolite
- Sillimanite schist and gneiss
- Sillimanite-biotite-cordie... granofels
- Thick-bedded quartzite, ferruginous quartzite, granule and pebble conglomerate
- Undivided
- Very coarse rutile-biotite metaquartzite
- White silstone, thin-bedded, fine sandstone. Possible interbedded evaporites

1:240,000 @ A4

0 2.5 5 7.5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Proposed Pipelines and Easement
- Gas Pipeline
- Waterways
- Roads
- Site Boundaries

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| Job Number | 4322301 |
| Revision | 0 |
| Date | 05 May 2016 |

# Regional geology

Figure 2.1

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Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: GA - Roads, Waterways, Placenames (2015). ARL - Study Areas, Proposed Pipelines (2015). NTG - Geology (2013) Created by: CM

# 3. Methods

## 3.1 Timeline of ecological assessments

A number of ecological assessments for the Nolans Project have been completed over a period of eight years. Flora surveys conducted by GHD (2010, 2011 and 2015) have included assessments of the proposed mine site, processing site, accommodation facility, access roads, borefield area and utilities corridor including potable water pipeline, water supply pipeline and power line corridor. Assessment also included a proposed haul route / transport corridor (2010) that is no longer being considered as part of the project infrastructure.

Table 3.1 summarises the surveys that have been completed within the Study area.

This report focusses on the results of the 2015 and 2010/11 GHD surveys (most recent information) and refers back to earlier surveys (2006-2011) where that information is still relevant. The methods detailed in this section focus on those used for the 2015 survey, which was the most comprehensive assessments of the entire Study area, and which assessed the latest (and therefore most applicable) Project footprint. Generally, methods used for the 2010/11 surveys completed by GHD were consistent with those used for the 2015 survey.

Table 3.1 Ecological surveys completed for the Nolans Project

| Date | Survey type | Area surveyed | Reference |
|---|---|---|---|
| 4 – 7 May 2006 | Landscape flora and fauna survey | Nolans Bore mine site | Low Ecological Services 2007 |
| 21 – 24 November 2006 | Landscape flora and fauna survey | Nolans Bore mine site | Low Ecological Services 2007 |
| 16–25 August 2010 | Baseline flora and fauna survey | Mine site and transport corridor (transport corridor no longer proposed) | GHD 2011<br>Relevant sites/ results incorporated into this assessment |
| 6 – 8 December 2011 | Baseline flora survey | Transport corridor (transport corridor no longer proposed) | GHD 2011<br>Relevant sites/ results incorporated into this assessment |
| 27 April – 3 May 2015 | Baseline flora and fauna survey | Processing site, accommodation village, borefield area, potable water pipeline and access tracks | Results discussed in this assessment |

## 3.2 Overview

Key tasks involved in the preparation of this flora and vegetation assessment included:

- Literature review of existing studies within or surrounding the Study area
- Database searches to identify threatened flora and ecological communities, and essential habitats recorded or predicted to occur in the Study area
- Flora field surveys including mapping and characterisation of vegetation types within the Study area
- Undertaking a systematic baseline flora survey of vegetation types within the Study area and providing an inventory of the flora species present
- Describing the existing terrestrial environment of the Study area in terms of its ecological values, including type of vegetation communities, their structure and floristic composition
- Describing the condition of vegetation communities and flora, including identifying introduced flora (weeds) present in the Study area and mapping significant infestations
- Assessing the significance of the Study area's vegetation in local and regional contexts
- Determining the likelihood of occurrence of threatened flora species, populations and Threatened Ecological Communities (TECs) listed under the TPWC and /or EPBC Acts, based on the presence/absence of suitable habitat within the Study area
- Assessment of the potential impact of the Project on the vegetation and flora present within the Study area
- Identifying measures to avoid, minimise, mitigate and offset potential impacts on ecological values within the Study area.

## 3.3 Desktop review

Prior to completing field survey, a desktop literature and database review was undertaken to gain an understanding of the ecological context of the Study area. Data reviewed included existing broad scale vegetation mapping, geological mapping, land system data, land unit mapping and flora records from Northern Territory and Commonwealth ecological databases.

Results of these searches provide an overview of previous records, known distributional ranges and habitat types; and are used as a basis for predicting threatened species that may occur in the Study area. The following databases and literature sources were reviewed prior to conducting field investigations:

- The Northern Territory Herbarium (Holtz) Database was used to identify flora species that have been previously recorded within a 20 km radius of the Study area (DLRM 2015)
- Commonwealth Department of the Environment (DotE) website search program, the Protected Matters Search Tool (PMST), was used to identify Matters of National Environmental Significance (MNES) listed under the EPBC Act potentially occurring in the locality (20 km radius). Information was downloaded in the form of an Environmental Report in February 2015
- Northern Territory land systems/vegetation mapping of the Southern Alice Springs District was reviewed to determine the broad vegetation types previously mapped within the Study area (NRETAS 2000)
- Aerial imagery was used to create a preliminary vegetation map based on recurring vegetation patterns observed within the Study area. This preliminary mapping was used to help stratify the placement of flora quadrats throughout the Study area

- Bureau of Meteorology online data was sourced to determine climatic conditions in the region (BOM 2015)
- Mapping of Sites of Conservation Significance in the Northern Territory was reviewed to determine any significant sites in the locality (DLRM 2015)
- Other literature relevant to the Study area that was reviewed as part of the desktop assessment included:
  - Albrecht, D.E. and Pitts, B. (2004). *The vegetation and plant species of the Alice Springs municipality, Northern Territory.* Greening Australia NT and the Department of Infrastructure, Planning and Environment, Alice Springs
  - Newsome, T. Reilly, T., Matthews, D. and Low, B. 2007 *Landscape Flora and Fauna Surveys of the Proposed Rare Earths Mine at Nolans Bore near Aileron*, NT. Consultancy report by Low Ecological Services, Alice Springs
  - Vegetation survey of the Northern Territory Australia (Wilson, B., Brocklehurst, P., Clarn, M., and Dickinson, K. 1990)
  - Northern Territory Draft Parks Master Plan (NRETA 2005).
  - Northern Territory Bioregions – Assessment of Key Biodiversity Values and Threatened Species (Baker *et al.* 2005)
  - Neave, H., Sparrow, B., and Clifford, M. (2006) Preliminary Report: *Towards a resource assessment of the Burt Plain Bioregion for Conservation Planning*. Biodiversity Conservation Department of Natural Resources, Environment and the Arts
  - Ward, S., and Harrison, L. (2009). *Recognising sites of conservation significance for biodiversity values in the Northern Territory*. Department of Natural Resources, Environment, the Arts and Sport, Darwin, Northern Territory
  - Harrison, L., McGuire, L., Ward, S., Fisher, A., Pavey, C., Fegan, M., and Lynch, B. (2009). *An inventory of sites of international and national significance for biodiversity values in the Northern Territory*. Department of Natural Resources, Environment, the Arts and Sport, Darwin, NT.

## 3.4 Vegetation surveys and land mapping

As is the case for the majority of the Northern Territory, existing vegetation mapping for the Study area and surrounding bioregions is very limited due to the lack of previous detailed vegetation survey. Vegetation mapping that does exist for the site includes vegetation mapping that has been completed for the whole Territory at 1:1,000,000 scale (Wilson *et al.* 1990).

Land system mapping in the Northern Territory includes broad scale mapping of regional landforms, soils and vegetation. The whole of the Study area is covered by land system mapping for the Alice Springs area which has been completed at a scale of 1:1,000,000 as part of the range condition assessment program that was completed by the Division of Land Research and Regional Survey completed by CSIRO between 1956 and 1957 (Perry *et al.* 1963).

This mapping was reviewed as part of the desktop assessment prior to field surveys.

## 3.5 Survey design

A random-stratified approach was used to survey a representative range of floristic communities and habitats across the Study area. The Project was stratified into sampling units based on vegetation patterns determined using existing vegetation mapping and aerial imagery in

combination with an electronic lithology dataset derived from 1:1 000 000 geology mapping (Geosciences Australia 2015).

Using the geology map and aerial imagery, the Study area was divided into relatively homogenous or discrete vegetation zones for assessment.

Survey locations were distributed randomly between vegetation zones.

## 3.6 Field survey

The vegetation and flora assessment completed by GHD within the Study area has included three discrete rounds of field survey. This includes survey of the mine site and haul road (haul road no longer part of the project) completed between 16-25 August 2010, survey of the power station and accommodation village site on the 6-7 December 2011 and a survey of the processing site, accommodation village, access roads, potable water pipeline, water supply pipeline and borefield area between the 27 May and 3 April 2015. The mine site area was not re-surveyed in 2015.

Flora survey techniques used in the baseline surveys were consistent with the *Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping* (Brocklehurst *et al.* 2007).

All surveys were conducted in accordance with TPWC Act permits issued to GHD by the Northern Territory Parks and Wildlife Commission.

Survey methods and effort are summarised in Table 2.3 and described in detail below.

Table 3.2 Summary of survey methods and effort

| Survey Period | Field staff | Survey methods | Survey effort |
|---|---|---|---|
| 16-25 August 2010 | Gillis Horner (Senior Botanist, GHD)<br>Sharnya Thomson (Senior Botanist, GHD) | Flora quadrats<br>Rapid check sites<br>Random meanders | 30 primary sites<br>34 secondary check sites |
| 6-7 December 2011 | Gillis Horner (Senior Botanist, GHD)<br>Arien Quin (Senior Botanist, GHD) | Flora quadrats<br>Rapid check sites<br>Random meanders | 13 primary sites<br>10 secondary check sites |
| 27 April– 3 May 2015 | Arien Quin (Senior Botanist, GHD)<br>David Albrecht (Senior Botanist, Ecological) | Flora quadrats<br>Rapid check sites<br>Random meanders | 35 primary sites<br>55 secondary check sites |

### 3.6.1 Flora quadrats

Sites selected using aerial imagery, land system and geological mapping were ground truthed to identify, describe and map vegetation communities present within the Study area.

Flora survey sites for vegetation mapping and habitat characterisation comprised a total of seventy-seven (77) 50 m x 50 m quadrats (or in the case of narrow riparian areas 10 X 250 m quadrats).

For each quadrat surveyed the following data were recorded:

- Site location including GPS coordinates
- General site description

- A full inventory of flora species present, along with heights and projected foliage cover for each taxa. All vascular plants were identified to subspecies level using nomenclature based on Short *et al.* (2011)
- Habitat information including patch size, aspect, drainage, geology, soil type and texture, estimated soil depth as well as percentage cover of:
  - Ground cover (pebbles/gravel/stones/small rocks/rocks/large rocks and boulders).
  - Litter
  - Bare earth
  - Ground layer vegetation
  - Crust
  - Exposed rock
  - Gravel.
- Structural information for the tree, shrub and ground strata including estimated percentage cover, height range and average height for each stratum as well as average height and percentage cover of each growth form present within the quadrat (i.e. tree, shrub, tussock grass, forb etc.)
- Degree of site disturbance including grazing intensity and fire frequency
- Estimates of basal area of trees per hectare (using a Bitterlich Gauge where appropriate).

A handheld GPS unit was used to record spatial locations of quadrats and a site photograph was taken from the north-east corner of each quadrat. The location of each quadrat is shown on Figure 3.1.

### 3.6.2 Secondary check sites

To assist with vegetation mapping, data was collected from 99 check sites according to methods described in Brocklehurst *et al.* (2007). At these sites dominant species in the canopy, mid and ground strata were recorded along with their average height and percentage cover. The location of each check site is shown in Figure 3.1.

### 3.6.3 Opportunistic collections

While walking from site to site, flora taxa not previously recorded within quadrats or check sites were noted. This ensured that a comprehensive species list was produced for the Study area.

### 3.6.4 Vegetation mapping

Vegetation mapping is the delineation of plant communities into groups or associations. The distinctive characteristics of these groups or associations include features such as species dominance, stratum structure and species composition.

The classification of vegetation 'types' within the Study area was based on dominant flora species present within each structural layer (i.e. canopy, shrub and ground layers). Structural attributes were assigned to the groups in order to produce a structural vegetation type classification.

Boundaries of vegetation communities were mapped in the field using a hand held GPS and by visual interpretation of Google Earth aerial imagery captured at c. 1: 10 000 scale (Google Earth 2015).

Vegetation types were described according to the National Vegetation Information System (NVIS), Level V: Association, which encompasses a description of the broad structural

formation (e.g. woodland, canopy height and cover) and the dominant species in three strata (Upper overstorey, Midstorey and Ground Layer) (Brocklehurst *et al.* 2007).

Vegetation mapping completed during the 2010 survey was somewhat coarser than the vegetation mapping completed during 2015, which mapped a number of sub-communities that were not separated out during the 2010 survey. For this reason, there are some slight differences in vegetation community names between the boundary of the mine site and the access road to the south. For example, the 2010 survey only mapped one Mulga community whereas the 2015 survey recognised three separate Mulga sub-communities. Similarly, areas of Grassy woodlands on alluvial plains were mapped as one community in 2010 whereas in 2015 three different sub-communities were mapped based on differences in understorey composition.

#### *Mosaics and complexes*

Vegetation mosaics were mapped when two or more communities could not be differentiated at the scale of the mapping. Vegetation complexes were mapped when two or more communities could not be distinguished in the field, typically due to the vegetation containing typical species from more than one community as is often the case when communities transition from one to another.

### 3.6.5 Introduced flora

The most common introduced species occurring in the Study area was *Cenchrus ciliaris* (Buffel Grass). Buffel Grass is an invasive species that is known to spread rapidly in arid and semi-arid regions of Australia (Miller *et al* 2010). Buffel Grass invasion represents a key threatening process for biodiversity in the region due to its rapid growth and potential to increase fire severity due to its ability to accumulate higher amounts combustible biomass compared to native understory species.

During the field survey the percentage Buffel Grass cover was assessed for each vegetation polygon and a score of 1-4 assigned:

- Score of 1 corresponding to very low Buffel Grass densities (< 5% cover)
- Score of 2 corresponding to low – moderate density (6-40% cover)
- Score of 3 corresponding to moderate to high densities (41-70% cover)
- Score of 4 corresponding to high densities (71-100% cover).

A map was then produced showing relative densities of Buffel Grass across the Study area. The locations of significant infestations of other introduced flora species were marked on a handheld Trimble GPS unit, including species present, and an estimate of the density and extent of infestations (Section 4.3.3).

## 3.7 Nomenclature

Identifications of flora were made in the field using CSIRO (2006), Jessop (1981), Latz (1995), Maslin (2001), Moore (2005), Sharp and Simon (2001), Wheeler (1992) and Woinarski *et al.* (2007).

The nomenclature applied is consistent with the Northern Territory Flora Checklist (Short *et al.* 2011), the Northern Territory Southern Region Flora Checklist (Albrecht *et al.* 2007) and the Mabberley update to family nomenclature adopted by the Northern Territory Herbarium.

Flora were identified to subspecies level where possible. The absence of certain diagnostic features (this is a function of the seasonal cycles of flora species) prevented identification of some plants to subspecies level. These taxa were identified to either species or genus level. Samples of taxa where positive identification was not possible in the field were identified in the Alice Springs Herbarium.

## 3.8 Assumptions and limitations

### 3.8.1 Vegetation mapping

Due to the size of the Study area and access limitations, the entire area could not be assessed during the field survey. To address this limitation, a subset of the Study area was ground-truthed during the field survey. The remaining extent of vegetation communities was mapped by extrapolation and interpretation of aerial imagery.

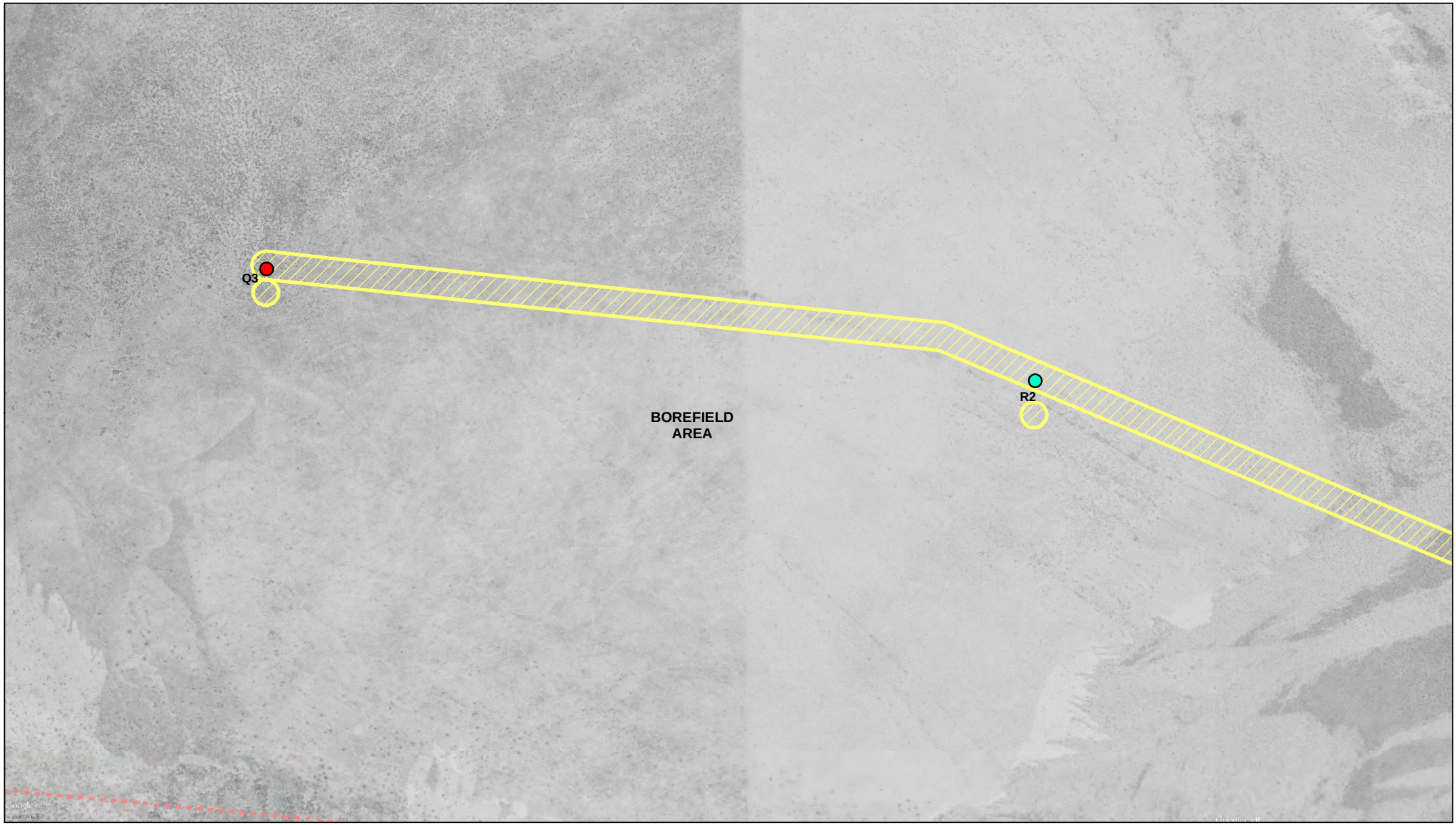
The scope of the assessment did not allow for detailed validation of the spatial or attribute accuracy of the resultant vegetation map. Thus there may be minor inaccuracies in the vegetation mapping due to errors in identifying subtle variations in the aerial imagery. Furthermore, given the scale of the mapping, small patches of vegetation (typically less than 250 X 250 m) were generally not differentiated from the surrounding vegetation type.

Mapping of quadrat locations using handheld GPS was accurate to c. ± 20 m. Locations of the quadrats may be 'inaccurate' to this extent.

Boundaries between vegetation communities usually form a transition zone or mosaic where the two communities meet. For the purpose of vegetation mapping a line needs to be drawn between two communities. Boundaries on the vegetation map should therefore not be taken as exact.

### 3.8.2 Flowering seasonality

Field surveys were conducted during 27 May – 3 April 2015, after an extended period without rainfall in the local area. It is highly likely that the area supports a large number of short lived flora species that were not identified during the survey period. These species are likely to be present on the Nolans site in stored energy (either in the soil seed bank or present as underground tubers). This limitation is partially compensated by the previous surveys of the mine site, which were completed during a more optimal survey period.

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Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

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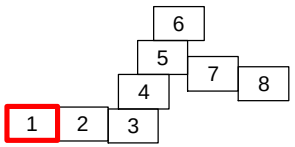
LEGEND

- Checksites
- Quadrats 2015
- Quadrats 2011
- Roads
- Study Area
- Borefield Area

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Date 18 Mar 2016

# Flora quadrats and checksites locations

Figure 3.1 (Page 1 of 8):

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Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM


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Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

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- Checksites
- Quadrats 2015
- Quadrats 2011
- Roads
- Study Area
- Borefield Area

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| | 6 | | |
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# Flora quadrats and checksites locations

Figure 3.1 (Page 2 of 8):

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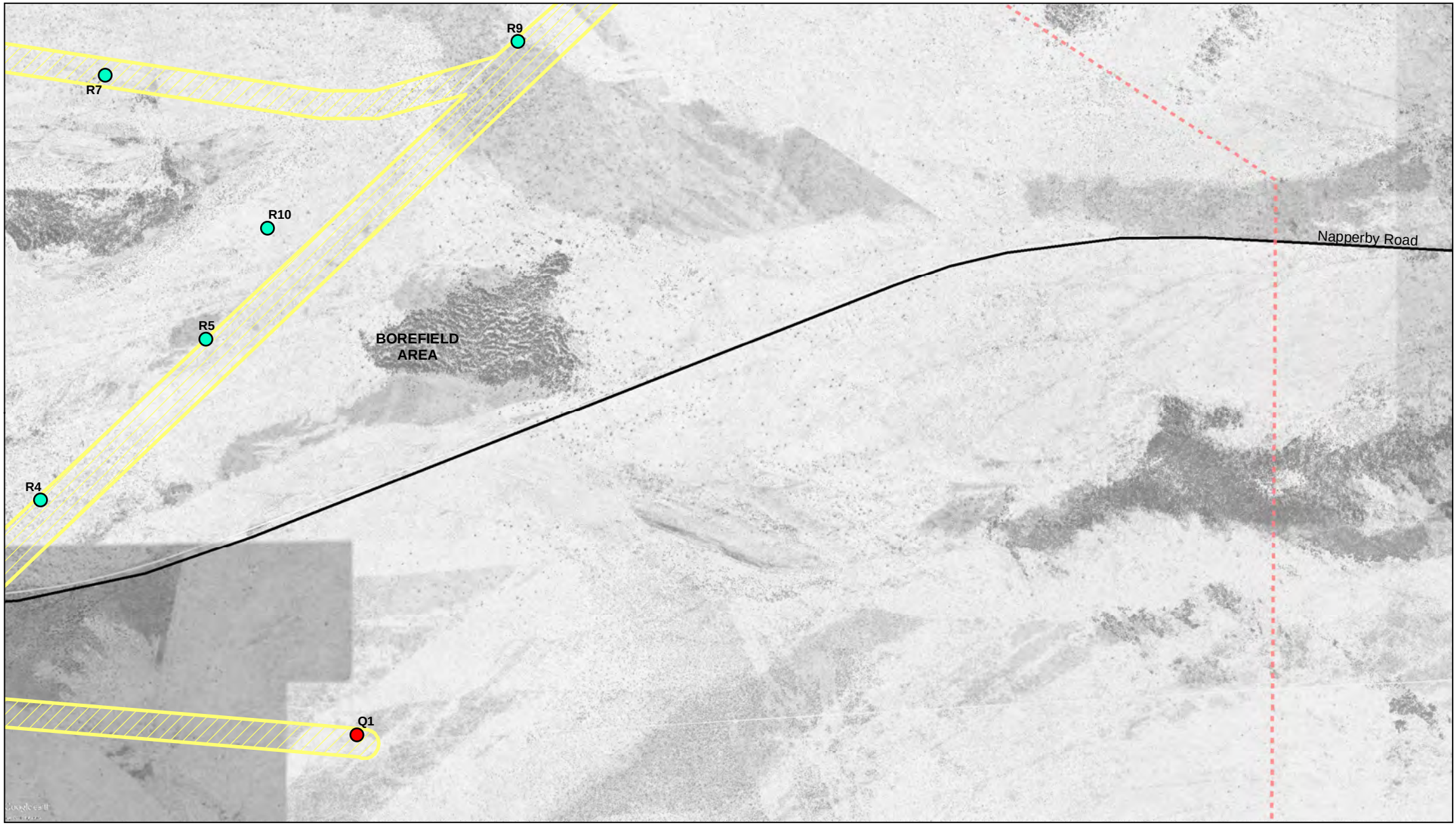


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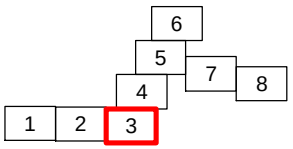
- Checksites
- Quadrats 2015
- Quadrats 2011
- Roads
- Study Area
- Borefield Area

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| Date | 18 Mar 2016 |

# Flora quadrats and checksites locations

Figure 3.1 (Page 3 of 8):

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Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



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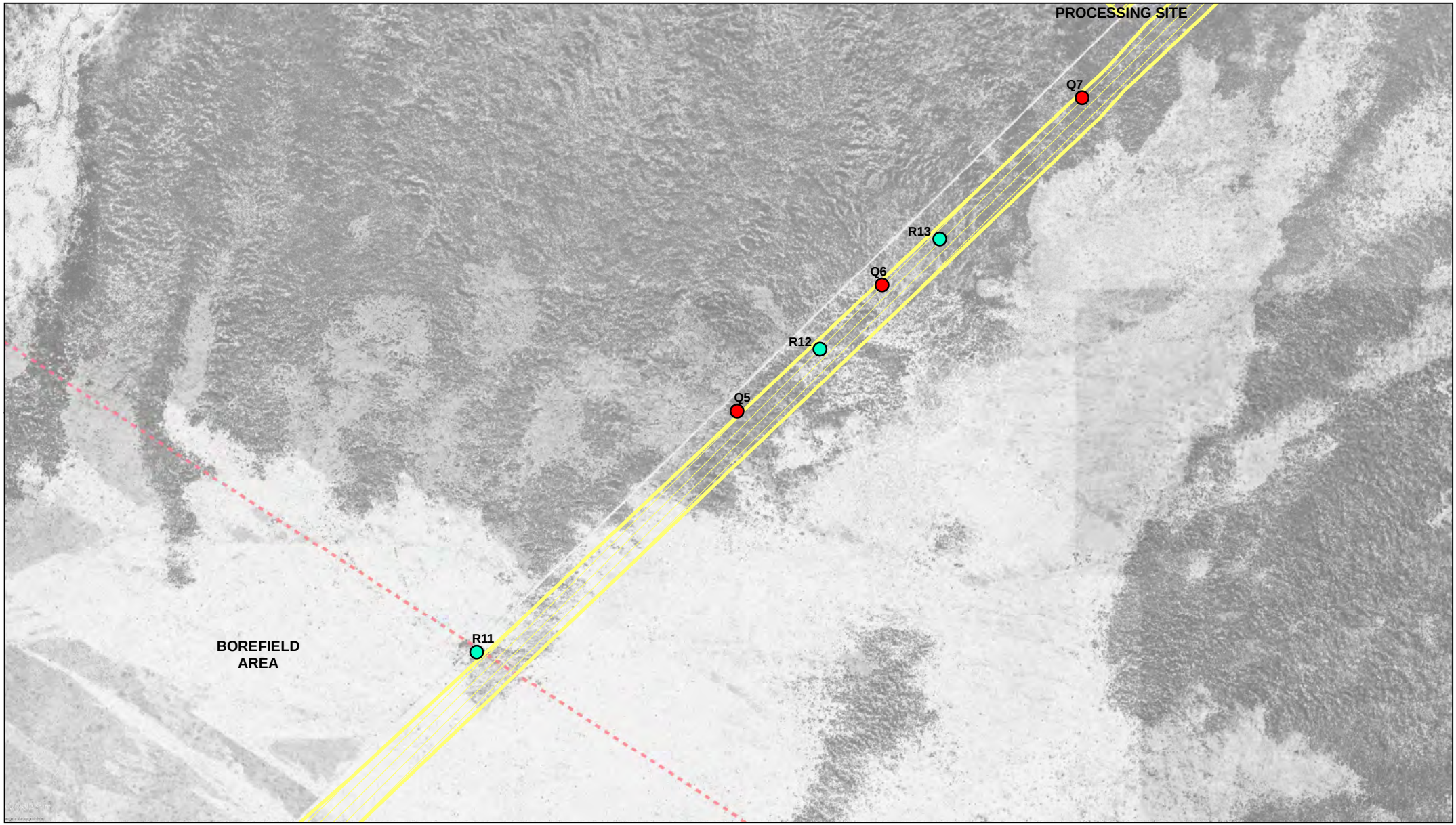


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Map Projection: Universal Transverse Mercator
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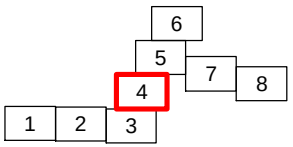
- Checksites
- Quadrats 2015
- Quadrats 2011
- Roads
- Study Area
- Borefield Area

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# Flora quadrats and checksites locations

Figure 3.1 (Page 4 of 8):

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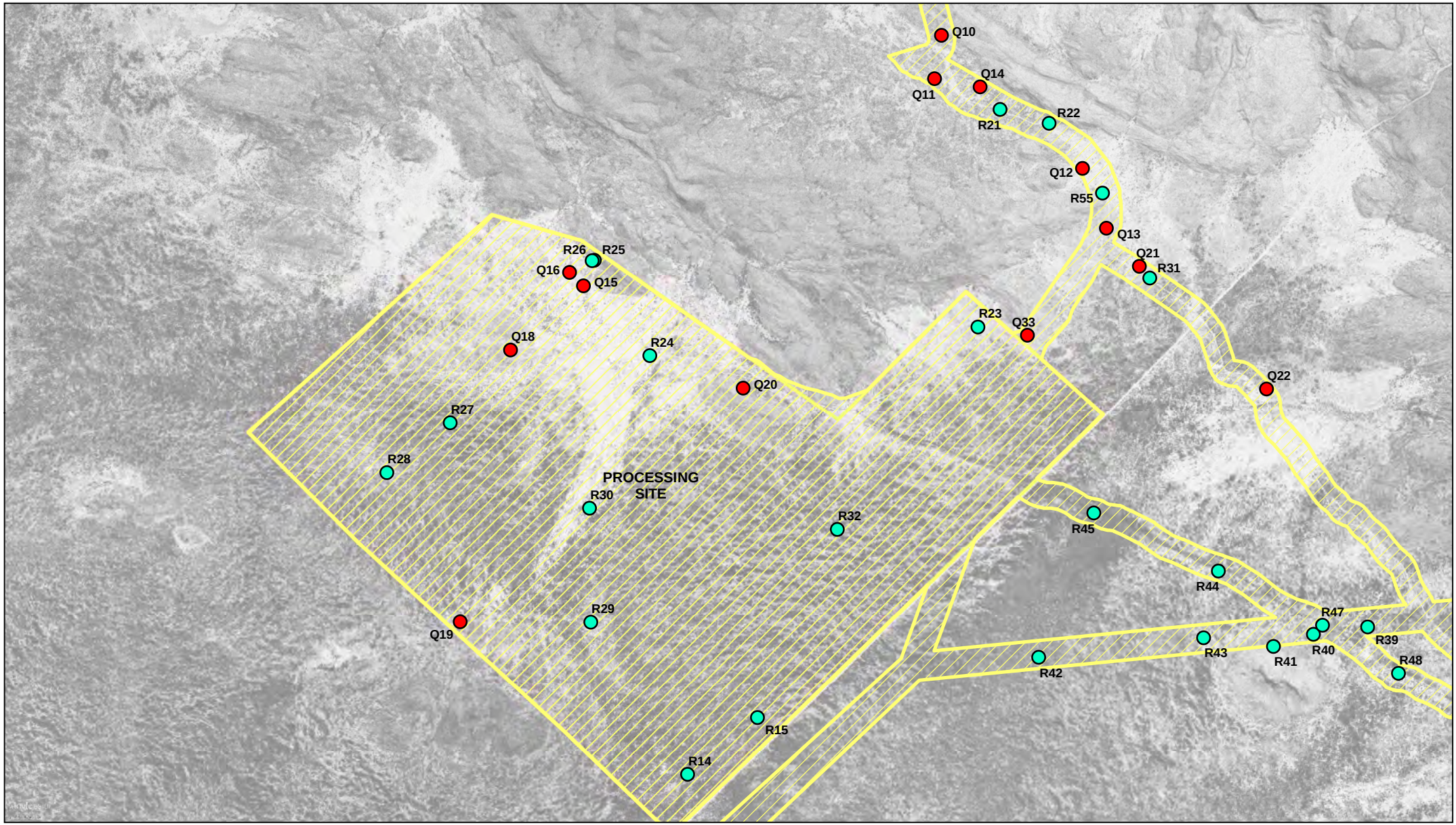


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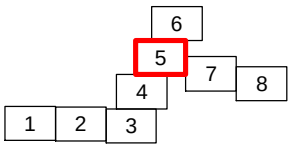


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# Flora quadrats and checksites locations

Figure 3.1 (Page 5 of 8):

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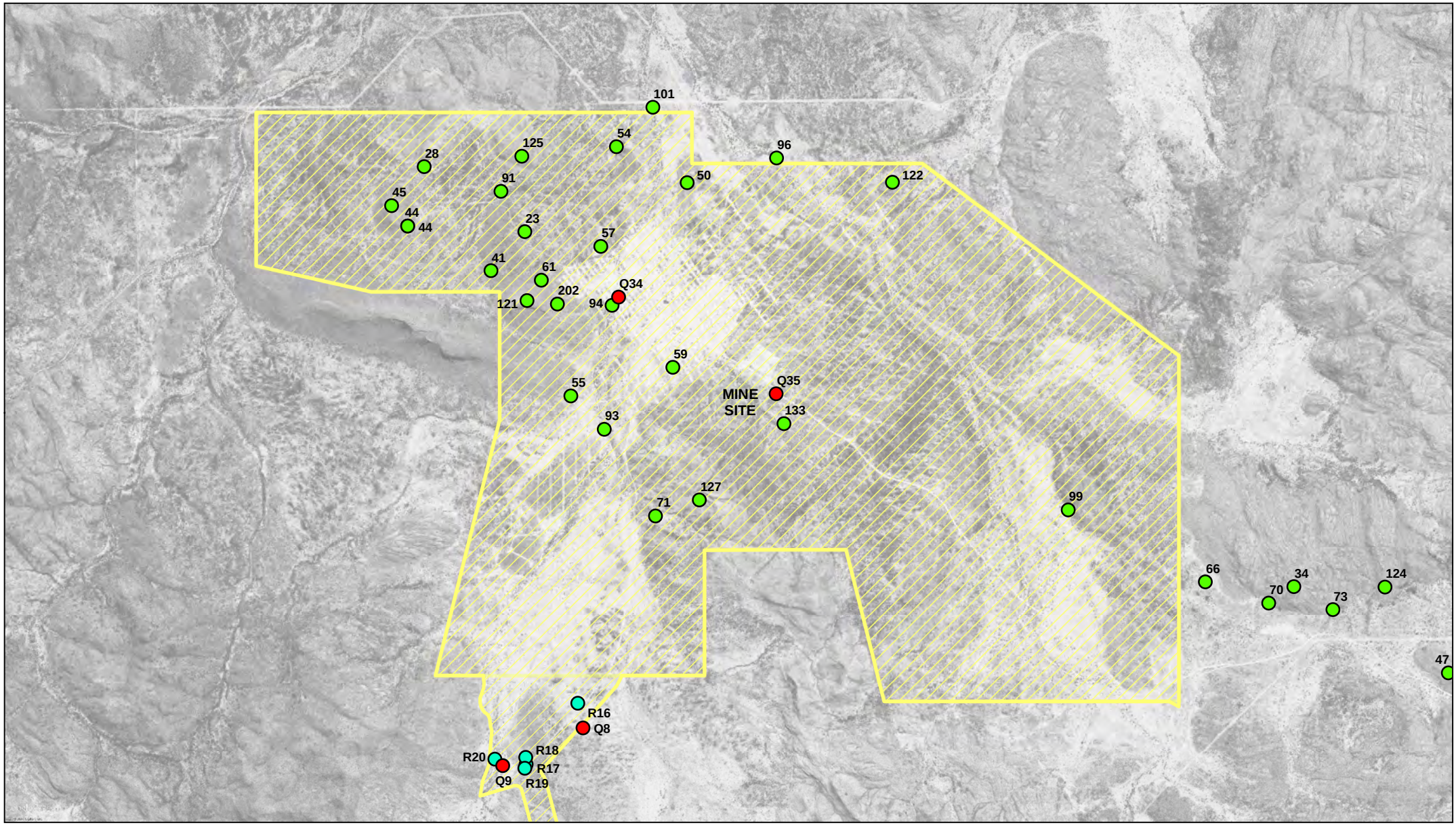


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- Quadrats 2015
- Quadrats 2011
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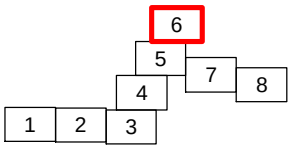


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# Flora quadrats and checksites locations

Figure 3.1 (Page 6 of 8):

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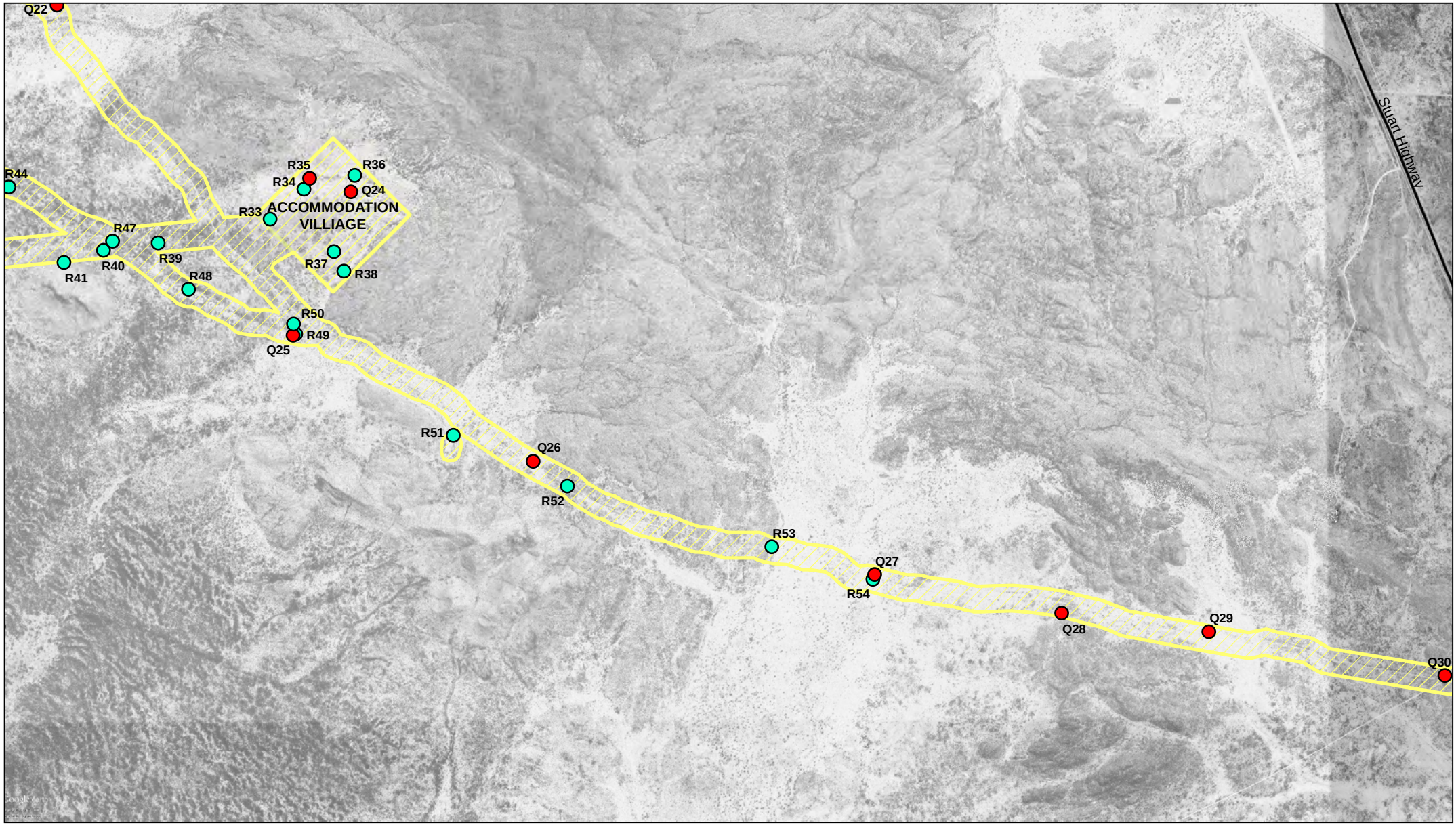


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Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
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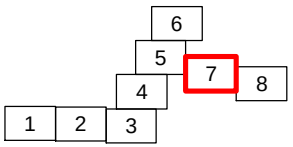
- Quadrats 2011
- Roads
- Study Area
- Borefield Area

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# Flora quadrats and checksites locations

Figure 3.1 (Page 7 of 8):

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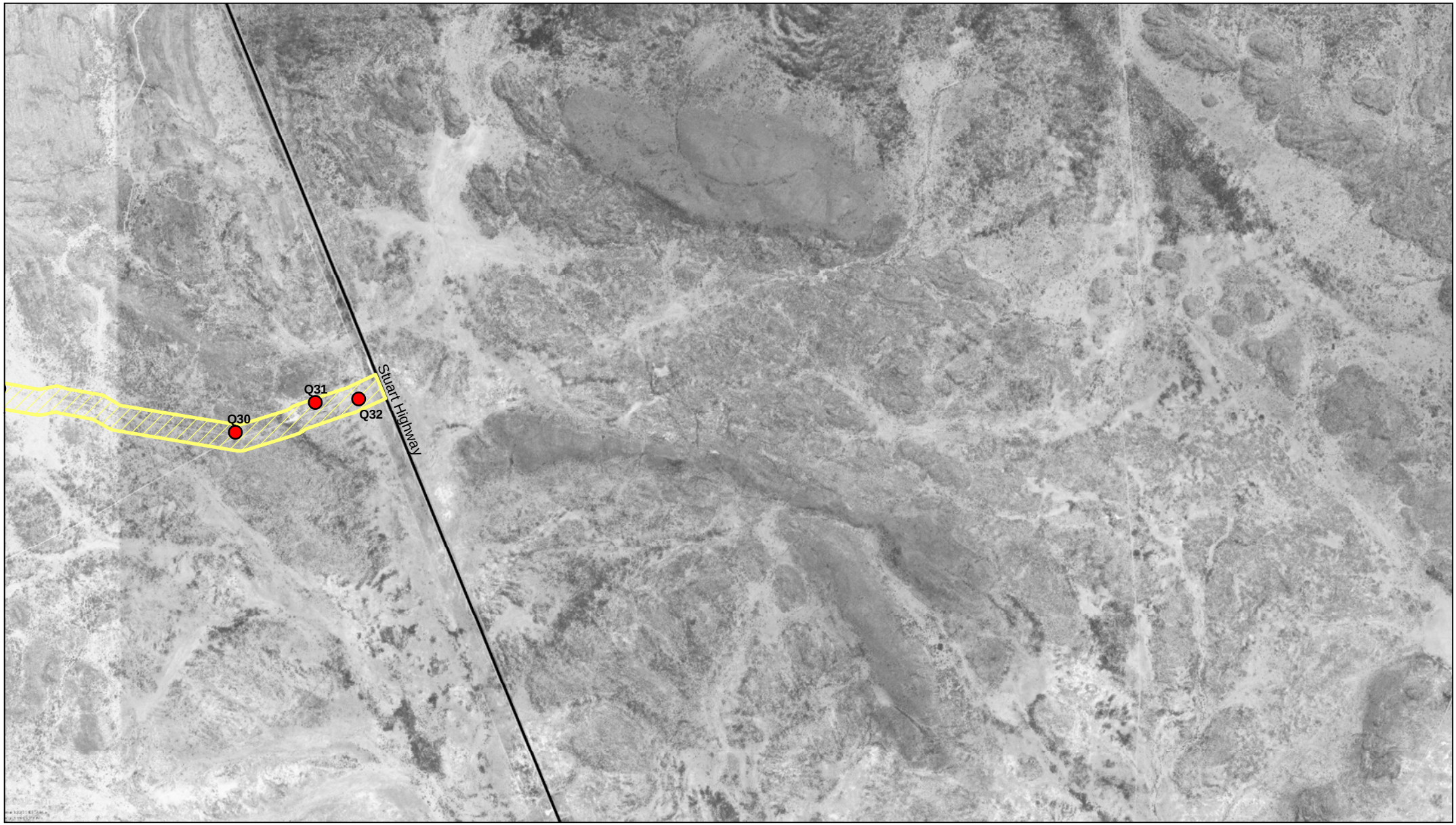
Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM




1:40,000 @ A4

0 250 500 750 1,000

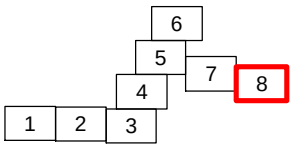
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Checksites
- Quadrats 2015
- Quadrats 2011
- Roads
- Study Area
- Borefield Area




Arafura Resources Limited
Nolans Project

Job Number 4322301
Revision 0
Date 18 Mar 2016

# Flora quadrats and checksites locations

Figure 3.1 (Page 8 of 8):

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Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM

# 4. Results

## 4.1 Desktop results

### 4.1.1 Existing flora records

The Northern Territory Government flora records for the locality contain 974 records of 412 species (DLRM 2015). These records do not include any threatened flora species listed under the TPWC Act. Database records for the locality include six near threatened species[2], five species endemic to the Northern Territory and eight species recorded as being data deficient[3]. A total of 20 exotic species have also been previously recorded within the locality (DLRM 2015).

There are ten threatened plant taxa known to occur in the Burt Plain bioregion. Eight of these species are listed under the TPWC Act and four are listed under the EPBC Act. Based on an assessment of habitats within the Study area it is unlikely that any of these species would occur in the Nolans site.

### 4.1.2 Results of previous surveys

Two flora surveys of the mine site were completed by Low Ecological Services in May and November 2006 (Low Ecological Services 2007). These surveys recorded a total of 185 flora species within four broad land units (riparian, rocky granite hills, shallow sand plains and rocky undulating plains). None of the flora species recorded is listed as having conservation significance under the EPBC or TPWC Acts.

### 4.1.3 NVIS vegetation types

The available vegetation mapping covering the site is 1:1,000,000 scale mapping of the NT (mapped at NVIS Level IV: Sub-Formation, which allows for description of one dominant genus for each stratum). Description of these vegetation types and occurrence is taken from the Northern Territory Government database (DRLM 2013). This product identifies four NVIS vegetation types within the Study area. These include:

- + Corymbia low woodland / Acacia tall open shrubland / Eragrostis low open tussock grassland
- Eucalyptus low open woodland / Acacia mid open shrubland / +Triodia low hummock grassland
- +Acacia tall open shrubland / Eragrostis low tussock grassland
- Acacia mid open mallee woodland / Acacia mid sparse shrubland / +Triodia low hummock grassland.

### 4.1.4 EPBC protected matters search tool

The PMST results did not identify any flora species listed under the EPBC Act that are known or predicted to occur in the locality.

[2] Under IUCN criteria this conservation category is defined as taxa that do not meet the criteria for Critically Endangered, Endangered or Vulnerable at present but is close to qualifying for or is likely to quality for a threatened category in the near future.

[3] Under IUCN data deficient taxa are defined as species where there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.

### 4.1.5 Threatened ecological communities

No EPBC Act-listed Ecological Communities are known or predicted to occur within or near the Study area. Only one ecological community is listed in the Northern Territory as threatened under the EPBC Act (Arnhem Plateau Sandstone Shrubland Complex), and this does not occur within or near the Study area.

There is currently no mechanism for listing Threatened Ecological Communities under Northern Territory legislation.

### 4.1.6 Sites of conservation significance

Scientists from the Northern Territory DLRM have identified places that are recognised as areas of national or international significance for biodiversity conservation. There are 67 sites of conservation significance (SOCS) across the Northern Territory, and there is broad community recognition of the importance of long term protection of conservation values within these sites. None of these sites occur within or near to the Study area.

## 4.2 Survey results

### 4.2.1 Flora species

A combined total of 326 flora species, comprising 319 native species and 15 exotic species were recorded within the Study area during the 2010, 2011 and 2015 survey periods. This represents approximately 28% of all flora species know to occur in the Burt Plain bioregion.

The Poaceae (grass family, 73 species, 67 native; 6 exotic), Fabaceae (pea family, 40 species, 39 native, one exotic), Chenopodiaceae (32 native species) and Malvaceae (25 native species) were the most species-rich families recorded.

Flora species recorded within the Study area and their associated vegetation communities are relatively common in the region with the exception of a few species. No threatened plants were recorded within the Study area. Three species recorded within the Study area are listed as near threatened (NT) and three species are listed as data deficient under the TPWC Act. An additional 11 species are noted to have bioregional significance.

Thirty-nine species recorded during the survey have not previously been recorded on the DLRM database for the locality. These new records combined with the existing Northern Territory Government flora records takes the total flora records for the locality to 451 species.

The full list of plant species recorded within the study area is presented in Appendix A.

The dominant species recorded within each of the vegetation types occurring within the Study area are discussed in the following sections.

## 4.3 Vegetation communities

Based on the fine-scale vegetation mapping and flora sampling performed by GHD a total of 14 vegetation communities were identified within the Study area. These vegetation communities each display a degree of variation which is to be expected given the influence of differing geology, soils, hydrology, fire regimes and grazing pressures. Despite these variations these communities have been defined based on similarities in landscape position, floristics, vegetation structure and patterns.

In addition to these communities there are a number of sub-communities and vegetation intergrades/mosaics that occur in the area. Vegetation intergrades have been mapped in areas that contain characteristic elements of two or more vegetation types, as is often the case where one community transitions into another. Mosaic communities within the Study area are mapped where two or more communities occur in patches that could not be delineated at the scale of mapping used in this assessment.

The dominant vegetation types within the Study area are Mulga shrublands, which occur on alluvial fans and plains containing clayey red earths and Triodia hummock grasslands which grow on sandy plains. Vegetation across the Study area is generally in good condition with little anthropologic disturbance and high species richness. In more fertile riparian areas and associated floodplains there is clear evidence of impacts associated with cattle grazing including weed invasion, reduction in ground cover species richness and soil erosion. In particular, there is a high abundance of the invasive grass *Cenchrus ciliaris* (Buffel Grass). There are also several areas that have been cleared within the mine site and borefields area during geotechnical and hydrological investigations at the site.

Vegetation communities identified and mapped within the Study area and their relative abundance are summarised in Table 4.1 and their distributions shown in Figure 4.1.

Adjacent to the access road to the proposed accommodation village is a small Coolabah Swamp. Although this vegetation is not within the Nolans site it has been included in the assessment as there is potential for this wetland to be indirectly impacted by the Project.

Although there is no detailed vegetation mapping available for the Study area, detailed vegetation mapping has been completed for the Alice Springs municipality by Albrecht and Pitts (2004). Vegetation descriptions published in that report (Albrecht and Pitts 2004) were reviewed, and where possible, vegetation communities present within the Study area were aligned to this mapping. Although many of the vegetation communities within the Study area have some attributes similar to vegetation communities mapped within the Alice Springs municipality, most displayed a degree of variation or difference. Therefore only broad affinities with vegetation mapping completed for the Alice Springs municipality are able to be presented in Table 4.1 (Albrecht and Pitts 2004).

Detailed descriptions of each vegetation type are outlined below. Vegetation mapping is provided in Figure 4.1.

Table 4.1 Comparisons of vegetation communities within study area with Albrecht and Pitts (2004) vegetation types

| Nolans Project 2010/11 and 2015 mapping | | Area (ha) | % of Study area | Albrecht and Pitts (2004) Mapping | |
|---|---|---|---|---|---|
| Vegetation type | Description | | | Vegetation type | Description |
| 1 | Riparian woodland along water courses and drainage channels | 261.1 | 4.6 | 22 | Large sandy red gum creeklines |
| 2a | Mulga shrubland on sandy red earths over spinifex | 46.4 | 0.8 | 16 | Mulga in valleys with red earth soils |
| 2b | Mulga shrubland on sandy red earths over tussock grasses | 1756.8 | 30.8 | 16 | Mulga in valleys with red earth soils |
| 2c | Mulga shrubland on sandy red earths over chenopods | 41.6 | 0.6 | 16 | Mulga in valleys with red earth soils |
| 3a | Mixed woodland over tussock grasses on alluvial plains | 780.2 | 13.7 | 17 | Ironwood and fork-leaved corkwood on alluvial flats |
| 3b | Mixed Woodland over spinifex on alluvial plains | 31.2 | 0.5 | N/A | Not described by Albrecht and Pitts 2004 |
| 3c | Mixed Woodland over a highly disturbed understorey dominated by *Cenchrus ciliaris* | 21.8 | 0.4 | N/A | Not described by Albrecht and Pitts 2004 |
| 4 | *Triodia schinzii* hummock grassland on red clayey sands | 0* | 0* | N/A | Not described by Albrecht and Pitts 2004 |
| 5 | Hakea/Senna shrubland on calcareous alluvial plains and low rises | 232.5 | 4.1 | N/A | Not described by Albrecht and Pitts 2004 |
| 6 | Eucalyptus (mallee)/*Acacia kempeana* shrubland with Triodia on rocky slopes | 59.9 | 1.0 | 1 | Hillside spinifex and mallee on quartzite slopes |
| 7 | Acacia/Triodia shrubland on rocky outcrops | 226.6 | 4.0 | 1 & 3 | Hillside spinifex and mallee on quartzite slopes; hillside spinifex on hills of granite, gneiss or schist |
| 8 | Acacia/Senna shrubland on rocky gneiss or schist outcrops with no spinifex | 3.2 | 0.05 | 4 | Witchetty Bush and/or Mulga on rocky hills of granite, gneiss or schist |

| Nolans Project 2010/11 and 2015 mapping | | Area (ha) | % of Study area | Albrecht and Pitts (2004) Mapping | |
|---|---|---|---|---|---|
| Vegetation type | Description | | | Vegetation type | Description |
| 9 | *Acacia kempeana* and/or Mulga shrubland on gravel | 126.3 | 2.2 | 5 | Witchetty Bush and/or Mulga on gravelly rises of granite, gneiss, schist or quartz |
| 10 | Claypans with chenopods and herbs | 0.3 | 0.005 | 25 | Claypans often with a fringing sandy herbfield |
| 11 | Cottonbush chenopod shrubland on highly erodible duplex soils | 13.5 | 0.2 | 18 | Needlebush and Cottonbush on erodible sandy-clay flats |
| 12 | *Triodia basedowii* hummock grassland on sand plains | 851.9 | 14..9 | 14 | Rises of loose sand with hard spinifex |
| 13 | Senna shrubland on quartz | 16.6 | 0.3 | 8 | Whitewood and Senna on gravelly rises associated with silcrete outcrop |
| 14 | Coolabah swamp associated with claypans | 2.6 | 0.04 | 24 | Coolabah associated with claypans |
| 2a/2b | Mulga shrubland on sand red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex | 1155.1 | 20.3 | 16 | Mulga in valleys with red earth soils |
| 2b/3a | Mulga shrubland on sandy red earths over tussock grasses / Mixed woodland over tussock grasses on alluvial plains | 11.8 | 0.2 | N/A | Not described by Albrecht and Pitts 2004 |
| 3a/12 | Mixed woodland over tussock grasses on alluvial plains / Cottenbush chenopod shrubland on highly erodible duplex soils | 20.2 | 0.4 | N/A | Not described by Albrecht and Pitts 2004 |
| 3b/2b | Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses. | 25.6 | 0.4 | N/A | Not described by Albrecht and Pitts 2004 |
| 9 | *Acacia kempeana* and/or Mulga shrubland on gravel | 126.3 | 2.2 | 5 | Witchetty Bush and/or Mulga on gravelly rises of granite, gneiss, schist or quartz |
| 10 | Claypans with chenopods and herbs | 0.3 | 0.005 | 25 | Claypans often with a fringing sandy herbfield |
| | **TOTAL** | **5704** | | | |

*This vegetation type was recorded only along the transport corridor that is no longer part of the study area.

### 4.3.1 Vegetation community 1 (V1) Riparian woodland along watercourses and drainage channels

Plate 4-1 Riparian woodland along Kerosene Camp Creek

#### *Vegetation structure and floristics*

The vegetation typically consists of three layers (ground, shrub and tree): This vegetation community is dominated by *Eucalyptus camaldulensis* subsp. *arida* with *Erythrina vespertilio*, *Atalaya hemiglauca*, *Acacia estrophiolata* and *Corymbia aparrerinja* also present in lower densities. Along smaller drainage channels *Eucalyptus camaldulensis* is generally absent and *Erythrina vespertilio* and/or *Corymbia aparrerinja* become the dominant species within the tree layer. The shrub layer is typically sparse and includes *Acacia cuthbertsonii, Acacia victoriae, Carissa lanceolata, Melaleuca glomerata* and *Acacia tetragonophylla*. The ground layer is dominated by the noxious weed *Cenchrus ciliaris.* Other species that are common within the ground layer include *Eulalia aurea*, *Themeda triandra, Chrysopogon fallax, Indigofera linifolia, Crotalaria eremaea, Cleome viscosa, Glycine canescens,* and *Pterocaulon spathulatum*.

- **Ground Layer**: <0.7 m tall (40–60 % cover) with several of the following species; *Eulalia aurea, Themeda triandra, Enteropogon acicularis, Enneapogon polyphyllus, Eriachne mucronata, Calotis plumulifera, Pluchea rubelliflora, Indigofera linifolia, Indigofera linnaei, Cleome viscosa, Aristida holathera, Cleome viscosa, Glycine canescens, Streptoglossa odorata*, *Pterocaulon spathulatum*.
- **Shrub Layer**: 0.5–5 m tall (10–15 % cover) with one or more of the following species; *Acacia victoriae, Eremophila latrobei* subsp. *glabra, Acacia aneura* var. *aneura, Senna artemisioides* subsp. *artemisioides, Senna artemisioides* subsp. *helmsii, Melaleuca glomerata, Acacia tetragonophylla.*

- **Overstorey Layer**: 4–15 m tall (10–30 % cover) with one or more of the following species; *Eucalyptus camaldulensis* subsp. *arida*, *Erythrina vespertilio, Acacia estrophiolata, Corymbia aparrerinja, Eucalyptus coolabah, Corymbia opaca.*
- **Characteristic species**: *Eucalyptus camaldulensis* subsp. *Arida.*
- **Introduced/exotic taxa**: *[4]*Cenchrus ciliaris* was the dominant ground layer species, ranging from 20—70 % cover. Other introduced species present within this vegetation community included, **Cynodon dactylon, *Citrullus lanatus, *Malvastrum americanum, *Eragrostis trichophora, *Digitaria bicornis* and *Vachellia farnesiana*.

**Mosaics and complexes:** Communities 1 (Riparian) and 2 (Mulga) form a vegetation complex where the transport corridor intersects the Allungra Creek drainage system. Within this mosaic *Corymbia aparrerinja* was present as an emergent tree and the ground and shrub layers are dominated by species from the Mulga shrubland community.

***Total area:*** 261 ha

***Number of quadrats:*** 10

***Quadrat numbers: 2011 survey =*** 91, 39, 94, 96, 99, 101

***2015 survey =*** 15,23,25,34

***Geology*:** Alluvium

***Landforms and substrate*:** Occurs on stream banks, levees and terraces of Kerosene Camp, Rabbit Flat and Nolans Creeks; with a substrate of unconsolidated brown sands and gravel. Also present along smaller unnamed drainage lines.

### 4.3.2 Vegetation community 2 (V2) Mulga shrubland on sandy red earths

#### *Vegetation structure and floristics*

Within the Study area this vegetation is quite variable both structurally and floristically but is characterised by the dominance of *Acacia aneura.* This heterogeneity is likely to be a reflection of differences in soil type and landscape position as well as differing fire regimes across the Study area. Three sub-communities occur within the Study area including one with an understorey dominated by spinifex, one with an understorey tussock grasses and one with an understorey dominated by chenopods. These sub-communities are described below.

[4] * denotes exotic species

### Vegetation sub-community 2a – Mulga shrubland on sandy red earths over spinifiex


Plate 4-2 Mulga shrubland on sandy red earths over spinifex

#### *Vegetation structure and floristics*

This sub-community is dominated by *Acacia aneura* with *Acacia kempeana* and *Eucalyptus gamophylla*, over a ground layer dominated by *Triodia basedowii.* This community is likely to have once been floristically similar to sub-community 2b however it has been invaded by spinifex that has intruded from the adjacent *Triodia basedowii* hummock grassland. Within the Study area this sub-community occurs in small patches within the borefields area (refer to Figure 4.1*).*

- **Ground Layer**: < 0.5 m tall (25–50 % cover), with several of the following species; *Triodia basedowii, Calandrinia balonensis, Aristida holathera, Sida* sp. Wakaya Desert (P.K.Latz 11894), *Evolvulus alsinoides var. villosicalyx, Thyridolepis mitchelliana Digitaria brownii, Portulaca filifolia.*
- **Shrub Layer**: 1–3 m tall (10–20 % cover), often with one or more of the following species; *Psydrax suaveolens*, *Eremophila latrobei* subsp. *glabra, Sida platycalyx.*
- **Overstorey Layer**: 3–8 m tall (15–50 % cover), with one or more of the following species; *Acacia aneura, Eucalyptus gamophylla, Acacia kempeana.*
- **Characteristic species**: *Acacia aneura.*
- **Introduced/exotic taxa**: Very occasional individuals of *Cenchrus ciliaris* were recorded within this community.

***Total area:*** 46.4 ha

***Number of quadrats:*** *2*

***Quadrat numbers 2015 survey:*** *3, 7*

***Geology:*** Red earth

***Landforms and substrate*:** Occurs on plains with sandy red earths.

**Vegetation sub-community 2b – Mulga shrubland on sandy red earths over tussock grasses.**


Plate 4-3 Mulga shrubland with tussock grass understorey along proposed gas pipeline

***Vegetation structure and floristics***

Throughout the majority of the Study area this community occurs as a tall shrubland to four m dominated by *Acacia aneura* with scattered *Corymbia opaca* and *Acacia kempeana*, over a lower shrub layer dominated by *Eremophila latrobei* subsp. *glabra* and *Senna artemisioides subsp helmsii*. The ground layer is dominated by a diverse array of grasses and forbs and tussock grasses. Common species included *Enneapogon polyphyllus, Tripogon loliiformis, Dactyloctenium radulans, Portulaca oleracea* var. *Undoolya, Aristida contorta, Evolvulus alsinoides, Sida platycalyx, Aristida holathera, Euphorbia drummondii, Sclerolaena cornishiana, Eragrostis eriopoda* sp. *'Red Earth'* and *Sida* sp *'Bond Springs'.* Species richness within the ground layer of this community appears to correlate with fire frequency and grazing intensity, with mature stands of mulga that are long unburnt having the highest species richness whilst younger stands that have been frequently burnt and exposed to intense grazing having relatively low species richness.

In the south of the Study area mulga shrubland form obvious thickets of alternating groves and intergroves, this growth pattern is evident as a distinct banding pattern on the aerial photography. Mulga banding patterns tend to occur in areas of subdued topography where leaf litter within groves is concentrated and water and nutrients from surface flows are trapped (Tongway and Ludwig 1990). These layers of litter provide for effective recycling of nutrients and also as a fertile bed for seedling establishment.

Throughout the Study area this community is in good to excellent condition with high species diversity and very few weeds.

- **Ground Layer**: < 0.5 m tall (25–60 % cover), with several of the following species; *Enneapogon polyphyllus, Eragrostis eriopoda* sp 'Red Earth', *Aristida holathera* var. *holathera, Abutilon otocarpum, Evolvulus alsinoides var. villosicalyx, Cheilanthes sieberi subsp. sieberi, Eriachne helmsii, Tripogon loliiformis*, *Dactyloctenium radulans, Portulaca oleracea* var. *Undoolya, Aristida contorta.*
- **Shrub Layer**: 1–3 m tall (10–20 % cover), often with one or more of the following species; *Senna artemisioides subsp. helmsii, Eremophila latrobei* subsp. *glabra.*
- **Overstorey Layer**: 3–8 m tall (15–50 % cover), with one or more of the following species; *Acacia aneura, Acacia aptaneura, Acacia cuthbertsonii* subsp. *cuthbertsonii, Acacia kempeana.*
- **Characteristic species**: *Acacia aneura*, *Acacia aptaneura.*
- **Introduced/exotic taxa**: Small isolated occurrences of the invasive weed **Cenchrus ciliaris* were recorded within this community.

***Total area:*** 2921.1 ha

***Quadrat numbers: 2011 survey:*** *21, 23, 28, 24, 44, 54, 57, 133*

***2015 survey:*** 5, 6, 7

***Number of quadrats:*** 11

***Landforms and substrate:*** Occurs on plains with clayey red earths of intermediate fertility.

***Mosaics:*** Within the proposed mine site area, this community contains patches of sub community 2a (Mulga shrubland over spinifex grasses). Area calculations for this mosaic have been included within this vegetation community as it was the dominant form throughout the mine site.

This community also forms a mosaic with vegetation types 3a and 3b in small patches throughout the study area.

### Vegetation sub-community 2c – Mulga shrubland on sandy red earths over chenopods


Plate 4-4 Mulga shrubland on sandy red earths over chenopods

#### *Vegetation structure and floristics*

This sub-community is dominated by sparse *Acacia aneura*, over a sparse ground layer dominated by chenopod shrubs. Within the Study area this vegetation community occurs within a floodout area located within the processing site.

- **Ground Layer**: < 0.5 m tall (10–25 % cover), *Sclerolaena bicornis, Sclerolaena cornishiana, Sclerolaena diacantha, Sclerolaena lanicuspis, Fimbristylis dichotoma, Atriplex elachophylla.*
- **Shrub Layer**: 1–3 m tall (< 1 % cover), often with one or more of the following species; *Acacia tetragonophylla, Hakea chordophylla, Eremophila latrobei subsp. Glabra.*
- **Overstorey Layer**: 3–8 m tall (5-20 % cover), with one or more of the following species; *Acacia aneura, Acacia kempeana. Corymbia opaca.*
- **Characteristic species**: *Acacia aneura.*
- **Introduced/exotic taxa**: Very occasional individuals of *Cenchrus ciliaris* were recorded within this community.

***Total area:*** 41.6

***Number of quadrats:*** *1*

***Quadrat numbers 2011 survey:*** Not recorded

***2015 survey:*** *8*

***Geology:*** Red earth

***Landforms and substrate*****:** Occurs on run on areas with hard clay pans

### 4.3.3 Vegetation community 3 (V3): mixed woodland on alluvial plains

#### Vegetation structure and floristics

This vegetation community is comprised of open woodland growing on fertile plains. Within the Study area this vegetation community occurs in three distinct sub-communities:

- Mixed woodland over tussock grasses
- Mixed woodland over spinifex
- Mixed woodland over a highly disturbed understorey dominated by *Cenchrus ciliaris.*

Floristic differences between the sub-communities are likely to be influenced by variations in soil type, fire regime, soil disturbance and grazing pressures.

Descriptions of these three sub-communities of alluvial woodland are provided below.

#### Vegetation sub-community 3a – Mixed Woodland over Tussock Grasses on alluvial plains


Plate 4-5 Mixed Woodland on alluvial plains dominated by tussock grasses

This vegetation community occurs as open woodland on fertile alluvial plains. Dominant canopy species include *Corymbia opaca* and *Hakea chordophylla* with scattered A*talaya hemiglauca and Erythrina vespertilio.* These occur over a sparse shrub layer dominated by *Acacia kempeana, Carissa lanceolata, Acacia aneura, Eremophila latrobei* var. *glabra* and various *Senna artemisioides* subspecies*.* The ground layer is dominated by tussock grasses including *Eragrostis eriopoda* sp 'Red Earth'*, Aristida contorta, Aristida holathera* subsp*. holathera, Enneapogon avenaceus, Aristida holathera* subsp. *holathera, Chrysopogon fallax, Abutilon otocarpum, Sclerolaena convexula, Indigofera colutea, Tribulus eichlerianus* and *Evolvulus alsinoides*.

- **Ground Layer**: < 0.5 m tall (30–60 % cover), with several of the following species; *Enneapogon polyphyllus, Aristida contorta, Sclerolaena convexula, Indigofera colutea, Eragrostis eriopoda sp. 'Red Earth', Sida cunninghamii, Fimbristylis dichotoma, Aristida holathera var. holathera, Tribulus eichlerianus, Cleome viscosa, Abutilon otocarpum, Sclerolaena convexula.*
- **Shrub Layer:** 0.8–3 m tall (5–20 % cover), often with one or more of the following species; *Acacia cuthbertsonii* subsp*. cuthbertsonii, Acacia melleodora, Carissa lanceolata, Senna artemisioides* subsp*. sturtii, Senna artemisioides* subsp*. helmsii, Eremophila freelingii, Acacia sericophylla, Senna artemisioides* subsp*. alicia*.
- **Overstorey Layer**: 3–10 m tall (1–5 % cover), with one or more of the following species; *Corymbia opaca, Erythrina vespertilio, Atalaya hemiglauca, Hakea chordophylla, Acacia estrophiolata, Acacia kempeana, Ventilago viminalis.*
- **Characteristic species**: *Acacia estrophiolata, Acacia kempeana, Corymbia opaca, Atalaya hemiglauca.*
- **Introduced/exotic taxa**: The invasive weed **Cenchrus ciliaris* occurs in typically low to moderate densities (5-30 %) within this community. Other introduced taxa recorded include **Malvastrum americanum, *Vechellia farnesiana, *Eragrostis barrelieri* and **Citrullus lanatus* (Appendix C).

***Total area:*** 780 ha

***Number of quadrats:*** 9

***Quadrat numbers:*** **2011 survey:** 64, 66, 70, 71, 73, 74

**2015 survey:** 14, 16, 24

***Geology:*** Alluvium

***Landforms and substrate:*** Occurs on alluvial plains and flats adjacent watercourses. Groundwater soaks occur along the base of rocky outcrops.

***Mosaics:*** Within the proposed mine site there are some areas mapped as this community that contain patches of VT 12 (Cottonbush/chenopod shrubland on highly erodible duplex soils). There are also small areas that include patches of VT 2b (Mulga shrublands on sandy red earths over tussock grasses).

### Vegetation sub-community 3b – mixed Woodland over spinifex on alluvial plains


Plate 4-6 Mixed woodland over spinifex within processing plant site

#### *Vegetation structure and floristics*

The overstorey of this community is similar in composition to sub-community 3a being dominated by a sparse canopy of *Corymbia opaca, Atalaya hemiglauca, Hakea cordifolia and Erythrina vespertilio* over a shrub layer dominated by *Carissa lanceolata, Gossypium sturtianum* var. *sturtianum* and *Senna* spp, however the ground layer of this vegetation type is dominated by *Triodia schinzii* rather than tussock grasses.

- **Ground Layer**: < 0.5 m tall (30–60 % cover), with several of the following species; *Triodia schinzii, Enneapogon polyphylla, Aristida hygrometrica, Tephrosia* sp. *Willowra* (G.M.Chippendale 4809), *Sclerolaena convexula, Fimbristylis dichotoma, Indigofera colutea*, *Tripogon loliiformis, Sclerolaena cornishiana, Abutilon otocarpum, Portulaca filifolia.*
- **Shrub Layer:** 0.8–3 m tall (5–20 % cover), often with one or more of the following species; *Carissa lanceolata, Gossypium sturtianum* var. *sturtianum, Senna artemisioides* subsp. *artemisioides, Senna artemisioides* subsp. *helmsii, Rhagodia eremaea, Eremophila freelingii*, *Senna artemisioides* subsp. *quadrifolia.*
- **Overstorey Layer**: 4–10 m tall (1–5 % cover), with one or more of the following species; *Corymbia opaca, Erythrina vespertilio, Atalaya hemiglauca, Acacia estrophiolata, Acacia kempeana, Ventilago viminalis.*
- **Characteristic species**: *Acacia estrophiolata, Acacia kempeana, Corymbia opaca, Atalaya hemiglauca, Triodia schinzii, Aristida hygrometrica.*
- **Introduced/exotic taxa**: The invasive weed *Cenchrus ciliaris* occurs in typically low-densities (0-10 %) within this community.

***Total area*:** 31.2 ha

***Number of quadrats*:** 2

***Quadrat numbers:*** **2011 survey:** Not recorded

**2015 survey:** 13, 22

***Geology:*** Alluvium

***Landforms and substrate:*** Occurs on alluvial plains between two ridgelines to the north and east of the processing facility.

**Vegetation sub-community 3c – mixed woodland over a highly disturbed understorey dominated by **Cenchrus ciliaris***


Plate 4-7 Mixed woodland over a highly disturbed understorey

***Vegetation structure and floristics***

In fertile floodplain areas that have been subject to intense grazing the understorey of this community has been highly disturbed and is dominated by the invasive weed *Cenchrus ciliaris.* This community has an overstorey similar to vegetation sub-communities 3a and 3b however the ground layer has significantly lower species diversity due to the dense cover of Buffel grass.

- **Ground Layer**: < 0.5 m tall (40–60 % cover), with several of the following species; **Cenchrus ciliaris, Fimbristylis dichotoma, Indigofera colutea, Enneapogon polyphyllus, Sclerolaena convexula, Chrysopogon fallax.*
- **Shrub Layer:** 0.8–3 m tall (1–10 % cover), often with one or more of the following species; *Carissa lanceolata, Senna artemisioides* subsp. *artemisioides, Senna artemisioides* subsp. *helmsii, Eremophila* latrobei subsp*. glabra.*

- **Overstorey Layer**: 4–10 m tall (1–5 % cover), with one or more of the following species; *Corymbia opaca, Erythrina vespertilio, Atalaya hemiglauca, Acacia estrophiolata, Acacia kempeana, Ventilago viminalis.*
- **Characteristic species**: *Acacia estrophiolata, Acacia kempeana, Corymbia opaca, Atalaya hemiglauca.*
- **Introduced/exotic taxa**: The invasive weed *Cenchrus ciliaris* occurs in high densities (25-50 % cover) within this community.

***Total area:*** 21.8 ha

***Number of quadrats:*** 2

***Quadrat numbers:*** **2011 survey:** Not recorded

**2015 survey:** 9, 12

***Geology:*** Quaternary alluvium

***Landforms and substrate:*** Occurs on alluvial plains

### 4.3.4 Vegetation community 4 (V4): *Triodia schinzii* hummock grassland on red clayey sands

Plate 4-8 *Triodia schinzii* hummock grassland within mine site

#### Vegetation structure and species

This vegetation community typically has 1–3 layers. The *Triodia*-dominated ground-layer is a dominant feature with sparse (and sometimes absent) shrub and emergent tree layers.

- **Ground Layer**: 0.05–1.5 m tall (20–70 % cover), including *Triodia schinzii, Ptilotus polystachyus, Aristida holathera var. holathera, Eriachne aristidea*.

- **Shrub Layer:** 0.5–6 m tall (10–60 % cover), including *Senna artemisioides subsp. artemisioides, Acacia murrayana, Senna artemisioides subsp. filifolia.*
- **Emergent (Tree) Layer**: 3–10 m tall (< 1 % cover) including *Corymbia opaca, Hakea macrocarpa, Grevillea eriostachya.*
- **Characteristic species**: *Triodia schinzii, Hakea macrocarpa, Grevillea eriostachya*.
- **Introduced/exotic taxa**: No introduced taxa were recorded within this community.

***Mosaics and Complexes*:** Vegetation communities 2 (Mulga) and 4 (*Triodia*) form a mosaic on aeolian plains, characterised by small (< 6 ha) scattered patches of shrubs in a matrix of *Triodia* hummock grassland.

***Total area:*** not present within Nolans site.

***Number of quadrats:*** 5

**Quadrat numbers 2011 survey**: 7, 80, 84, 89, 200

**2015 survey:** not recorded

***Landforms and substrate:*** Occurs on extensive aeolian plains containing red clayey sands, to the east of the mineral lease.

### 4.3.5 Vegetation community 5 (V5): *Hakea*/*Senna* shrubland on calcareous alluvial plains and low rises

Plate 4-9 *Hakea*/*Senna* shrubland within mineral lease

***Vegetation structure and species***

This vegetation community occurs on calcareous plains and low rises. The sparse canopy layer is dominated by *Hakea chordophylla, Corymbia opaca, Acacia aneura* and *Acacia cuthbertsonii*

*subsp. cuthbertsonii* over a shrub layer characterised by *Senna and Eremophila spp.* Ground layer consists of a relatively sparse covering of grasses and forbs including *Enneapogon cylindricus Triodia spicata, Evolvulus alsinoides var. villosicalyx, Sclerolaena cornishiana, Sida platycalyx, Tripogon loliiformis.*

Woody species richness is relatively high along lower sandy footslopes in the vicinity of runoff areas and groundwater soaks.

- **Ground Layer**: < 0.3 m tall (15–40 % cover), with several of the following species: *Enneapogon polyphyllus, Triodia spicata, Evolvulus alsinoides* var. *villosicalyx, Sclerolaena cornishiana, Sida platycalyx, Tripogon loliiformis.*
- **Shrub Layer:** 0.5–2.5 m tall (5–45 % cover), often with one or more of the following species: *Senna artemisioides* subsp. *sturtii, Senna artemisioides* subsp. *artemisioides, Eremophila latrobei* subsp. *glabra, Senna artemisioides* subsp. *Alicia.*
- **Emergent (Tree) Layer**: 5–8 m tall (5–20 % cover), with one or more of the following species, *Hakea chordophylla, Corymbia opaca, Acacia aptaneura, Acacia cuthbertsonii* subsp. *cuthbertsonii.*
- **Characteristic species**: *Hakea chordophylla.*
- **Introduced/exotic taxa**: *Cenchrus ciliaris* was locally dominant (up to 70 % cover) in areas cleared for mineral exploration. Other introduced species recorded include *Eragrostis minor*.

***Total area:*** 232.5 ha

***Number of quadrats:*** 4

***Quadrat numbers: 2011 survey:*** 47, 55, 50, 59

***2015 survey:*** not recorded

***Landforms and substrate***: Occurs on alluvial plains and rises containing calcareous (calcrete) sands and gravels in the mineral lease.

### 4.3.6 Vegetation community 6 (V6): *Eucalyptus* (mallee)/*Acacia kempeana* shrubland with /*Triodia* on rocky slopes

Plate 4-10 Eucalyptus (mallee)/*Acacia kempeana* shrubland with Triodia on rocky slopes within mine site

***Vegetation structure and floristics***

The vegetation usually has three layers (ground, shrub and mallee tree layer).

- **Ground Layer**: 0.05–0.7 m tall (60–65 % cover), including *Triodia spicata*, *Trachymene glaucifolia* and *Corchorus sidoides*.
- **Shrub Layer:** 0.6–2.5 m tall (25–40 % cover), often including, *Senna artemisioides subsp. artemisioides, Acacia melleodora, Eremophila latrobei* subsp*. glabra, Senna artemisioides subsp. alicia, Senna glutinosa* subsp*. glutinosa.*
- **Overstorey Layer**: 5–8 m tall (30–60 % cover), including *Eucalyptus gamophylla, Acacia kempeana.*
- **Characteristic species**: *Eucalyptus gamophylla, Corchorus sidoides.*
- **Introduced/exotic taxa**: No introduced taxa were recorded in this community.

***Total area:*** 59.9 ha

***Number of quadrats:*** 3

***Quadrat numbers: 2011 survey:*** 41, 61, 202

***2015 survey:*** not recorded

***Landforms and substrate***: Occurs on alluvial foothill fans, typically with sandy, gravelly or stony substrates. This vegetation community is similar to VT 7 however it occurs in areas that are less steep with fewer rocks.

### 4.3.7 Vegetation community 7 (V7): *Acacia* / *Triodia* shrubland on rocky outcrops

Plate 4-11 Acacia shrubland with Triodia hummocks on rocky outcrops

#### *Vegetation structure and floristics*

This vegetation community is characterised by low acacias and *Senna* spp. growing on stony rises and low hills comprised of granite or quartzite with shallow soils with rocky surface fragments.

The structure of the community is confined to a sparse shrub layer dominated by low growing *Atalaya hemiglauca, Acacia cuthbertsonii, Senna artemisioides* subsp. *helmsii, Acacia melleodora, Acacia monticola* and *Grevillea wickhamii* subsp. *aprica* over a species rich ground layer dominated by *Triodia spicata* and/or *T. hubbardii*:

- **Ground Layer**: 0.05–1.5 m tall (15–35 % cover), including *Triodia spicata, Triodia hubbardii, Melhania oblongifolia, Eriachne mucronata, Evolvulus alsinoides* var. *villosicalyx, Ptilotus incanus*, *Tephrosia supina*, *Heliotropium cunninghamii, Enneapogon polyphyllus, Eriachne mucronata.*
- **Shrub Layer:** 0.6–2.5 m tall (5–15 % cover), typically including *Acacia melleodora, Acacia monticola, Grevillea wickhamii* subsp. *aprica, Acacia sericophylla, Acacia spondylophylla, Senna artemisioides* subsp. *helmsii. Eremophila longifolia.*
- **Characteristic species**: *Acacia melleodora, Acacia monticola, Triodia spicata, Grevillea wickhamii* subsp. *aprica, Eriachne mucronata, Tephrosia supina, Aristida nitidula.*

- **Introduced/exotic taxa**: Isolated individuals of **Cenchrus ciliaris* are present within this vegetation type.

***Total area:*** 226.6 ha

***Number of quadrats:*** 10

***Quadrat numbers: 2011 survey:*** 34, 45, 121, 122, 124, 125, 127

***2015 survey:*** 10, 20, 30

***Landforms and substrate:*** Found on crests and slopes of rocky outcrops with shallow gravelly or stony soils.

### 4.3.8 Vegetation community 8 (V8) Acacia/Senna shrubland on rocky gneiss or schist outcrops with no spinifex


Plate 4-12 Rocky outcrop with no spinifex within processing area

#### *Vegetation structure and floristics*

This vegetation community is similar to vegetation community 8 however it does not have spinifex and associated species within the ground and shrub layers. As with vegetation community 8 this vegetation type occurs on stony rises and low hills comprised of granite, gneiss or schist with shallow soils with rocky surface fragments.

The structure of the community is confined to a sparse shrub layer dominated by low growing *Atalaya hemiglauca, Indigofera leucotricha, Senna artemisioides* subsp. *sturtii, Senna artemisioides* subsp. *helmsii, Eremophila latrobei* and *Acacia monticola* over a species rich ground layer dominated by *Enneapogon polyphyllus* and *Eriachne mucronata.*

- ***Ground Layer****: 0.05–1.5 m tall (15–25 % cover), including Enneapogon polyphyllus, Eriachne mucronata, Melhania oblongifolia, Cheilanthes lasiophylla. Abutilon fraseri, Sida*

*filiformis, Hybanthus aurantiacus, Amaranthus interruptus, Cleome viscosa, Tripogon loliiformis, Indigofera colutea, Cymbopogon ambiguous.*

- ***Shrub Layer:*** *0.6–2.5 m tall (5–15 % cover), typically including Acacia melleodora, Indigofera leucotricha, Senna artemisioides subsp. helmsii, Senna artemisioides subsp. stuartii, Hibiscus sturtii 'Granite Form'. Ptilotus obovatus.*

***Characteristic species****: Indigofera leucotricha, Hibiscus sturtii 'Granite Form'.*

***Introduced/exotic taxa:*** Isolated individuals of *Cenchrus ciliaris* are present within this vegetation type.

***Total area:*** 3.1 ha

***Number of quadrats:*** 7

***Quadrat numbers 2011 survey:*** 121, 122, 124, 125, 127

***2015 survey:*** 33, 35,

***Landforms and substrate:*** Found on crests and slopes of rocky outcrops with shallow gravelly or stony soils.

### 4.3.9 Vegetation community 9 (V9) Acacia kempeana and/or mulga shrubland on gravel


Plate 4-13 *Acacia kempeana* and/or mulga shrubland on gravel

***Vegetation structure and floristics***

This community occurs on red earths with gravelly/stony surface fragments at the base of ranges. The tree layer is very sparse and is dominated by *Corymbia opaca* which occurs over a shrub layer dominated by *Acacia kempeana, Acacia cuthbertsonii* subsp. *cuthbertsonii, Senna artemisioides* subsp. *helmsii and Eremophila latrobei*. The ground layer contains a variety of

grasses and forbs including *Aristida contorta, Fimbristylis dichotoma, Tripogon loliiformis, Sclerolaena convexula, Enneapogon polyphyllus and Sclerolaena cornishiana.*

- **Ground Layer**: < 0.4 m tall (10–20 % cover), with several of the following species; *Aristida contorta*, *Enneapogon polyphyllus, Tripogon loliiformis, Fimbristylis dichotoma, Dactyloctenium radulans, Portulaca filifolia, Evolvulus alsinoides var. villosicalyx, Sclerolaena cornishiana, Sida platycalyx, Gomphrena lanata, Sclerolaena cornishiana.*
- **Shrub Layer:** 0.5–4 m tall (20–40 % cover), often with one or more of the following species: *Acacia kempeana, Acacia aneura, Acacia cuthbertsonii* subsp. *cuthbertsonii*: *Senna artemisioides subsp. helmsii, Eremophila latrobei* subsp*. glabra, Senna artemisioides* subsp. *sturtii, Eremophila freelingii.*
- **Emergent (Tree) Layer**: 5–8 m tall (0-1% cover), with one or more of the following species; *Hakea chordophylla, Corymbia opaca.*
- **Characteristic species**: *Acacia kempeana, Aristida contorta.*
- **Introduced/exotic taxa**: **Cenchrus ciliaris* was present in relatively low abundance (<5 % cover).

***Total area:*** 126.3 ha

***Number of quadrats:*** 4

***Quadrat numbers: 2010 survey:*** Not recorded

***2015 survey:*** 11,18,21,28

***Landforms and substrate:*** Occurs on gravelly soils at the base of ranges and rocky outcrops.

### 4.3.10 Vegetation community 10 (V10) Claypans with chenopods and herbs


Plate 4-14 Claypan on alluvial plains

#### *Vegetation structure and floristics*

This community occurs on clay pans that have formed in depressions on the alluvial plains. These areas would typically hold water for extended periods after rain and as such provide habitat for a number of ephemeral plants typically found in moist environments. The tree and shrub layers of the community are absent and the ground layer is relatively sparse with low species richness. Common plants include *Marsilea exarata, Fimbristylis dichotoma, Goodenia lunata* and *Centipeda thespidioides.*

Within the Study area this vegetation community occurs just outside the project footprint adjacent to a Coolabah woodland. A second patch of this community occurs adjacent to the proposed access track. It is possible that this is not a natural community in this area but has been formed following construction of the track which in turn has altered the local hydrology by preventing the runoff of water from nearby slopes to the drainage line to the south. This has then led to the pooling of water and development of wetland floristic elements. Within this area there is relatively low species diversity and many of the species characteristics of the clay pan community located further south are absent.

- **Ground Layer**: < 0.2 m tall (5–20 % cover), with several of the following species; *Atriplex elachophylla, Sclerolaena birchii, Trianthema triquetra, Alternanthera angustifolia, Fimbristylis dichotoma, Eragrostis kennedyae, Abutilon macrum, Solanum quadriloculatum Marsilea exarata, Goodenia lunata, Centipeda thespidioides.*
- **Characteristic species**: *Marsilea exarata, Goodenia lunata, Eragrostis kennedyae, Trianthema triquetra.*
- **Introduced/exotic taxa**: No introduced species were recorded within this community.

***Total area:*** 0.3 ha

***Number of quadrats:*** 1

***Quadrat numbers: 2011 survey:*** Not recorded

***2015 survey:*** 26

***Geology:*** Quaternary alluvium

***Landforms and substrate:*** Occurs on light clay soils that have formed pans in small depressions on alluvial plains.

### 4.3.11 Vegetation community 11 (V11) Cottonbush/chenopod shrubland on highly erodible duplex soils


Plate 4-15 Cottonbush/chenopod shrubland on highly erodible duplex soils

#### *Vegetation structure and floristics*

This community occurs on scolded earths and highly erodible duplex soils. These soils are typically high in salts and consequently these areas are largely devoid of vegetation (>70% bare ground) and restricted to species tolerant of this environment. The tree layer is generally absent and the shrub layer consists of a low number of scattered shrubs:

- **Ground Layer**: < 0.4 m tall (10–20 % cover), with several of the following species; *Fimbristylis dichotoma, Boerhavia coccinea, Dactyloctenium radulans, Portulaca filifolia, Eriachne obtusa, Oxychloris scariosa.*
- **Shrub Layer:** 0.5–4 m tall (0-5 % cover), often with one or more of the following species; *Sclerolaena bicornis, Sclerolaena cornishiana, Maireana aphylla, Acacia tetragonophylla, Atriplex elachophylla, Hakea leucoptera* subsp. *leucoptera.*

- **Characteristic species**: *Sclerolaena bicornis, Maireana aphylla, Oxychloris scariosa.*
- **Introduced/exotic taxa**: *Cenchrus ciliaris* was present in relatively low abundance (<1 % cover).

***Total area:*** 13.5 ha

***Number of quadrats:*** 2

***Quadrat numbers: 2011 survey:*** Not recorded

***2015 survey:*** 27, 29

***Landforms and substrate:*** Occurs on scolded earths and highly erodible duplex soils.

### 4.3.12 Vegetation community 12 (V12) *Triodia basedowii* hummock grassland on sandplains


Plate 4-16 *Triodia basedowii* hummock grassland in borefields area

***Vegetation structure and floristics***

Throughout the Study area this community occurs on deep Aeolian sands on flat to gently undulating plains. There is considerable local variation within the community with some areas characterised by a dense ground covering of *Triodia* while others have a more open ground layer with a higher diversity of shrubs, understorey herbs and tussock grasses. This heterogeneity is largely correlated with differences in fire regimes across the Study area.

There is no overstorey within this community and the sparse shrub layer to 4 m is dominated by *Grevillia juncifolia, Eucalyptus gamophylla, Acacia melleodora* and *Acacia kempeana* with *Acacia aneura, Senna pleurocarpa, Hakea divaricata* and *Acacia murrayana* also occasionally present. The ground layer is the dominant vegetation stratum and is dominated by *Triodia*

*basedowii*. Tussock grasses such as *Eriachne helmsii, Eragrostis eriopoda* subsp*. Sandy fireweed* and *Aristida holathera* also occur frequently within this vegetation community. In more recently burnt sites species such as *Dicrastylis lewellinii, Leptosema chambersii, Scaevola parviflora* subsp *parviflora, Sida* sp. Pindan (B.G. Thomson 3398)*, Ptilotus schwartzii,* and *Solanum centrale* are common, these species reduce in number as time since fire increases and spinifex becomes more dominant.

- **Ground Layer**: < 0.5 m tall (10–40 % cover), with several of the following species; *Triodia basedowii, Sida* sp Pindan (B.G. Thomson 3398)*, Dicrastylis lewellinii, Leptosema chambersii, Eragrostis eriopoda* subsp *Sandy fireweed, Eriachne helmsii, Paraneurachne muelleri, Aristida holathera* var*. holathera, Scaevola parvifolia, Solanum centrale, Paspalidium reflexum.*
- **Shrub Layer:** 0.1–4 m tall (1–15 % cover), often with one or more of the following species; *Grevillia juncifolia*, *Acacia melleodora*, *Eucalyptus gamophylla, Acacia kempeana, Acacia aneura, Senna pleurocarpa, Acacia bivenosa, Keraudrenia nephrosperma, Petalostylis cassioides.*
- **Characteristic species**: *Triodia basedowii, Scaevola parvifolia, Dicrastylis lewellinii, Leptosema chambersii, Grevillia juncifolia.*
- **Introduced/exotic taxa**: No exotic species were recorded within this vegetation community.

***Total area:*** 851.9 ha

***Number of quadrats:*** 3

***Quadrat numbers: 2011 survey:*** Not recorded

***2015 survey:*** 1, 2, 4

***Landforms and substrate:*** Occurs on Aeolian sands on flat to gently undulating plains.

### 4.3.13 Vegetation community 13 (V13) Senna shrubland on quartz


Plate 4-17 Senna shrubland on quartz near Stuart Highway

#### *Vegetation structure and floristics*

This community occurs on stony soils with loose quartz fragments. Within the Study area this community is confined to a small patch at the eastern end of the access track that runs from the Stuart Highway to the proposed accommodation facility. The tall shrub layer is very sparse and is dominated by *Acacia aneura* which occurs over a lower shrub layer dominated by *Senna artemisioides* subsp *alicia and Eremophila duttonii.* The ground layer contains a variety of grasses and forbs including *Sclerolaena cuneata, Sporobolus actinocladus*, *Neurachne munroi, Aristida contorta, Goodenia lanata, Sclerolaena lanicuspis and Enneapogon avenaceus.*

- **Ground Layer**: < 0.4 m tall (1–10 % cover), with several of the following species; *Sclerolaena cuneata, Sporobolus actinocladus*, *Neurachne munroi, Aristida contorta, Goodenia lanata, Sclerolaena lanicuspis, Enneapogon avenaceus, Einadia nutans subsp eremaea, Sclerolaena cornishiana, Tripogon loliiformis, Sida fibulifera.*
- **Shrub Layer:** 0.5–1.5 m tall (5–15 % cover), often with one or more of the following species; *Senna artemisioides* subsp *alicia, Eremophila duttonii, Carissa lanceolata, Acacia tetragonophylla, Rhagodia eremaea, Mariana aphylla.*
- **Tall Shrub Layer:** *3-5 m tall (1 % cover) dominated by Acacia aneura.*
- **Characteristic species**: *Senna artemisioides* subsp. *alicia, Eremophila duttonii, Sporobolus actinocladus, Neurachne munroi.*
- **Introduced/exotic taxa**: No exotic species were recorded within this vegetation type.

***Total area:*** 16.6 ha

***Number of quadrats:*** 3

***Quadrat numbers: 2011 survey:*** Not recorded

***2015 survey:*** 19, 31, 32

***Landforms and substrate:*** Occurs on soils with loose quartz fragments derived from quartzofeldspathic gneiss.

### 4.3.14 Vegetation community 14 (V14) Coolabah swamp associated with claypans


Plate 4-18 Coolabah swamp on claypan adjacent to access road

***Vegetation structure and floristics***

This community occurs to the south of the Study area on a claypan within the floodplain of Rabbit Creek. It is characterised by *Eucalyptus coolabah* subsp *arida* over a highly disturbed understorey that has been heavily impacted by cattle. The ground layer of this community is largely bare, with patches of Buffel Grass and occasional forbs. Although dry at the time of the survey, this claypan would hold water for extended periods following rain and is likely to contain a number of ephemeral species.

- **Ground Layer**: < 0.3 m tall (1–10 % cover), with several of the following species; *Cenchrus ciliaris, Centipeda thespidioides, Centipeda minima* subsp. *minima, Macgregoria racemigera, Fimbristylis dichotoma, Boerhavia repleta, Goodenia molesta. Leptochloa fusca* subsp*. muelleri, Wahlenbergia queenslandica, Cullen australasicum, Phyllanthus* sp. *Broad Tuberculate Seeds.*
- **Shrub Layer:** not present.

- **Canopy Layer:** 8-10 m tall (5-15 % cover) dominated by *Eucalyptus coolabah* subsp *arida.*
- **Characteristic species**: *Eucalyptus coolabah* subsp *arida.*
- **Introduced/exotic taxa**: The invasive weed *Cenchrus ciliaris* occurs in moderate (5-15 % cover) densities.

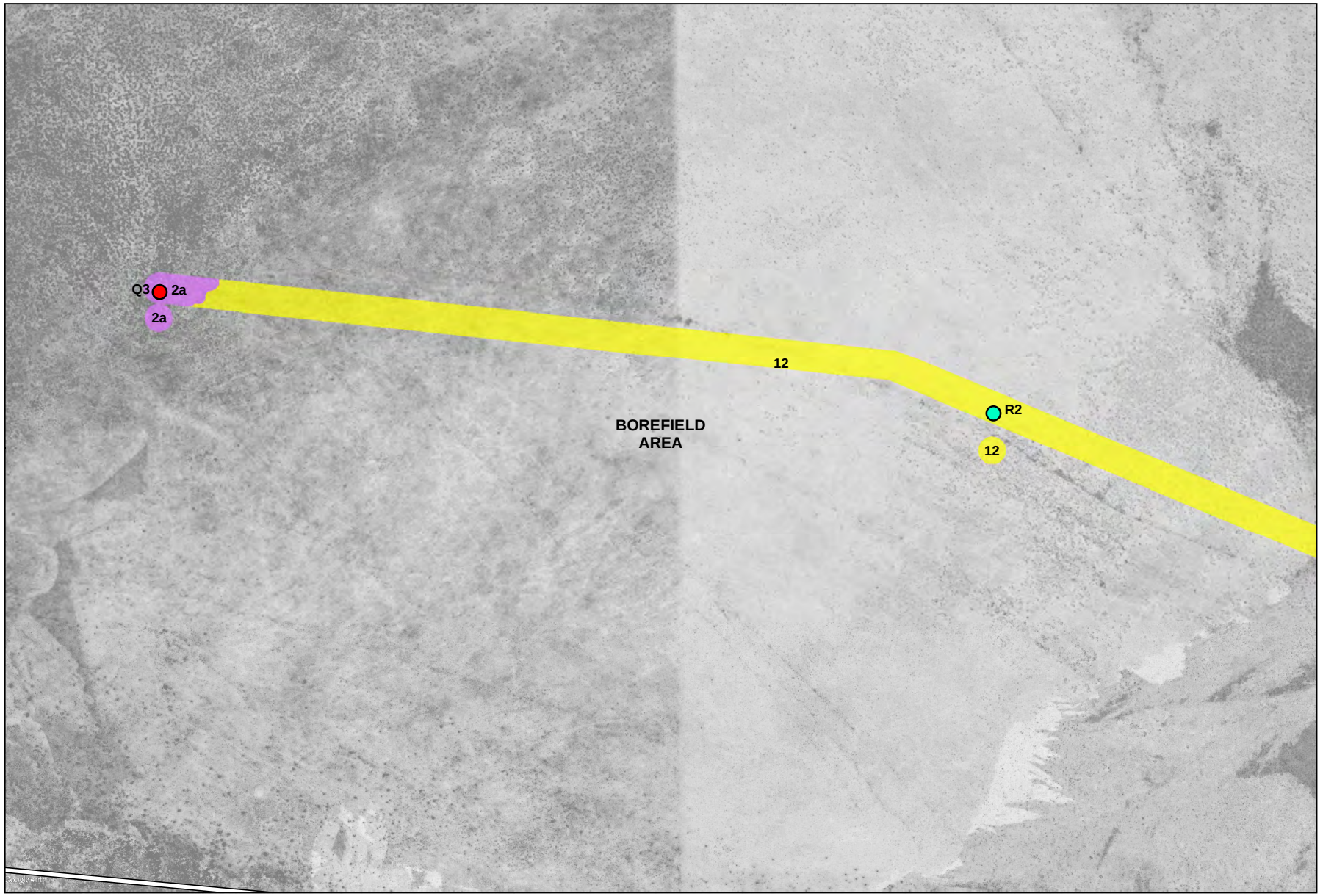
***Total area:*** not within, but adjacent to Study area.

***Number of quadrats:*** 1

***Quadrat numbers: 2011 survey:*** Not recorded

***2015 survey:*** 17

***Landforms and substrate:*** Occurs on claypan on red earths.




## Vegetation Community

| | |
|---|---|
| 1 | Riparian woodland along water courses and drainage channels |
| 2a | Mulga shrubland on sandy red earths over spinifex |
| 2a / 2b | Mulga shrubland on sandy red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex |
| 2b | Mulga shrubland on sandy red earths over tussock grasses |
| 2b / 3 a | Mulga shrubland on sandy red earths over tussock grasses / Mixed woodland over tussock grasses on alluvial plains |
| 2c | Mulga shrublands on sandy red earths over chenopods |
| 3 | Mixed Woodland over tussock grasses |
| 3a / 12 | Mixed woodland over tussock grasses on alluvial plains / Cottonbush chenopod shrubland on highly erodible duplex soils |
| 3b | Mixed woodland over spinifex on alluvial plains |
| 3b / 2b | Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses |
| 3c | Mixed woodland over a highly disturbed understorey dominated by *Cenchrus ciliaris* |
| 5 | Hakea/Senna Shrubland on Calcareous Alluvial Plains and Low Rises |
| 6 | Eucalyptus (mallee)/*Acacia kempeana*/Triodia Shrubland on Rocky Slopes |
| 7 | Acacia/Triodia shrubland on rocky outcrops |
| 8 | Acacia/Senna shrubland on rocky gneiss or schist outcrops with no spinifex |
| 9 | Acacia kempeana and /or mulga shrubland on gravel |
| 10 | Claypans with chenopods and herbs |
| 11 | Cottonbush chenopod shrubland on highly erodible duplex soils |
| 12 | *Triodia basedowii* hummock grassland on sandplains |
| 13 | Senna shrubland on quartz |
| 14 | Coolabah swamp associated with claypans |

1:40,000 @ A4

0 250 500 750 1,000

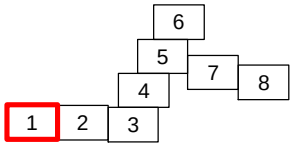
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Checksites
- Quadrats 2015
- Quadrats 2011
- Existing Roads
- Site Boundaries




Arafura Resources Limited
Nolans Project

Job Number 4322301
Revision 0
Date 18 Mar 2016

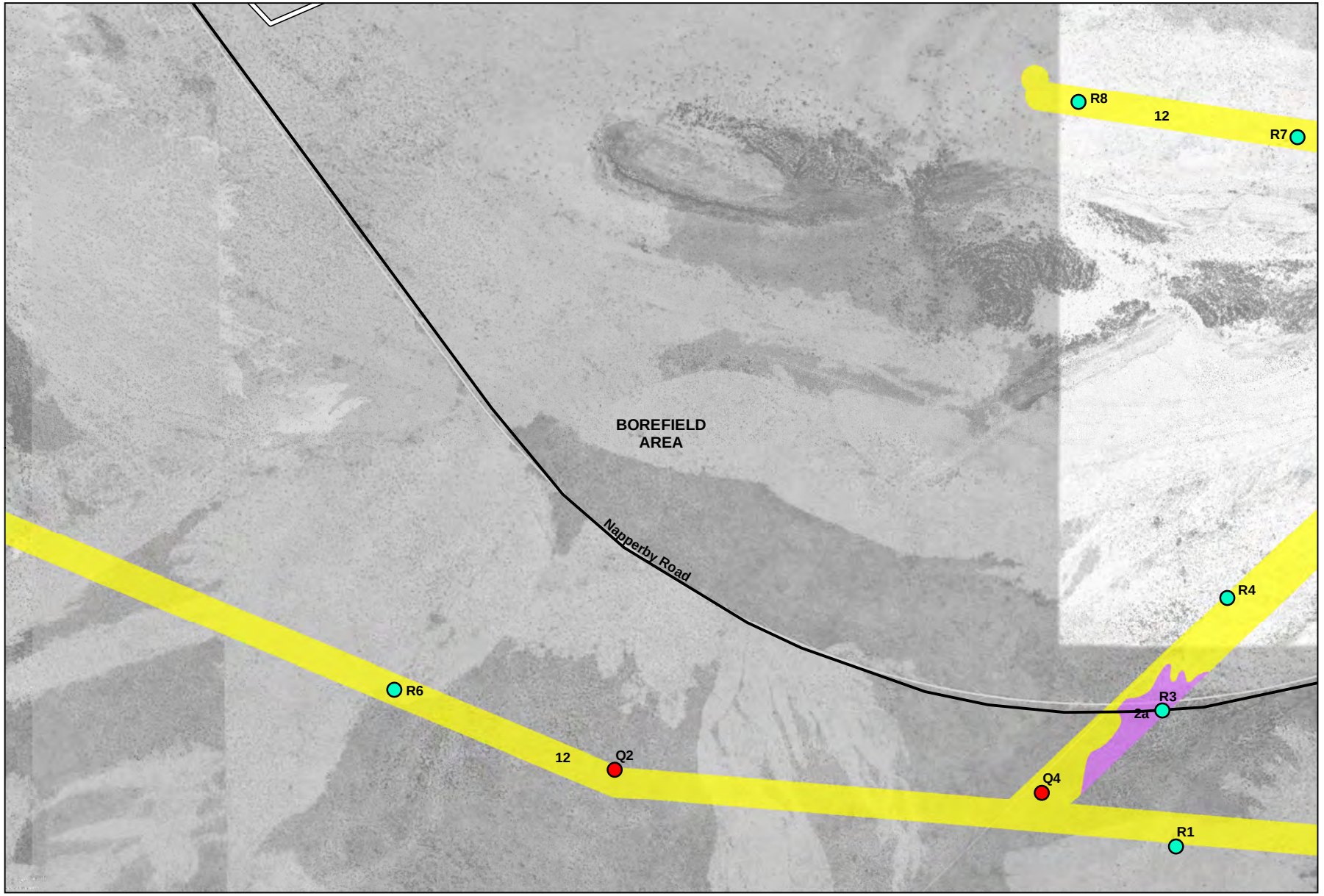
# Vegetation communities within the Study area Figure 4.1 (Page 1 of 8):

G:\43\22301\GIS\Maps\4322301_307_VegetationMappingQuadrats.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM




**Vegetation Community**

| | |
|---|---|
| 1 | Riparian woodland along water courses and drainage channels |
| 2a | Mulga shrubland on sandy red earths over spinifex |
| 2a / 2b | Mulga shrubland on sandy red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex |
| 2b | Mulga shrubland on sandy red earths over tussock grasses |
| 2b / 3 a | Mulga shrubland on sandy red earths over tussock grasses / Mixed woodland over tussock grasses on alluvial plains |
| 2c | Mulga shrublands on sandy red earths over chenopods |
| 3 | Mixed Woodland over tussock grasses |
| 3a / 12 | Mixed woodland over tussock grasses on alluvial plains / Cottonbush chenopod shrubland on highly erodible duplex soils |
| 3b | Mixed woodland over spinifex on alluvial plains |
| 3b / 2b | Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses |
| 3c | Mixed woodland over a highly disturbed understorey dominated by *Cenchrus ciliaris* |
| 5 | Hakea/Senna Shrubland on Calcareous Alluvial Plains and Low Rises |
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| 7 | Acacia/Triodia shrubland on rocky outcrops |
| 8 | Acacia/Senna shrubland on rocky gneiss or schist outcrops with no spinifex |
| 9 | Acacia kempeana and /or mulga shrubland on gravel |
| 10 | Claypans with chenopods and herbs |
| 11 | Cottonbush chenopod shrubland on highly erodible duplex soils |
| 12 | *Triodia basedowii* hummock grassland on sandplains |
| 13 | Senna shrubland on quartz |
| 14 | Coolabah swamp associated with claypans |

1:40,000 @ A4

0 250 500 750 1,000

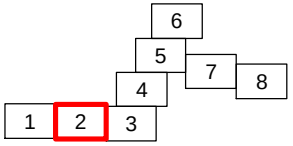
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries




Arafura Resources Limited
Nolans Project

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Date 18 Mar 2016

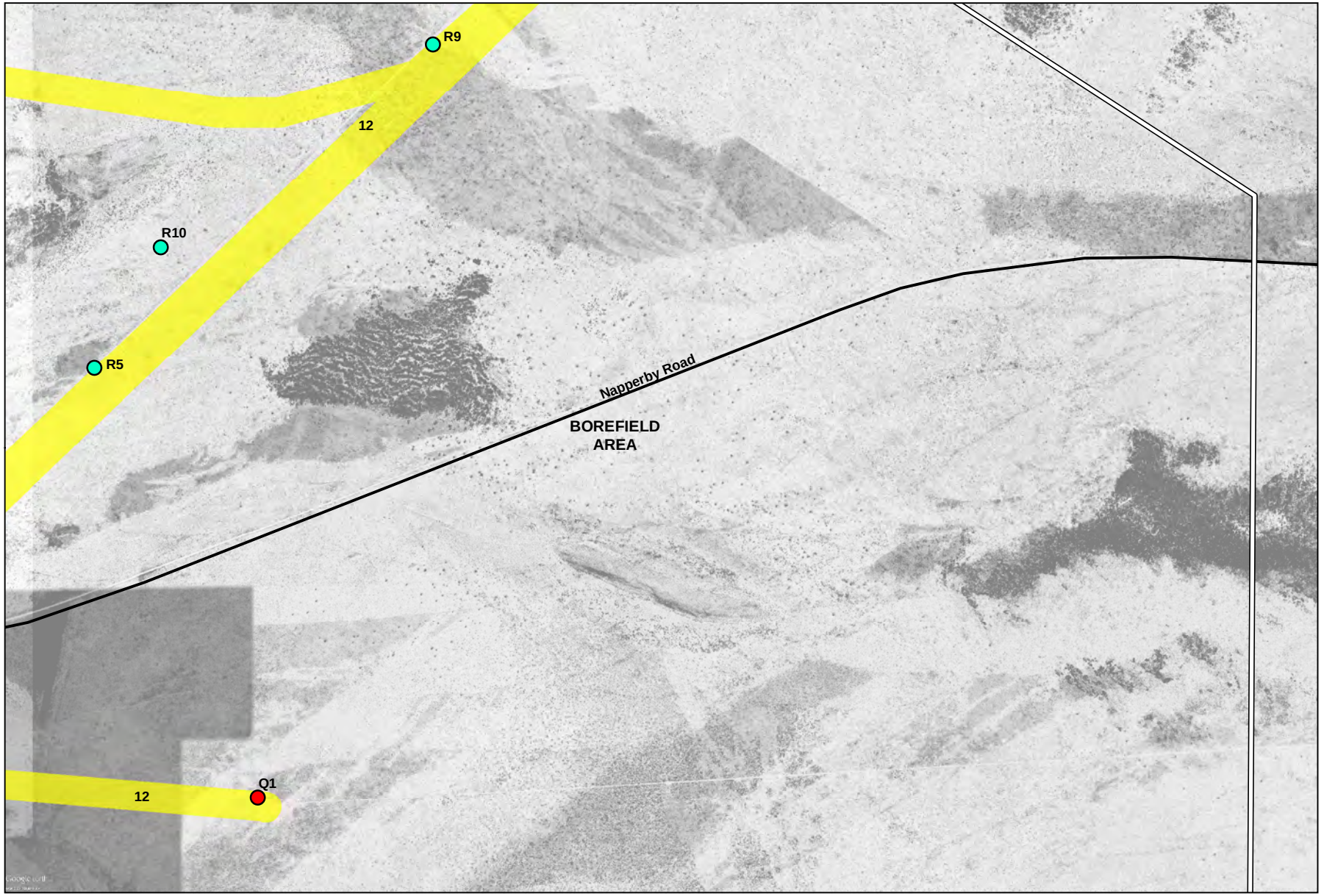
# Vegetation communities within the Study area Figure 4.1 (Page 2 of 8):

G:\43\22301\GIS\Maps\4322301_307_VegetationMappingQuadrats.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM




**Vegetation Community**

| | |
|---|---|
| 1 | Riparian woodland along water courses and drainage channels |
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| 12 | *Triodia basedowii* hummock grassland on sandplains |
| 13 | Senna shrubland on quartz |
| 14 | Coolabah swamp associated with claypans |

1:40,000 @ A4

0 250 500 750 1,000

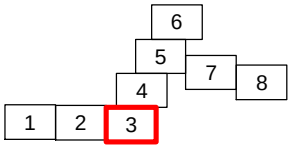
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries

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Nolans Project

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|---|---|
| Job Number | 4322301 |
| Revision | 0 |
| Date | 18 Mar 2016 |

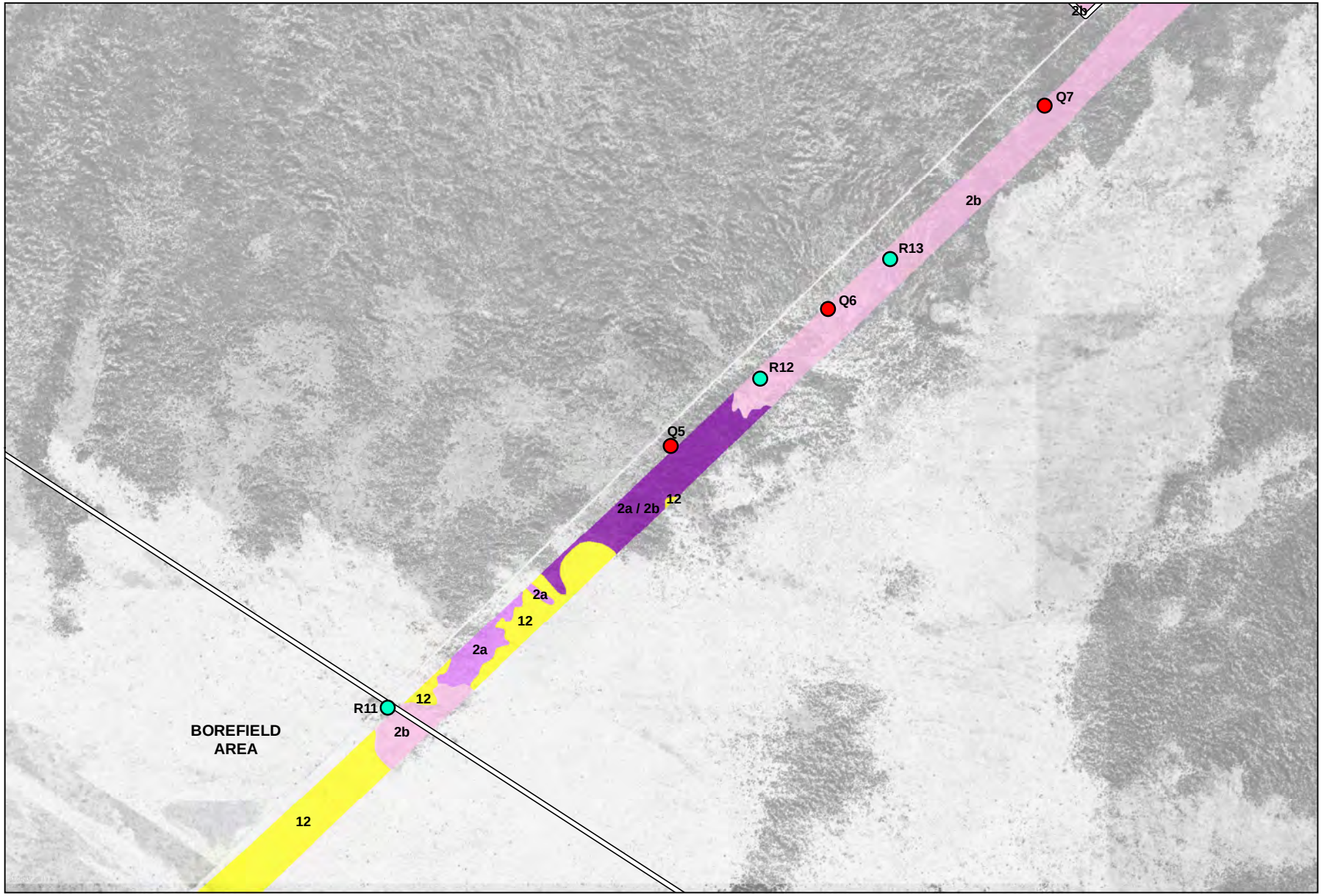
# Vegetation communities within the Study area Figure 4.1 (Page 3 of 8):

G:\43\22301\GIS\Maps\4322301_307_VegetationMappingQuadrats.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM




## Vegetation Community

| | |
|---|---|
| 1 | Riparian woodland along water courses and drainage channels |
| 2a | Mulga shrubland on sandy red earths over spinifex |
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| 12 | *Triodia basedowii* hummock grassland on sandplains |
| 13 | Senna shrubland on quartz |
| 14 | Coolabah swamp associated with claypans |

1:40,000 @ A4

0 250 500 750 1,000

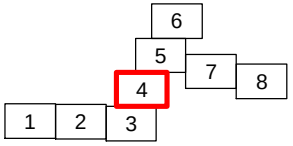
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries

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Revision 0
Date 18 Mar 2016

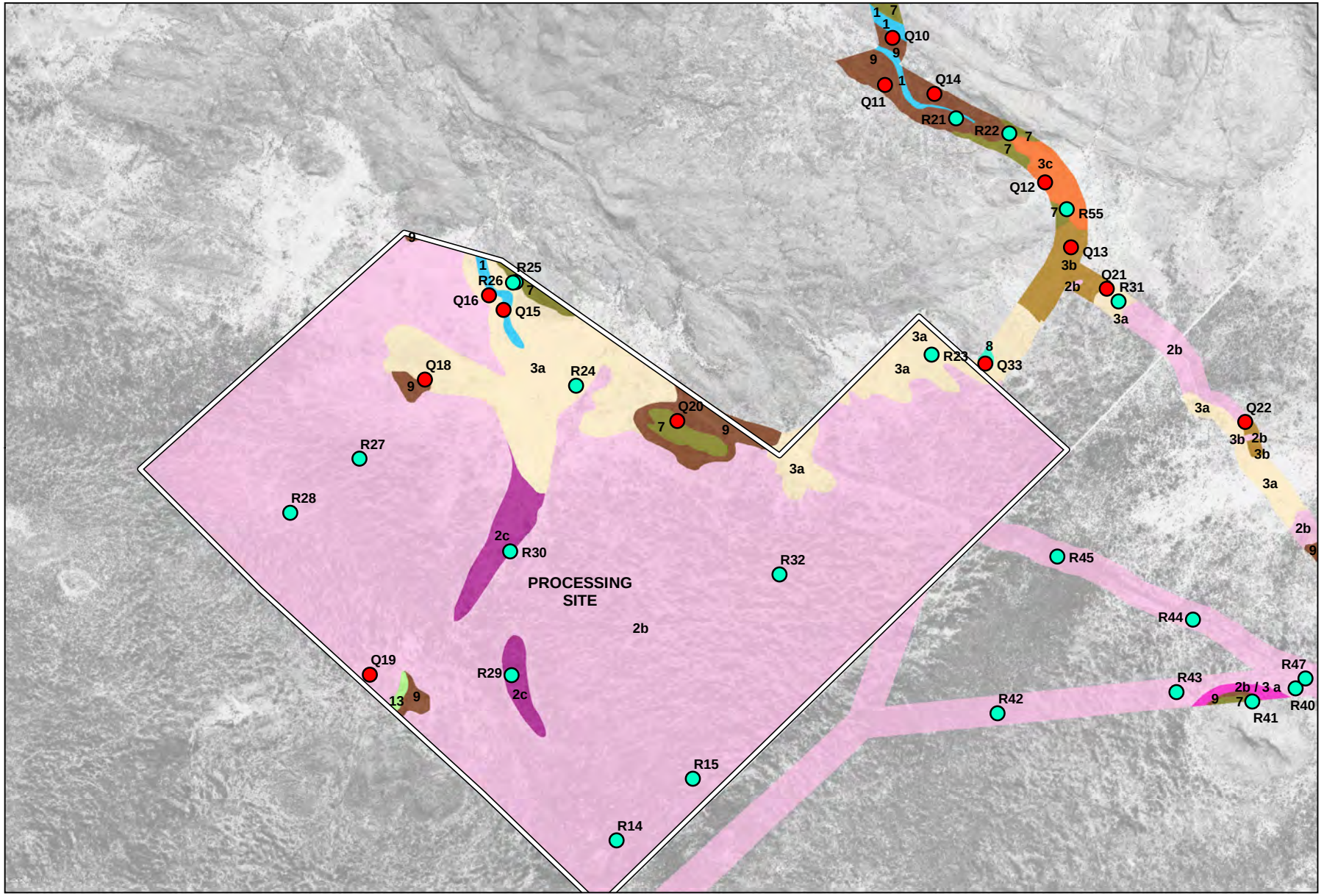
# Vegetation communities within the Study area Figure 4.1 (Page 4 of 8):

G:\43\22301\GIS\Maps\4322301_307_VegetationMappingQuadrats.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM




## Vegetation Community

| | |
|---|---|
| 1 | Riparian woodland along water courses and drainage channels |
| 2a | Mulga shrubland on sandy red earths over spinifex |
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| 14 | Coolabah swamp associated with claypans |

1:40,000 @ A4

0 250 500 750 1,000

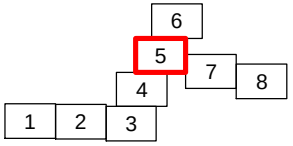
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries

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Nolans Project

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Revision 0
Date 18 Mar 2016

# Vegetation communities within the Study area Figure 4.1 (Page 5 of 8):

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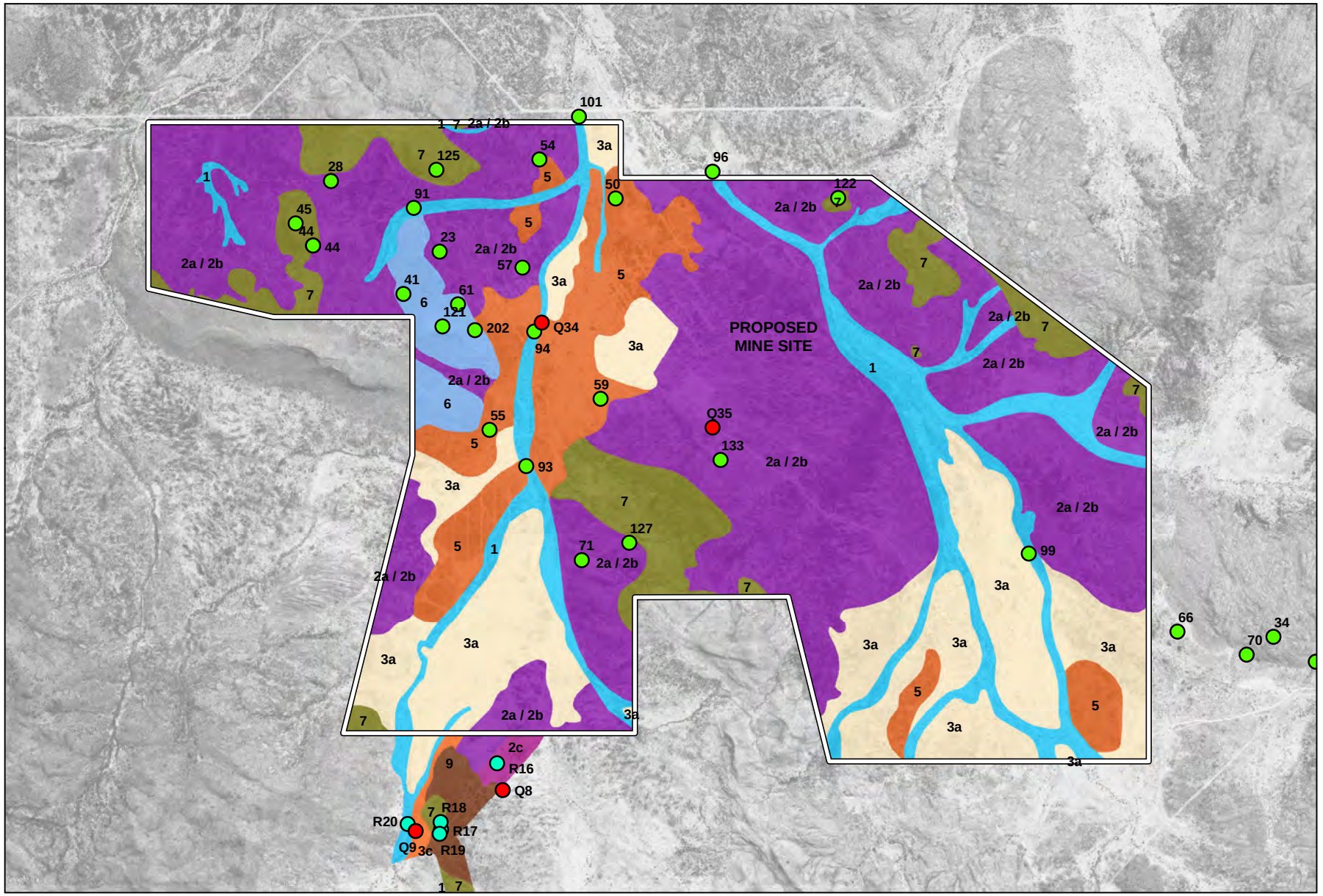
Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM




## Vegetation Community

| | |
|---|---|
| 1 | Riparian woodland along water courses and drainage channels |
| 2a | Mulga shrubland on sandy red earths over spinifex |
| 2a / 2b | Mulga shrubland on sandy red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex |
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1:40,000 @ A4

0 250 500 750 1,000

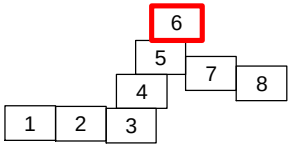
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries

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|---|---|
| Job Number | 4322301 |
| Revision | 0 |
| Date | 18 Mar 2016 |

# Vegetation communities within the Study area Figure 4.1 (Page 6 of 8):

G:\43\22301\GIS\Maps\4322301_307_VegetationMappingQuadrats.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM


## Vegetation Community

| | |
|---|---|
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1:40,000 @ A4

0 250 500 750 1,000

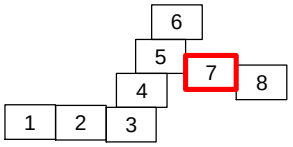
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries

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Date 18 Mar 2016

# Vegetation communities within the Study area Figure 4.1 (Page 7 of 8):

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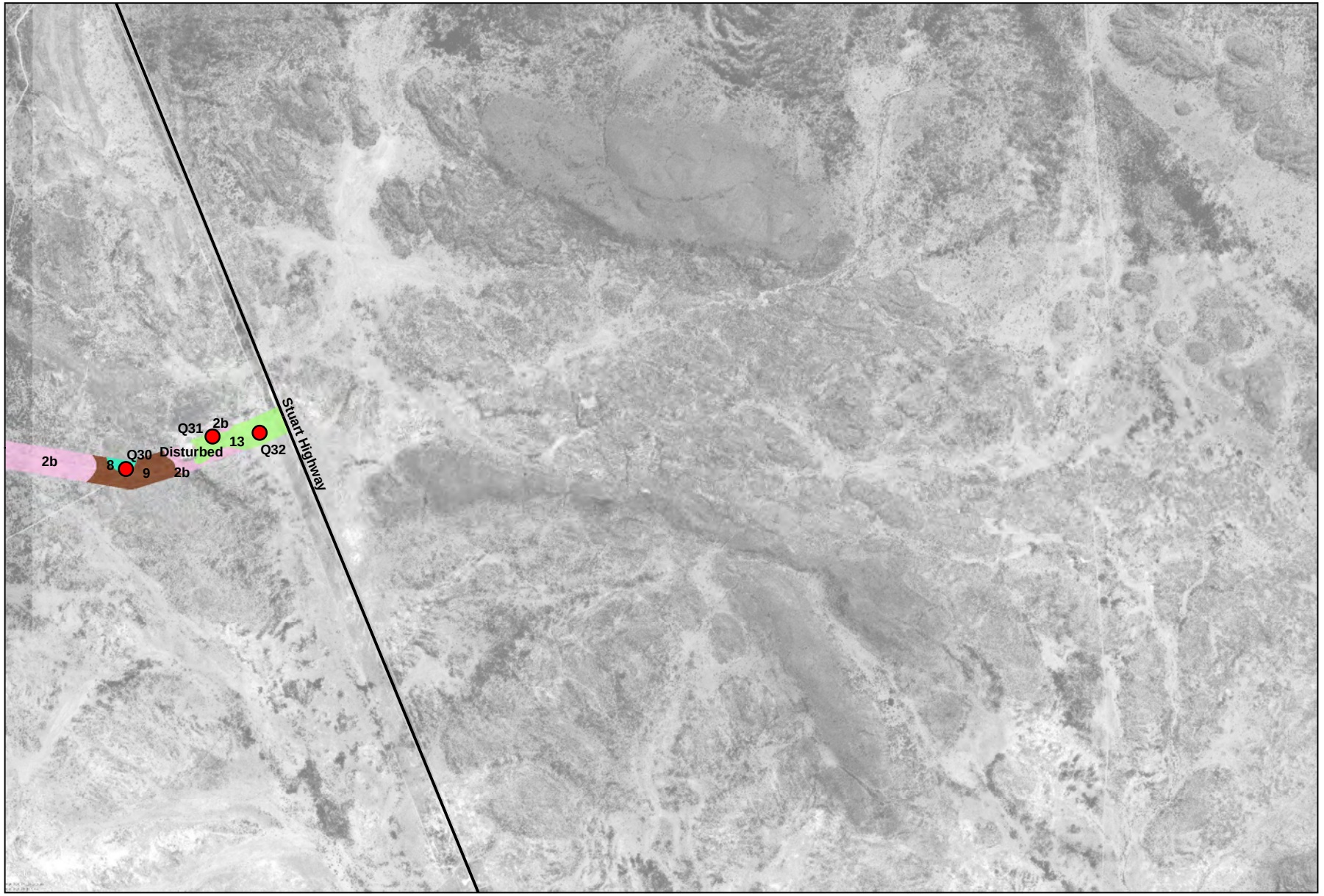
Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM




## Vegetation Community

| | |
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1:40,000 @ A4

0 250 500 750 1,000

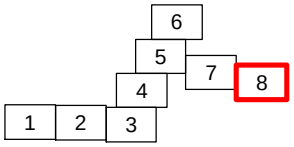
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries

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Nolans Project

| | |
|---|---|
| Job Number | 4322301 |
| Revision | 0 |
| Date | 18 Mar 2016 |

# Vegetation communities within the Study area Figure 4.1 (Page 8 of 8):

G:\43\22301\GIS\Maps\4322301_307_VegetationMappingQuadrats.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM

## 4.4 Vegetation condition

The Study area contains a high level of vegetation/habitat heterogeneity (diversity) including hummock grasslands, shrublands, woodlands and riparian corridors. This is largely due to the wide variety of landforms (watercourses, alluvial plains, aeolian plains, alluvial foothill fans, rocky hills), particularly within the mine site and processing site areas.

Species richness within the Study area is relatively high with highest diversity recorded in areas of rocky outcrops (51 ± 1) and mulga shrublands (46 ± 6) although plant species were well represented across the Study area with a mean species richness of 34 plant taxa per quadrat. Some patches of mature mulga stands had up to 66 species recorded within a 50 X 50 m quadrat.

The native vegetation in the Study area is in overall good condition. This conclusion is based on:

- high local-scale species richness
- the presence of multiple age classes of woody species
- the low incidence of exotic species in many of the vegetation communities
- abundant flowering activity noted in *Triodia* and *Senna* populations during the 2010 surveys (presumably in response to the above average rainfall that had fallen in the months leading up to the survey).

### 4.4.1 Clearing

The vegetation is largely intact with minimal vegetation lost due to clearing although there is some evidence of native vegetation clearing associated with mineral and geotechnical exploration in the vicinity of Nolans Bore and within the borefields area. Mineral exploration activity has resulted in losses of approximately 150 ha of native vegetation, predominantly from vegetation community 5 (*Hakea*/*Senna* shrubland). Small amounts of vegetation clearing have also occurred for construction of Darwin to Alice Springs gas pipeline and unsealed tracks throughout the Study area. An abrupt tree-line surrounding the paddock north-east of Nolans Bore suggests this area (approximately 20 ha) has been cleared, possibly for livestock management.

### 4.4.2 Fire

There is some evidence of recent fire within the Study area in 2015, in particular vegetation communities 3 and 7 (Mixed woodlands on alluvial plains and Acacia/Triodia shrubland on rocky outcrops) exhibited evidence of widespread burning (e.g. charred stems and grass butts).

### 4.4.3 Exotic species

A total of fourteen exotic species were recorded during the field survey (refer to Table 4.2). With the exception of *Cenchrus ciliaris (*Buffel Grass), these species generally occurred in low abundance across the Study area.

One of these species (*Tribulus terrestris* (Caltrop)) is listed as a Class B (spread must be controlled) and Class C (not to be introduced to the NT) noxious weeds under the WM Act. *Caltrop* is a spreading annual or bi-annual herb. Its fruit is a woody burr with sharp ridged spines. The species is known to cause photosensitisation and nitrate poisoning in livestock and its fruit can cause injury to the feet of cattle and horses (Smith 2002). Caltrop is recognised a taxonomically complex species and it is thought to have both native and introduced elements

(Baker 1998). This species was found in low abundance throughout all vegetation types within the study area. It is likely that this species is spread by cattle and vehicle movement.

Overall there is a low to moderate level of infestation of exotic species within the Study area with the most prevalent species being Buffel Grass. This species was recorded predominantly within floodplain and riparian vegetation types and in areas that have been disturbed by cattle and/or by mining exploration.

Table 4.2 Exotic species recorded within the study area

| Species Name | Common Name | Legislative status (WM Act) |
|---|---|---|
| *Tribulus terrestris* s.lat. | Caltrop | Listed as a Class B and Class C Noxious Weed |
| *Bidens bipinnata* | Cobblers Pegs | Not listed |
| *Cenchrus ciliaris* | Buffel Grass | Not listed |
| *Chloris barbata* | Purple-top Chloris | Not listed |
| *Chloris virgata* | | Not listed |
| *Citrullus lanatus* | Paddy Melon | Not listed |
| *Cynodon dactylon* var. *dactylon* | Couch Grass | Not listed |
| *Digitaria ciliaris* | Summer Grass | Not listed |
| *Eragrostis barrelieri* | Pitted Lovegrass | Not listed |
| *Eragrostis trichophora* | | Not listed |
| *Eragrostis minor* | Lovegrass | Not listed |
| *Malvastrum americanum* | Malvastrum | Not listed |
| *Vachellia farnesiana* var. *farnesiana* | Mimosa Bush | Not listed |
| *Sonchus oleraceus* | Milk Thistle | Not listed |

Buffel Grass invasion has been identified as a major threat to biodiversity within the Burt Plain bioregion (Neave *et al* 2006). *Cynodon dactylon* (Couch Grass) has also been recognised as a potentially serious environmental weed posing a significant threat to biodiversity in the region (Neave *et al* 2006).

The most abundant and widespread weed throughout the Study area was *Cenchrus ciliaris* (Buffel Grass) and although not listed under any of the schedules of the Northern Territory's *Weed Management Act 2001* Buffel grass is an invasive weed that is known to spread rapidly in arid and semi-arid regions of Australia (Miller *et al* 2010).

Buffel Grass is a deep rooted perennial grass native to northern Africa, the Middle East and India. It has been planted extensively in central Australia and elsewhere for cattle fodder and to help control erosion (Pitts and Albrecht 2000). The species is considered to be a significant environmental weed due to its ability to alter the species composition and structure of plant communities by outcompeting native taxa. It has also been associated with increased fire severity due to its ability to rapidly accumulate high amounts of combustible biomass compared to native understory species (Miller *et al* 2010). It also has the ability to rapidly re-sprout after fire and can accumulate enough biomass to burn again in a short period of time compared with native species (Neave *et al* 2006). Increased fire severity has been correlated with the mortality of overstorey tree species and a reduction in post-fire re-establishment of native species thus leading to altered plant community structure.

Buffel Grass generally requires lighter textures soils (sandy loams) and relatively high available phosphate levels which are generally associated with alluvial plains and calcareous landforms (Miller 2000). Riparian vegetation communities are also particularly susceptible to invasion.

Within the Study area Buffel grass was mostly restricted to preferred habitat within alluvial plains and riparian drainage lines. It was also abundant in disturbed areas within other vegetation

communities, adjacent tracks, cattle yards, the Northern Territory Gas Pipeline, mineral exploration areas and creek banks.

Communities growing on red earths (i.e. mulga community 2), sand plains (*Triodia* Hummock grassland, V4) and on rocky slopes and outcrops (vegetation communities 6, 7 and 8) typically had a relatively low cover of Buffel Grass. Relative covers of Buffel Grass across the Study area are shown in Figure 4.2.

Soil disturbance associated with proposed mining activity has the potential to accelerate the spread of Buffel Grass and other exotic species throughout the Study area.

Other taxa present within the Study area that have been identified as having the potential to impact on biodiversity - although to a significantly lesser degree that Buffel and Couch Grass - include *Malvastrum americanum, Eragrostis barrelieri* and *Eragrostis trichophora* (Neave *et al* 2006). At present these species are present in low numbers throughout the Study area and were confined to riparian areas and associated floodplains.


1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

*Eragrostis tricophora*

Existing Gas Pipeline

Roads

Indicative Gas Pipeline Corridor

Site Boundaries

**Buffel Grass (%)**

< 5%

6 - 40%

41 - 70%

71 - 100%

1 2 3 4 5 6 7 8

Arafura Resources Limited
Nolans Project

Job Number 4322301
Revision 0
Date 18 Mar 2016

# Buffel grass present in Study area

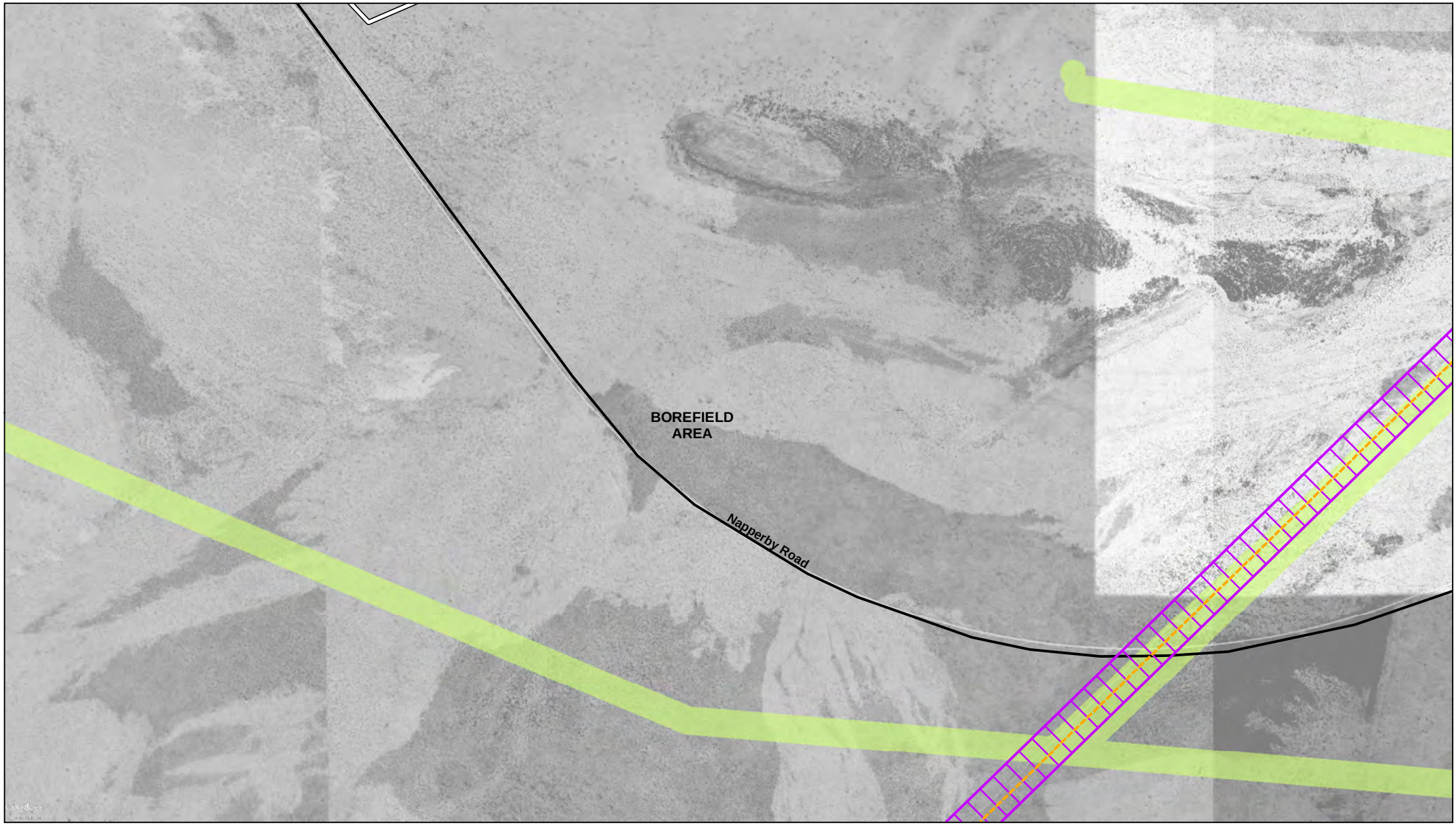
Figure 4.2 (Page 1 of 8):

G:\43\22301\GIS\Maps\4322301_305_WeedMapping.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM




1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

*Eragrostis tricophora*
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries

**Buffel Grass (%)**

< 5%
6 - 40%
41 - 70%
71 - 100%

6
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Arafura Resources Limited
Nolans Project

Job Number 4322301
Revision 0
Date 18 Mar 2016

# Buffel grass present in Study area

Figure 4.2 (Page 2 of 8):

G:\43\22301\GIS\Maps\4322301_305_WeedMapping.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM


1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

*Eragrostis tricophora*
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries

**Buffel Grass (%)**

< 5%
6 - 40%
41 - 70%
71 - 100%

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Arafura Resources Limited
Nolans Project

Job Number 4322301
Revision 0
Date 18 Mar 2016

# Buffel grass present in Study area

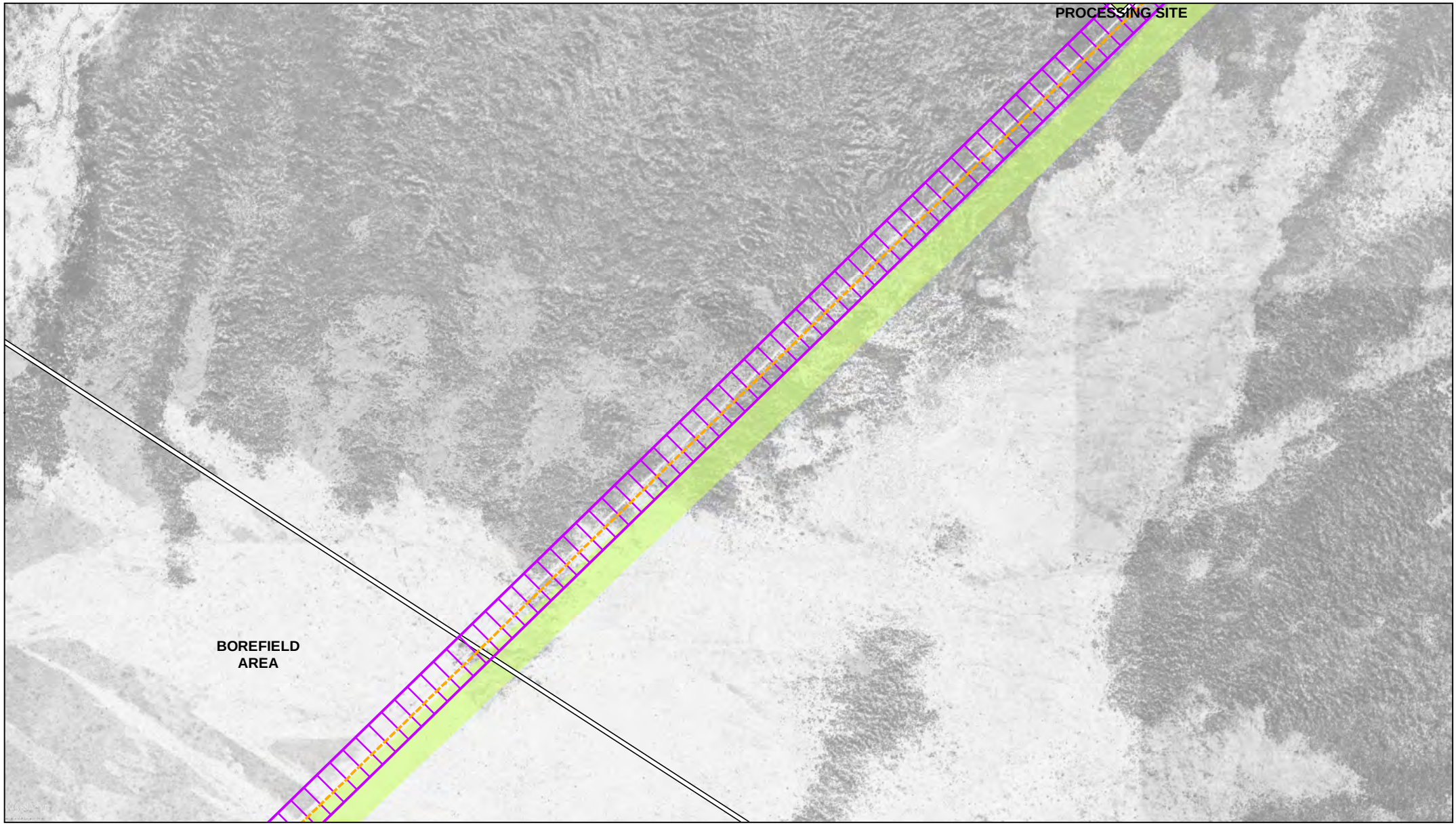
Figure 4.2 (Page 3 of 8):

G:\43\22301\GIS\Maps\4322301_305_WeedMapping.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM




1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

*Eragrostis tricophora*
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries

**Buffel Grass (%)**

< 5%
6 - 40%
41 - 70%
71 - 100%

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Arafura Resources Limited
Nolans Project

Job Number 4322301
Revision 0
Date 18 Mar 2016

# Buffel grass present in Study area

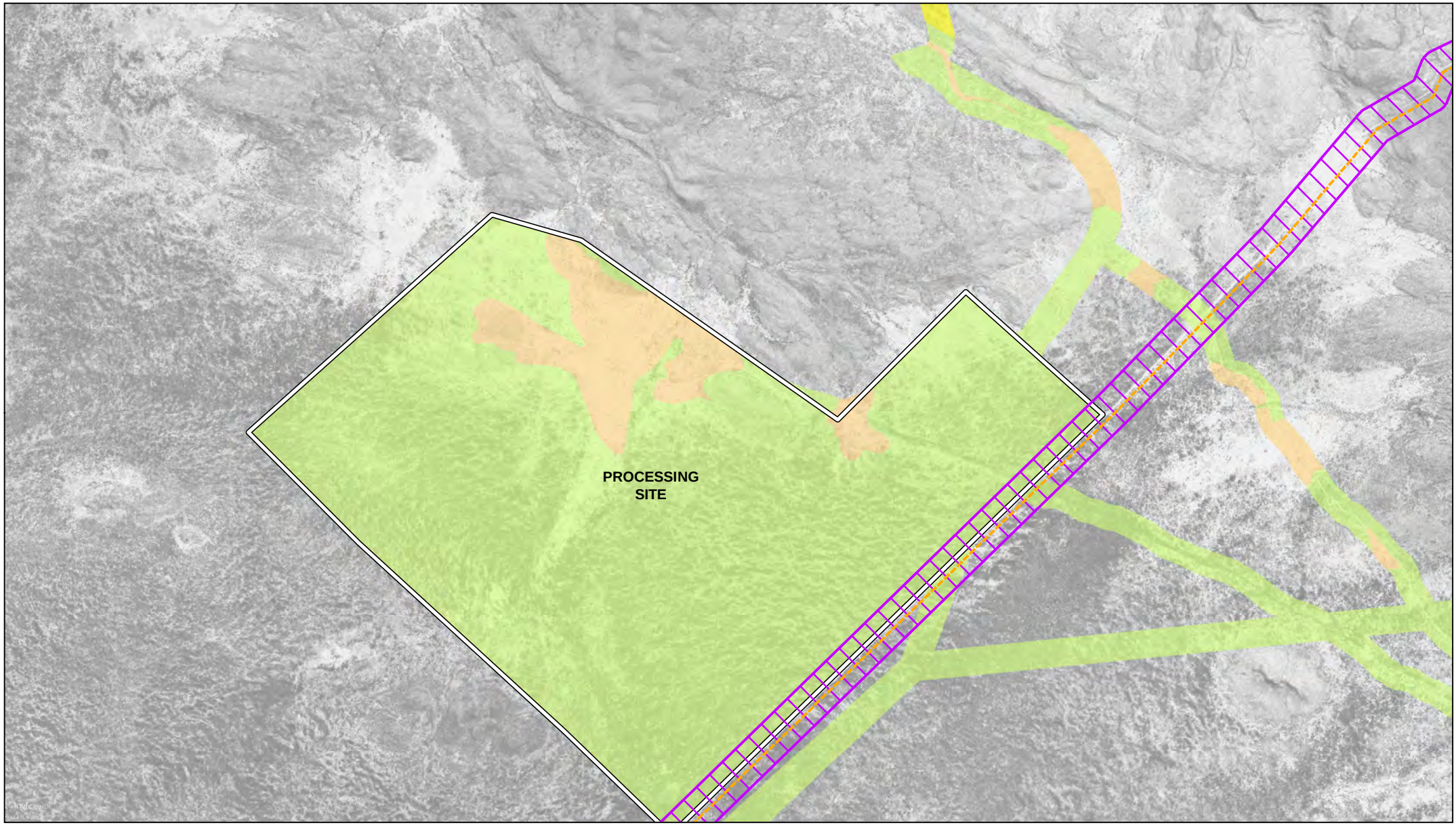
Figure 4.2 (Page 4 of 8):

G:\43\22301\GIS\Maps\4322301_305_WeedMapping.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM




1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

*Eragrostis tricophora*
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries

**Buffel Grass (%)**

< 5%
6 - 40%
41 - 70%
71 - 100%

1 2 3 4 5 6 7 8

Arafura Resources Limited
Nolans Project

Job Number 4322301
Revision 0
Date 18 Mar 2016

# Buffel grass present in Study area

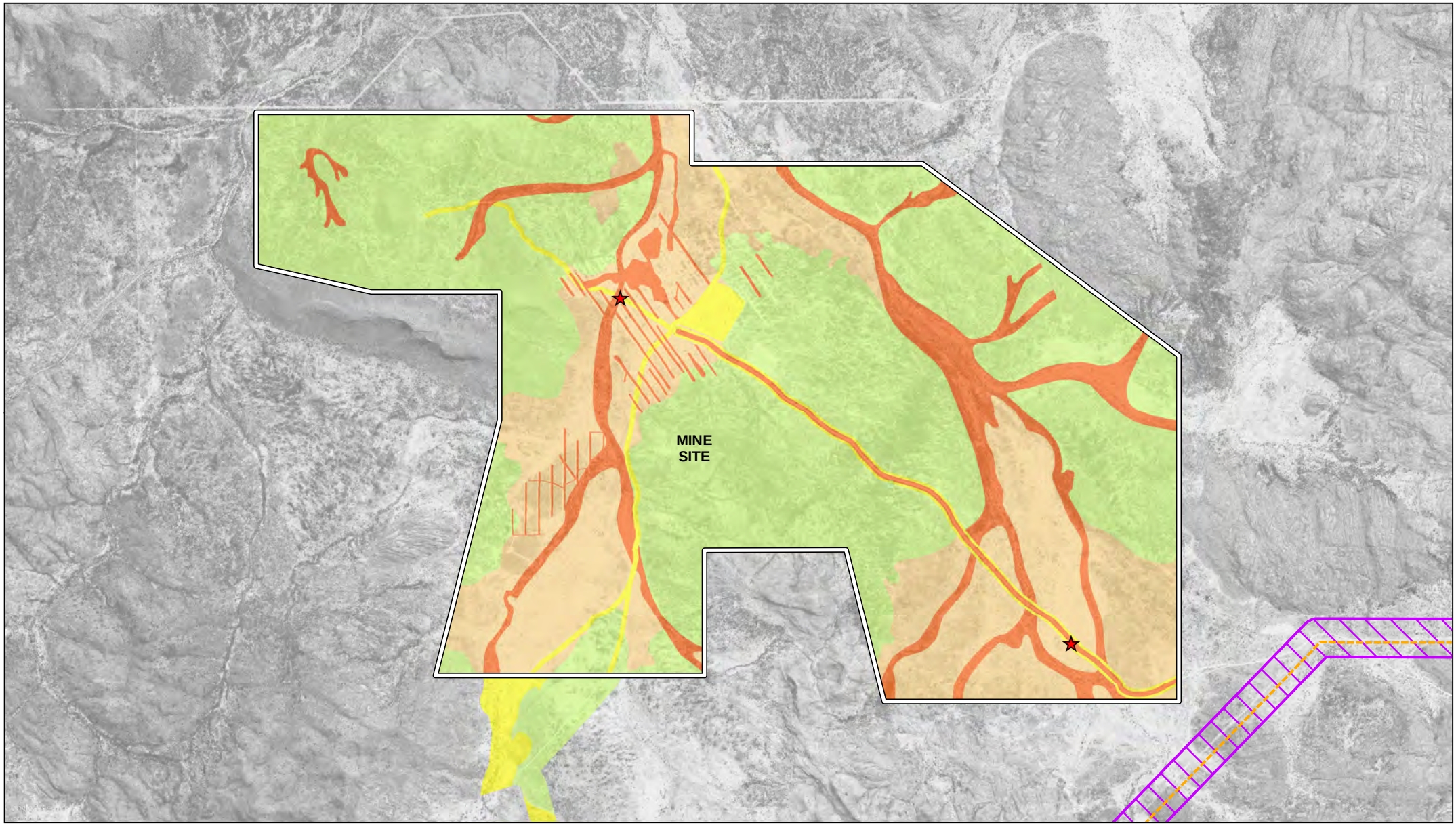
Figure 4.2 (Page 5 of 8):

G:\43\22301\GIS\Maps\4322301_305_WeedMapping.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM




1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

*Eragrostis tricophora*
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries

**Buffel Grass (%)**

< 5%
6 - 40%
41 - 70%
71 - 100%

1 2 3 4 5 6 7 8

Arafura Resources Limited
Nolans Project

Job Number 4322301
Revision 0
Date 18 Mar 2016

# Buffel grass present in Study area

Figure 4.2 (Page 6 of 8):

G:\43\22301\GIS\Maps\4322301_305_WeedMapping.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM


1:40,000 @ A4

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Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

*Eragrostis tricophora*
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries
**Buffel Grass (%)**
< 5%
6 - 40%
41 - 70%
71 - 100%

1 2 3 4 5 6 7 8

Arafura Resources Limited
Nolans Project

Job Number 4322301
Revision 0
Date 18 Mar 2016

# Buffel grass present in Study area

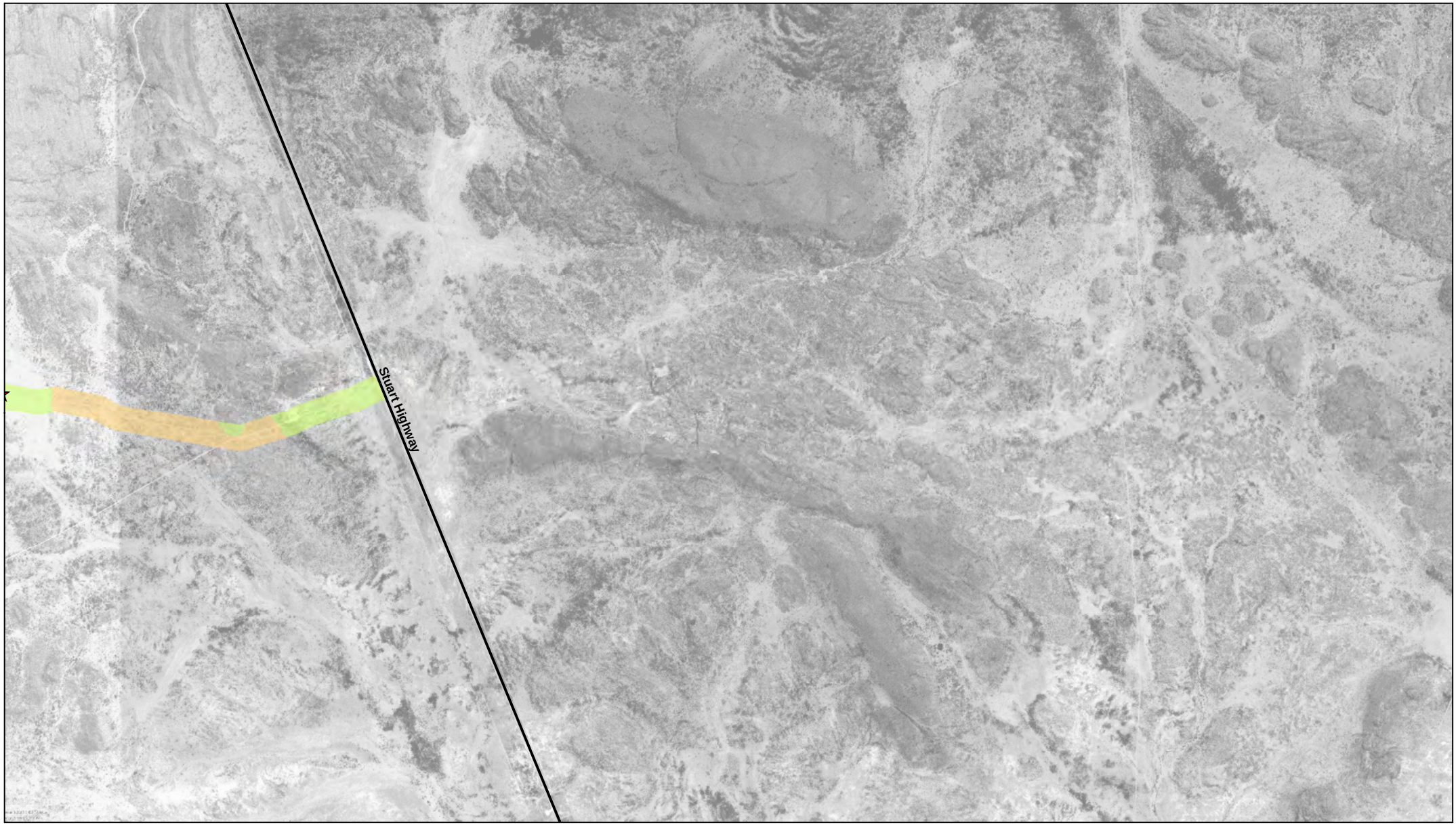
Figure 4.2 (Page 7 of 8):

G:\43\22301\GIS\Maps\4322301_305_WeedMapping.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM




1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

*Eragrostis tricophora*
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries

**Buffel Grass (%)**

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1 2 3 4 5 6 7 8

Arafura Resources Limited
Nolans Project

Job Number 4322301
Revision 0
Date 18 Mar 2016

# Buffel grass present in Study area

Figure 4.2 (Page 8 of 8):

G:\43\22301\GIS\Maps\4322301_305_WeedMapping.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com



Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM

## 4.5 Flora and communities of conservation significance

### *Overview*

No flora species listed under the EPBC Act have been recorded or are predicted to occur within 20 km of the Study area. There are three species listed under the EPBC Act that are known to occur within 100 km of the Study area. These are:

- *Macrozamia macdonnellii* which grows on rocky sites, predominantly in gorges and on steep sheltered slopes within the MacDonnell Ranges bioregion
- *Olearia macdonnellensis* which is only known to occur as a small number of isolated sub-populations in the central-western portion of the MacDonnell Ranges
- *Eleocharis papillosa* which occurs in temporary wetlands, predominately freshwater and semi-saline swamps (TSSC 2008).

It is highly unlikely that any of these species would occur within the Study area due to the lack of suitable habitat.

There were no communities of national significance known or predicted to occur within 100 km of the Study area.

The DLRM herbarium database search identified 412 plant taxa known to occur within 20 km of the Study area. Under the TPWC Act, 390 are of 'least concern' (i.e. widespread and abundant taxa), eight are 'not evaluated', eight are 'data deficient' and six are listed as 'near threatened' (Holtz 2015).

### *Nationally and Territory significant flora*

No flora species listed as threatened under the EPBC or TPWC Acts were recorded within the Study area during surveys of the site.

The survey did identify three flora species that are listed as near threatened and three species listed as data deficient under the TPWC Act. These species area listed in Table 4.3.

Table 4.3 Near threatened and data deficient species recorded within the study area

| Species name | Common name | Status under TPWC Act |
|---|---|---|
| *Abutilon lepidum* | - | Near threatened |
| *Acacia aneura* var. *conifera* | Christmas Tree Mulga | Data deficient |
| *Digitaria hystrichoides* | Curly Umbrella Grass | Near threatened |
| *Euphorbia ferdinandii* | Caustic Weed | Data deficient |
| *Eragrostis lanicaulis* | - | Data deficient |
| *Vittadinia obovata* | - | Near threatened |

*Abutilon lepidum* is a small herb growing to 0.5 m tall listed as near threatened under the TPWC Act. Within the Study area, *Abutilon lepidum* was recorded growing near the base of rocky outcrops within vegetation community 7 (Acacia/Triodia shrubland on rocky outcrops).

*Eragrostis lanicaulis* is a rhizomatous perennial grass to 0.5 m tall. Within the Study area this species was recorded in low numbers growing on alluvial plains. This species is listed as data deficient under the TSWC Act.

*Acacia aneura var. conifera* is a tree to 8 m tall that is closely related to the more common *Acacia aneura.* This species was recorded just outside the Proposal site adjacent to a Coolabah Swamp. Within this patch there were approximately 100 individuals of this species.

*E. ferdinandii* is an upright, sparsely branching herb, up to 30 cm tall. Sixteen records of *E. ferdinandii* were recorded within the Study area, most of which were located in Mulga shrubland and *Triodia* grassland communities along the proposed access tracks. This species is listed as data deficient under the TSWC Act.

*Digitaria hystrichoides* is a perennial grass to 0.6 m. This species was recorded at one location within the Study area (Quadrat 8), where it was found growing in low abundance within alluvial woodland. This species is listed as near threatened under the TSWC Act.

*Vittadinia obovata* is a small herb growing to 0.2 m tall, listed as near threatened under the TPWC Act. Three individuals of *Vittadinia obovata* were recorded growing on a rocky outcrop near Quadrat 33 (Figure 3.1).

### *Regionally significant flora*

Eleven species listed as having bioregional conservation significance were recorded within the Study area. These species have conservation significance due to them being either at the limit of their range or being rare in the bioregion (DLRM 2015). These species and their regional conservation codes are listed in Table 4.4.

Table 4.4 Species with bioregional significance recorded within the study area

| Species Name | Common Name | Regional Conservation Code DLRM 2015) |
|---|---|---|
| *Maireana aphylla* | Cottonbush, Leafless Bluebush | BRT (northern range limit) |
| *Maireana scleroptera* | | BRT (northern range limit) |
| *Convolvulus remotus* | | BRT (apparently rare) |
| *Swainsona phacoides* s.lat. | Dwarf Swainsona, Woodland Swainsona | BRT (northern range limit) |
| *Prostanthera striatiflora* | Striped Mint-bush | BRT (northern range limit) |
| *Acacia murrayana* | Colony Wattle, Murrays Wattle | BRT (northern range limit) |
| *Aristida arida* | | BRT (northern range limit) |
| *Aristida hygrometrica* | Northern Kerosene Grass, Corkscrew Grass | BRT (apparently rare, disjunct) |
| *Thyridolepis mitchelliana* | Window Mulga Grass, Mulga Mitchell Grass, Mulga Grass | BRT (northern range limit) |
| *Oldenlandia mitrasacmoides* subsp. *mitrasacmoides* | | BRT (southern range limit) |
| *Spartothamnella teucriiflora* | Mulga Stick-plant | BRT (northern range limit) |

Key – BRT = Burt Plains bioregion

Within the Study area 326 species were recorded. This represents 28% of species known to occur within the Burt Plain Bioregion.

The flora of the Burt Plain bioregion has many taxa in common with neighbouring bioregions, e.g. 79% of plant taxa found in the Burt Plain bioregion have been recorded in the MacDonnell Ranges bioregion (Neave et al 2006). There is however, a lack of systematic flora surveys across southern Northern Territory bioregions (excluding the MacDonnell Ranges and Finke Bioregions (Neave et al 2004), limiting the value of a comparison of species richness between bioregions for determining regional significance for conservation planning.

### *Nationally and regionally significant vegetation communities*

No nationally or regionally significant vegetation communities were recorded within the Study area.

Dominant vegetation communities within the Study area include mulga communities on red earths (51.9%) and hummock grasslands on sand plains (15%). The next largest community represented in the Study area are mixed woodlands on alluvial plains (4.6%).

Most of the vegetation types present within the Study area are well represented within the Burt Plain bioregion, however less than 1% of the Burt Plain bioregion is conserved within reserves; and thus vegetation communities within the Study area are poorly represented in the National estate (e.g. hummock grassland 0.01%, Acacia woodland 0.05%, Eucalyptus low Woodland with Tussock Grass Understorey 0.01% (NRETAS 2005)).

Mixed woodlands dominated by bean trees (*Erythrina vespertilio*) are in decline in the southern Northern Territory (Neave 2006). This may be as a result of grazing pressure and inappropriate fire regimes (P. Latz pers comm. 2010). *E. vespertilio* was a co-dominant canopy species in two of the vegetation communities in the Study area; riparian woodland and mixed woodlands on alluvial plains (VT 1 and 3). This species was locally abundant on alluvial plains adjacent riparian zones and at the foot of rocky outcrops (associated with groundwater springs). The size structure of the population indicates that these stands have adequate levels of regeneration.

Riparian vegetation (VT1, 4.6% of the Study area) provides a range of critical ecosystem services within the catchment such as protecting stream banks from erosion, filtering contaminants and nutrients, providing habitat for flora and fauna and reducing levels of soil erosion during run off events. For these reasons Riparian woodland within the Study area is considered sensitive vegetation and a locally significant plant community (DLRM 2015).

Neave *et al* (2006) provides an overview of important vegetation types within the Burt Plain bioregion. These include a number of wetlands and mesic areas, sites of botanical significance and flora and fauna hotspots. The Study area does not contain any of these identified sites. There is however, a small wooded Coolibah swamp adjacent to the Nolans site (but outside the proposal site) that is considered an important vegetation type (Neave *et al* 2006). This vegetation should be protected during construction and operation of the proposal. Refer to Figure 4.1.

Despite most of the vegetation types within the Study area being well represented in the bioregion, Neave et al (2006) recognise that common vegetation types can be regarded as having conservation significance if they meet any of the following criteria:

- Habitat with high species richness that supports a high abundance of native species, and or is structurally complex
- Habitat supporting species of high conservation values (e.g. threatened species, endemic species, poorly reserved species and/or rare species)
- Habitat that is of good quality (i.e. its compositional and structural integrity and ecological processes have not been undermined)
- Habitat that is poorly reserved.

A number of vegetation communities within the Study area would meet one or more of these criteria. These communities include:

- V2 - Mulga shrubland on sandy red earths. This vegetation community is poorly reserved within the Burt Plain bioregion

- V7 – Acacia/Triodia shrubland on rocky outcrops. This vegetation provides habitat for the threatened Black Footed Rock Wallaby
- V8 - Rocky or gravelly gneiss or schist outcrops with no spinifex. This vegetation provides habitat for the threatened Black Footed Rock Wallaby
- V12 - *Triodia basedowii* hummock grassland on sandplains. This vegetation provides habitat that supports a known population of Brush-tailed mulgara and Great desert skink, both of which are listed as vulnerable species under both the TSC and EPBC Acts
- V14 - Coolabah swamps associated with claypans (adjacent to Nolans site). This vegetation represents habitat that is poorly reserved within the Burt Plain Bioregion.

# 5. Legislative context

Arafura Resources Limited submitted a Notice of Intent (NOI) for the Project to the NT EPA on 4 July 2013 for consideration under the NT Environmental Assessment *Act 1982* (EA Act). On 13 November 2013, the NT EPA decided that the Project required assessment under the Act at the level of an EIS. The TOR for the Nolans Project, finalised in May 2015, identify assessment requirements for both the NT EPA and Commonwealth DotE.

This flora and vegetation assessment has been prepared to accompany the Environmental Impact Statement (EIS) for the Project that has been prepared in accordance with the EA Act.

The following section summarises the legislation relevant to flora and vegetation that has been considered as part of this assessment.

## 5.1 Commonwealth environmental legislation

### 5.1.1 Environment Protection and Biodiversity Conservation Act 1999

The purpose of the EPBC Act is to ensure that actions likely to cause a significant impact on MNES undergo an assessment and approval process. Under the EPBC Act, an action includes a proposal, undertaking, proposal or activity. An action that 'has, will have or is likely to have a significant impact on a MNES is deemed to be a 'controlled action' and may not be undertaken without prior approval from the Australian Government Minister for the Environment (the 'Minister').

The EPBC Act identifies nine MNES these include:

- World heritage properties
- National heritage places
- Wetlands of international importance (listed under the Ramsar Convention)
- Threatened species and ecological communities
- Migratory species
- Commonwealth marine areas
- Nuclear actions (including uranium mining)
- The Great Barrier Reef Marine Park
- A water resource, in relation to coal seam gas development and large coal mining development.

Potential impacts on any MNES must be subject to assessments of significance pursuant to the EPBC Act Significant Impact Guidelines (DotE 2013). If a significant impact is considered likely, a referral under the EPBC Act must be submitted to the Commonwealth Environment Minister.

This study assesses MNES that relate to vegetation and flora including the likelihood of vegetation and flora listed under the EPBC Act of occurring within the Study area and their potential to be impacted by the proposal. Assessments of the likelihood of occurrence for EPBC matters related to threatened flora and communities are discussed in Section 4.

## 5.2 Territory environmental legislation

### 5.2.1 Territory Parks and Wildlife Conservation Act 2006

The extended title of the TPWC Act is:

> *"An Act to make provision for, and in relation to, the establishment of Territory Parks and other Parks and Reserves, and the study, protection, conservation and sustainable utilisation of wildlife".*

The TPWC Act has provisions for parks and reserves, animals and plants (including wildlife and protected wildlife).

The TPWC Act defines wildlife as that being in a park, reserve, sanctuary, wilderness zone or area of essential habitat, or is a vertebrate that is indigenous to Australia (other than fish), or is specifically prescribed as being protected by the TPWC Regulations. Protected wildlife is protected wildlife whether or not the property with the wildlife is vested in the Territory.

The TPWC Act prohibits the intentional killing of any terrestrial or marine vertebrate (with the exception of fish).

All threatened species are classed as protected wildlife. The TPWC Act precludes the taking of and interference with protected species of wildlife. The Act includes "Principles of Management". These require that a threatened species be managed in a manner that "maintains or increases their population or the extent of their distribution at or to a sustainable level". Threatened species are defined under the Territory's Wildlife regulations as being species that are 'extinct", "critically endangered", "endangered" and "vulnerable".

This study assesses the likelihood of vegetation and flora listed under the TPWC Act of occurring within the study area and their potential to be impacted by the proposal. Assessments of the likelihood of occurrence for flora species listed under the TPWC Act are discussed in Section 4.

### 5.2.2 Weeds Management Act 2001

The *Weeds Management Act 2001* (WM Act) is in place to prevent the spread of weeds and to ensure that the management of weeds is an integral component of land management. This is to be conducted in accordance with the Northern Territory Weeds Management Strategy 1996-2005 (NRETA, date unknown) or any other strategy adopted to control weeds in the Territory.

#### *Noxious Weeds*

Declared noxious weeds in the NT are plants proclaimed under the WM Act. The legislation requires that reasonable attempts be made to control or eradicate these species. Categories of noxious weeds include the following:

- Schedule Class A/C Weeds: These plants do not occur in the NT but pose a significant threat if they invade or if present, pose a serious threat. Reasonable effort must be made to eradicate these weeds.
- Schedule Class B/C Weeds: These weeds often occur widely in the NT. They are capable of spreading further and should be prevented from doing so. Continuing control measures are required to prevent their spread. Reasonable attempts must be made to contain the growth and prevent the movement of these plants.

- Schedule Class C Weeds: This category includes plants that pose an unacceptable risk of spreading in the Territory or to other parts of Australia if they were to be sold or traded in the NT and are a serious threat to another State or Territory of Australia. All schedule Class A and B weeds are considered to be Class C weeds.

The manager of the mine site has responsibilities to manage weeds in accordance with this Act.

One noxious weed (*Tribulus terrestris*) was recorded within the study area. This plant should be controlled in accordance with the WM Act.

## 5.3 Northern Territory policies and guidelines

### 5.3.1 Northern Territory Environmental Protection Authority Survey Guidelines

In November 2013 the NT EPA released a series of guidelines related to implementation of the *Environmental Assessment Act* and the *Waste Management and Pollution Control Act 2009*. Those guidelines relevant to this Assessment are:

- Guidelines on Environmental Offsets and Associated Approval Conditions (Version 2.0)
- Guidelines on Assessment Impacts on Terrestrial Biodiversity (Version 2.0).

This flora and vegetation assessment was prepared in accordance with the guidelines outlined above.

The Department of Land Resource Management (DLRM) has developed standardised methodologies for surveying terrestrial flora in the Northern Territory (*Guidelines and Field Methodology for Vegetation Survey and Mapping* (Brocklehurst *et al.* 2007)). These guidelines were complied with when undertaking this assessment.

# 6. Impact assessment

This section identifies the range of potential direct and indirect impacts on flora and vegetation presented by the project. These include potential impacts during construction and/or during operations. The construction period is expected to last up to 30 months, and mining and processing operations will continue for a period of 41 years following construction.

## 6.1 Overview

The layout of the proposed Nolans site is shown in Figure 1.1 and shows the three principle areas comprising the mine site, processing plant and borefield; in addition to workers accommodation village, utilities corridors and access road.

### 6.1.1 Construction

Construction activities will include all areas of the Nolans site and compromise earthworks, mine site pre stripping and top soil stockpiling, vegetation clearing, construction of infrastructure including waste storage facilities, drainage infrastructure and building pads for modular building structures, construction of roads and access tracks.

Infrastructure requirements during construction will include:

- In the mine site – pit, concentrator plant, waste rock dumps, tailings storage facility, topsoil stockpiles, run of mine (ROM) pad, heavy and light vehicle workshop, administration building, workshops, wash down area, haul roads, sediment and erosion control infrastructure
- At the processing site – extraction processing units, sulphuric acid plant, process residue storage facilities (RSFs), evaporation ponds, power plant, slurry pipeline
- In the borefield area – well head, pumping stations, above ground water transfer pipelines, raw water storage tank, service roads and power supply
- Construction of access and haul roads, utilities corridors
- Other infrastructure to be constructed includes accommodation camp, water treatment plant, security gate, and fuel and materials storage facilities.

Construction activities have the potential to impact on flora and vegetation:

- Directly through clearing of flora and vegetation and associated direct loss of habitat during construction
- Directly or indirectly through alteration of hydrological regimes associated with earthworks and associated changes to land surface areas and/or construction of linear infrastructure and/or other impediments to surface flows
- Indirectly through erosion and/or sedimentation resulting from vegetation clearing during construction.

### 6.1.2 Operation

Operational activities will include mining, processing and storage of waste rock and tailings materials and water extraction from the borefield. Operational activities have the potential to impact on flora and vegetation:

- Directly through the introduction of new exotic flora species and/or spread of existing exotic flora species into new areas

- directly though changes to fire regimes in local vegetation communities
- Indirectly though groundwater drawdown from the borefield and/or changes to groundwater flows impacting groundwater dependent ecosystems
- Directly through dust emissions from the project
- Indirectly though contamination of surface and/or groundwater.

These potential impacts are discussed in further detail below.

### 6.1.3 Clearing of flora and vegetation

Clearing of approximately 4,161 ha of native vegetation would be required for construction of the Nolans site, including waste rock dumps and tailings storage facility, processing site and associated infrastructure, utilities corridors, roads and accommodation village.

Areas to be cleared for construction will be grubbed of trees and larger vegetation, with material collected and stored for reuse in rehabilitation. Topsoil, where present, will be removed and stored for future use in rehabilitation. Where necessary, stockpiles will be protected with erosion and sediment control structures and stabilised to prevent excessive wind erosion.

Clearing areas for the Nolans site are provided in Table 6.1. The areas of each vegetation community to be impacted by the Project are provided in Table 6.2.

Table 6.1 Areas of impact

| Item | Disturbance Area (ha) |
|---|---|
| Mine site | 2,263 |
| Processing site | 1,587 |
| Accommodation village | 32 |
| Access roads | 125 |
| Access track / utilities corridor | 154 |
| **Total** | **4,161** |

Table 6.2 Vegetation communities impacted by the project

| | Vegetation community | Area to be impacted (ha) | % of Nolans site |
|---|---|---|---|
| **V*** | **Description** | | |
| 1 | Riparian woodland along water courses and drainage channels | 239.96 | 5.77 |
| 2a | Mulga shrubland on sandy red earths over spinifex | 5.90 | 0.14 |
| 2b | Mulga shrubland on sandy red earths over tussock grasses | 1411.45 | 33.92 |
| 2c | Mulga shrubland on sandy red earths over chenopods | 34.82 | 0.84 |
| 3a | Mixed woodland over tussock grasses | 657.18 | 15.79 |
| 3b | Mixed woodland over spinifex | 10.97 | 0.26 |
| 3c | Mixed woodland over a highly disturbed understorey dominated by **Cenchrus ciliaris* | 6.46 | 0.16 |
| 4 | *Triodia schinzii* hummock grassland on red clayey sands | 0.00 | 0.00 |

| | Vegetation community | Area to be impacted (ha) | % of Nolans site |
|---|---|---|---|
| 5 | Hakea/Senna shrubland on calcareous alluvial plains and low rises | 232.49 | 5.59 |
| 6 | Eucalyptus (mallee)/*Acacia kempeana* shrubland with Triodia on rocky slopes | 59.86 | 1.44 |
| 7 | Acacia/Triodia shrubland on rocky outcrops | 205.99 | 4.95 |
| 8 | Rocky gneiss or schist outcrops with no spinifex | 0.37 | 0.01 |
| 9 | Acacia kempeana and/or Mulga shrubland on gravel | 44.44 | 1.07 |
| 10 | Claypans with chenopods and herbs | 0.12 | 0.00 |
| 11 | Cottonbush chenopod shrubland on highly erodible duplex soils | 3.55 | 0.09 |
| 12 | *Triodia basedowii* hummock grassland on sand plains | 105.39 | 2.53 |
| 13 | Senna shrubland on quartz | 5.96 | 0.14 |
| 14 | Coolabah woodland on claypans | 0.00 | 0.00 |
| 2a/2b | Mulga shrubland on sand red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex | 1112.43 | 26.73 |
| 2b/3a | Mulga shrubland on sandy red earths over tussock grasses / Mixed woodland over tussock grasses on alluvial plains | 5.23 | 0.13 |
| 3a/12 | Mixed woodland over tussock grasses on alluvial plains / Cottenbush chenopod shrubland on highly erodible duplex soils | 5.05 | 0.12 |
| 3b/2b | Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses. | 13.35 | 0.32 |
| | Disturbed | 0.59 | 0.01 |
| **TOTAL** | | **4161.56** | **100** |

None of the vegetation communities to be cleared as a result of the Project are listed as threatened under the EPBC or TPWC Act.

Vegetation clearing in these communities will involve removal of a diverse range of non-threatened native flora species, including mature trees. The average species richness within vegetation communities present within the Nolans site varies from 51 (+/- 1) within Acacia/ Triodia shrubland on rocky outcrops, to 11 species within Claypans with chenopod and herbs. None of the vegetation communities within the Nolans site however, are considered to have significant levels of species richness or structural complexity.

Vegetation communities present within the Nolans site are well represented in the Burt Plain bioregion. The two most common vegetation communities in the bioregion, Mulga shrublands on sandy red earths (VT 2) and mixed woodland over tussock grasses (VT 3a) together comprise 78 % of the vegetation proposed to be impacted within the Nolans site.

- Mulga shrublands on sandy red earths (VT 2) comprise 62 % of the Nolans site. This vegetation type corresponds to the Wilson Map Unit 65 – *Acacia aneura* (Mulga) tall open –shrubland with *Eragrostis eriopoda* (Woollybutt) open grassland understorey.
- There is approximately 2.7 million ha of this vegetation type mapped within the Burt Plain bioregion (Wilson *et al.* 1990, Pert 2006). The removal of approximately 2,565 ha of Mulga shrubland for the Project would therefore represent 0.09 % of the bioregional extent of this vegetation community.
- Approximately 15.8 % of the Nolans site is covered in mixed woodland over tussock grasses (VT 3a). This community is closely aligned to the Wilson Map Unit 59 – *Acacia*

*estrophiolata* (Ironwood), *Atalaya hemiglauca* (Whitewood) low open-woodland with open grassy understorey, which has been mapped as covering 12.3 % or 919,927 ha within the Burt Plain bioregion. The removal of approximately 657 ha of mixed woodland represents less than 0.07 % of this community within the bioregion.

There are a number of less common vegetation communities in the bioregion that occur in small patches or along linear drainage lines throughout the Nolans site. These include Riparian woodland (VT 1), Cottonbush chenopod shrubland (VT 11), Eucalyptus (Mallee)/*Acacia kempeana* shrubland with Triodia on rocky slopes (VT 6) and Claypans with chenopods and herbs (VT10). These communities are not considered to be rare or threatened at a regional scale.

#### *Mitigation measures*

Mitigation measures to prevent or minimise impacts associated with vegetation clearing would comprise:

- Minimise vegetation clearing where practical
- Procedures for demarcating the limits of clearing, and no-go areas
- Use already-disturbed areas (rather than undisturbed areas) wherever possible (e.g. laydown areas for construction)
- Demarcate the limits of clearing, and no-go areas to prevent construction activities from encroaching on adjoining native vegetation
- Undertake weed control prior to vegetation clearing so that vegetative material mulched and reused directly on site is not contaminated.

### 6.1.4 Edge effects

'Edge effects are inherent or natural in nature i.e. wherever changes in vegetation or landscape cause sudden changes in vegetation structure but can have negative impacts if their creation alters ecological processes. In general, edge effects increase in relation to the dissimilarity between adjoining habitats.

Removal of vegetation causes new environmental conditions to develop along the edges of the remaining vegetation, and this is particularly dramatic in areas that once contained canopy and/or shrub layers of vegetation. Edge effects include the introduction of changes in light conditions, changes in wind conditions and changes in the amount of heat and/or cold that penetrates both the soil and vegetation environment along such edges. The removal of vegetation generally promotes the invasion of exotic species and/or disturbance tolerant native plants as a result of the changes in environmental conditions i.e. more light and more heat. Often it is exotic species that will colonise the edges of cleared areas.

The Nolans site is already exposed to the impacts of exotic species such as Buffel Grass, which is present through much of the area. The development of the Nolans project provides additional opportunities for the creation of edge effects as a result of clearing.

Consequences are likely to include the introduction or spread of weed species and dust to new areas of vegetation, which are currently less affected by these impacts, reducing flora and fauna habitat values in the newly exposed edge areas.

### 6.1.5 Alteration of hydrological regimes

Project activities including earthworks, construction of buildings, changes to land surface areas and other impediments to surface flows associated with infrastructure development and

construction of linear infrastructure has the potential to impact on flora and vegetation communities directly or indirectly through alteration of surface and sub-surface flows.

Vegetation in riparian zones (including Kerosene Camp Creek and Rabbit Creek) and floodplain areas are likely to be at least partially dependent on surface or subsurface water flows.

The construction of areas of hardstand and linear infrastructure may interfere with natural surface water flows by blocking or disrupting the movement of water across the landscape. Additionally, the proposed mining operation may impact surface water flows through changes to areas of natural inundation, increased concentration of flows and/or disruption to sheet flow patterns.

Flow pathways including drainage channels, distributed channels and sheet flow areas may be impacted thus directly affecting downstream sensitive vegetation. The key vegetation that is vulnerable to such changes in environmental flow are the vegetation communities that are at least partially dependent on surface water flows including sheet flow i.e. Mulga shrubland (VT 1) and the riparian vegetation along Kerosene Camp Creek and within drainage channels (VT 2).

Approximately 19.2% of the Nolans site is comprised of riparian areas and floodplains that may be subject to seasonal inundation or surface water flows at least occasionally. A reduction in surface water flows has during low rainfall periods and may result in additional water stress for individual plants and in the long term have the potential to result in the death of understorey species and also overstorey mulga shrubs leading to alterations to community composition.

Haul roads and access roads will need to cross a relatively large number of ephemeral creeks the majority of which have small upstream catchments (typically less than 3 $km^2$).

Engineering controls that assist in maintaining surface water flows would be incorporated into road designs to ameliorate any potential risks to vegetation and flora due to changes in flows. These include culvert designs, longitudinal drainage along access roads and haul roads and floodway crossings. Given the relatively small variation in relief across the Project site, these practices would also provide other benefits such as erosion control.

The diversion of local runoff from areas upstream of the Processing Plant will be achieved by means of flood protection bunds and/or shallow drainage ditches. These structures will be typically designed to convey runoff from a 1 in 25-year ARI storm rainfall event with the assumption that the height of any pond embankments will be sufficient to prevent ingress from external flood runoff during an event that is compatible with the design of its water containment capacity (1 in 100-year ARI storm rainfall).

### 6.1.6 Soil erosion

During construction, soils will be stripped in areas where new structures are to be constructed, with material stockpiled for later use in rehabilitation. There is potential for soil erosion in areas that have been stripped of vegetation.

Soil erosion has the potential to impact Kerosene Camp Creek and associated drainage lines through the release of sediments from site during flow events. This may result in impacts to riparian vegetation along creek and drainage lines.

Concentrated and/or altered hydrology in the construction footprint could further exacerbate the mobilisation and transport of sediment. Potential impacts on flora and vegetation contained in creeks and drainage lines may include increases in stream sediment load, changes in channel form and integrity and/or changes in stream hydrology.

Soil protection measures will be implemented during construction and operation of the mine site including:

- Preparation of an Erosion and Sediment Control Plan (ESCP) that provides a framework, and strategies for managing erosion and sedimentation processes during construction and operations
- Implementation of progressive rehabilitation of disturbed areas, and stabilisation and rehabilitation of waste landforms
- Regular inspection, management and maintenance of erosion and sediment control measures.

### 6.1.7 Introduction and/or spread of invasive species

Weeds compete with native species for space, nutrients and water, and have the potential to alter the structure and composition of vegetation communities. Weeds are commonly spread by wind, plant and machinery, surface runoff or animal movement. There is the potential for project activities to introduce new weed species and/or spread existing weeds into new areas via clearing activities, vehicle and machinery movement around the Nolans site, movement or stockpiling of soil and inappropriate waste management.

The removal of vegetation would also result in the creation of new exposed edges that are likely to be more susceptible to weed invasion.

A number of weed species are known to be present within the Nolans site (Section 4.4.3). One of the exotic species (*Tribulus terrestris*), recorded during baseline surveys is listed as a declared weed under the *Weeds Management Act 2001* and one species (*Cenchrus ciliaris,* Buffel Grass) has been identified as a high threat environmental weeds in the Burt Plain bioregion.

Buffel Grass is a highly invasive species with potential to spread throughout the Nolans site. The proliferation of Buffel Grass has the potential to increase fire frequency and create hotter fires due to its ability to accumulate higher amounts combustible biomass compared to native understory species. Increased fire severity has been correlated with the mortality of overstorey tree species, a reduction in post-fire re-establishment of native species and altered plant community structure. Buffel Grass invasion has been identified as a major threat to biodiversity within the Burt Plain bioregion (Neave *et al* 2006).

*Cynodon dactylon* (Couch Grass) is also present in low abundance along drainage lines within the Nolans site. This species has also been recognised as a potentially serious environmental weed posing a significant threat to biodiversity in the region (Neave *et al* 2006). This is due to the ability of Couch Grass to rapidly proliferate and spread along drainage systems and out-compete native plant species for space and light and nutrients.

The remainder of the introduced species recorded within the Nolans site are unlikely to have a significant impact on ecosystems as they are present in relatively low numbers and frequency and are not considered to be highly invasive.

A Weed Management Plan (WMP) will be developed as part of a Biodiversity Management Plan for the Project, to minimise the risks associated with the introduction of spread of weeds through the site. Further details of mitigation measures that would be included in the WMP are outlined in Section 7.

### 6.1.8 Changes to fire regime

Construction and operational activities, particularly hot works, are potential ignition sources. In addition, it may be necessary to conduct controlled burns to minimise fuel loads in the vicinity of the mine site. Without adequate fire management in place, there is potential for these activities to result in uncontrolled bushfires.

Although wildfire has an influential role in arid zone ecology and is a necessary ecological process in some habitats, too frequent fire can have detrimental impacts on vegetation communities. For instance, fires that are too frequent or too hot have the potential to impact vegetation composition and flora diversity, with some species unable to reach reproductive maturity if time since fire is too short. Additionally, unseasonal fire (i.e. late dry season), or fire in habitats that don't respond well to fire, can also result in detrimental impacts to vegetation composition and flora diversity.

Measures to mitigate the impacts of unplanned wildfire will be included in the project CEMP as detailed in Section 8.

### 6.1.9 Lowering of the water table

Four key groundwater areas have been identified within the vicinity of the Nolans site. These include:

- The Ti-Tree Basin
- Nolans Mine Site and surrounding fractured rock aquifer/basement
- The area referred to collectively as the Southern Basins
- The area where the Ti-Tree Basin borders or abuts the Southern Basins which is referred to as the Margins Area.

A hydrological assessment that has been completed for the Project considers the four areas in a single model, to assess the collective (and individual) impacts of the proposed groundwater extraction (GHD 2015b). Groundwater extraction is proposed to occur from the Nolans Mine Site for pit dewatering (within the Ti-Tree Water Control District) and within the Southern Basins (borefield) for process and potable water.

The groundwater flow regime is predicted to significantly change in the mine area and result in a permanent sink (i.e. perpetually discharging low point) due to evaporation of pit water. Drawdowns are as expected very large at the pit site, reflective of pit levels during operation (i.e. as deep as 390 mAHD which equates to approximately 260 m of drawdown at the completion of mining), and then reflective of the pit lake levels (modelled levels at 575 mAHD which equates to approximately 80 m of drawdown) during closure as the water rebounds to a level where groundwater flow equates to evaporation.

Changes to the water table can result in changes in surface vegetation and habitat characteristics. Lowering of the water table has the potential to result in a decline in availability of water to ecosystems including riparian vegetation resulting in loss of habitat for species relying on riparian habitat. Riparian vegetation (dominated by *Eucalyptus camaldulensis* (River Red Gums) line the larger creeks and rivers in the study area including Napperby Creek, Day Creek and Woodforde River as well as a number of unnamed drainage lines that occur throughout the study area.

Groundwater dependent vegetation in discharge zones and floodout areas would be susceptible to rapid changes in groundwater levels, in particular riparian woodlands, which are likely to be at least partially dependant on groundwater. Lowering of the groundwater level is likely to result in the die back of riparian vegetation and/or changes to species composition within the community. In particular, the *Eucalyptus camaldulensis* (River red gum) trees *Corymbia aparreninja* (Ghost Gum) growing along creeks and drainage lines in and around the Nolans site, particularly if the drawdown occurs quickly, or the level of drawdown is large. In either of these situations groundwater dependent species are unlikely to be able to adapt to the changing groundwater levels. Impacts are likely to be evident as far away as Day Creek, to the west of the borefields.

The riparian vegetation immediately adjacent to the mine area (both upstream to the point of the diversion and downstream in Kerosene Camp Creek to the confluence of Nolans Creek) is highly likely to be catastrophically impacted by the mining operations (i.e. riparian vegetation will die and not recolonise the area), and these conditions will persist beyond mining and into closure. The reason for this includes, but is not limited to:

- the difference in availability of surface water and therefore recharge to groundwater as well as water for direct contact with riparian vegetation (i.e. a section of the creek will longer exist and a section of the creek will be diverted)
- there will be no availability of groundwater within the drawdown cone.

It is reasonable to assert the impact will be greatest immediately adjacent to the pit and decrease radially with distance from the pit. A reasonable estimate for the downgradient extent of this based on the both the modelled drawdown cone and where Kerosene Camp Creek receives additional surface water flow from adjacent catchments (which is likely to in part mask this impact) is the confluence with Nolans Creek. This length of Kerosene Camp Creek beyond the mining area is approximately 1 km long. At this point the groundwater model predicts a drawdown of only 2 m during mining but approaches 20 m in the long term closure model (1000 years).

Modelled drawdown from the borefield peaks in the order of 1.5 m in the vicinity of Day Creek and rebounds rapidly once pumping ceases (GHD 2016b). If vegetation is currently dependent on the groundwater at these locations, based on watertable level observations (of approximately 28 m below top of collar) in the adjacent SB0026 (RC00026 RN19038), tree roots must be capable of extracting water from greater than 20 m deep, even accounting for the river bank and collar heights. If vegetation is capable of extending its root systems to such depths it is hypothesised that it is reasonable to expect that it could gradually extend its root system a further 1.5 m over the predicted drawdown period during mining and it is therefore anticipated that the slow rate of drawdown would give riparian vegetation the opportunity to adapt to the lowering water table over time.

Groundwater modelling shows that no floodout areas within the Ti-Tree Basin will be impacted by groundwater abstraction in the mine area. The important Allungra Creek floodout is in a different catchment to the mine area and the modelled groundwater drawdown is well away from the area. Any surface features such as roads should be designed in manner that they allow features such as the Allungra Creek to behave in similar manner as they currently do to ensure recharge still occurs as is currently does.

In the Southern Basins, there may be minor localised impacts to floodout vegetation and or soaks due to a decrease in groundwater availability for evapotranspiration. The impact will be determined by the current groundwater dependence and how the difference in availability of groundwater affects floodout vegetation and soaks. Given the scale of distance, the minor drawdowns predicted, the percentage differences in groundwater available and the gradual nature of the predicted changes, it is assumed that this impact will be negligible.

A key measure of availability of groundwater for riparian floodout vegetation areas within Ti-Tree Basin, within the model, is the impact to groundwater available for evapotranspiration. Using this measure, a peak of 5% change in evapotranspiration across the basin was modelled (at the end of the 1000-year closure period) representing a peak change of 4 $m^3$/day (0.05 L/s). Of all the model outputs, evapotranspiration is considered to be the least reliable, however this does demonstrate a degree of change to the system dynamics which helped inform the groundwater assessment.

Outside of the Ti-Tree Basin in the basement rocks, the modelled groundwater available for evapotranspiration (excluding the pit waters) decreased by a peak of 8% at 119 $m^3$/day

(1.4 L/s). No modelled change was observed in the Margins area, and this is expected as the model indicates no groundwater is available for evapotranspiration (i.e. at depths of 1.5 m or less) under normal conditions.

Measures to minimise risks associated with lowering the water table would include further predictive groundwater modelling to determine the likelihood of impact on sensitive vegetation.

### 6.1.10 Diversion of Kerosene Camp Creek

Kerosene Camp Creek, which currently traverses the centre of the proposed mine site is a potential source of uncontrolled inflow to the open pit. If unmitigated, the open pit has the potential to capture 30% of the runoff that currently reaches the Woodeford River from Kerosene Camp Creek and Nolans Creek during flow events.

Due to the proposed location of the open pit on the flow path of Kerosene Camp Creek, it will be necessary to divert Kerosene Camp Creek to the west of the mine site. The diversion will be designed to prevent surface water from the creek entering the mine site during a 1 in 100-year ARI storm rainfall event.

The diversion of Kerosene Camp Creek in the mine site area may result in landform disturbance and an altered hydrological regime in the old creek bed and in the new creek alignment. This may cause impacts on riparian flora and vegetation downstream of the diversion, including:

- Changes in surface and sub-surface flow downstream of the diversion resulting in impacts on riparian and ephemeral ecosystems and vegetation dependent on overland flows
- Loss or changes in the composition of riparian vegetation associated with old creek channel due to the reduction in water flow. Although this vegetation will be within the minesite footprint and would be therefore cleared as a result of mining operations.
- Loss of vegetation due to the construction of the new diversion.

### 6.1.11 Contamination of surface and groundwater

There are several risks associated with the construction and operation of the Project that could lead to contamination of surface and/or groundwater, and consequent potential impacts on flora and vegetation. These include:

- Contamination of ephemeral creeks/ drainage lines or the groundwater caused by embankment failure or overtopping and subsequent uncontrolled release from waste storage ponds including the Residue Storage Facilities (RSFs) at Processing Site and/or the TSF at the mine site
- Inappropriate storage and handling of hazardous substances at the Nolans site may also result in uncontrolled release, spills or passive discharge into drainage lines
- Release to groundwater or drainage channels of acid mine drainage from waste rock dumps.

Other potential sources of contaminants to surface and groundwater include:

- Contamination via sediment runoff from areas stripped of vegetation or from soil stockpiles during flow events
- Runoff from hardstand areas, including roads, processing areas and site facilities
- Run off from waste treatment areas (including the water treatment plant, wastewater treatment plant, and landfill facilities)

- Leakage or spillage of hydrocarbons from pipelines, vehicles, wash down areas and workshops, refuelling bays and fuel, oil and grease storages.

There are a number of sensitive riparian habitats close to the development footprint, including Kerosene Camp Creek and its associated drainage lines. These areas are sensitive receptors for any adverse impacts on soil and water quality potentially arising from the Project.

Possible embankment overtopping of Tailings Storage Facility (TSF) containing beneficiation tailings during rain events, leading to an uncontrolled release of liquor may result in immediate inundation of flora within flow path of overtopped embankment; with secondary longer term impacts including vegetation dieback associated with the contamination of surrounding land and ephemeral creeks.

Risk of contamination as described above will be mitigated by engineering design measures, erosion and sediment controls, appropriate storage and handling of hydrocarbons and chemicals, ongoing stabilisation and rehabilitation of disturbed areas, siting of stockpiles away from natural drainage lines, dust control, establishment of sediment basins and operation and maintenance procedures.

No process or contaminated water stream will be discharged to the environment. Clean water will be diverted around the site.

Other mitigation measures include:

- Selection of appropriate ANCOLD risk category and adherence to relevant design standards for the provision of adequate storage capacity, spillway capacity and freeboard allowance
- Embankment piezometers and survey pins, regular dam inspections
- Adherence to prescribed maximum operating level and retention of freeboard
- Development and implementation of a Water Management Plan.

### 6.1.12 Dust emissions

Dust is a potential problem for mining projects in regions that experience extended dry periods. Central Australia exhibits an arid and unpredictable climate characterised by extended periods without rain. Drilling, blasting, excavation, handling of materials and movement of machinery is likely to result in dispersion of particulates and dust, particularly from mining activities.

Dust deposition on leaf surfaces may physically affect individual plants such as by blocking and/or damaging stomata or abrasion of the leaf surface or cuticle which may impact on metabolic processes. Dust can also contribute to cumulative effects such as drought stress on already stressed plants which may in turn lead to the loss of individual plants and longer term changes to vegetation structure and composition.

The following activities are identified as the primary generators of dust:

- Uncontrolled dispersion of particulates and dust from the concentrator (comminution and beneficiation circuits) at the Mine Site, resulting in dispersion of particulate, gas or dust
- Operation of RE processing units, sulfuric acid plant and gas fired generators at the Processing Site results in dispersion of particulate, gas or dust
- Haulage and transport of material within the Mine Site, along haul roads and tracks resulting in dispersion of particulate, gas or dust
- General site movements over unsealed surfaces resulting in dispersion of particulate, gas or dust

- Drilling, blasting, excavation and materials handling at the mine site during operations
- Wind erosion mobilising dust from exposed surfaces, such as pits, waste dumps, tailings and residue storage facilities, laydown areas, stockpiles, roads and sites of vegetation clearing.

Whilst the impacts from dust are unlikely to result in the loss of vegetation communities per se, dust has the potential to add an additional stressor to individual plants or plant communities that may be impacted by the effects of weeds and frequent fire, for example. Impacts on vegetation from dust are likely to be relatively minor and largely restricted to areas adjacent to the mine site

A Dust Management Plan will be developed and implemented as part of the Project EMP.

### 6.1.13 Impacts on vegetation and species of National Environmental Significance

No vegetation communities or flora species listed as threatened under the EPBC Act were recorded within the Nolans site or are likely to occur.

### 6.1.14 Impacts on vegetation of regional significance

Neave *et al*. (2004) identifies a number of criteria for determining important habitats within the Burt Plain bioregion. Vegetation of bioregional significance has been identified by Neave *et al.* (2004) as not only areas of rare habitat but also vegetation that is well represented elsewhere but is regarded as having conservation value as they meet any of the following criteria:

*Habitat with high species richness that supports a high abundance of native species, and/or is structurally complex.*

*These attributes may relate to the:*

- *Number of vegetation types and the degree of contrast between them*
- *Availability of shelter sites (e.g. nesting sites, ground litter and logs, rock crevices) and water and food resources (e.g. presence of nectar producing shrubs)*
- *Topographic/geological complexity creating a range of micro-habitats.*

None of the vegetation communities are considered to have significantly high species richness or structural complexity and the communities present are well represented in the Burt Plain bioregion. The average species richness within vegetation communities present within the Nolans site varies from 51 within Acacia / Triodia shrubland on rocky outcrops (VT 7) to 11 within Claypans with chenopods and herbs (VT 10).

The two most common vegetation communities within the Nolans site are Mulga shrublands on sandy red earths (VT 2) and mixed woodlands over tussock grasses on alluvial plains (VT 3a).

Mulga shrublands on sandy red earths (VT 2) makes up 62% of the Nolans site. This vegetation type corresponds to the Wilson Map Unit 65 – *Acacia aneura* (Mulga) tall open –shrubland with *Eragrostis eriopoda* (Woollybutt) open grassland understorey. There is approximately 2,771,054 of this vegetation type mapped within the Burt Plain bioregion (Wilson *et al.* 1990, Pert 2006). The removal of 2,565 ha of Mulga shrubland for the Project would therefore result in the disturbance of approximately 0.09% of this vegetation community within the bioregion.

Approximately 15.8 % of the Nolans site is covered in mixed woodland over tussock grasses (VT 3a). This community is closely aligned to the Wilson Map Unit 59 – *Acacia estrophiolata* (Ironwood), *Atalaya hemiglauca* (Whitewood) low open-woodland with open grassy understorey, which has been mapped as covering 12.3% or 919,927 ha within the Burt Plain bioregion. The

removal of approximately 657 ha of mixed woodland would therefore equate to the removal of less than 0.07% of this community within the bioregion.

There are a number of less common vegetation communities that occur in small patches or along linear drainage lines throughout the Study area. These include Riparian Woodland (VT 1) dominated by bean trees (*Erythrina vespertilio*), Cottonbush chenopod shrubland (VT 11), Eucalyptus (mallee)/*Acacia kempeana/* Triodia shrubland on rocky slopes (VT 6) and Claypans with chenopods and herbs (VT10). These communities however, are not considered to be rare or threatened at a regional scale

None of the vegetation types within the Nolans site have a notable abundance of shelter or nesting sites for fauna or significant water or food resources. Rocky habitats within the Nolans site are known to provide habitat for the threatened black-footed rock wallaby. These habitats include Eucalyptus (mallee)/*Acacia kempeana* shrubland with Triodia on rocky slopes and Acacia/Triodia shrubland on rocky outcrops, which represent approximately 6% of the Nolans site.

*Habitat supporting species of high conservation value (e.g. threatened species, endemic species, poorly reserved species and/or rare species).*

Vegetation within the Nolans site partially meets this criterion as it supports a number of threatened fauna species including Brush-tailed Mulgara (*Dasycercus blythi*), Black-footed Rock-wallaby (*Petrogale lateralis*), and Great Desert Skink (*Liopholis kintorei)* which were recorded during fauna surveys completed at the site (GHD 2015a). A number of other threatened fauna species have also been predicted to occur at the site based on the presence of suitable habitat (GHD 2015a).

None of the vegetation communities present are considered to be rare in the region and all are well represented in the surrounding locality and elsewhere in the Burt Plain bioregion. The fauna survey did not identify any fauna species of conservation significance that would solely rely on habitats within the Nolans site as these species would utilise similar habitats surrounding the Nolans site.

*Habitat that is of good quality (i.e. its compositional and structural integrity and ecological processes have not been undermined). The level of habitat integrity is influenced by:*

- *The presence / absence (or low cover abundance) of environmental weeds, especially Buffel Grass and Couch Grass, both of which are known to outcompete native plant taxa and alter habitat parameters for native fauna*
- *The presence / absence (or low abundance) of introduced animal species*
- *The presence / absence of an appropriate fire regime (inappropriate regimes are known to impact on species composition and canopy condition)*
- *Degree of isolation from infrastructure such as roads and water points (reduced risk of weed invasion and over-grazing)*
- *The state of the hydrological regime (altered regimes may lead to changes in site species composition).*

The Nolans site has a moderate cover abundance of environmental weeds including the invasive species *Cenchrus ciliaris* (Buffel Grass). Overall however, the condition of vegetation in the Study area was good with weeds mostly confined to drainage lines and more fertile floodplain areas.

There is evidence of recent widespread fires across the site however no information is available regarding the history of fires at the site. A search of the North Australian Fire Information website however shows that nearby areas were most recently burnt in 2011 (NAFI 2015).

The Nolans site is located near to the Stuart Highway, and has been subjected to cattle grazing for over 130 years. The area therefore is unlikely to have particularly good habitat such that it would be considered to have regional significance.

*Habitat that is poorly reserved elsewhere.*

Dominant vegetation communities within the Study area include Mulga communities on sandy red earths (VT 2b) and mixed woodlands over tussock grasses on alluvial plains over spinifex (VT 3a).

Most of the vegetation types present within the Nolans site are well represented within the Burt Plain bioregion, however less than 1% of the Burt Plain bioregion is conserved within reserves; and thus vegetation communities within the Study area are poorly represented in conservation reserves, e.g. hummock grassland 0.01%, Acacia woodland 0.05%, Eucalyptus low Woodland with Tussock Grass Understorey 0.01%(NRETAS 2005).

### 6.1.15 Impacts on Sites of Conservation Significance

The Project is not likely to result in impacts to and Sites of Conservation Significance.

# 7. Mitigation measures

The project will result in direct impacts to native vegetation and flora species as described in Section 6. There is also the potential for indirect impacts on retained vegetation and habitats within and adjacent to the Nolans site.

This section presents an overview of recommended mitigation measures to avoid or minimise the potential impacts of the Project on vegetation and native flora. Mitigation measures will be incorporated into the EMP for the Project.

The Project will result in some unavoidable impacts to some elements of the natural environment; however, these impacts are not expected to result in a significant impact on local or regional occurrences of vegetation communities or flora species.

## 7.1 Avoidance of impacts

It is recommended that detailed Project design consider options for aligning infrastructure footprints to avoid or minimise clearing of vegetation. In particular, the Project should aim to avoid where possible, sensitive vegetation types such as riparian vegetation. Additionally, the design should also seek to minimise modifications to surface water flows that would cause vegetation stress, or the proliferation of introduced flora species.

Selection of appropriate ANCOLD risk category and adherence to relevant design standards for the provision of adequate storage capacity, spillway capacity and freeboard allowance will minimise risk of storage facility failure or overtopping.

Engineering controls that maintain existing surface water flows should be incorporated into road and infrastructure designs to ameliorate any potential risks to vegetation and flora due to changes in flows as a result of the development of linear infrastructure. These include culvert designs, longitudinal drainage along access roads and haul roads and floodway crossings. Given the relatively small variation in relief across the Nolans site, these practices would also provide other benefits such as erosion control.

Design features that recognise the need to maintain existing surface water flows include the installation of at-grade flood ways where the access road crosses a water course, and culverts to maintain flows under the access road where the drainage line is well defined (i.e. along Kerosene Camp and Rabbit Creeks).

The diversion of stream flow from areas upstream of the Processing Plant by means of flood protection bunds and/or shallow drainage ditches should be implemented. These structures will be typically designed to convey runoff from a 1 in 25-year ARI storm rainfall event with the assumption that the height of any pond embankments will be sufficient to prevent ingress from external flood runoff during an event that is compatible with the design of its water containment capacity (1 in 100-year ARI storm rainfall).

## 7.2 Mitigation of impacts

### 7.2.1 Project construction

Where possible the amount of land disturbance and vegetation clearing should be minimised. Construction personnel would be briefed during inductions regarding the conservation value of surrounding habitats and their responsibilities with regard to protecting these habitats during construction.

Additional control measures will include:

- Preparation of a Biodiversity Management Plan (BMP)
- Procedures for demarcating the limits of clearing and no-go areas
- Staged clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with ESCP
- Use of already-disturbed areas (rather than undisturbed areas) wherever possible (e.g. lay down areas for construction)
- Development and implementation of a land stabilisation and revegetation strategy
- Progressive revegetation of cleared land as activities are completed
- Where possible buffer widths recommended by the Northern Territory Land Clearing Guidelines would be applied to riparian areas
- An Erosion and Sediment Control Plan (ESCP) would be developed as a sub plan to the EMP including:
  - Installation of erosion and sediment control measures prior to construction
  - Regular inspection of erosion and sediment control measures, particularly following rainfall events, to ensure their ongoing functionality
  - Runoff from disturbed and rehabilitated areas diverted into sediment ponds and not discharged into the natural system
  - Constructing adequate bunds around potential contamination sources, to contain contaminated water in the event of heavy rainfall
  - Runoff from ROM pad, stockpiles and workshops would be directed to sediment basins
  - Siting of stockpiles away from natural drainage channels
  - Staged clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with ESCP
  - Avoid land clearing for construction during the Wet Season
  - Minimise surface water infiltration, water runoff and groundwater seepage
  - Preparation of a Water Management Plan for construction activities
  - Spill clean-up procedures developed and implemented
  - Personnel to be trained in the use of spill kits and emergency response procedures.

### 7.2.2 Project operation

Additional control measures will be implemented during project operation including:

- A **Weed Management Plan** (WMP) will be prepared and include the following:
  - Information regarding type and location of weeds of concern within the Nolans site
  - Description of sensitive receivers (such as native vegetation and waterways)
  - Measures to prevent the spread of weeds, including hygiene procedures for equipment, footwear and clothing
  - Mitigation measures to minimise the spread of weeds such as ensuring that any machinery entering the Nolans site is free of weed seed. This would typically be managed through inspections and the use of vehicle wash down stations
  - Keeping vehicles to established tracks and roads, and limiting the use of vehicles off-road

  - Areas supporting existing weed infestations, or vulnerable to weed infestation, will be avoided where practicable
  - Protocols for weed removal prior to vegetation clearing so that vegetative material would be clean and able to be mulched and reused directly on site
  - Weed disposal protocols
  - Ongoing control of new weed outbreaks
  - Annual monitoring of the Nolans site (including rehabilitated areas) and surrounding vegetation to identify new weed populations and monitor the effectiveness of weed control measures
  - Topsoil from weed affected areas will be stockpiled in a designated area with appropriate signage and bunding. Weed infested topsoil will be treated as required to eradicate weeds prior to re-spreading in rehabilitation areas
  - All staff and contractors will be informed of weed hygiene measures and weed reporting requirements during the site induction.
- Development and implementation of a **Fire Management Plan** (FMP) including:
  - Establishment and maintenance of fire breaks around high-risk areas / activities
  - -All welding, cutting and grinding works undertaken will require approval via an internal hot works permit
  - Active fire management and vegetation reduction program where necessary
  - Installation / implementation of fire detection and suppression systems including dedicated fire extinguishers
  - All site personnel will be required to undertake fire control training, including the correct use of extinguishers
  - All vehicles are required to carry a fire extinguisher and two-way radio
  - Emergency response procedures, team and equipment
  - Establishment of dedicated fire water system on site
  - Strict fire prevention management protocols to prevent wildfire during clearing activities
  - Erosion control in waterways, if fire should occur and results in loss of vegetation that otherwise stabilises soil/sediments
  - Undertake active fire management and the use of cool-season control burns if needed.
- Development and implementation of a **Water Management Plan** (WMP) including:
  - Undertake predictive groundwater flow modelling to confirm the extent of groundwater drawdown
  - Establish ground water monitoring bores to assess impacts over time on water table
  - Visual monitoring of vegetation potentially at risk of impact from a lowering of the water table
  - If significant impacts are identified, consider mitigation options. This could include modification of the pumping regime to manage groundwater levels.
- Development and implementation of a **Dust Management Plan** would include as a minimum, application of industry dust control measures including:
  - Use of water sprays on haul roads, unsealed surfaces, covering of exposed loads where practicable and maintaining moisture levels in bulk loose construction materials

- Minimising hauling and vehicle travel in conditions when wind strength results in spatially extensive and heavy dust deposition in surrounding habitats
- Reduced vehicle speeds for high-use areas/roads
- Minimise open areas exposed to wind erosion
- Wetting of ore before crushing and design controls such as use of hooded crusher, covered conveyor and an enclosed HPRG
- Topsoil striping to occur only during suitable wind and weather conditions
- Review of wind directions and wind speeds prior to drilling, blasting or excavation of materials
- Minimise time between top soil stripping and construction/mining operations
- Progressive reinstatement of waste dumps and cleared land as construction works are completed
- Controlled emissions release via stack and scrubber- Ongoing dust deposition monitoring program.

## 7.3 Rehabilitation

Progressive rehabilitation will be guided by the following principles with regard to flora and vegetation:

- Areas not required for ongoing operations will be progressively rehabilitated
- Locate and design landforms to be rehabilitated to optimise blending with the surrounding topography
- Topsoil will be stripped and stockpiled in a designated area, to prevent erosion or run-off
- Minimise soil erosion particularly on the batters of the waste rock dump
- Stockpile vegetative material and topsoil for later use
- Minimise length of stockpiling of vegetation and topsoil
- Seeds collected for the rehabilitation program will be sourced locally, wherever possible.
- Annual monitoring of rehabilitation areas would be undertaken prior to, and following completion of rehabilitation
- If monitoring identifies that completion criteria are not being met, additional rehabilitation and monitoring would be completed until such criteria are met.

Rehabilitated areas would be monitored to ensure the success of the rehabilitation programme and impacts from mining activities. Monitoring of rehabilitated sites would be undertaken annually until completion criteria have been met. The monitoring would assess the species diversity, plant density and community structure against agreed completion criteria.

## 7.4 Closure

A Conceptual Mine Closure Plan will be developed and will be refined as a component of the Mine Management Plan. The plan outlines general and area specific decommissioning and closure measures, completion criteria and post closure monitoring requirements for the Project. The Conceptual Mine Closure Plan aims to ensure that:

- Mining is planned and carried out to ensure a sustainable mine closure outcome is achieved

- Self-sustaining native vegetation communities are returned after mining, which in species composition and ecological function are representative of naturally occurring analogue sites.

A post-closure monitoring programme will be initiated, with the aim of confirming that the rehabilitation and closure has been effective and the closure criteria satisfied. Post-closure monitoring will include assessments of public safety, geotechnical stability, physical stability, chemical stability and revegetation success.

# 8. Risk assessment

## 8.1 Risk assessment

Risk is expressed and assessed in terms of a combination of the consequence of an event and the associated likelihood of occurrence.

A “real chance or probability” of a significant impact from a particular source is defined as there being an extreme or high risk of a population (or the fauna community) experiencing of a significant consequence as defined in the guidelines e.g. reduce the diversity or modify the composition of plant and animal species in a National Heritage place.

The initial levels of risk and determination of residual risk (after avoidance, mitigation and management actions have been applied) have been undertaken using standard qualitative risk assessment procedures consistent with AS/NZS ISO 31000:2009 ‘Risk Management – Principles and guidelines’, with the exception of economic risk which is not addressed in the guidelines.

Assessment of risk has been conducted through consideration of the circumstances around risks, identifying necessary controls to address potential impacts and assuming effective implementation of planned and committed mitigation of potential impacts. Avoidance, mitigation and management actions are proposed in an attempt to reduce residual risk (risk after actions) where possible to below “Extreme” or “High” risk outcomes to the extent reasonably practicable as part of reducing the overall project risk profile.

The depth of focus on risk controls is linked to the level of risk and opportunity for reduction to meet organisational commitments and goals linked to an environmentally and socially responsible operation, and those requirements are part of the regulatory obligations and impact assessment guidelines.

Table 8.1 provides a summary of the qualitative risk matrix adopted and the levels of risk for the various consequence and likelihood combinations and a brief description of each risk classification and the likely responses for the threatened species assessed is provided in Table 8.2 and Table 8.3. The risk assessment completed for flora and vegetation is included as Appendix B to this report.

### Table 8.1 Qualitative risk analysis matrix

| Likelihood | Consequence Level | | | | |
|---|---|---|---|---|---|
| | Insignificant | Minor | Moderate | Major | Catastrophic |
| Almost Certain | Medium | High | High | Extreme | Extreme |
| Likely | Medium | Medium | High | High | Extreme |
| Possible | Low | Medium | Medium | High | High |
| Unlikely | Low | Low | Medium | Medium | High |
| Rare | Low | Low | Low | Medium | Medium |

Table 8.2 Definition of level of likelihood

| Level of Likelihood | Definitions |
|---|---|
| **Almost certain** | The event is expected to occur in most circumstances<br>This event could occur at least once during a project of this nature<br>91-100% chance of occurring during the project |
| **Likely** | The event will probably occur in most circumstances<br>This event could occur up to once during a project of this nature<br>51-90% chance of occurring during the project |
| **Possible** | The event could occur but not expected<br>This event could occur up to once every 10 projects of this nature<br>11-50% chance of occurring during the project |
| **Unlikely** | The event could occur but is improbable<br>This event could occur up to once every 10-100 projects of this nature<br>1-10% chance of occurring during the project |
| **Rare** | The event may occur only in exceptional circumstances<br>This event is not expected to occur except under exceptional circumstances (up to once every 100 projects of this nature)<br>Less than 1% chance of occurring during the project |

Table 8.3 Definitions of levels of consequence

| Levels of Consequence | Definitions |
|---|---|
| **Critical** | Extensive long term environmental harm and/or harm that is extremely widespread. Impacts unlikely to be reversible within 10 years. |
| **Major** | Major or widespread, unplanned environmental impact on or off the site. Significant resources required to respond and rehabilitate. |
| **Significant** | Significant, unplanned environmental impact contained within the site or minor impact that is off the site. |
| **Moderate** | Moderate, unplanned localised environmental impact contained on-site or with negligible off-site impact. |
| **Minor** | Minor environmental impact. Any impacts are contained on-site and short term in nature. |

# 9. Conclusion

A combined total of 326 flora species, comprising 319 native species and fifteen exotic species were recorded within the Study area during the 2011 and 2015 survey periods. This represents approximately 28% of all flora species know to occur in the Burt Plain bioregion.

Flora species recorded within the Study area and their associated vegetation communities are relatively common in the region with the exception of a few species. No threatened flora species or vegetation communities were recorded within the Study area however:

- Three flora species recorded within the Study area are listed as near threatened and three species are listed as data deficient under the TPWC Act
- An additional 11 flora species were noted to have bioregional significance.

Based on the fine-scale vegetation mapping and flora sampling undertaken by GHD, a total 14 vegetation communities were identified within the Study area. These vegetation communities each display a degree of variation which is to be expected given the influence of differing fire regimes, grazing pressures, soils, hydrology and geology. Despite these variations, these communities have been defined based on similarities in landscape position, floristics, vegetation structure and patterns.

The dominant vegetation communities within the Study area are:

- Mulga shrublands, which occur on alluvial fans and plains containing clayey red earths
- Mixed woodland which grow on alluvial plains.

Vegetation is generally in good condition with little anthropologic disturbance and high species richness. However, in the more fertile riparian areas and in the floodplains there is clear evidence of impacts associated with cattle grazing; including soil erosion, widespread weeds, and a reduction in ground cover species. In particular, there is a high abundance of the invasive grass *Cenchrus ciliaris* (Buffel Grass). There are also several areas that have been cleared within the mine site and borefields area during geotechnical and hydrological investigations at the site.

The project will result in the removal of approximately 4,161 ha of native vegetation. None of the vegetation communities proposed to be removed has national or regional significance. The majority of the vegetation to be cleared for the project would be from two vegetation communities (Mulga shrubland on sandy red earths (VT 2) and mixed woodland over tussock grasses on alluvial plains (VT 3a)). Both of these communities are well represented at the local and regional scale.

The proposal has the potential to impact on flora and vegetation, or exacerbate existing threatening processes through:

- Clearing of vegetation during construction
- Alteration of hydrological regimes associated with earthworks and construction activities and associated changes to land surface areas, and/or impediments to surface flows
- Introduction and/or spread of invasive exotic flora species
- Changes to fire regimes
- Erosion and sedimentation resulting from vegetation clearing during construction
- Groundwater drawdown and/or changes to groundwater flows impacting groundwater dependent ecosystems

- Contamination of surface and/or groundwater
- Dust emissions from construction, mining and processing activities.

Mitigation measures would be implemented throughout the construction, operation and decommissioning phases of the Project to minimise potential impacts on vegetation and flora.

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# Appendices

# Appendix A - Flora species list

| Family | Species Name | Common Name | Exotic | TPWC Act (NT) | EPBC Act (Cth) | Regional Conservation Code |
|---|---|---|---|---|---|---|
| ACANTHACEAE | *Dipteracanthus australasicus* subsp. *australasicus* | | | | | |
| ACANTHACEAE | *Rostellularia adscendens* | | | | | |
| ADIANTACEAE | *Cheilanthes lasiophylla* | Woolly Cloak Fern | | | | |
| ADIANTACEAE | *Cheilanthes sieberi* subsp. *pseudovellea* | Mulga Fern, Rock Fern | | | | |
| AIZOACEAE | *Trianthema triquetra* | Red Spinach | | | | |
| AMARANTHACEAE | *Achyranthes aspera* | Chaff-flower | | | | |
| AMARANTHACEAE | *Alternanthera angustifolia* | Narrow-leaf Joyweed | | | | |
| AMARANTHACEAE | *Alternanthera nana* | Hairy Joyweed | | | | |
| AMARANTHACEAE | *Amaranthus interruptus* | Native Amaranth | | | | |
| AMARANTHACEAE | *Gomphrena lanata* | | | | | |
| AMARANTHACEAE | *Ptilotus decipiens* | | | | | |
| AMARANTHACEAE | *Ptilotus helipteroides* | Hairy Mulla | | | | |
| AMARANTHACEAE | *Ptilotus incanus* | | | | | |
| AMARANTHACEAE | *Ptilotus macrocephalus* | Large Green Pussy-tails, Feather Heads | | | | |
| AMARANTHACEAE | *Ptilotus obovatus* | Smoke Bush, Silver Bush, Silver Tails | | | | |
| AMARANTHACEAE | *Ptilotus polystachyus* | Long Pussy-tails | | | | |
| AMARANTHACEAE | *Ptilotus schwartzii* | | | | | |
| AMARANTHACEAE | *Ptilotus sessilifolius* | Crimson Foxtail, Silver Tails | | | | |
| APIACEAE | *Trachymene glaucifolia* | Wild Parsnip, Blue Parsnip | | | | |
| APOCYNACEAE | *Carissa lanceolata* | Conkerberry, Conkle Berry, Kungsberry Bush | | | | |
| ASCLEPIADACEAE | *Marsdenia australis* | Bush Banana, Lungkwa, Doubah | | | | |
| ASCLEPIADACEAE | *Rhyncharrhena linearis* | Mulga Bean, Bush Bean, Puya | | | | |

| Family | Species Name | Common Name | Exotic | TPWC Act (NT) | EPBC Act (Cth) | Regional Conservation Code |
|---|---|---|---|---|---|---|
| ASCLEPIADACEAE | *Sarcostemma viminale* subsp. *australe* | Caustic Vine, Pencil Caustic, Milk Bush, Milk Vine | | | | |
| ASTERACEAE | *Bidens bipinnata* | Cobblers Pegs, Beggars Ticks | ✓ | | | |
| ASTERACEAE | *Brachyscome ciliaris complex* | Variable Daisy | | | | |
| ASTERACEAE | *Calotis latiuscula* | Leafy Burr-daisy, Yellow-flowered Burr-daisy | | | | |
| ASTERACEAE | *Centipeda minima* subsp. *minima* | | | | | |
| ASTERACEAE | *Centipeda racemosa* | Erect Sneezeweed | | | | |
| ASTERACEAE | *Centipeda thespidioides* | Desert Sneezeweed, Gilgai Sneezeweed | | | | |
| ASTERACEAE | *Chrysocephalum apiculatum* | Small Yellow Button, Common Everlasting, Yellow Buttons | | | | |
| ASTERACEAE | *Chrysocephalum eremaeum* | Sandhill Everlasting | | | | |
| ASTERACEAE | *Leucochrysum stipitatum* | Spinifex Everlasting | | | | |
| ASTERACEAE | *Pluchea ferdinandi-muelleri* | | | | | |
| ASTERACEAE | *Pluchea rubelliflora* | | | | | |
| ASTERACEAE | *Pterocaulon serrulatum* | Fruit-salad Bush, Apple Bush | | | | |
| ASTERACEAE | *Pterocaulon sphacelatum* | Apple Bush, Bush Vicks | | | | |
| ASTERACEAE | *Senecio magnificus* | Perennial Yellowtop, Tall Yellowtop, Rubbish Daisy | | | | |
| ASTERACEAE | *Streptoglossa odora* | Aromatic Daisy | | | | |
| ASTERACEAE | *Vittadinia obovata* | | | NT | | |
| ASTERACEAE | *Vittadinia pustulata* | | | | | |
| BORAGINACEAE | *Heliotropium cunninghamii* | | | | | |
| BORAGINACEAE | *Heliotropium tanythrix* | | | | | |
| BORAGINACEAE | *Trichodesma zeylanicum* var. *zeylanicum* | Cattle Bush, Camel Bush | | | | |

| Family | Species Name | Common Name | Exotic | TPWC Act (NT) | EPBC Act (Cth) | Regional Conservation Code |
|---|---|---|---|---|---|---|
| BRUNONIACEAE | *Brunonia australis* | Pincushion, Blue Pincushion | | | | |
| CAESALPINIACEAE | *Petalostylis cassioides* | Petalostylis | | | | |
| CAESALPINIACEAE | *Senna artemisioides nothosubsp. artemisioides* | Silver Cassia | | | | |
| CAESALPINIACEAE | *Senna artemisioides* subsp. *sturtii* | Dense Cassia | | | | |
| CAESALPINIACEAE | *Senna artemisioides* subsp. *alicia* | | | | | |
| CAESALPINIACEAE | *Senna artemisioides* subsp. *filifolia* | Desert Cassia, Broom Bush, Punty Bush | | | | |
| CAESALPINIACEAE | *Senna artemisioides* subsp. *helmsii* | Blunt-leaf Cassia | | | | |
| CAESALPINIACEAE | *Senna artemisioides* subsp. *quadrifolia* | | | | | |
| CAESALPINIACEAE | *Senna glutinosa* subsp. *glutinosa* | | | | | |
| CAESALPINIACEAE | *Senna glutinosa* subsp. *pruinosa* | | | | | |
| CAESALPINIACEAE | *Senna pleurocarpa* var. *pleurocarpa* | Chocolate Bush | | | | |
| CAESALPINIACEAE | *Senna venusta* | Graceful Cassia | | | | |
| CAMPANULACEAE | *Wahlenbergia queenslandica* | Bluebell | | | | |
| CAPPARACEAE | *Capparis mitchellii* | Wild Orange, Native Orange, Bumble, Native Pomegranate | | | | |
| CAPPARACEAE | *Cleome viscosa* | Tickweed, Mustard Bush | | | | |
| CARYOPHYLLACEAE | *Polycarpaea corymbosa* | | | | | |
| CHENOPODIACEAE | *Atriplex elachophylla* | Annual Saltbush, Saltbush | | | | |
| CHENOPODIACEAE | *Chenopodium auricomum* | Northern Bluebush, Swamp Bluebush | | | | |
| CHENOPODIACEAE | *Dissocarpus paradoxus* | Cannon-ball Saltbush, Curious Saltbush, Hard-head Saltbush | | | | |

| Family | Species Name | Common Name | Exotic | TPWC Act (NT) | EPBC Act (Cth) | Regional Conservation Code |
|---|---|---|---|---|---|---|
| CHENOPODIACEAE | *Dysphania kalpari* | Rat-tail Goosefoot, Kalpari | | | | |
| CHENOPODIACEAE | *Dysphania melanocarpa* | Black-fruited Goosefoot, Black Crumbweed | | | | |
| CHENOPODIACEAE | *Einadia nutans* subsp. *eremaea* | Climbing Saltbush | | | | |
| CHENOPODIACEAE | *Enchylaena tomentosa* | Ruby Saltbush, Sturts Saltbush, Plum Puddings, Berry Cottonbush | | | | |
| CHENOPODIACEAE | *Eremophea spinosa* | | | | | |
| CHENOPODIACEAE | *Maireana aphylla* | Cottonbush, Leafless Bluebush | | | | BRT (northern range limit) |
| CHENOPODIACEAE | *Maireana georgei* | Golden Bluebush, Satiny Bluebush | | | | |
| CHENOPODIACEAE | *Maireana planifolia* | | | | | |
| CHENOPODIACEAE | *Maireana scleroptera* | | | | | BRT (northern range limit) |
| CHENOPODIACEAE | *Maireana villosa* | Silky Bluebush | | | | |
| CHENOPODIACEAE | *Rhagodia eremaea* | Tall Saltbush | | | | |
| CHENOPODIACEAE | *Salsola tragus* | Buckbush, Rolypoly, Tumbleweed | | | | |
| CHENOPODIACEAE | *Sclerolaena bicornis* var. *bicornis* | Goathead Burr, Bassia Burr | | | | |
| CHENOPODIACEAE | *Sclerolaena convexula* | Tall Copper Burr | | | | |
| CHENOPODIACEAE | *Sclerolaena cornishiana* | Cartwheel Burr | | | | |
| CHENOPODIACEAE | *Sclerolaena costata* | | | | | |
| CHENOPODIACEAE | *Sclerolaena cuneata* | Succulent Copper Burr | | | | |
| CHENOPODIACEAE | *Sclerolaena diacantha* s.lat. | Grey Copper Burr, Horned Saltbush | | | | |
| CHENOPODIACEAE | *Sclerolaena lanicuspis* | Woolly Copper Burr | | | | |
| CHENOPODIACEAE | *Sclerolaena* sp. Saline soils *(D.E.Albrecht 6723)* | | | NE~ | | |
| COMMELINACEAE | *Commelina ensifolia* | Wandering Jew | | | | |
| CONVOLVULACEAE | *Convolvulus remotus* | | | | | BRT (rare) |

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|---|---|---|---|---|---|---|
| CONVOLVULACEAE | *Evolvulus alsinoides* var. *villosicalyx* | Blue Periwinkle, Tropical Speedwell | | | | |
| CONVOLVULACEAE | *Ipomoea muelleri* | Native Morning Glory | | | | |
| CONVOLVULACEAE | *Ipomoea racemigera* | | | | | |
| CUCURBITACEAE | *Austrobryonia centralis* | Kangaroo Balls | | | | |
| CUCURBITACEAE | *Citrullus lanatus* | Paddy Melon, Pie Melon, Wild Melon, Camel Melon | ✓ | | | |
| CUCURBITACEAE | *Cucumis argenteus* | Head-ache Vine | | | | |
| CUPRESSACEAE | *Callitris glaucophylla* | Native Pine, White Cypress Pine | | | | |
| CUSCUTACEAE | *Cuscuta victoriana* | | | | | |
| CYPERACEAE | *Bulbostylis barbata* | Short-leaved Rush | | | | |
| CYPERACEAE | *Cyperus iria* | | | | | |
| CYPERACEAE | *Cyperus squarrosus* | Bearded Flat-sedge | | | | |
| CYPERACEAE | *Eleocharis pallens* | Pale Spike-rush | | | | |
| CYPERACEAE | *Fimbristylis dichotoma* | Eight Day Grass, Common Fringe-rush | | | | |
| CYPERACEAE | *Fimbristylis eremophila* | Desert Fringe-rush | | | | |
| EUPHORBIACEAE | *Euphorba papillata* var. *papillata* | | | | | |
| EUPHORBIACEAE | *Euphorbia albrechtii* | | | | | |
| EUPHORBIACEAE | *Euphorbia boophthona* | Bottletree Caustic, Gascoyne Spurge | | | | |
| EUPHORBIACEAE | *Euphorbia centralis* | | | | | |
| EUPHORBIACEAE | *Euphorbia drummondii* | Caustic Weed, Caustic Creeper, Mat Spurge | | | | |
| EUPHORBIACEAE | *Euphorbia ferdinandii* | | | DD | | |
| EUPHORBIACEAE | *Euphorbia tannensis* | Caustic Bush, Desert Spurge | | | | |
| EUPHORBIACEAE | *Phyllanthus* sp. *Broad tuberculate seeds (B.G.Thomson 2370)* | | | | | |
| EUPHORBIACEAE | *Sauropus trachyspermus* | Slender Spurge | | | | |

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|---|---|---|---|---|---|---|
| FABACEAE | *Crotalaria eremaea* subsp. *strehlowii* | Rattlepod, Desert Rattlepod | | | | |
| FABACEAE | *Crotalaria smithiana* | Yellow Rattlepod | | | | |
| FABACEAE | *Cullen australasicum* | Tall Verbine | | | | |
| FABACEAE | *Erythrina vespertilio* | Bean Tree, Batswing Coral Tree | | | | |
| FABACEAE | *Glycine canescens* | Silky Glycine | | | | |
| FABACEAE | *Indigofera colutea* | Sticky Indigo | | | | |
| FABACEAE | *Indigofera erubescens* | | | | | |
| FABACEAE | *Indigofera hirsuta* | Hairy Indigo | | | | |
| FABACEAE | *Indigofera leucotricha* | Silver Indigo, White Indigo | | | | |
| FABACEAE | *Indigofera linifolia* | Native Indigo | | | | |
| FABACEAE | *Indigofera linnaei* | Birdsville Indigo, Nine-leaved Indigo | | | | |
| FABACEAE | *Leptosema chambersii* | Upside-down Plant, Chambers Leptosema | | | | |
| FABACEAE | *Lotus cruentus* s.lat. | Red-flower Trefoil, Pink-flower Tefoil | | | | |
| FABACEAE | *Rhynchosia minima* | Native Pea, Rhynchosia | | | | |
| FABACEAE | *Swainsona phacoides* s.lat. | Dwarf Swainsona, Woodland Swainsona | | | | BRT (northern range limit) |
| FABACEAE | *Tephrosia* sp, *Granite* | | | | | |
| FABACEAE | *Tephrosia* sp. *Willowra (G.M.Chippendale 4809)* | | | | | |
| FABACEAE | *Tephrosia sphaerospora* | Mulga Trefoil | | | | |
| FABACEAE | *Tephrosia supina* | | | | | |
| GOODENIACEAE | *Goodenia goodeniacea* | Sandplain Goodenia | | | | |
| GOODENIACEAE | *Goodenia heterochila* | Serrated Goodenia | | | | |
| GOODENIACEAE | *Goodenia larapinta* | Stick Hand-flower | | | | |
| GOODENIACEAE | *Goodenia lunata* | Heavy-soil Hand-flower | | | | |
| GOODENIACEAE | *Goodenia modesta* | | | | | |
| GOODENIACEAE | *Goodenia triodiophila* | Spinifex Goodenia | | | | |

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|---|---|---|---|---|---|---|
| GOODENIACEAE | *Goodenia vilmoriniae* | Purple Hand-flower | | | | |
| GOODENIACEAE | *Scaevola ovalifolia* | Bushy Fanflower | | | | |
| GOODENIACEAE | *Scaevola parvifolia* subsp. *parvifolia* | Fanflower | | | | |
| GYROSTEMONACEAE | *Codonocarpus cotinifolius* | Desert Poplar, Firebush, Native Poplar, Western Bell Fruit | | | | |
| LAMIACEAE | *Prostanthera striatiflora* | Striped Mint-bush | | | | BRT (northern range limit) |
| LORANTHACEAE | *Amyema maidenii* subsp. *maidenii* | Pale-leaf Mistletoe | | | | |
| LORANTHACEAE | *Lysiana spathulata* | Flat-leaved Mistletoe | | | | |
| LORANTHACEAE | *Lysiana subfalcata* | | | | | |
| MALVACEAE | *Abutilon fraseri* subsp. *fraseri* | Dwarf Lantern-bush | | | | |
| MALVACEAE | *Abutilon lepidum* | | | NT | | |
| MALVACEAE | *Abutilon leucopetalum* | Desert Lantern-bush | | | | |
| MALVACEAE | *Abutilon macrum* | Slender Lantern-bush | | | | |
| MALVACEAE | *Abutilon otocarpum* | Keeled Lantern-bush, Desert Chinese Lantern, Desert Lantern | | | | |
| MALVACEAE | *Gossypium australe* | Native Cotton, Tall Desert Rose | | | | |
| MALVACEAE | *Gossypium bickii* | Low Desert Rose | | | | |
| MALVACEAE | *Gossypium sturtianum* var. *sturtianum* | Sturts Desert Rose | | | | |
| MALVACEAE | *Hibiscus burtonii* | Burtons Hibiscus | | | | |
| MALVACEAE | *Hibiscus solanifolius* | Tomato-leaved Hibiscus | | | | |
| MALVACEAE | *Hibiscus sturtii* var. *campylochlamys* | Sturts Hibiscus | | | | |
| MALVACEAE | *Hibiscus sturtii* var. *grandiflorus (granite form)* | Sturts Hibiscus | | | | |
| MALVACEAE | *Hibiscus sturtii var. platychlamys* | Sturts Hibiscus | | | | |

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|---|---|---|---|---|---|---|
| MALVACEAE | *Malvastrum americanum* | Malvastrum, Spiked Malvastrum | ✓ | | | |
| MALVACEAE | *Sida ammophila* | Sand Sida | | | | |
| MALVACEAE | *Sida cunninghamii* | | | | | |
| MALVACEAE | *Sida fibulifera* | Silver Sida, Pin Sida | | | | |
| MALVACEAE | *Sida filiformis* s.lat. | Fire Sida, Fine Sida | | | | |
| MALVACEAE | *Sida platycalyx* | Lifesaver Burr, Teddy Bears Arsehole | | | | |
| MALVACEAE | *Sida rohlenae* subsp. *rohlenae* | Shrub Sida | | | | |
| MALVACEAE | *Sida sp. Bond Springs (D.J.Nelson 2538)* | | | | | |
| MALVACEAE | *Sida* sp. Kathleen Springs *(A.C.Beauglehole 26934)* | | | | | |
| MALVACEAE | *Sida* sp. *Pindan (B.G.Thomson 3398)* | | | | | |
| MALVACEAE | *Sida* sp. Rainbow Valley *(D.E.Albrecht 6601)* | | | | | |
| MALVACEAE | *Sida* sp. *Wakaya Desert (P.K.Latz 11894)* | | | | | |
| MARSILEACEAE | *Marsilea exarata* | Swayback Nardoo, Little Nardoo | | | | |
| MENISPERMACEAE | *Tinospora smilacina* | Snake Vine | | | | |
| MIMOSACEAE | *Acacia adsurgens* | Whipstick Wattle, Sugar Brother | | | | |
| MIMOSACEAE | *Acacia aneura* | Mulga | | | | |
| MIMOSACEAE | *Acacia aneura* var. *conifera* | Christmas Tree Mulga | | DD | | |
| MIMOSACEAE | *Acacia aptaneura* | Mulga | | | | |
| MIMOSACEAE | *Acacia ayersiana* | Ayers Rock Mulga, Uluru Mulga | | | | |
| MIMOSACEAE | *Acacia bivenosa* | Hill Umbrella Bush | | | | |
| MIMOSACEAE | *Acacia cuthbertsonii* subsp. *cuthbertsonii* | Silver Witchetty, Pirli | | | | |

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|---|---|---|---|---|---|---|
| MIMOSACEAE | *Acacia estrophiolata* | Ironwood, Southern Ironwood | | | | |
| MIMOSACEAE | *Acacia kempeana* | Witchetty Bush | | | | |
| MIMOSACEAE | *Acacia ligulata* | Umbrella Bush, Dune Wattle, Small Cooba | | | | |
| MIMOSACEAE | *Acacia maitlandii* | Maitlands Wattle, Spiny-leaved Wattle | | | | |
| MIMOSACEAE | *Acacia melleodora* | Waxy Wattle | | | | |
| MIMOSACEAE | *Acacia minyura* | Desert Mulga | | | | |
| MIMOSACEAE | *Acacia murrayana* | Colony Wattle, Murrays Wattle | | | | BRT (northern range limit) |
| MIMOSACEAE | *Acacia sericophylla* | | | | | |
| MIMOSACEAE | *Acacia sericophylla* | Dogwood, Wirewood | | | | |
| MIMOSACEAE | *Acacia spondylophylla* | Curry Wattle, Spine-leaf Wattle | | | | |
| MIMOSACEAE | *Acacia tenuissima* | Broom Wattle, Minyana | | | | |
| MIMOSACEAE | *Acacia tetragonophylla* | Dead Finish, Kurara | | | | |
| MIMOSACEAE | *Acacia victoriae* | Acacia Bush, Bramble Wattle, Victoria Wattle | | | | |
| MIMOSACEAE | *Vachellia farnesiana* var. *farnesiana* | Mimosa Bush, Sweet Acacia, Sweet Wattle, Prickly Mimosa | ✓ | | | |
| MYOPORACEAE | *Eremophila duttonii* | Harlequin Fuchsia-bush, Red Poverty Bush | | | | |
| MYOPORACEAE | *Eremophila freelingii* | Rock Fuchsia Bush | | | | |
| MYOPORACEAE | *Eremophila gilesii* subsp. *gilesii* | Mulga Fuchsia, Giles Desert Fuchsia, Turkey Bush | | | | |
| MYOPORACEAE | *Eremophila latrobei* subsp. *glabra* | Native Fuchsia | | | | |
| MYOPORACEAE | *Eremophila longifolia* | Emu Bush, Weeping Emu Bush, Long-leaved Desert Fuchsia | | | | |

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|---|---|---|---|---|---|---|
| MYOPORACEAE | *Eremophila sturtii* | Turpentine Bush, Sturts Desert Fuchsia, Narrow-leaved Emu-bush | | | | |
| MYRTACEAE | *Corymbia aparrerinja* | Ghost Gum, White Gum, Desert White Gum | | | | |
| MYRTACEAE | *Corymbia opaca* | Bloodwood | | | | |
| MYRTACEAE | *Eucalyptus camaldulensis* subsp. *arida* | River Red Gum | | | | |
| MYRTACEAE | *Eucalyptus coolabah* subsp. *arida* | Coolabah | | | | |
| MYRTACEAE | *Eucalyptus gamophylla* | Blue Mallee, Twin-leaved Mallee, Blue-leaved Mallee | | | | |
| MYRTACEAE | *Eucalyptus pachyphylla* | Red-bud Mallee | | | | |
| MYRTACEAE | *Melaleuca glomerata* | Inland Teatree | | | | |
| NYCTAGINACEAE | *Boerhavia coccinea* | Tar Vine | | | | |
| NYCTAGINACEAE | *Boerhavia repleta* | | | | | |
| OLEACEAE | *Jasminum didymum subsp. lineare* | Native Jasmine, Wild Jasmine | | | | |
| PITTOSPORACEAE | *Pittosporum angustifolium* | Native Apricot, Weeping Pittosporum, Native Willow | | | | |
| POACEAE | *Aristida arida* | | | | | BRT (northern range limit) |
| POACEAE | *Aristida biglandulosa* | Cane Grass Three-awn, Two-gland Three-awn | | | | |
| POACEAE | *Aristida contorta* | Bunched Kerosene Grass, Mulga Grass | | | | |
| POACEAE | *Aristida holathera* var. *holathera* | Erect Kerosene Grass, White Grass, Arrow Grass | | | | |
| POACEAE | *Aristida hygrometrica* | Northern Kerosene Grass, Corkscrew Grass | | | | BRT (rare, disjunct) |
| POACEAE | *Aristida inaequiglumis* | Curly Wiregrass, Fire Grass, Unequal Three-awn | | | | |
| POACEAE | *Aristida nitidula* | Flat-awned Three-awn | | | | |

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|---|---|---|---|---|---|---|
| POACEAE | *Aristida obscura* | Brush Three-awn, Brush Wiregrass | | | | |
| POACEAE | *Bothriochloa ewartiana* | Desert Bluegrass | | | | |
| POACEAE | *Cenchrus ciliaris* | Buffel Grass | ✓ | | | |
| POACEAE | *Chloris barbata* | Purple-top Chloris, Purple-top Rhodes Grass | ✓ | | | |
| POACEAE | *Chrysopogon fallax* | Golden Beard Grass, Ribbon Grass, Weeping Grass, Spear Grass | | | | |
| POACEAE | *Cymbopogon ambiguous* | Lemon-scented Grass, Native Lemon Grass, Scent Grass, Scented Oil grass | | | | |
| POACEAE | *Cymbopogon obtectus* | Silkyheads, Lemon-scented Grass | | | | |
| POACEAE | *Cynodon dactylon* var. *dactylon* | Couch Grass | ✓ | | | |
| POACEAE | *Dactyloctenium radulans* | Button Grass, Finger Grass, Toothbrush Grass | | | | |
| POACEAE | *Digitaria brownii* | Cotton Panic Grass | | | | |
| POACEAE | *Digitaria ciliaris* | Summer Grass | ✓ | | | |
| POACEAE | *Digitaria coenicola* | Umbrella Grass, Finger Panic Grass | | | | |
| POACEAE | *Digitaria ctenantha* | Comb Finger Grass | | | | |
| POACEAE | *Digitaria hystrichoides* | Curly Umbrella Grass, Summer Grass | | NT | | |
| POACEAE | *Enneapogon avenaceus* | Native Oat-grass, Bottlewashers | | | | |
| POACEAE | *Enneapogon clelandii* | Conetop Nine-awn, Clelands Nine-awn | | | | |
| POACEAE | *Enneapogon cylindricus* | Jointed Nine-awn, Limestone Oat-grass, Jointed Bottlewasher | | | | |
| POACEAE | *Enneapogon polyphyllus* | Woolly Oat-grass, Oat-grass, Leafy Nine-awn | | | | |

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|---|---|---|---|---|---|---|
| POACEAE | *Enteropogon acicularis* s.lat. | Curly Windmill Grass, Umbrella Grass, Spider grass | | | | |
| POACEAE | *Enteropogon ramosus* | Creek Windmill Grass, Curly Windmill Grass | | | | |
| POACEAE | *Eragrostis barrelieri* | Pitted Lovegrass | ✓ | | | |
| POACEAE | *Eragrostis cumingii* | Fairy Grass, Cumings Lovegrass | | | | |
| POACEAE | *Eragrostis dielsii* | Mallee Lovegrass | | | | |
| POACEAE | *Eragrostis elongata* | Clustered Lovegrass, Close-headed Lovegrass | | | | |
| POACEAE | *Eragrostis eriopoda subsp. Red earth (D.J.Nelson 1651)* | | | | | |
| POACEAE | *Eragrostis eriopoda subsp. Sandy fireweed (P.K.Latz 12908)* | | | | | |
| POACEAE | *Eragrostis kennedyae* | Small-flowered Lovegrass | | | | |
| POACEAE | *Eragrostis lanicaulis* | | | DD | | |
| POACEAE | *Eragrostis laniflora* | Hairy-flowered Woollybutt | | | | |
| POACEAE | *Eragrostis leptocarpa* | Drooping Lovegrass | | | | |
| POACEAE | *Eragrostis setifolia* | Neverfail, Narrow-leaf Neverfail | | | | |
| POACEAE | *Eragrostis speciosa* | Handsome Lovegrass | | | | |
| POACEAE | *Eragrostis trichophora* | | ✓ | | | |
| POACEAE | *Eragrostis xerophila* | Knottybutt Neverfail | | | | |
| POACEAE | *Eriachne aristidea* | Three-awn Wanderrie | | | | |
| POACEAE | *Eriachne helmsii* | Woollybutt Wanderrie | | | | |
| POACEAE | *Eriachne mucronata* | Mountain Wanderrie | | | | |
| POACEAE | *Eriachne obtusa* var. *Short narrow inflorescence (R.B.Brown 267)* | Northern Wanderrie, Wiregrass | | | | |
| POACEAE | *Eriachne pulchella* | Pretty Wanderrie | | | | |

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|---|---|---|---|---|---|---|
| POACEAE | *Eulalia aurea* | Silky Browntop, Sugar Grass | | | | |
| POACEAE | *Leptochloa fusca* subsp. *muelleri* | Brown Beetle Grass | | | | |
| POACEAE | *Monachather paradoxus* | Bandicoot Grass, Mulga Oats | | | | |
| POACEAE | *Neurachne munroi* | Dwarf Mulga Grass | | | | |
| POACEAE | *Oxychloris scariosa* | Winged Chloris | | | | |
| POACEAE | *Panicum decompositum* var. *decompositum* | Native Millet, Native Panic, Australian Millet | | | | |
| POACEAE | *Panicum effusum* | Hairy Panic | | | | |
| POACEAE | *Paspalidium clementii* | Clements Paspalidium | | | | |
| POACEAE | *Paspalidium rarum* | Bunch Paspalidium | | | | |
| POACEAE | *Paspalidium reflexum* | | | | | |
| POACEAE | *Perotis rara* | Comet Grass | | | | |
| POACEAE | *Schizachyrium fragile* | Firegrass, Red Spathe Grass, Small Red-leaf | | | | |
| POACEAE | *Sporobolus actinocladus* | Katoora | | | | |
| POACEAE | *Sporobolus australasicus* | Australian Dropseed | | | | |
| POACEAE | *Sporobolus blakei* | | | | | |
| POACEAE | *Themeda avenacea* | Swamp Kangaroo Grass | | | | |
| POACEAE | *Themeda triandra* | Kangaroo Grass | | | | |
| POACEAE | *Thyridolepis mitchelliana* | Window Mulga Grass, Mulga Mitchell Grass, Mulga Grass | | | | BRT (northern range limit) |
| POACEAE | *Tragus australianus* | Small Burr-grass, Sock Grass, Tickgrass | | | | |
| POACEAE | *Triodia basedowii* | Hard Spinifex, Lobed Spinifex | | | | |
| POACEAE | *Triodia hubbardii* | Hubbards Spinifex | | | | |
| POACEAE | *Triodia schinzii* | Feathertop Spinifex | | | | |
| POACEAE | *Triodia spicata* | Spike-flowered Spinifex | | | | |

| Family | Species Name | Common Name | Exotic | TPWC Act (NT) | EPBC Act (Cth) | Regional Conservation Code |
|---|---|---|---|---|---|---|
| POACEAE | *Tripogon loliiformis* | Five-minute Grass, Rye Beetle Grass | | | | |
| POACEAE | *Urochloa holosericea* | Silky-top Armgrass | | | | |
| POACEAE | *Urochloa piligera* | Hairy Armgrass, Hairy Summer Grass, Green Summer Grass | | | | |
| POACEAE | *Yakirra australiensis* var. *australiensis* | Desert Flinders Grass | | | | |
| PORTULACACEAE | *Calandrinia balonensis* | Broad-leaf Parakeelya | | | | |
| PORTULACACEAE | *Calandrinia stagnensis* | | | | | |
| PORTULACACEAE | *Portulaca filifolia* s.lat. | Slender Pigweed | | | | |
| PORTULACACEAE | *Portulaca oleracea* var. *Undoolya (R.A.Perry 3267)* | Munyeroo | | | | |
| PROTEACEAE | *Grevillea juncifolia* subsp. *juncifolia* | Desert Grevillea, Honey Grevillea, Honeysuckle Grevillea | | | | |
| PROTEACEAE | *Grevillea striata* | Beefwood | | | | |
| PROTEACEAE | *Grevillea wickhamii* subsp. *aprica* | Holly-leaf Grevillea | | | | |
| PROTEACEAE | *Hakea divaricata* | Fork-leaved Corkwood | | | | |
| PROTEACEAE | *Hakea leucoptera* subsp. *leucoptera* | Needlewood, Needle Bush, Needle Hakea | | | | |
| PROTEACEAE | *Hakea lorea* subsp. *lorea* | Southern Long-leaf Corkwood | | | | |
| PROTEACEAE | *Hakea macrocarpa* | Flat-leaved Hakea | | | | |
| RHAMNACEAE | *Ventilago viminalis* | Supplejack, Vine Tree | | | | |
| RUBIACEAE | *Oldenlandia mitrasacmoides* subsp. *mitrasacmoides* | | | | | BRT (southern range limit) |
| RUBIACEAE | *Psydrax ammophila* | | | | | |
| RUBIACEAE | *Psydrax latifolia* | Native Currant, Orange Bush | | | | |
| RUBIACEAE | *Psydrax suaveolens* | Mulga Native Currant | | | | |

| Family | Species Name | Common Name | Exotic | TPWC Act (NT) | EPBC Act (Cth) | Regional Conservation Code |
|---|---|---|---|---|---|---|
| RUBIACEAE | *Synaptantha tillaeacea* var. *tillaeacea* | Synaptantha | | | | |
| SANTALACEAE | *Anthobolus leptomerioides* | Desert Broombush, Uta-wuta | | | | |
| SANTALACEAE | *Exocarpos sparteus* | Slender Cherry, Broombush | | | | |
| SANTALACEAE | *Santalum lanceolatum* | Plumbush, Wild Plum | | | | |
| SAPINDACEAE | *Atalaya hemiglauca* | Whitewood | | | | |
| SCROPHULARIACEAE | *Buchnera linearis* | Dainty Bush Flower | | | | |
| SCROPHULARIACEAE | *Stemodia viscosa* | Sticky Blue-rod, Pinty-pinty | | | | |
| SOLANACEAE | *Nicotiana rosulata* subsp. *ingulba* | Sandhill Pituri, Native Tobacco | | | | |
| SOLANACEAE | *Nicotiana simulans* | Native Tobacco | | | | |
| SOLANACEAE | *Solanum aridicola* | Native Tomato, Potato Bush, Potato Weed | | | | |
| SOLANACEAE | *Solanum centrale* | Desert Raisin, Kampurarrpa | | | | |
| SOLANACEAE | *Solanum cleistogamum* | Shy Nightshade | | | | |
| SOLANACEAE | *Solanum ferocissimum* | Spiny Potato Bush | | | | |
| SOLANACEAE | *Solanum lithophilum* | Native Tomato, Potato Bush, Potato Weed | | | | |
| SOLANACEAE | *Solanum quadriloculatum* | Wild Tomato, Tomato Bush | | | | |
| STACKHOUSIACEAE | *Macgregoria racemigera* | Spinifex Snow, Desert Snow, Carpet-of-Snow | | | | |
| STERCULIACEAE | *Androcalva loxophylla* | Desert Fire Weed | | | | |
| STERCULIACEAE | *Keraudrenia nephrosperma* | | | | | |
| STERCULIACEAE | *Melhania oblongifolia* | Velvet Hibiscus | | | | |
| STERCULIACEAE | *Waltheria indica* | | | | | |
| TILIACEAE | *Corchorus sidoides* | Flannel Weed | | | | |
| VERBENACEAE | *Clerodendrum floribundum* | Smooth Clerodendrum, Smooth Spiderbush, Lollybrush, Lolly Bush | | | | |
| VERBENACEAE | *Dicrastylis lewellinii* | Purple Sand-sage | | | | |
| VERBENACEAE | *Newcastelia cephalantha* | | | | | |

| Family | Species Name | Common Name | Exotic | TPWC Act (NT) | EPBC Act (Cth) | Regional Conservation Code |
|---|---|---|---|---|---|---|
| VERBENACEAE | *Spartothamnella teucriiflora* | Mulga Stick-plant, Scented Stick-plant | | | | BRT (northern range limit) |
| VIOLACEAE | *Hybanthus aurantiacus* | Orange Spade Flower | | | | |
| ZYGOPHYLLACEAE | *Tribulopis angustifolia* | | | | | |
| ZYGOPHYLLACEAE | *Tribulus astrocarpus* | Mulga Caltrop, Star-burr | | | | |
| ZYGOPHYLLACEAE | *Tribulus eichlerianus* | Bindieye | | | | |
| ZYGOPHYLLACEAE | *Tribulus macrocarpus* | Winged-fruit Caltrop | | | | |
| ZYGOPHYLLACEAE | *Tribulus terrestris* s.lat. | Cat-head, Caltrop, Bindieye | ✓ | NE | | |

Key : NT = near threatened, DD = data deficient, NE = not evaluated, BRT = Burt Plain bioregion

# Appendix B – Risk assessment

## Project risk – flora and vegetation

| Source of Impact | Consequence | Minimising, mitigation and management actions | Residual Risk | | | Level of certainty |
|---|---|---|---|---|---|---|
| | | | Consequen | likelihood | Residual Risk | |
| Site establishment (including vegetation clearing and soil compaction) results in altered environment character and modification to ecological processes from construction of Project | Reduction of terrestrial flora and fauna habitat locally and/or regionally. | Develop and implement a Biodiversity Management Plan (BMP), including:<br>-Plans to minimise vegetation clearing where possible particularly within sensitive vegetation communities<br>- Where possible apply buffer widths recommended by the Northern Territory Land Clearing Guidelines in riparian areas<br>- Procedures for demarcating the limits of clearing, and no-go areas<br>- Use of already-disturbed areas (rather than undisturbed areas) wherever possible (e.g. lay down areas for construction).<br>- Staged clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with ESCP.<br>- Avoid land clearing for construction during the Wet Season- Develop and implement Vegetation Clearing sub plans which include areas not to be cleared (no-go areas).<br>Development and implementation of a land stabilisation and revegetation strategy<br>- Weed removal prior to vegetation clearing so that vegetative material would be clean and able to be mulched and reused directly on site. | Minor | Unlikely | Low | Medium |
| | Adverse impact on habitat critical to the survival of a species or community. | | | | | |
| | Fragment or damage habitat important for the conservation of biological diversity. | | | | | |
| | Cause a long term reduction in rare, endemic or unique plant populations or species. | | | | | |
| | Modification, destruction, removal or isolation of habitat availability or quality such that a threatened species or community is likely to decline. | | | | | |
| | Loss of sensitive vegetation outside known impact area, including reduction in riparian vegetation along watercourses and drainage channels. | | | | | |

| Source of Impact | Consequence | Minimising, mitigation and management actions | Residual Risk | | | Level of certainty |
|---|---|---|---|---|---|---|
| | | | Consequen | likelihood | Residual Risk | |
| | Increased likelihood of weed establishment in cleared areas. | -Development and implementation of a Weed Management sub-plan as part of the Project BMP and would include.<br>-Information regarding type and location of weeds of concern within the Nolans site<br>-Description of sensitive receivers (such as native vegetation and waterways)<br>-Measures to prevent the spread of weeds, including hygiene procedures for equipment, footwear and clothing<br>-Mitigation measures to minimise the spread of weeds such as ensuring that any machinery entering the Nolans site is free of weed seed. This would typically be managed through the use of vehicle wash down stations<br>-Keeping vehicles to established tracks and roads, and limiting the use of vehicles off-road<br>-Protocols for weed removal prior to vegetation clearing so that vegetative material would be clean and able to be mulched and reused directly on site.<br>-Proposed weed control methods and targeted areas<br>-Weed disposal protocols<br>-Weed spraying program as required<br>-Annual weed monitoring and mapping. | Minor | Unlikely | Low | Medium |

| Source of Impact | Consequence | Minimising, mitigation and management actions | Residual Risk | | | Level of certainty |
|---|---|---|---|---|---|---|
| | | | Consequen | likelihood | Residual Risk | |
| Construction of linear infrastructure (e.g. access tracks, water supply pipelines, powerlines etc.) results in reduction in native vegetation and disturbance of habitat. | Loss of native vegetation allowing for weed establishment, along exposed edges and in cleared areas. | Development and implementation of a Weed Management sub-plan as part of the Project BMP and would include.<br>-Information regarding type and location of weeds of concern within the Nolans site<br>-Description of sensitive receivers (such as native vegetation and waterways)<br>-Measures to prevent the spread of weeds, including hygiene procedures for equipment, footwear and clothing<br>-Mitigation measures to minimise the spread of weeds such as ensuring that any machinery entering the Nolans site is free of weed seed. This would typically be managed through the use of vehicle wash down stations<br>-Keeping vehicles to established tracks and roads, and limiting the use of vehicles off-road<br>-Protocols for weed removal prior to vegetation clearing so that vegetative material would be clean and able to be mulched and reused directly on site.<br>-Proposed weed control methods and targeted areas<br>-Weed disposal protocols<br>-Weed spraying program as required<br>-Annual weed monitoring and mapping. | Minor | Unlikely | Low | Medium |

| Source of Impact | Consequence | Minimising, mitigation and management actions | Residual Risk | | | Level of certainty |
|---|---|---|---|---|---|---|
| | | | Consequen | likelihood | Residual Risk | |
| Transport of materials, vehicle movements and inappropriate waste management allows for introduction of new weeds and spread of existing weeds during construction and operation phases. | Modify or inhibit ecological processes and/or<br>reduction in the diversity or modify the composition of vegetation communities. | Development of a Weed Management Plan to document mitigation measures to control existing weeds, and to stem the spread of others. To include:<br>- Cleaning vehicles (brushdown facilities) that are new to the site, to prevent the introduction of new weeds<br>- Keeping vehicles to established tracks and roads, and limiting the use of vehicles off-road<br>- Annual monitoring of the Nolans site (including rehabilitated areas) and surrounding vegetation to identify new weed populations and monitor the effectiveness of weed control measures - Weed control activities in consultation/partnership with Aileron / Napperby Station owners during borefield construction. | Minor | Possible | Medium | Medium |
| Wind erosion mobilising dust from exposed surfaces, such as from pits, waste dumps, tailings storage facility, laydown areas, stockpiles, roads and sites of vegetation clearing. | Dust deposition leading to disturbance / loss of general terrestrial flora species and vegetation communities.<br>Modify or inhibit ecological processes<br>Reduce the diversity or modify the composition of vegetation communities. | Develop and implement a Dust Management Plan which would include<br>standard dust mitigation procedures such as:<br>Use of water sprays on haul roads, unsealed surfaces, covering of exposed loads where practicable and maintaining moisture levels in bulk loose construction materials<br>Minimising hauling and vehicle travel in conditions when wind strength results in spatially extensive and heavy dust deposition in surrounding habitats<br>Reduced vehicle speeds for high-use areas/roads<br>Minimise open areas exposed to wind erosion<br>- Topsoil striping to occur only during suitable wind and weather conditions<br>- Minimise time between top soil stripping and construction/mining operations<br>- Wetting of ore before crushing and design controls such as use of hooded crusher, covered conveyor and an enclosed HPRG.<br>- Ongoing dust deposition monitoring program<br>Progressive reinstatement of cleared land as construction works are completed to minimise exposed material and dust generation. | Insignificant | Unlikely | Low | Medium |

| Source of Impact | Consequence | Minimising, mitigation and management actions | Residual Risk | | | Level of certainty |
|---|---|---|---|---|---|---|
| | | | Consequen | likelihood | Residual Risk | |
| Drilling, blasting, excavation and materials handling at the Mine Site during operations results in dispersion of particulates and dust from the Mine Site. | Inert dust deposition leading to disturbance / loss of general flora species and vegetation communities within the dispersion area. | Develop and implement a Dust Management Plan and Radiation Management Plan. To include dust mitigation procedures specific to drilling, blasting and materials handling including:<br>- Review of wind directions and wind speeds prior to drilling, blasting or excavation of materials.<br><br>Develop and implement an Erosion and Sediment Control Plan (ESCP), including:<br>- Use of buffer zones, sediment fences and sediment ponds to arrest the transport of water borne sediment from the site | Insignificant | Unlikely | Low | Medium |

| Source of Impact | Consequence | Minimising, mitigation and management actions | Residual Risk | | | Level of certainty |
|---|---|---|---|---|---|---|
| | | | Consequen | likelihood | Residual Risk | |
| Operation of concentrator (comminution and beneficiation circuits) at the Mine Site, resulting in dispersion of particulate, gas or dust.<br><br>Inputs to the concentrator include ROM Ore, desalination water and unspecified Reagents.<br>. | Dust deposition leading to disturbance / loss of general flora species and vegetation communities due to physical and chemical impacts within the dispersion area. | Develop and implement a Dust Management Plan and Radiation Management Plan. To include standard dust mitigation procedures including:<br>- Use of water sprays on haul roads, unsealed surfaces, covering of exposed loads where practicable and maintaining moisture levels in bulk loose construction materials<br>Minimising hauling and vehicle travel in conditions when wind strength results in spatially extensive and heavy dust deposition in surrounding habitats<br>Reduced vehicle speeds for high-use areas/roads<br>Minimise open areas exposed to wind erosion<br>- Topsoil striping to occur only during suitable wind and weather conditions<br>- Minimise time between top soil stripping and construction/mining operations<br>- Wetting of ore before crushing and design controls such as use of hooded crusher, covered conveyor and an enclosed HPRG.<br>- Ongoing dust deposition monitoring program<br>Progressive reinstatements of cleared land as construction works are completed to minimise exposed material and dust generation.<br>- Controlled emissions release via stack and scrubber<br><br>Develop and implement an Erosion and Sediment Control Plan (ESCP), including:<br>- Use of buffer zones, sediment fences and sediment ponds to arrest the transport of water borne sediment from the site | Insignificant | Unlikely | Low | Medium |
| Operation of RE processing units, sulfuric acid plant and gas fired generators at the Processing Site results in dispersion of emissions | Deposition of dust leading to disturbance / loss of general flora species and vegetation communities due to physical and chemical impacts within the dispersion area. | Design to include emission controls to minimise dispersion of emissions, including potentially:<br>- Low NOx burners in design<br>- Scrubbers installed to control sulfuric acid mist, as required<br>- Specific controls for HF emissions | Insignificant | Unlikely | Low | Medium |

| | | | | | | |
|---|---|---|---|---|---|---|
| Diversion of Kerosene Camp Creek and complete alteration of waterway form | Diversion of the old channel resulting in<br>-loss of overland and subsurface flow<br>-loss of riparian areas in the diversion area and<br>- impact on ecological communities and riparian areas associated with irregular floodouts in the floodplain associated with the old channel of Kerosene Camp Creek. | Develop and implement a Biodiversity Management Plan (BMP), including:<br>- Plans to minimise vegetation clearing where possible particularly within sensitive vegetation communities<br>- Where possible apply buffer widths recommended by the Northern Territory Land Clearing Guidelines in riparian areas<br>- Procedures for demarcating the limits of clearing, and no-go areas<br>- Use of already-disturbed areas (rather than undisturbed areas) wherever possible (e.g. lay down areas for construction).<br>- Staged clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with ESCP.<br>- Avoid land clearing for construction during the Wet Season- develop and implement Vegetation Clearing sub plans which include areas not to be cleared (no-go areas).<br>Development and implementation of a land stabilisation and revegetation strategy<br>- Weed removal prior to vegetation clearing so that vegetative material would be clean and able to be mulched and reused directly on site.<br>Development and implementation of a Weed Management Plan for mitigation measures to control existing exotic vegetation, and to stem the spread of others.<br>Development and implementation of a Water Management Plan, including:<br>- Runoff from disturbed areas will be diverted into sediment ponds and not discharged into the natural environment<br>- Design outlet to have similar gradient to existing and reduce angle at which the diversion enters the natural channel<br>Install groundwater monitoring bores and provide substitute water source from elsewhere for affected stock bores if required. | Moderate | Possible | Medium | Low level |

| Source of Impact | Consequence | Minimising, mitigation and management actions | Residual Risk | | | Level of certainty |
|---|---|---|---|---|---|---|
| | | | Consequen | likelihood | Residual Risk | |
| External bushfire, resulting in structural failures and release of process consumables, products or ignition of gas inventory. | Disturbance or loss of vegetation with potential for change in vegetation composition, including simplification in structure and diversity. | Development and implementation of Fire Management Plan, including:<br>-All welding, cutting and grinding works undertaken will require approval via an internal hot works permit<br>-Maintenance of fire breaks around high-risk areas / activities<br>-Active fire management and vegetation reduction program;<br>-All site personnel will be required to undertake fire control training, including the correct use of extinguishers<br>-All vehicles are required to carry a fire extinguisher and two-way radio<br>-Dedicated fire water system to be maintained on site<br>-Emergency response procedures, team and equipment<br>-Undertake active fire management and the use of cool-season control burns if needed<br>-Erosion control in waterways, if fire should occur and results in loss of vegetation that otherwise stabilises soil/sediments. | Moderate | Rare | Low | Medium |
| Alteration to surface water flows caused by construction of roads and hard stands or embankments. | Modify or inhibit ecological processes.<br>Reduce the species diversity or modify the composition of vegetation communities. | Incorporate engineering controls into road that act to maintain surface water flows (e.g. floodways and culverts).<br>The diversion of local runoff from areas upstream of the Processing Plant will be achieved by means of flood protection bunds and/or shallow drainage ditches. These structures will be typically designed to convey runoff from a 1 in 25-year ARI storm rainfall event with the assumption that the height of any pond embankments will be sufficient to prevent ingress from external flood runoff during an event that is compatible with the design of its water containment capacity (1 in 100-year ARI storm rainfall). | Moderate | Rare | Low | Medium |

| Source of Impact | Consequence | Minimising, mitigation and management actions | Residual Risk | | | Level of certainty |
|---|---|---|---|---|---|---|
| | | | Consequen | likelihood | Residual Risk | |
| Progressive water table drawdown from groundwater extraction rates from the Southern basins borefield | Decline in availability of water to ecosystems, including riparian vegetation associated with Day Creek with downstream impacts to Lake Lewis. | -Undertake hydrogeological investigations.<br>-Undertake predictive groundwater flow modelling.<br>-Monitoring program, including bores to assess impacts on water table<br>-Development and implementation of groundwater and surface water management strategies<br>-Monitoring vegetation potentially at risk of impact from a lowering of the water table. | Moderate | Possible | Medium | Low |
| Embankment overtopping of Tailings Storage Facility (TSF) containing beneficiation tailings at Mine Site, leading to an uncontrolled release of liquor | Immediate inundation of flora within flow path of overtopped embankment, with secondary longer term impacts including potential vegetation loss associated with the contamination of surrounding land and ephemeral waterways from the uncontrolled release. | -Development and implementation of Water Management Plan.<br>-Selection of most restrictive ANCOLD risk category and adherence to relevant design standards for the provision of adequate storage capacity and freeboard allowance. Selection of Probable Maximum Precipitation (PMP) for design, is maximum theoretical rainfall event.<br>-Embankment piezometers and survey pins, regular dam inspections<br>- Adherence to prescribed maximum operating level and retention of freeboard | Minor | Rare | Low | Medium |
| Embankment failure or overtopping of Water Leach, Neutralisation and Phosphate Residue Storage Facilities (RSFs) at Processing Site, due to slope instability or extreme weather event | Immediate inundation of flora within flow path of failed embankment, with secondary longer term impacts including potential vegetation loss associated with the contamination of surrounding land and ephemeral waterways from the uncontrolled release. | Development and implementation of Water Management Plan.<br>Selection of appropriate ANCOLD risk category and adherence to relevant design standards for the provision of adequate storage capacity, spillway capacity and freeboard allowance.<br>Embankment piezometers and survey pins, regular dam inspections<br>Adherence to prescribed maximum operating level and retention of freeboard | Minor | Rare | Low | Medium |

| Source of Impact | Consequence | Minimising, mitigation and management actions | Residual Risk | | | Level of certainty |
|---|---|---|---|---|---|---|
| | | | Consequen | Iikelihood | Residual Risk | |
| Contamination of surface and/or groundwater caused by erosion and sedimentation, hydrocarbon or chemical spills. | Disturbance to riparian vegetation communities and/or changes to species composition. | Preparation and implementation of an Erosion and Sediment Control Plan as part of the Project EMP including:<br>-Regular inspection of erosion and sediment control measures, particularly following rainfall events, to ensure their ongoing functionality.<br>-Siting of stockpiles away from natural drainage channels.<br>-Staged clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with ESCP.<br>-Avoid land clearing for construction during the Wet Season.<br>-Minimise surface water infiltration, water runoff and groundwater seepage.<br>-Preparation of a Water Management Plan for construction and operational activities.<br>-Runoff from ROM pad, stockpiles and workshops directed to sediment basins.<br>-All mining equipment refuelled, serviced and repaired within designated areas outlined for such activity.<br>-Constructing adequate bunds around sources of potential contamination, to contain contaminated water in the event of heavy rainfall.<br>-Spill clean-up procedures developed and implemented.<br>-Personnel trained in the use of spill kits and emergency response procedures. | Moderate | Unlikely | Low | Medium |

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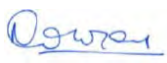
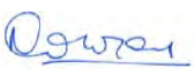
| 0 | Arien Quin | Nicole Conroy |  | Nicole Conroy |  | 29/03/16 |
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