SUPPORTING INFORMATION
REFERRAL TO CLEAR NATIVE VEGETATION

PREPARED FOR:

THUNDERBIRD OPERATIONS PTY LTD

APRIL 2023

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NATIVE VEGETATION CLEARING PERMIT APPLICATION SUPPORTING INFORMATION

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TABLE OF CONTENTS

1. INTRODUCTION 1
2. PROJECT DESCRIPTION 3
2.1 PROJECT DESCRIPTION 3
2.2 CURRENT AND PROPOSED CLEARING AREAS 3
3. BIOPHYSICAL ENVIRONMENT 6
3.1 CLIMATE 6
3.2 BIOREGIONALISATION 6
3.3 LAND SYSTEM AND SOILS 6
3.4 VEGETATION ASSOCIATION 7
3.5 VEGETATION COMMUNITIES AND CONDITION 7
3.6 ECOLOGICAL COMMUNITIES 11
3.7 FLORA SPECIES 11
3.8 CONSERVATION SIGNIFICANT FLORA 11
3.9 FAUNA HABITAT 13
3.10 FAUNA SPECIES 13
3.11 CONSERVATION SIGNIFICANT FAUNA SPECIES 13
3.12 HYDROLOGY, WETLANDS, AND WATERWAYS 16
3.13 GROUNDWATER 18
4. PROJECT ELEMENTS AND POTENTIAL IMPACTS 19
4.1 CLEARING OF NATIVE VEGETATION 19
4.1.1 Purpose Permit Clearing Area 19
4.1.2 Potential Impacts and their Significance 19
4.2 FAUNA 19
5. ASSESSMENT AGAINST CLEARING PRINCIPLES 20
6. REFERENCES 22

TABLES

Table 1: Statewide Statistics for Vegetation Association 750 7
Table 2: Priority Flora Recorded Within the Purpose Permit Area 11
Table 3: Significant Fauna Recorded by Baseline Surveys 14
Table 4: Assessment of Clearing Against the Clearing Principles 20

FIGURES

Figure 1 Project Location 2
Figure 2: Proposed Changes to Great Northern Highway Layout 4
Figure 3 Purpose Permit and Proposed Clearing Areas 5
Figure 4 Beard Vegetation Association of the Proposed Purpose Permit Area 9
Figure 5: Vegetation Communities of the Proposed Purpose Permit Area 10
Figure 6: Location of Significant Flora 12
Figure 7: Significant Fauna of the Area 15
Figure 8: Local Drainage of the Purpose Permit Area 17

APPENDICES

Appendix 1 Flora and Vegetation of the Thunderbird Mineral Sands Project Area (Mattiske, 2016) 25
Appendix 2 Level 1 Flora and Fauna Assessment, Ecologia 2012 26
Appendix 3: Terrestrial and Subterranean Fauna Assessment, Ecologia, 2014 27
Appendix 4: Flora and Fauna Assessment, Ecologia, 2015 28
Appendix 5: Targeted Greater Bilby Assessment, Ecologia, 2016 29

1. INTRODUCTION

Thunderbird Operations Pty Ltd (Thunderbird) are planning to undertake mining of mineral sands from the Thunderbird deposit, a greenfield site located on the Dampier Peninsula within the Kimberley region of Western Australia (Figure 1). The Project will include a mineral sands mine and processing facilities with supporting infrastructure and services for production and export of heavy mineral sands products for a period of about 40 years.

Access to the Mine Site will be via upgrade of the existing Mt Jowlaenga Homestead Road. Upgrade works form part of the project approved by Ministerial Statement 1080 and EPBC Act approval EPBC 2016/7648. Additional works are required to allow safe access from the Great Northern Highway to the site. This includes construction of slip lanes and an acceleration lane extending for up to 1.5 km from the intersection of the Great Northern Highway and the Site Access Road. These areas are located on land managed by Main Roads Western Australia (MRWA) as part of an easement for the Great Northern Highway and are outside of the area of current Project approvals. Thunderbird Operations are seeking a referral to clear native vegetation to authorise land clearing for these works within the Great Northern Highway easement.

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Image: Copernicus Sentinel Data 2020
Grid: GDA94 / MGA zone 51
0 10 20 km

Thunderbird Operations Pty Ltd
Thunderbird Mineral Sands Project

Figure 1

Location Plan

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2. PROJECT DESCRIPTION

2.1 PROJECT DESCRIPTION

Thunderbird Operations Pty Ltd are in the process of developing a mineral sands project within the Dampier Peninsular in the Kimberley region of Western Australia. The Project involves:

- Mining of heavy mineral sands from the Thunderbird deposit over a 40-year period.
- Onsite primary and secondary processing of ore to produce a range of saleable mineral sands products.
- Disposal of process wastes in an initial above ground tailings storage facility (TSF) followed by progressive backfilling of the mine pit and subsequent rehabilitation of backfilled areas.
- Development of infrastructure to support the Project including power generation facilities, accommodation village, administration and maintenance buildings, internal roads, communications infrastructure, borefield and waste storage and disposal facilities.
- Upgrade and extension of the existing pastoral road (Mt Jowlaenga Homestead Road) from the Great Northern Highway to form a 30-km Site Access Road.
- Transport of mineral sands products from the Project via the Site Access Road and Great Northern Highway to the Ports of Derby and Broome for export.

Main Roads Western Australia require an upgrade of the Great Northern Highway and the Site Access Road intersection through the addition of slip lanes and an accelerating lane to provide for safe vehicle movement. The layout of the slip lane and acceleration lane in relation to the intersection is shown in Figure 2.

2.2 CURRENT AND PROPOSED CLEARING AREAS

The proposed clearing will include the area immediately surrounding the junction of the Site Access Road and Great Northern Highway (GNH) and extending for approximately 1.5 km of the GNH. The clearing will occur within the GNH road reserve located on Lot 278 on Plan 240321 and Lot 420 on Plan 218391.

The proposed clearing area has been calculated from a review of the proposed design in conjunction with aerial imagery. This application requests approval to clear up to 3.48 ha of native vegetation as shown in Figure 3.

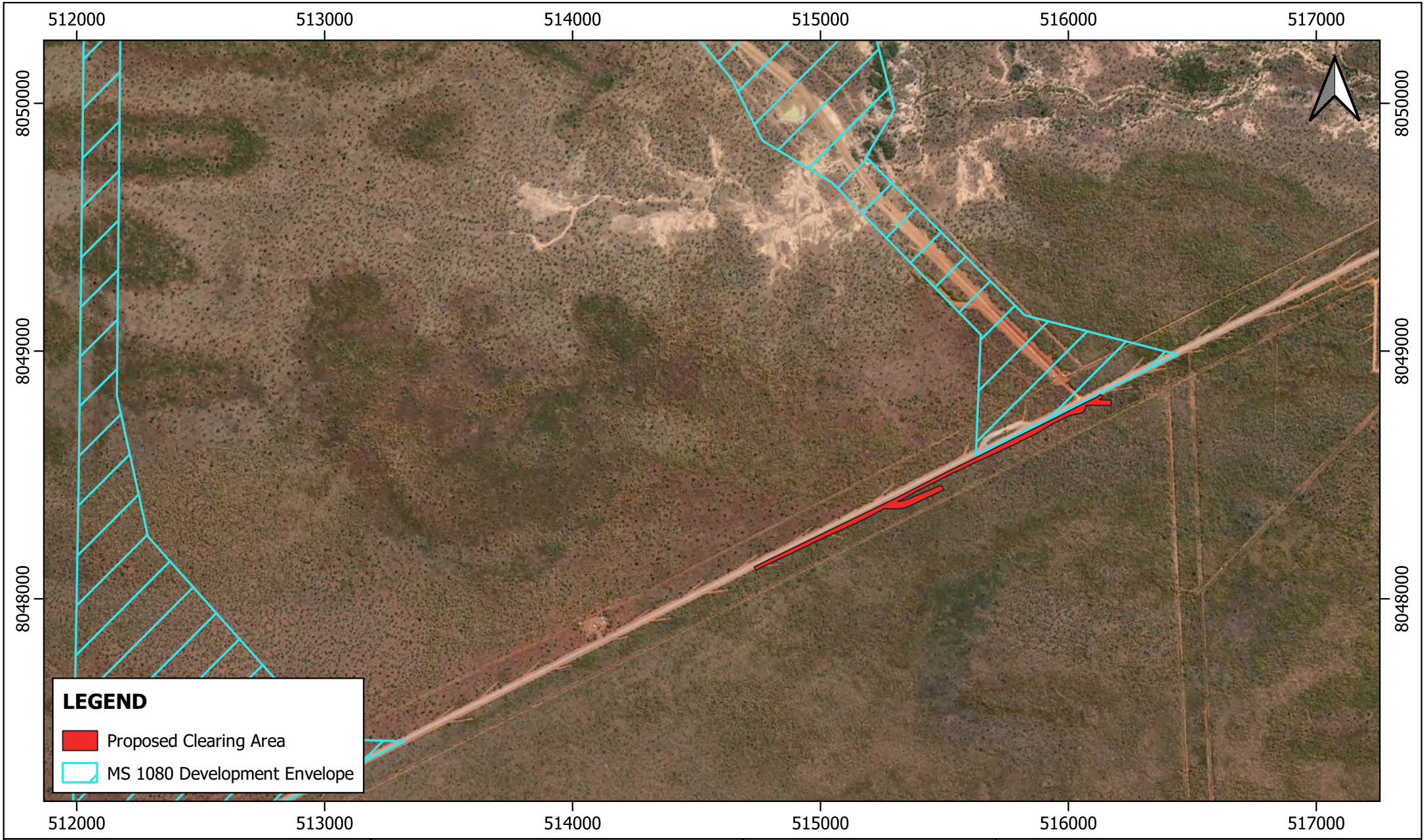

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Figure 2

Site Layout

Kimberley Mineral Sands
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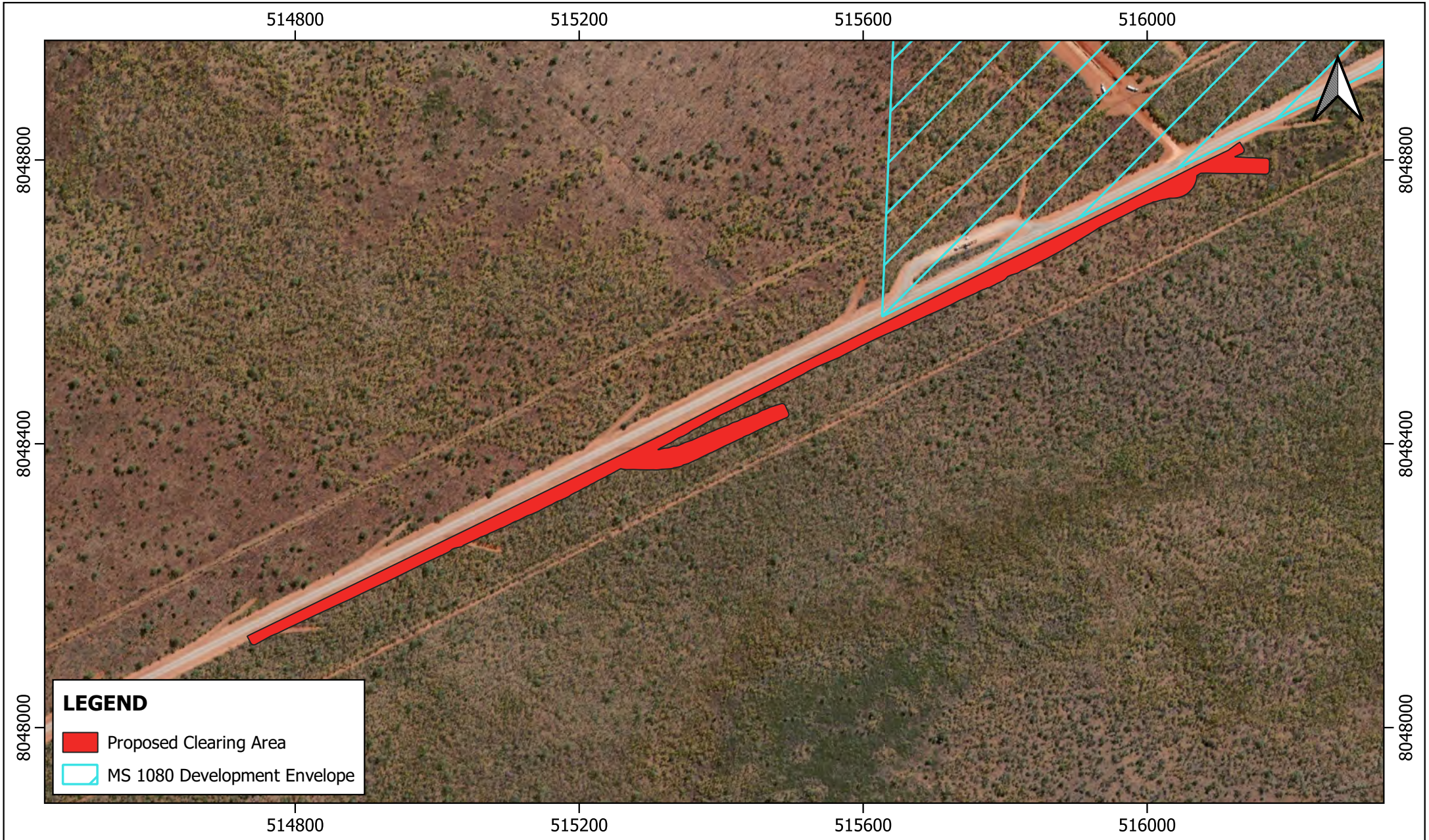

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Figure 3

Proposed Clearing Area

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3. BIOPHYSICAL ENVIRONMENT

3.1 CLIMATE

The Dampier Peninsula is located in the sub-tropical Kimberley region of Western Australia. The climate at the Project is described as 'grassland, hot (winter drought)' by Stern, de Hoedt and Ernst (2000). High temperatures and humidity in the summer months coincide with the wet season while lower (yet still warm) temperatures and humidity in the winter months coincide with the dry season (BoM 2022). Weather data collected from an automatic weather station at the Mine Site Development Envelope since November 2014, in addition to regional stations in the broader vicinity to the Project (chiefly Derby Aerodrome) indicate:

- Average maximum temperatures between 30.8°C and 38.2°C, with a highest recorded temperature of 45.6°C.
- Average minimum temperatures between 14.6°C and 26.3°C, with a lowest recorded temperature of 6°C.
- Average humidity of around 40% in the dry season and approaching 80% in the wet season.
- An average annual rainfall of 694 mm that mostly falls during the 'wet' season between November and April; however, rain is very variable with the lowest recorded annual rainfall of 153 mm and highest of 1,503 mm.
- Rainfall events in excess of 100 mm commonly associated with tropical lows and cyclones, however, high rainfall is not necessarily associated with cyclone activity.
- Cyclone season occurs between November and April; however, cyclones rarely occur in November and have been observed as late as May.
- Morning winds tend to be easterlies between April and August and northwesterlies between September and March. Afternoon winds are predominantly north-westerlies all year round with the exception of May and June when southeasterlies are also likely (BoM 2022).
- Potential evapotranspiration averages 1,980 mm per year, varying moderately across seasons. Evapotranspiration generally remains higher than rainfall throughout the year, resulting in water limited conditions for vegetation (CSIRO 2009).

3.2 BIOREGIONALISATION

According to the Interim Biogeographic Regionalisation of Australia (IBRA), the proposed area of clearing is located in the Pindanland Subregion (DL2) of the Dampierland 2 bioregion (Graham 2001). The Pindanland subregion occupies 5,198,904 ha and is described as a fine-textured sand-sheet with subdued dunes, comprised of the sandplains of the Dampier Peninsula and western part of Dampierland, including the Fitzroy River paleodelta. Broad scale vegetation mapping characterises this subregion as consisting of:

- Ephemeral herblands and/or grasslands with scattered low trees.
- Various Eucalypt and Melaleuca woodlands.
- Mixed species tussock grasslands or sedgelands.
- Mangroves around coastal areas.
- Coastal dune communities.

3.3 LAND SYSTEM AND SOILS

According to the *Soil and Landscape Mapping — Best Available* (DPIRD-027) dataset (Department of Primary Industries and Regional Development (DPIRD), 2022) two land systems are located within the proposed clearing area:

- The Yeeda land system (soil mapping unit 335Ye) — characterised by sandplains and occasional dunes; comprises the majority of the proposed clearing area.
- The Wanganut land system (soil mapping unit 335Wa) — characterised by low-lying sandplains and dunefields with through-going drainage; occupies the north-eastern portion of the proposed clearing area.

Both of these land systems are typically subject to frequent fires but are generally not prone to degradation or erosion; however, it has been noted that these systems may be susceptible to degradation without proper management (Payne and Schoknecht 2011).

A baseline assessment of the Mine Site Development Envelope was undertaken and identified the presence of four soil types within the project site boundary:

- Shallow red Pindan sands over sandstone.
- Deep red sandy Pindan soils.
- Yellow sandy soils.
- Bleached Sands Over Clay/Loam.

The proposed area of clearing is characterised in the ASRIS Acid Sulfate Soil (ASS) mapping as having an 'Extremely Low' probability (low confidence) of occurrence within 2 m of the natural soil surface.

3.4 VEGETATION ASSOCIATION

A review of the Pre-European Vegetation (DPIRD-006) dataset (Department of Primary Industries and Regional Development (DPIRD), 2019) indicates the proposed area of clearing is located within the Dampierland vegetation association (750) which is described as Pindan Shrublands by the 2018 Statewide Vegetation Statistics Report from the DBCA's Remote Sensing and Spatial Analysis Programme (DBCA, 2019). This is illustrated in Figure 4. Furthermore, Figure 4 demonstrates that the vegetation association (750) is well represented within the 10km buffer of the proposed clearing area.

The Dampierland IBRA region contains more than 99% of its pre-European clearing extent as is shown in Table 1.

Vegetation Association	Pre-European Extent (ha)	Current Extent (ha)	% Remaining	Current Extent in All DBCA-Managed Land (ha)
750 (Pindan Shrubland)	1,229,182.16	1,225,280.52	99.68	34,114.53

3.5 VEGETATION COMMUNITIES AND CONDITION

Vegetation mapping was conducted by Mattiske in 2016 as part of baseline studies for the Project (Appendix 1). In broad terms, the vegetation of the Thunderbird Project Area consists of vegetation, where there is a sparse overstorey of Eucalyptus/Corymbia species — typically *Corymbia greeniana/Eucalyptus tectifica* — over a midstorey of Acacia species, dominated by *Acacia tumida var. tumida*, and a ground storey of mixed grasses, with *Triodia caelestialis* (P3), *Triodia schinzii*, and Chrysopogon species (*C. pallidus, C. timorense*) being dominant. Other common species in the upper storey included *Brachychiton diversifolius, Corymbia zygophylla*, *Erythrophleum chlorostachys*, and *Eucalyptus flavescens*. *Atalaya hemiglauca, Bauhinia cunninghamii, Dolichandrone heterophylla, Ehretia saligna, Gardenia pyriformis subsp. keartlandii, Grevillea pyramidalis, Hakea arborescens*, and *Hakea macrocarpa* were common midstorey species. Some of these, such as *Bauhinia cunninghamii*, were often of sufficient size as to form a component of the upper storey. The vegetation described based on the statistical analysis of the survey data, is essentially pindan.

The vegetation mapping identified 15 vegetation communities of which 14 were woodland communities and one was a shrubland community (Figure 5). Two woodland communities, (W7 and W8) account for 86.3% of the 18,885 ha mapped. Review of the mapping indicates the area adjacent to the proposed clearing is pindan vegetation community W8. The W8 vegetation community is described as:

> *Erythrophleum chlorostachys, Brachychiton diversifolius* subsp. *Diversifolius* and *Corymbia greeniana* mid open woodland over *Acacia tumida* var. *tumida*, *Bauhinia cunninghamii* and *Dodonaea hispidula* var. *arida* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland on orange-brown to red fine sandy soils on flats (Mattiske 2016).

Some of the proposed clearing area falls beyond the area surveyed by Mattiske, however extrapolation of mapping results indicates that the proposed clearing area will also be community W8.

The Mattiske Report concluded that the vegetation of the Project Area is common and widespread through the broader Kimberley region.

Baseline flora data (Mattiske 2016) indicates the vegetation condition is in Good condition, with the broader vegetation condition of the Mine Site Development Envelope generally regarded as Very Good to Excellent. It is likely that the vegetation condition of the area to be cleared has experienced some degree of impact associated with construction and use of the Great Northern Highway.

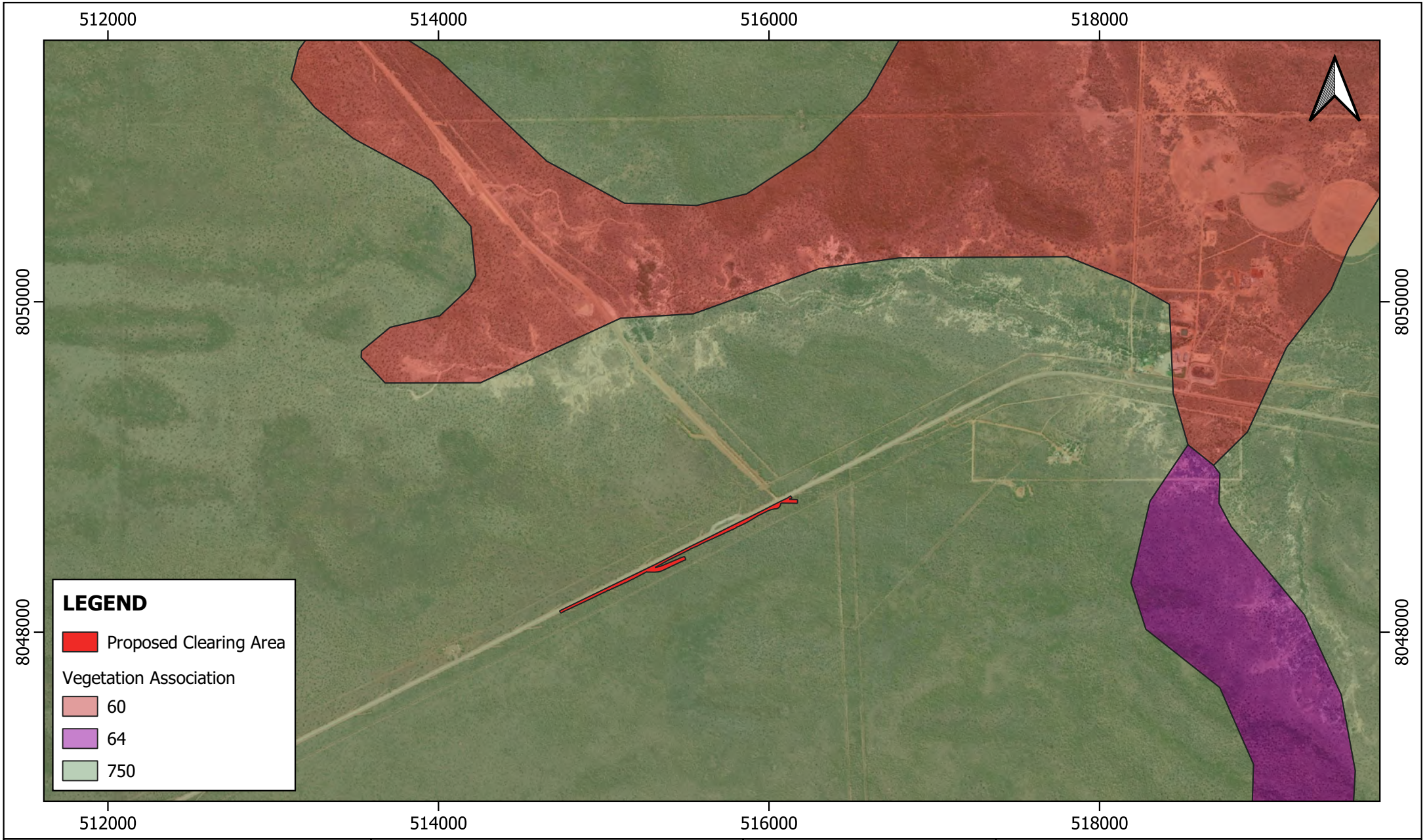

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Figure 4

Vegetation Association

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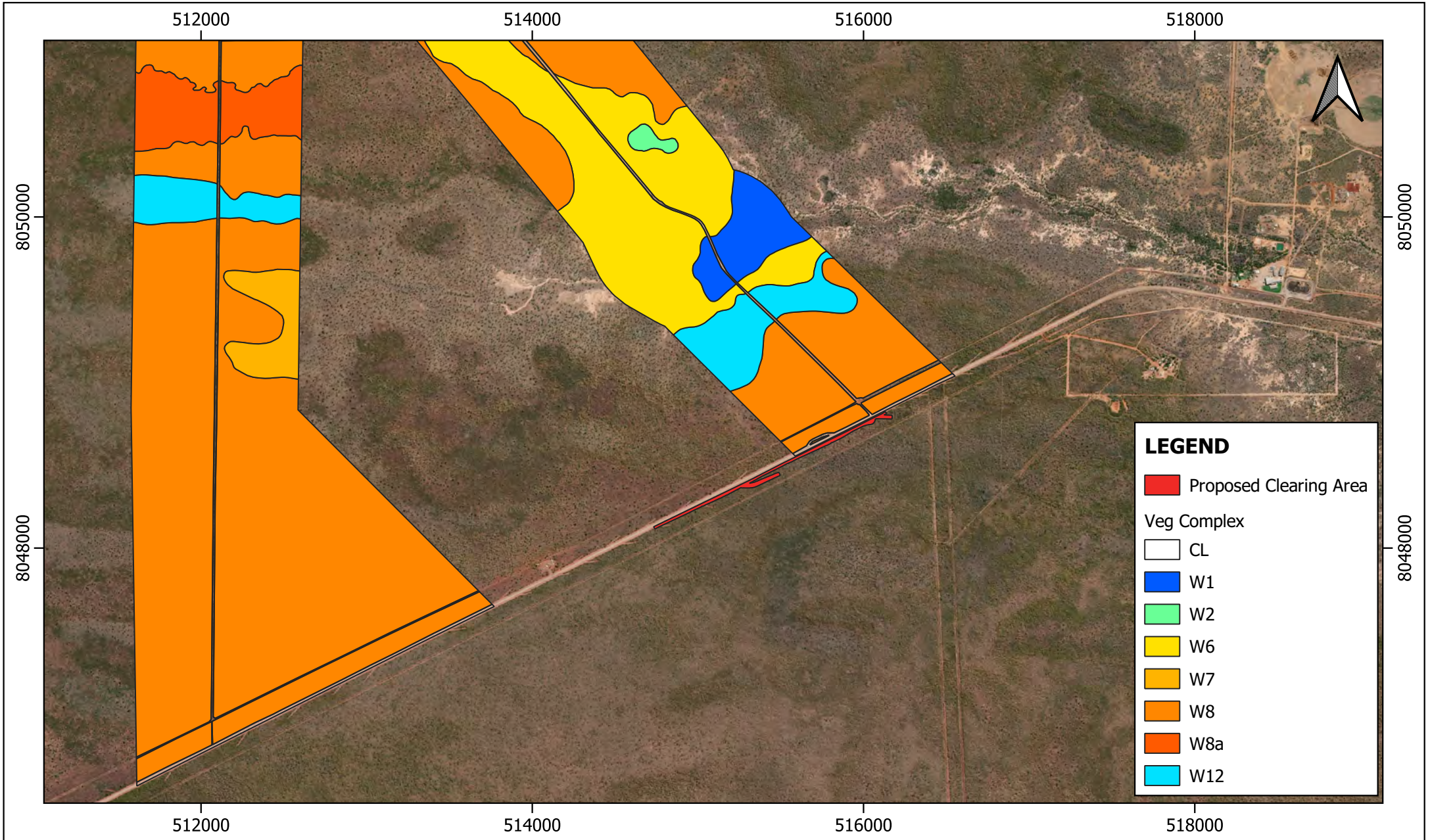

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Figure 5

Vegetation Complex

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3.6 ECOLOGICAL COMMUNITIES

No Threatened or Priority Ecological Communities as defined by the Commonwealth *Environment Protection and Biodiversity Conservation Act* or State *Biodiversity Conservation Act 2016* are located within or near to the proposed clearing area.

3.7 FLORA SPECIES

Five flora and vegetation surveys were undertaken for the broader Project area and surrounds between 2012 and 2016 (Ecologia 2012a, 2014a, 2015; Mattiske 2016a, 2016b).

A total of 255 vascular plant taxa representing 129 genera and 44 families were recorded in the broader survey area of the Thunderbird Project (Mattiske 2016a). The majority of taxa recorded belonged to the Poaceae and Fabaceae families (46 and 45 taxa respectively), with Malvaceae (18 taxa), Cyperaceae (14 taxa), Myrtaceae (14 taxa), Amaranthaceae (12 taxa) and Convolvulaceae (10 taxa) families also recorded (Mattiske 2016a).

3.8 CONSERVATION SIGNIFICANT FLORA

No Threatened flora species pursuant to Schedule 1 of the *Biodiversity Conservation Act 2016* (WA) (BC Act) or Section 178 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) were recorded by any of the five flora and vegetation surveys either within or directly adjacent to the proposed clearing area, nor within the broader Thunderbird Project area.

Two Priority flora taxa, *Triodia caelestialis* and *Pterocaulon intermedium*, both Priority 3 taxa listed under the BC Act, were recorded within the Thunderbird Project flora survey area including observations within 2 km of the proposed clearing area; however, both species have since been delisted (Mattiske 2016a).

A list of significant flora recorded across the five flora and vegetation surveys is presented in Table 2 and shown in Figure 6 with respect to the proposed clearing area.

Table 2: Priority Flora Recorded Within the Purpose Permit Area

Species	Conservation Status	Within Proposed Clearing	Habitat Preference	Likelihood of Occurrence
Fuirena incrassata	P3	No	Sand or sandy clay; swamps, creek beds, claypans, semi-saline lakes	Unlikely
Fuirena nudiflora	P1	No	Sand; swamps, creek beds	Unlikely
Tephrosia valleculata	P3	No	Sandy, often shallow, soil around sandstone; rock outcrops	Unlikely

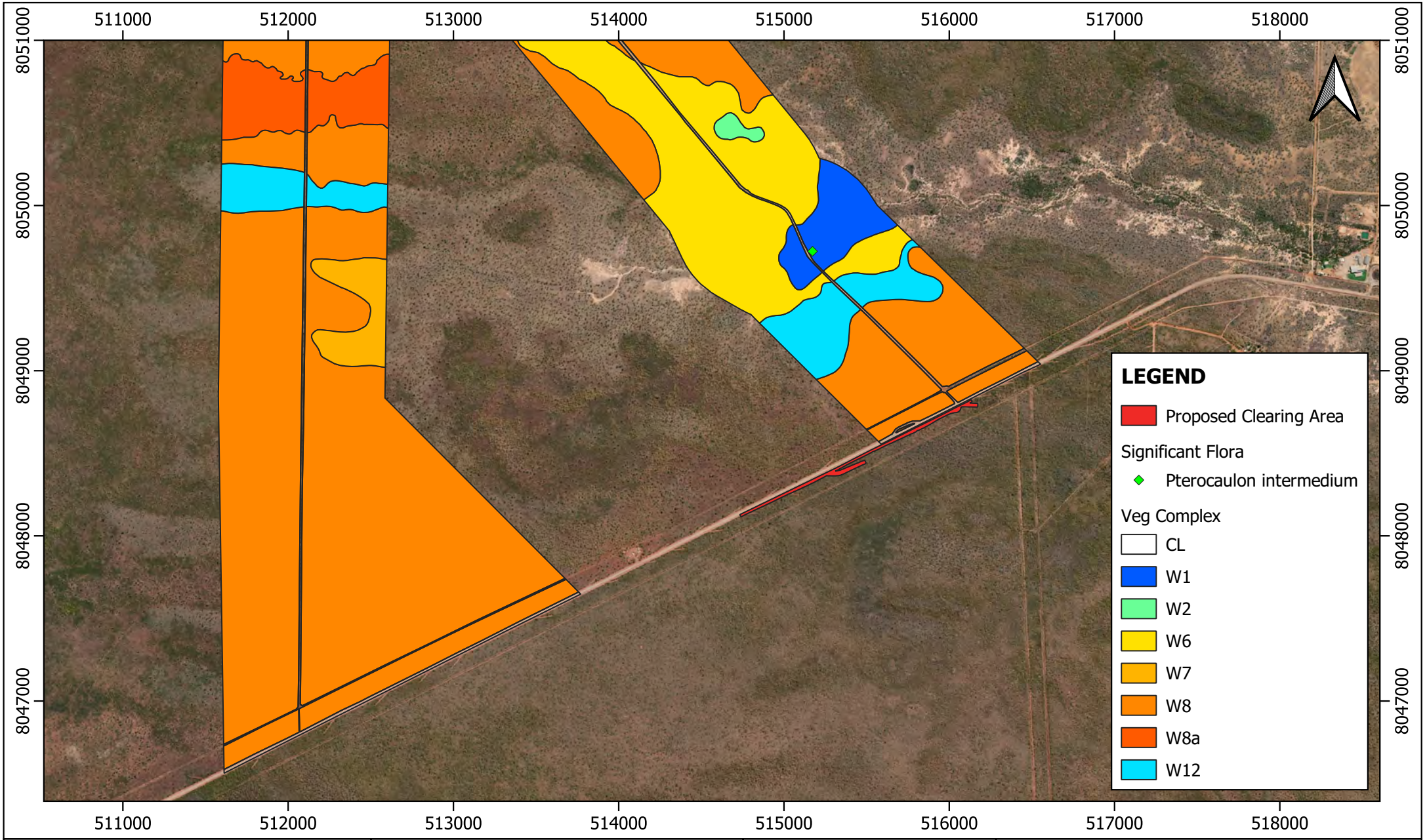

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Figure 6

Significant Flora

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3.9 FAUNA HABITAT

Surveys performed by Ecologia (2012a, 2014a, 2015) identified three broad habitats within the Project area:

- Pindan Shrubland.
- Savannah Woodland.
- Sandstone Range and Footslopes.

The Pindan Shrubland habitat is most extensive covering most of the central and southern region. The geology of this habitat is characterised by flat plains, with weak orange to red sandy-loam soils. The dominant tree species is scattered *Corymbia greeniana*, over a moderately open to dense shrub layer consisting primarily of *Acacia tumida var tumida, Acacia platycarpa* and *Grevillea refracta*. The ground vegetation layer consists of a mix of grasses including *Triodia caelestialis, Aristida holathera var holathera, Crysopogon sp., Eriachne obtusa* and *Sorghum plumosum*. Leaf litter density is highly variable as a result of fire history and patchy shrub density (Ecologia 2015).

Fauna habit of the proposed clearing area is Pindan Shrubland, with an area of Savannah Woodland located approximately one kilometre to the north in association with a minor, ephemeral watercourse.

3.10 FAUNA SPECIES

Four fauna assessments were undertaken for the Project over an area of about 15,715 ha between 2012 and 2016 (Ecologia 2012a, 2014b, 2015, 2016). While these studies may have recorded species that are not all likely to occur within the proposed clearing area, they do provide an indication of the likely fauna that could be present.

A total of 20 mammals, 118 birds, 44 reptiles and 8 amphibians were recorded within the general Thunderbird Project area over the course of the four fauna assessments (Appendix 2, Appendix 3, Appendix 4 and Appendix 5).

A Level 2 Short Range Endemic (SRE) survey was undertaken in March 2014 by Ecologia (Ecologia 2014a), after which a targeted survey was conducted in December of that year (Ecologia 2014c). These surveys recorded 22 taxa identified as being potential SRE and one species confirmed (the land snail *Rhagada bulgana*). With 17 of the 22 taxa found beyond the Project area, it is considered unlikely any SREs will be dependent on the vegetation within the proposed clearing area.

3.11 CONSERVATION SIGNIFICANT FAUNA SPECIES

The fauna surveys (Ecologia 2012a, 2014b, 2015, 2016) identified nine conservation significant fauna that have the potential to occur within the Project area and surroundings, with the habitat for the greater bilby and the short-tailed mouse identified as being directly impacted by the Thunderbird Project. However, of the nine conservation significant fauna recorded, only the Common Greenshank (listed as marine and migratory under the EPBC) was recorded within the vicinity of the proposed proposed clearing area (Figure 7). The surveys also identified the area as containing suitable habitat for the Gouldian finch, Oriental pratincole, Dampierland plain slider, and Dampierland burrowing snake.

Fauna species of significance recorded within the Thunderbird Project during these surveys are listed in Table 3.

Table 3: Significant Fauna Recorded by Baseline Surveys

Species	Conservation Status		Habitat Preference	Likelihood of Occurrence
	EPBC Act	BC Act		
Mammals				
Short-tailed mouse *Leggadina lakedownensis*		P4	Spinifex and tussock grassland on cracking clays. Also, acacia shrubland, samphire, woodlands, and stony ranges.	Likely
Greater bilby *Macrotis lagotis*	VU	VU	Varieties of habitats on soft soil, including spinifex grassland, acacia shrubland, open woodland, and cracking clays.	Likely
Ghost bat *Macroderma gigas*	VU	VU	Caves, rock piles and abandoned mines.	Unlikely
Reptiles				
Dampierland Peninsula goanna *Varanus sparnus*		P1	Sandy areas	Possible
Birds				
Fork-tailed swift *Apus pacificus*	Mi		Almost entirely aerial, particularly associated with storm front. Occur over inland plains.	Has been recorded, however likelihood is low
Oriental cuckoo/ Horsfield's cuckoo *Cuculus optatus*	Mi	Mi	Forest, monsoon forests; wet sclerophyll forests; paperbark swamps; mangroves	Unlikely
Red goshawk *Erythrotriorchis radiatus*	VU	VU	Open forests and woodlands, tropical savannas traversed by wooded rivers, rainforest margins, and gorge and escarpment country	Unlikely
Gouldian finch *Erythrura gouldiae*	EN	P4	Tropical savannas; breed in rocky hills with hollow-bearing eucalypts near water	Unlikely
Rainbow Bee-eater *Merops ornatus*	Mi	Mi	Open country, most vegetation types, dunes, banks.	Possible
Grey wagtail *Motacilla cinerea*	Mi	Mi	Predominantly banks and rocky areas along flowing freshwater habitats	Unlikely
Yellow wagtail *Motacilla flava*	Mi	Mi	Short grasslands (usually damp or watered), swamp margins, sewage ponds, bore overflows, and irrigated areas	Unlikely
Wood sandpiper *Tringa glareola*	Mi	Mi	Mainly shallow, fresh waters, river pools, claypans; occasionally brackish swamps; rarely salt lakes, estuaries and intertidal mudflats	Unlikely
Common greenshank *Tringa nebularia*	Mi	Mi	Intertidal mudflats, estuaries, freshwater and saline wetlands along the coast and inland	Unlikely

Targeted surveys for the greater bilby identified their presence as being widespread based on observations of diggings, scats, and active and inactive burrows. Evidence of greater bilby occurrence was primarily recorded within the Pindan Shrubland vegetation type. More specifically, the greater bilby was recorded predominantly within dense, mature *Acacia tumida var. tumida* woodland micro-habitat.

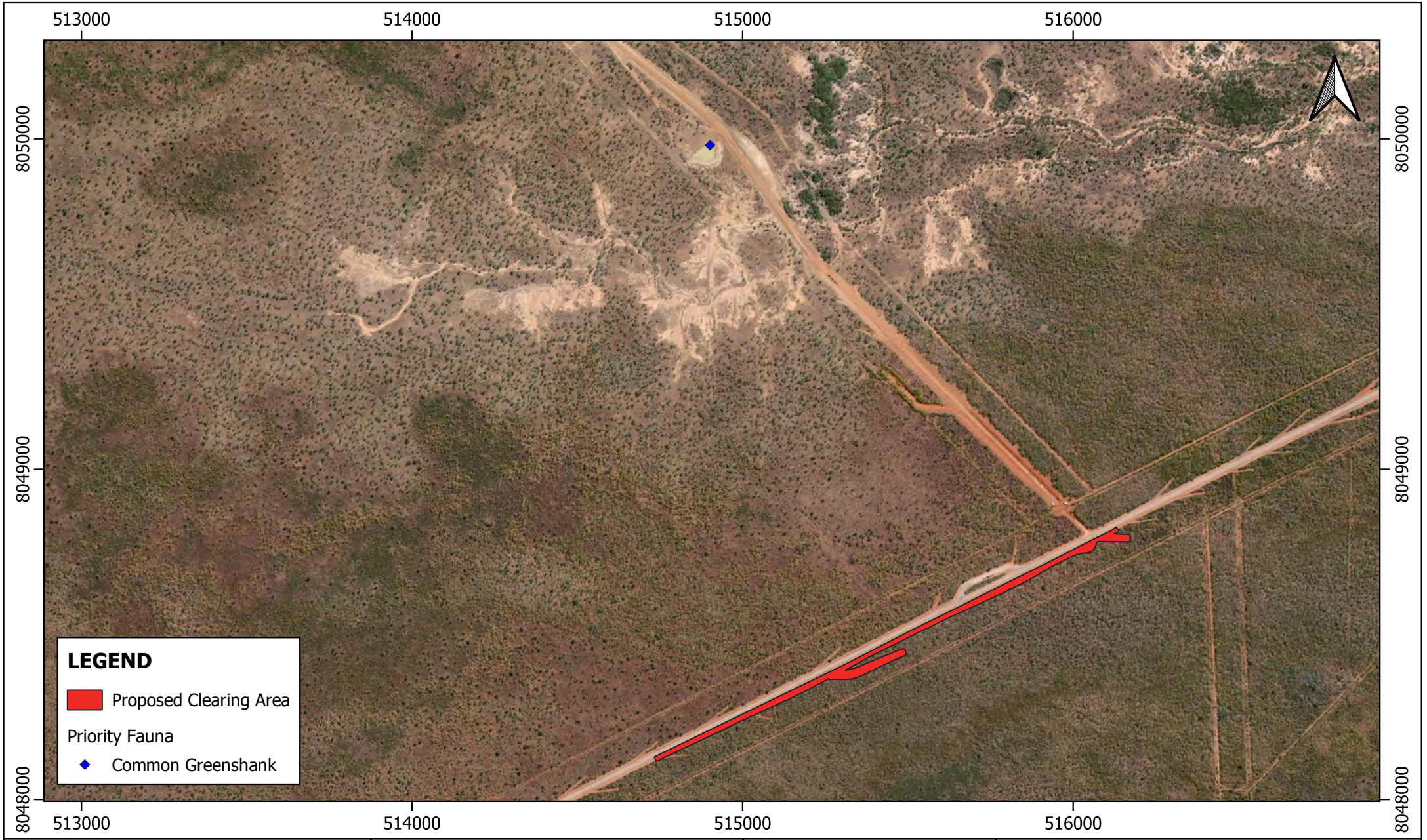

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Figure 7

Priority Fauna

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3.12 HYDROLOGY, WETLANDS, AND WATERWAYS

The Proposed Clearing Area:

- Does not fall under a defined Surface Water Area, with the nearest Surface Water Area, the Fitzroy River and Tributaries Surface Water Area proclaimed under the RIWI Act located approximately 40 km to the east.
- Lies approximately 700 m south of an ephemeral watercourse (part of the Little Logue River).
- Supports no permanent, seasonal, or ephemeral lakes.
- Is not located within a proclaimed public drinking water source area (PDWSA) gazetted under the *Country Area Water Supply Act 1947* (WA) (CAWS Act).
- Is not located within a Clearing Control Catchment as defined in the CAWS Act.
- Contains no RAMSAR wetlands.

A baseline surface hydrology assessment was carried out by MBS for the Thunderbird Project area in 2016 (MBS 2016). All watercourses in the immediate area of the Project and the proposed clearing area appear to be ephemeral, thus typically remain dry until after significant rainfall events. The sandy soils present in the area appear to possess high hydraulic conductivity, thus exhibit very high infiltration rates and low runoff rates.

The drainage of the proposed clearing area and surrounds is shown in Figure 8.

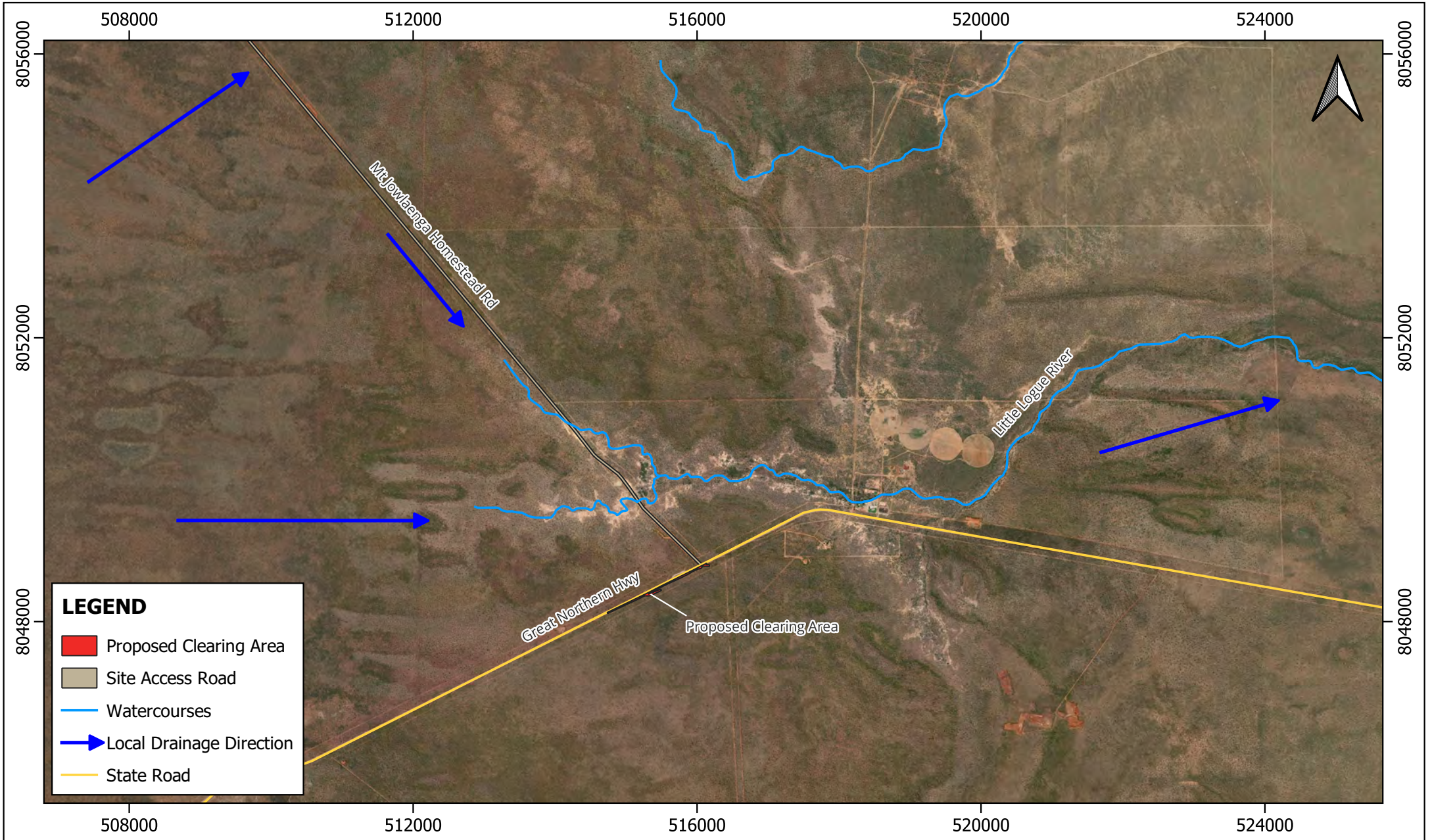

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Figure 8

Drainage Direction of Little Logue River

Kimberley Mineral Sands
Thunderbird Operations Pty Ltd

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3.13 GROUNDWATER

Two baseline hydrogeology studies were performed for the Project and provide a broad overview of the Project's hydrogeological setting; the first assessment was undertaken by Pennington Scott (2014) and the second by Rockwater (2016).

It was indicated that the Dampier Peninsula is characterised by a deep inland watertable which becomes shallower towards the coastal plain, with depth to groundwater exceeding 20 m through much of the Project area. This is likely to be similarly reflected within the proposed clearing area. The Broome Sandstone Aquifer underlies much of the Dampier Peninsula, comprising an unconfined to semi-confined major aquifer that serves as the chief groundwater resource in the West Kimberley. Groundwater salinity within the aquifer is low and increases towards the coast. Groundwater monitoring data is relatively sparse, with most data concentrated in the vicinity of Broome townsite. Recharge is mostly attributed to rainfall percolation during the wet season. No identified areas of groundwater discharge appear to occur within or in the vicinity of the proposed clearing area.

The proposed clearing area is located in the Canning-Kimberly Groundwater Area, which is a proclaimed groundwater area under the *Rights in Water Irrigation Act*.

4. PROJECT ELEMENTS AND POTENTIAL IMPACTS

4.1 CLEARING OF NATIVE VEGETATION

4.1.1 Proposed Clearing Area

The proposed clearing area consists of Pindan Shrubland immediately adjacent to the Great Northern Highway and the Project's Site Access Road. The proposed acceleration and slip lanes are expected to be constructed within the 3.48 ha clearing footprint on the southern side of GNH (Figure 2, Figure 3).

4.1.2 Potential Impacts and their Significance

The proposed clearing will result in the removal of up to 3.48 ha of Vegetation Association 750. This is unlikely to be significant as the Dampierland IBRA region contains over 99% of its pre-European clearing extent, with Vegetation Association 750 also retaining in excess of 99% of its pre-European clearing extent (Government of Western Australia, 2019). On this basis, the proposed clearing is unlikely to adversely impact on species diversity or recruitment.

While individual specimens of flora species that make up the vegetation type will be lost during this proposed clearing, there are no known conservation significant flora species likely to be present within the proposed clearing area.

4.2 FAUNA

The fauna habitat present within and surrounding the proposed clearing area is consistent with the Pindan Shrubland, thus similar habitat will be available nearby for fauna species. Based on the relatively small area to be cleared and considered against the extensive remaining uncleared area of this vegetation type, impacts to fauna are considered likely to be insignificant and limited to a minor amount of habitat loss and fragmentation.

5. ASSESSMENT AGAINST CLEARING PRINCIPLES

When preparing a Clearing Permit application, an assessment of the proposed clearing against the ten clearing principles is undertaken to inform the decision-making process. The assessment carried out by MBS Environmental as it relates to the proposed additional clearing of vegetation adjacent to the existing section of the Great Northern Highway is provided in Table 4. This assessment suggests that the proposed clearing is unlikely to be at variance with any of the clearing principles.

Table 4: Assessment of Clearing Against the Clearing Principles

Principle	Description	MBS Assessment
A	Native vegetation should not be cleared if it comprises a high level of biological diversity	The proposed clearing is unlikely to be at variance with this principle because: • The maximum clearing area will be about 34,800 m^2. • Vegetation appears homogenous and representative of the most common vegetation types for that regional area, namely Pindan Shrubland W8 as defined by Mattiske (2016a). • No conservation significant flora species are likely to occur within the proposed clearing area. • The vegetation has previously been impacted by construction of the Great Northern Highway.
B	Native vegetation should not be cleared if it comprises the whole, or a part of, is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia	The proposed clearing is unlikely to be at variance with this principle because: • The maximum area to be cleared (3.48 ha) comprises a very small proportion of the remaining extent of Vegetation Association 750 (approximately 1,225,000 ha as of 2018) that it is unlikely to be of substantial importance to indigenous fauna that favours this habitat, particularly considering the abundance of Vegetation Association 750 in the surrounding area and as it is located immediately adjacent to the Great Northern Highway. • No significant fauna species are likely to have a permanent presence in the proposed clearing area given it is located on either side of the Great Northern Highway and has been disturbed by highway construction and maintenance activities. The greater bilby may utilise the proposed clearing area recognising this is a highly transient and mobile species. Pindan Plain habitat used by the greater bilby is locally and regionally common and widespread.
C	Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare (Threatened) flora	The proposed clearing is unlikely to be at variance with this principle because no flora species listed as Threatened under the BC Act or the EPBC Act has been recorded within or in the vicinity of the proposed clearing area.
D	Native vegetation should not be cleared if it comprises the whole or part of, or is necessary for the	The proposed clearing is unlikely to be at variance with this principle because no threatened ecological community is present within the proposed clearing area, with the closest located approximately 20 km to the south.

Principle	Description	MBS Assessment
	maintenance of, a threatened ecological community	
E	Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared	The proposed clearing is unlikely to be at variance with this principle because: • The site is located in the Beard Vegetation Association 750 Pindan Shrubland. • According to 2018 data relating to Statewide vegetation statistics, the pre-European extent of vegetation association 750 was 1,229,182.16 ha, with the 2018 current extent remaining being 1,225,280.52 ha, or 99.68%, with some 34,144.53 ha in DBCA managed lands. • Vegetation Association 750 is widespread and common throughout the local area including the Site Access Road, as well as the broader region, thus the area to be cleared is not considered to be a significant remnant.
F	Native vegetation should not be cleared if it is growing in, or in associated with, an environment associated with a watercourse or wetland	The proposed clearing is unlikely to be at variance with this as: • The nearest watercourse is approximately 700 m away and exhibits a different vegetation type to that of the proposed clearing area. • The proposed clearing will most likely be of insufficient magnitude to affect the surrounding hydrology.
G	Native vegetation should not be cleared if the clearing of the land is likely to cause appreciable land degradation	The proposed clearing is unlikely to be at variance with this principle because the proposed clearing is adjacent to already cleared land that functions as a regional Highway with little change to the surrounding land condition expected.
H	Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area	The proposed clearing area is unlikely to be at variance with this principle because the area is located within a currently designated road reserve and as no nature reserves occur within 50 km.
I	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water	The proposed clearing is unlikely to be at variance with this principle because: • The nearest watercourse is a minor ephemeral stream approximately 700 m to the north of the proposed Purpose Permit Area, thus flows are unlikely to be impacted. • Rockwater (2016) determined that the depth to groundwater is more than 20 m below surface level for most of the local area.
J	Native vegetation should not be cleared if clearing the vegetation is likely to cause or exacerbate the incidence of flooding	The proposed clearing is not at variance with this principle as it will function as a relatively limited expansion of pre-existing cleared land on a large plain, thus is unlikely to result in a substantial change to the surface hydrology of the surrounding area.

6. REFERENCES

Biodiversity Conservation Act 2016 (WA) (BC Act)

Bureau of Meteorology (BoM). 2023. Climate and weather data for Derby Aero. http://www.bom.gov.au/climate/averages/tables/cw_003032.shtml (accessed January 2023). Canberra: BoM

Country Area Water Supply Act 1947 (WA) (CAWS Act)

CSIRO. 2009. Water in the Fitzroy region, pp 61–128 in Water in the Timor Sea Drainage Division. A report to the Australian Government from the CSIRO Northern Australia Sustainable Yields Project. CSIRO Water for a Healthy Country Flagship, Australia. Canberra: CSIRO.

Department of Biodiversity, Conservation and Attractions (DBCA), (2019), 2018 Statewide Vegetation Statistics (formerly CAR Reserve Analysis): Full Report, accessed December 2022 via: https://catalogue.data.wa.gov.au/dataset/dbca-statewide-vegetation-statistics.

Department of Biodiversity, Conservation and Attractions, (DBCA), (2022), Threatened Ecological Communities (DBCA-038), accessed December 2022 via: https://catalogue.data.wa.gov.au/dataset/threatened-ecological-communities.

Department of Primary Industries and Regional Development (DPIRD), (2019), Pre-European Vegetation (DPIRD-006), accessed December 2022 via: https://catalogue.data.wa.gov.au/dataset/pre-european-dpird-006.

Department of Primary Industries and Regional Development (DPIRD), (2020), Native Vegetation Extent (DPIRD-005), accessed December 2022 via: https://catalogue.data.wa.gov.au/dataset/native-vegetation-extent.

Department of Primary Industries and Regional Development (DPIRD), (2022), Soil Landscape Mapping - Best Available (DPIRD-027), accessed December 2022 via: https://catalogue.data.wa.gov.au/dataset/soil-landscape-mapping-best-available.

Ecologia Environment. 2012a. Thunderbird Dampier Peninsula Project Level 1 Flora and Fauna Assessment. Unpublished report prepared for Sheffield Resources Limited.

Ecologia Environment. 2012b. Thunderbird Dampier Peninsula Project Cultural Heritage Flora And Fauna Assessment Report To The Kimberley Land Council Aboriginal Corporation and The Native Title Claim Group. Unpublished report prepared for Sheffield Resources Limited.

Ecologia Environment. 2014a. Thunderbird Project Level 2 Flora and Vegetation Report. Unpublished report prepared for Sheffield Resources Limited.

Ecologia Environment. 2014b. Thunderbird Project Level 2 Terrestrial and Subterranean Fauna Assessment. Unpublished report prepared for Sheffield Resources Limited.

Ecologia Environment. 2014c. Thunderbird Project Short Range Endemic Invertebrate Targeted Survey. Unpublished Report Prepared for Sheffield Resources.

Ecologia Environment. 2015. Thunderbird Project Haul Road and Accommodation Village Flora and Fauna Assessment. Unpublished report prepared for Sheffield Resources Limited.

Ecologia Environment. 2016. Thunderbird Project Targeted Greater Bilby Assessment. Unpublished report prepared for Sheffield Resources Limited.

Environmental Protection Act 1986 (WA) (EP Act)

Environment Protection and Biodiversity Conservation Act 1999 (Cwlth) (EPBC Act)

Graham, G. 2001. Dampierland 2 (DL2 - Pindanland subregion). In A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002. Perth: Department of Parks and Wildlife.

Mattiske Consulting Pty Ltd. 2016a. Flora and Vegetation of the Thunderbird Mineral Sands Project Area. Unpublished report prepared for Sheffield Resources Limited.

Mattiske Consulting Pty Ltd (Mattiske). 2016b. Potential Groundwater Dependent Ecosystems in the Thunderbird Mineral Sands Project Area. Unpublished report prepared for Sheffield Resources Limited.

MBS Environmental (MBS). 2022. Thunderbird Mineral Sands Project Mining Proposal. Unpublished report prepared for Sheffield Resources.

MBS Environmental (MBS). 2017. Thunderbird Mineral Sands Project Public Environmental Review. Unpublished report prepared for Sheffield Resources.

MBS Environmental (MBS). 2016. Thunderbird Surface Hydrology. Unpublished report prepared for Sheffield Resources.

MBS Environmental (MBS). 2018. Works Approval Amendment Application. Unpublished report prepared for Sheffield Resources.

Payne, A. L. and Schoknect, N. 2011. *Land Systems of the Kimberley Region, Western Australia*. Technical Bulletin No. 98. Perth: Department of Agriculture and Food.

Pennington Scott. 2014. Thunderbird Mineral Sands Project H3 Hydrogeological Assessment. Unpublished report prepared for Sheffield Resources Limited.

Rights in Water Irrigation Act 1914 (WA) (RIWI Act)

Rockwater 2016. H3 – Level Hydrogeological Assessment of The Thunderbird Project. Report prepared for Sheffield.

Stern, H., de Hoedt, G. and Ernst, J. 2000. Objective Classification of Australian Climates. *Australian Meteorological Magazine*, 49: 87-96

APPENDICES

APPENDIX 1 FLORA AND VEGETATION OF THE THUNDERBIRD MINERAL SANDS PROJECT AREA (MATTISKE, 2016)

FLORA AND VEGETATION OF THE

THUNDERBIRD MINERAL SANDS PROJECT AREA

Prepared for

Sheffield Resources Limited

Prepared by

Mattiske Consulting Pty Ltd

September 2016

MBS1601/020/16

Mattiske Consulting Pty Ltd

Disclaimer and Limitation

This report has been prepared on behalf of and for the exclusive use of Sheffield Resources Limited, and is subject to and issued in accordance with the agreement between Sheffield Resources Limited and Mattiske Consulting Pty Ltd. Mattiske Consulting Pty Ltd accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.

This report is based on the scope of services defined by Sheffield Resources Limited, budgetary and time constraints imposed by Sheffield Resources Limited, the information supplied by Sheffield Resources Limited (and its agents), and the method consistent with the preceding.

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TABLE OF CONTENTS

Page

1. SUMMARY 1
2. INTRODUCTION 3
   2.1 Location and Scope of Proposal 3
   2.2 Western Australia's Flora – A Legislative Perspective 3
   2.2.1 Threatened and Priority Flora 6
   2.2.2 Threatened and Priority Ecological Communities 7
   2.2.3 Clearing of Native Vegetation 8
   2.3 Declared (Plant) Pest Organisms 9
   2.4 Local and Regional Significance 9
3. OBJECTIVES 11
4. METHODS 12
   4.1 Desktop Survey 12
   4.2 Data from Flora and Vegetation Surveys of the Thunderbird Project Area Completed between 2012 and 2015 12
   4.3 Field Survey 12
   4.4 Statistical Analysis of Data and Vegetation Mapping 14
   4.5 Vegetation Descriptions 14
5. DESKTOP SURVEY RESULTS 15
   5.1 Climate 15
   5.2 IBRA7 Biogeographical Sub-regions 15
   5.3 Beard's Vegetation Mapping 17
   5.4 Land Systems 20
   5.5 Geology, Soils and Topography 24
   5.6 Pre-European Vegetation 25
   5.7 Current Land Use 26
   5.8 Previous Surveys in the Thunderbird Project Area 30
   5.9 Fire History 32
   5.10 Threatened Ecological Communities 34
   5.11 Priority Ecological Communities 34
   5.12 Threatened and Priority Flora 36
   5.13 Introduced (Exotic) Plant Species 38
6. FIELD SURVEY RESULTS 42
   6.1 Field Survey Coverage, Limitations and Constraints 42
   6.2 Flora 45
   6.2.1 Proportion of Flora Surveyed 45
   6.2.2 Threatened and Priority Flora 46
   6.2.3 Taxa with Extensions to their Range 47
   6.2.4 Introduced (Exotic) Plant Species 47
   6.3 Statistical Analysis of Data 49
   6.4 Vegetation Mapping 50
   6.5 Area Coverage of Vegetation Communities 54
   6.6 Threatened Ecological Communities 54
   6.7 Priority Ecological Communities 55
   6.8 Condition of the Vegetation 55
7. DISCUSSION 56
8. CONCLUSIONS 63
9. ACKNOWLEDGEMENTS 65
10. LIST OF PERSONNEL 65
11. REFERENCES 65

TABLES

1: Rainfall at Derby Aero in the four months preceding flora and vegetation surveys in the Thunderbird Project Area

2: Extent of IBRA sub-regions intersecting the Thunderbird Project Area

3 Extent of Land Systems intersecting the Thunderbird Project Area

4: Extent of pre-European vegetation associations intersecting the Thunderbird Project Area

5: Vegetation units delineated by Ecologia within the Thunderbird Project Area

6: Threatened and Priority flora taxa in the vicinity of the Thunderbird Project Area

7: Introduced plant species in the vicinity of the Thunderbird Project Area

8: Survey limitations and constraints

9: Priority flora taxa recorded in the Thunderbird Project Area, June 2016

10: Locations of introduced species recorded in the Thunderbird Project Area

11: Area coverage of each vegetation community in the Thunderbird Project Area

FIGURES

1: Thunderbird Mineral Sands Project Locality and Pastoral Stations

2: Thunderbird Mineral Sands Project Tenements (as at 11/07/2016)

3: Rainfall and temperature data for Derby Aero

4: Thunderbird Mineral Sands Project IBRA Regions, Showing Managed Lands and Waters

5: Thunderbird Mineral Sands Project Land Systems

6: Soil-landscape provinces and zones of the Kimberley

7: Thunderbird Mineral Sands Project Soils

8: Thunderbird Mineral Sands Project Pre-European vegetation

9: Thunderbird Mineral Sands Project Heritage Areas

10: Ecologia veg mapping

11A: Thunderbird Mineral Sands Project Threatened and Priority Ecological Communities and Flora

11B: Thunderbird Mineral Sands Project Conservation Significant Flora

12: Thunderbird Project Area Quadrat Locations, Tracks Driven and Foot Traverses

13: Average randomised species accumulation curve

14: Dendrogram of the 242 survey quadrats established across the Thunderbird Project Area

15: Thunderbird Project Area Vegetation overview

PLATES

1: * *Sida acuta*

2: * *Cenchrus ciliaris*

3: * *Portulaca pilosa*

4: * *Stylosanthes hamata*

5: Photograph of *Melaleuca alsophila* or *Melaleuca viridiflora* and *Eucalyptus tectifica* low, open woodland, over *Chrysopogon pallidus* sparse tussock grassland and *Cyperus conicus* sparse sedgeland, facing south-east from quadrat north-west corner.

6: Photograph of *Melaleuca alsophila* or *Melaleuca viridiflora* and *Eucalyptus tectifica* low, open woodland, over *Chrysopogon pallidus* sparse tussock grassland and *Cyperus conicus* sparse sedgeland, facing north-west from quadrat north-west corner

APPENDICES

A: Legislative protection for Western Australia's Environment

B: Coordinates delineating the boundary of the Thunderbird Project Area

C: Vascular plant species recorded from the desktop assessment and within the Thunderbird Project Area

D: Assessment of threatened and priority flora potentially present in the Thunderbird Project Area

E: Location of vegetation survey quadrats within the Thunderbird Project Area

F: Vascular plant species recorded in each survey quadrat in the Thunderbird Project Area

G: Locations and populations of Priority flora recorded within the Thunderbird Project Area

H: Threatened and Priority Flora report forms

I: Thunderbird Project Area vegetation

J: Vascular plant species recorded in each defined vegetation community in the Thunderbird Project Area

K: Summary of vegetation communities on the Thunderbird Project Area

ABBREVIATIONS

The following abbreviations are used throughout this document:

BAM Act	*Biosecurity and Agriculture Management Act 2007*
BOM	Commonwealth Bureau of Meteorology
DAFWA	Department of Agriculture and Food, Western Australia
DER	Department of Environment Regulation
DMP	Department of Mines and Petroleum
DotE	Department of the Environment

ABBREVIATIONS

DPaW	Department of Parks and Wildlife
Ecologia	Ecologia Environment
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESCAVI	Executive Steering Committee for Australian Vegetation Information
Mattiske	Mattiske Consulting Pty Ltd
NVIS	National Vegetation Information System
PEC	Priority Ecological Community
Sheffield	Sheffield Resources Limited
TEC	Threatened Ecological Community
TSSC	Western Australian Threatened Species Scientific Committee
WAH	Western Australian Herbarium
WAOL	Western Australian Organism List

1. SUMMARY

Mattiske Consulting Pty Ltd was commissioned by Sheffield Resources Limited to undertake a Level 2 flora and vegetation survey of the Thunderbird Project Area. The Thunderbird Project Area occupies an area of 18,886 ha and is situated on the Dampier Peninsula, between Broome and Derby, across the Mt Jowlaenga and Yeeda Stations.

The Thunderbird Project Area has been the subject of three flora and vegetation surveys completed between 2012 and 2015. Prior to undertaking the field survey in June 2016, Mattiske Consulting Pty Ltd reviewed the historical literature relating to the flora and vegetation of the region, as well as undertaking a gap analysis of the three surveys which had previously been completed in the Thunderbird Project Area. The gap analysis identified four principle areas which warranted additional survey work in the Thunderbird Project Area. These were:

1. A change in the boundary of the Thunderbird Project Area, as compared to the areas surveyed between 2012 and 2015, necessitating the establishment of survey quadrats in areas which previously did not fall within the present Thunderbird Project Area boundary;
2. The lower than desirable density of quadrats surveyed in the previous surveys to ensure adequate coverage for a Level 2 vegetation survey;
3. Mapping of the vegetation within the Thunderbird Project Area which did not reflect the landforms present; and
4. A review of an area within the Thunderbird Project Area which had been described as having similarities with the Lolly Well Springs wetland complex Priority 3 PEC.

A total of 255 vascular plant taxa which are representative of 129 genera and 44 families were recorded in the Thunderbird Project Area during the 2016 survey. The majority of taxa recorded were representative of the Poaceae (46 taxa), Fabaceae (45 taxa), Malvaceae (18 taxa), Cyperaceae (14 taxa), Myrtaceae (14 taxa), Amaranthaceae (12 taxa) and Convolvulaceae (10 taxa) families. Overall, when data from the three previous flora surveys of the Thunderbird Project Area are assessed together with the data from the present survey, approximately 81% of the species potentially present within the Thunderbird Project Area have been recorded. This, together with the fact that four surveys have been completed over a four-year period, demonstrates that the area has been thoroughly assessed floristically, and that the conditions for a Level 2 survey have been satisfied.

A total of 14 vegetation communities were defined and mapped, based on a statistical analysis of the combined data from the present and three past surveys of the Thunderbird Project Area. Two of these vegetation communities, W6 and W8, which constitute pindan vegetation (low sparse eucalypt woodlands over *Acacia tumida* shrubland over *Triodial Chrysopogon* grasslands), accounted for approximately 86% of the surveyed area. The other main communities mapped were associated with the drainage channels (*Melaleuca viridifloral Melaleuca alsophila* woodland) and rocky hills within the Thunderbird Project Area. Overall, the vegetation communities mapped and species recorded in the Thunderbird Project Area are consistent with the historical mapping of John Beard (1976) and the more recent land systems mapping of Kimberley by Schoknecht and Payne (2010). The majority of the

Thunderbird Project Area comprised red sandy flats supporting pindan vegetation. Indicative impact areas show that impacts associated with planned mining operations may impact the W6 and W8 communities. These communities are essentially the common pindan vegetation of the region, and hence likely impacts are considered to be low.

The priority taxon *Triodia caelestialis* (P3) was recorded widely across the survey area. A second priority taxon, *Pterocaulon intermedium* (P3), was recorded infrequently, and was not associated with any specific vegetation community delineated. Both taxa are expected to be recorded outside the Thunderbird Project Area boundary, and hence overall impacts are considered likely to be low.

An area within the Thunderbird Project Area, which statistically groups with community W1, a drainage channel community consisting of *Melaleuca viridifloral Melaleuca alsophila*, was claimed by Ecologia (2014) to have some resemblance to the Lolly Wells Spring PEC. This claim was not supported by any statistical analysis or reasonable argument. A review by Mattiske indicates that the claimed area is simply an internal drainage area set in a low lying area amongst gentle slopes.

2. INTRODUCTION

Sheffield Resources Limited (Sheffield) proposes to develop a mineral sands (zircon and ilmenite) mining operation at its Thunderbird Mineral Sands Project Area, hereinafter referred to as the Thunderbird Project Area, in the West Kimberley region of Western Australia. The Thunderbird Project Area has been the subject of three flora and vegetation surveys completed by Ecologia Environment (Ecologia) between 2012 and 20152. These surveys were a Level 1 flora and fauna assessment (Ecologia 2012), a Level 2 flora and vegetation survey (Ecologia 2014) and a Haul Road and Accommodation Camp flora and fauna assessment (Ecologia 2015).

Mattiske Consulting Pty Ltd (Mattiske) was commissioned in May 2016 by Sheffield, to undertake a further flora and vegetation assessment of the Thunderbird Project Area. The reasons for undertaking an additional survey included a change to the Thunderbird Project Area boundary, with previously unsurveyed areas now forming part of the project area, and the identification of gaps in the original surveys which warranted additional survey work being undertaken.

2.1 Location and Scope of Proposal

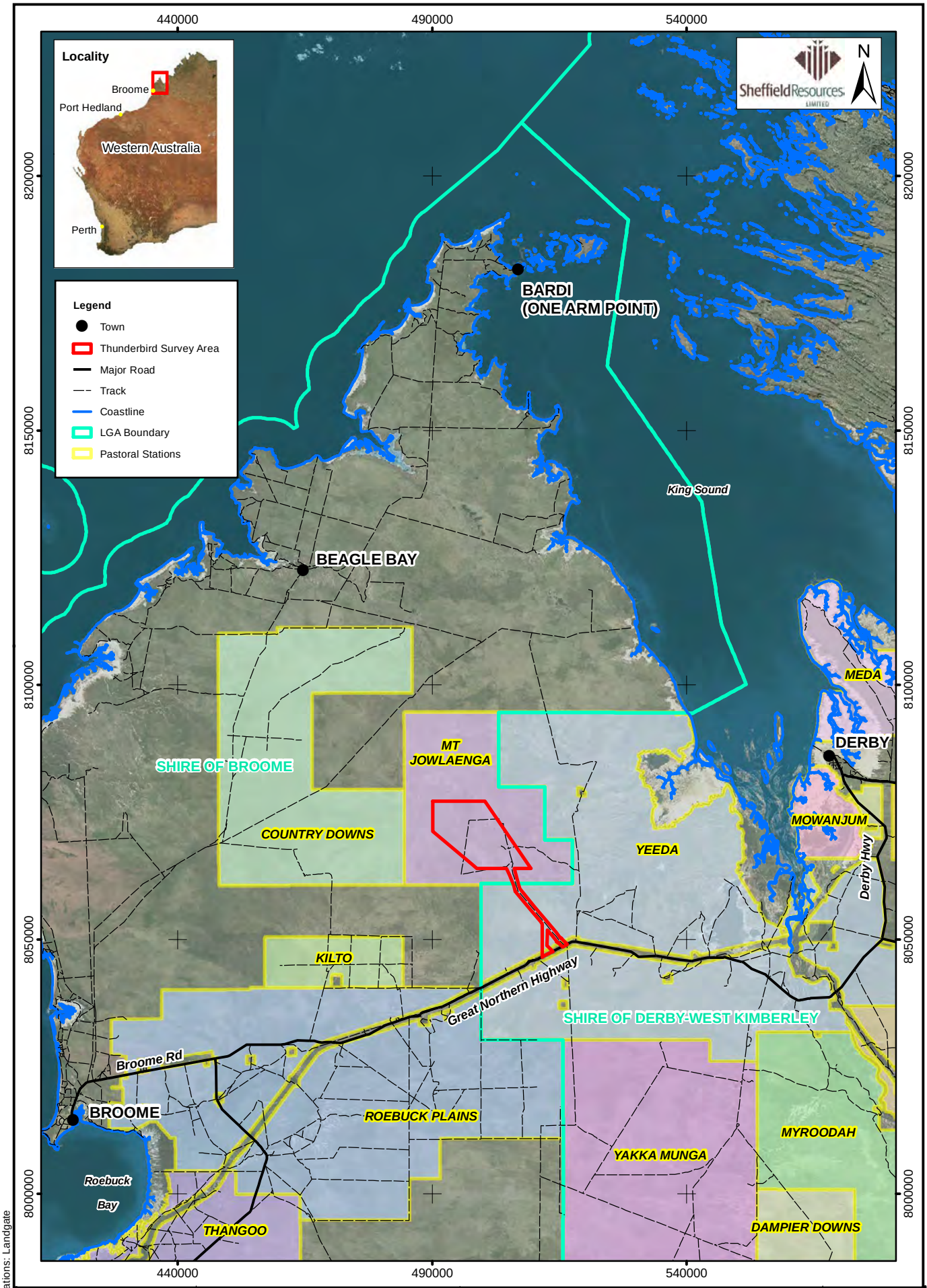
The Thunderbird Project Area is located approximately 98 km northeast of Broome and 72 km west of Derby in the West Kimberley region of Western Australia (Figure 1). The Thunderbird Project Area is situated on the Mt Jowlaenga and Yeeda Stations, and occupies an area of approximately 18,886 ha.

The Thunderbird Project Area is located within granted mining leases M04/311, M04/313, M04/357, M04/454, granted exploration tenements E04/2083, E04/2159, E04/2171, E04/2084, granted miscellaneous licences L04/85, L04/93, L04/86, L04/92, L04/84, L04/81, pending mining lease M04/459, and pending miscellaneous licences L04/82 and L04/83 (Figure 2).

The scope of the survey was to complete a Level 2 flora and vegetation assessment of the Thunderbird Project Area, whose boundary had been modified relative to previously completed flora surveys. New vegetation survey quadrats were established in areas previously not surveyed. In addition, after completing a gap analysis of the previous survey work, additional survey work within the original survey areas was undertaken to provide a more comprehensive survey of the Thunderbird Project Area.

2.2 Western Australia's Flora – A Legislative Perspective

Western Australia has a unique and diverse flora, and is recognised as one of the world's 34 biodiversity hotspots (Myers *et al.* 2000). In this context, Western Australia possesses a high degree of species richness and endemism. This is particularly pronounced in the south-west region of the state. The Department of Parks and Wildlife (DPaW) flora statistics indicate that there are currently over 12,000 native plant species known to occur within Western Australia (DPaW 2016a). Scientific knowledge of many of these species is limited.



Source: Pastoral Stations: Landgate

0 5 10 15 20 km

Scale: 1:1,000,000
MGA94 (Zone 51)

CAD Ref: a2409_f50_01

Date: Jul 2016 | Rev: A | A4

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28 Central Road, Kalamunda WA 6076 ~ Tel: 9257 1625 ~ Fax: 9257 1640
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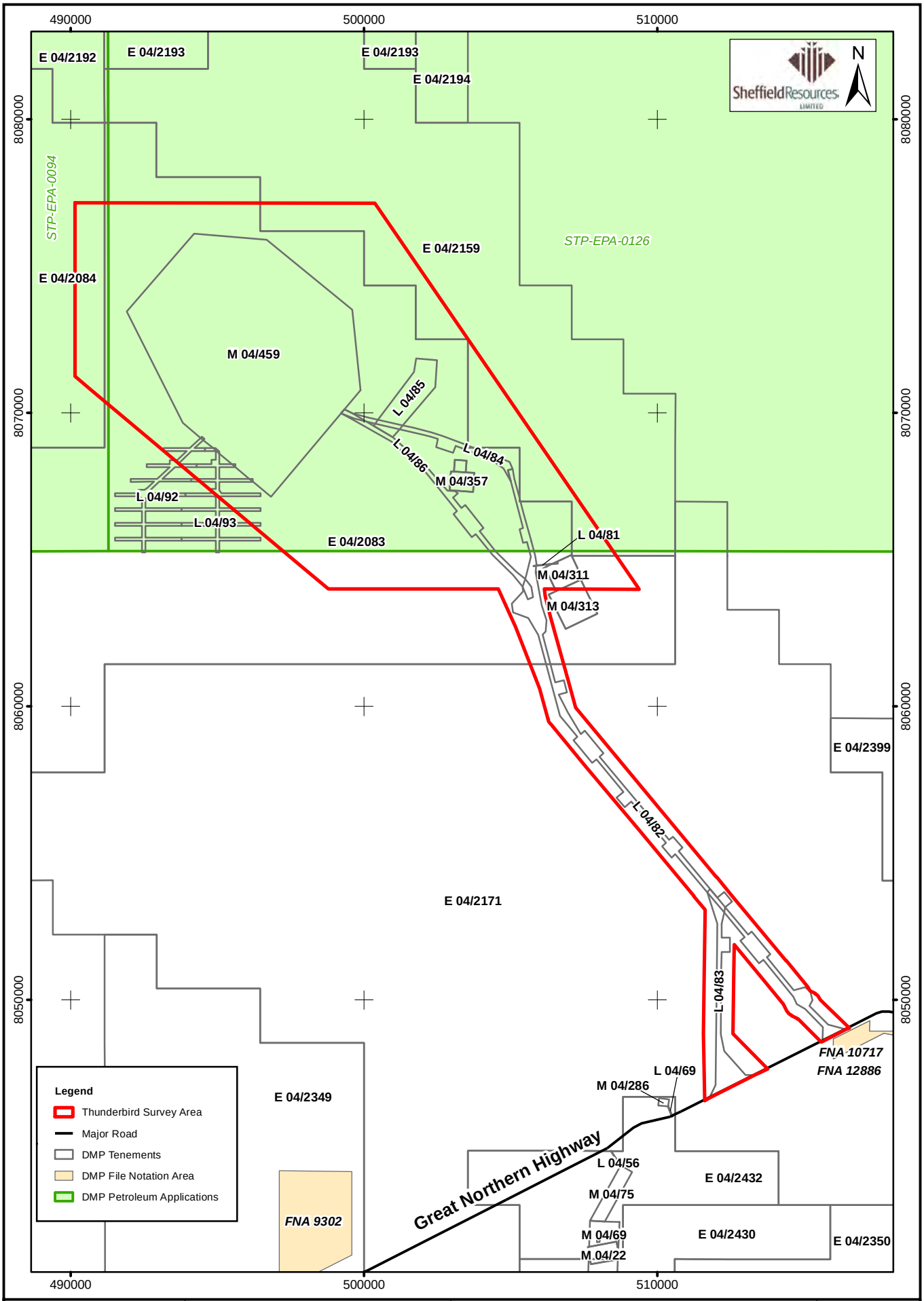
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

Thunderbird Mineral Sands Project
Locality
Showing Pastoral Stations

Figure: **1**



0 1 2 3 km

Scale: 1:175,000
MGA94 (Zone 51)

CAD Ref: a2409_f50_02

Date: Jul 2016 | Rev: A | A4

Source: Tenements: DMP, Catchments: DoW

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Thunderbird Mineral Sands Project
Tenements
as at 11/07/2016

Figure: **2**

The legislative protection of flora within Western Australia is principally governed by three Acts. These are:

- The *Wildlife Conservation Act 1950*;
- The *Environmental Protection Act 1986*; and
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

The unique flora of Western Australia is potentially under threat due to historical clearing practices associated with agricultural, mining and human habitation activities. As a consequence of these historical clearing practices a number of flora species have become threatened or have the potential to become threatened as their habitat is impacted by human activity. In addition, some areas of the State have been affected by past clearing practices such that entire ecological communities are under threat. The following sections describe these threatened and priority flora and ecological communities, and outline the legislative protection afforded to them.

At the State level, the *Wildlife Conservation Act 1950* provides for taxa of native flora (and fauna) to be specially protected because they are subject to identifiable threats. Protection of these taxa has been identified as being warranted because they may become extinct, are threatened, or are otherwise in need of special protection. Ecological communities that are deemed to be threatened are afforded protection under the *Environmental Protection Act 1986*. Listings of threatened species and communities are reviewed annually by the Western Australian Threatened Species Scientific Committee (TSSC), which is a body appointed by the Minister for the Environment and supported by the DPaW. The TSSC reviews threatened and specially protected flora (and fauna) listings on an annual basis. Recommendation for additions or deletions to the listings of specially protected flora (and fauna) is made to the Minister for the Environment by the TSSC, via the Director General of the DPaW, and the WA Conservation Commission. Under Schedule 1 of the *Wildlife Conservation Act 1950*, the Minister for the Environment may declare a class or description of flora to be threatened flora throughout the State, by notice published in the *Government Gazette* (DPaW 2016b).

At the Commonwealth level, under the *Environment Protection and Biodiversity Conservation Act 1999*, a nomination process exists, to list a threatened species or ecological community. Additions or deletions to the lists of Threatened species and communities are made by the Minister for the Environment, on advice from the Federal Threatened Species Scientific Committee. *Environment Protection and Biodiversity Conservation Act 1999* lists of Threatened flora and ecological communities are published on the Department of the Environment (DotE) website (2016a, 2016b).

2.2.1 Threatened and Priority Flora

Flora within Western Australia that is considered to be under threat may be classed as either threatened flora or priority flora. Where flora has been gazetted as threatened flora under the *Wildlife Conservation Act 1950*, it is an offence "to take" such flora without the written consent of the Minister. The *Wildlife Conservation Act 1950* states that "to take" flora includes to gather, pluck, cut, pull up, destroy, dig up, remove or injure the flora or to cause or permit the same to be done by any means.

Priority flora constitute species which are considered to be under threat, but for which there is insufficient information available concerning their distribution and/or populations to make a proper evaluation of their conservation status. Such species are considered to potentially be under threat, but do not have legislative protection afforded under the *Wildlife Conservation Act 1950*. The DPaW categorises priority flora according to their conservation priority, using five categories, P1 to P4, to denote the conservation priority status of such species, with P1 listed species being the most threatened, and P4 the least. Priority flora species are regularly reviewed, and may have their priority status changed when more information on the species becomes available. Appendix A1 sets out definitions of both threatened and priority flora (DPaW 2016c).

At the Commonwealth level, under the *Environment Protection and Biodiversity Conservation Act 1999*, threatened species can be listed as extinct, extinct in the wild, critically endangered, endangered, vulnerable, or conservation dependent, by the Commonwealth Minister for the Environment. Refer to Appendix A2 for a description of each of these categories of threatened species. Under the *Environment Protection and Biodiversity Conservation Act 1999*, a person must not take an action that has or will have a significant impact on a listed threatened species without approval from the Commonwealth Minister for the Environment, unless those actions are not prohibited under the Act.

The current *Environment Protection and Biodiversity Conservation Act 1999* list of Threatened flora may be found on the Department of the Environment (2016a) website.

2.2.2 Threatened and Priority Ecological Communities

An ecological community is defined as a naturally occurring biological assemblage that occurs in a particular type of habitat composed of specific abiotic and biotic factors. At the State level, ecological communities may be considered as threatened once they have been identified as such by the Western Australian Threatened Ecological Communities Scientific Advisory Committee. A threatened ecological community is defined, under the *Environmental Protection Act 1986*, as an ecological community listed, designated or declared under a written law or a law of the Commonwealth as threatened, endangered or vulnerable. There are four State categories of threatened ecological communities, or TECs: presumed totally destroyed (PD); critically endangered (CR); endangered (EN); and vulnerable (VU) (DPaW 2015d). A description of each of these categories of TECs is presented in Appendix A3. Threatened ecological communities are gazetted as such (DPaW 2016e).

At the Commonwealth level, some Western Australian TECs are listed as threatened, under the *Environment Protection and Biodiversity Conservation Act 1999*. Under the *Environment Protection and Biodiversity Conservation Act 1999*, a person must not take an action that has or will have a significant impact on a listed threatened ecological community without approval from the Commonwealth Minister for the Environment, unless those actions are not prohibited under the Act. A description of each of these categories of TECs is presented in Appendix A4. The current *Environment Protection and Biodiversity Conservation Act 1999* list of threatened ecological communities can be located on the DotE (2016b) website.

Ecological communities identified as threatened, but not listed as threatened ecological communities, can be classified as priority ecological communities (PECs). These communities are under threat, but there is insufficient information available concerning their distribution to make a proper evaluation of their conservation status. The DPaW categorises priority ecological communities according to their conservation priority, using five categories, P1 to P5, to denote the conservation priority status of such ecological communities, with P1 communities being the most threatened and P5 the least. Appendix A5 sets out definitions of priority ecological communities (DPaW 2016d). A list of current priority ecological communities can be viewed at the DPaW (2016f) website.

2.2.3 Clearing of Native Vegetation

Under the *Environmental Protection Act 1986*, the clearing of native vegetation requires a permit to do so, from the Department of Environment Regulation or the Department of Mines and Petroleum, unless that clearing is exempted under specific provisions listed in Schedule 6 of the Act, or are prescribed in the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. Under the *Environmental Protection Act 1986*, "native vegetation" means indigenous aquatic or terrestrial vegetation, and includes dead vegetation unless that dead vegetation is of a class declared by regulation to be excluded from this definition but does not include vegetation in a plantation. Under the *Environmental Protection Act 1986*, Section 51A, "clearing" means the killing or destruction of, the removal of, the severing or ringbarking of trunks or stems of, or the doing of any other substantial damage to, some or all of the native vegetation in an area, and includes the draining or flooding of land, the burning of vegetation, the grazing of stock, or any other act or activity, that causes any of the aforementioned consequences or results.

Under the *Environmental Protection Act 1986*, ten principles are set out, under which native vegetation should not be cleared. These principles state that native vegetation should not be cleared, if:

a. it comprises a high level of biological diversity;
b. it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia;
c. it includes, or is necessary for the continued existence of, threatened flora;
d. it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community;
e. it is significant as a remnant of native vegetation in an area that has been extensively cleared;
f. it is growing in, or in association with, an environment associated with a watercourse or wetland;
g. the clearing of the vegetation is likely to cause appreciable land degradation;
h. the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area;
i. the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water; or
j. the clearing of the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.

The *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*, under Regulation 5, sets out prescribed clearing actions that do not require a clearing permit, as defined in Section 51C of the *Environmental Protection Act 1986*. However, exemptions under these Regulations do not apply in Environmentally Sensitive Areas (ESA's).

Under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*, under Regulation 6 – "Environmentally sensitive areas" include "the area covered by vegetation within 50 m of threatened flora, to the extent to which the vegetation is continuous with the vegetation in which the threatened flora is located". Similarly, "the area covered by a threatened ecological community" is listed as an environmentally sensitive area under Regulation 6.

2.3 Declared (Plant) Pest Organisms

The *Biosecurity and Agriculture Management Act 2007* (BAM Act), Section 22, makes provision for a plant taxon to be listed as a declared pest organism in respect to parts of, or the entire State. According to the BAM Act, a declared pest is defined as a prohibited organism (Section 12), or an organism for which a declaration under section 22 (2) of the Act is in force.

Under section 26 (1) of the BAM Act, a person who finds a declared plant pest must report, in accordance with subsection (2), the presence or suspected presence of the declared pest to the Director General or an inspector of the Department of Agriculture and Food Western Australia.

Under the *Biosecurity and Agriculture Management Regulations 2013*, declared plant pests are placed in one of three control categories, C1 (exclusion), C2 (eradication) or C3 (management), which determines the measures of control which apply to the declared pest (Appendix A6). According to section 30 (3) of the BAM Act, the owner or occupier of land, or a person who is conducting an activity on the land, must take the prescribed control measures to control the declared pest if it is present on the land.

The current listing of declared pest organisms and their control category is available on the Western Australian Organism List (WAOL), at the Biosecurity and Agriculture Management website of the Department of Agriculture and Food Western Australia (DAFWA 2016).

2.4 Local and Regional Significance

Flora or vegetation may be locally or regionally significant in addition to statutory listings by the State or Federal Government.

In regards to flora; species, subspecies, varieties, hybrids and ecotypes may be significant other than as threatened flora or priority flora, for a variety of reasons, including:

- a keystone role in a particular habitat for threatened species, or supporting large populations representing a significant proportion of the local regional population of a species;
- relic status;

- anomalous features that indicate a potential new discovery;
- being representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- the presence of restricted subspecies, varieties, or naturally occurring hybrids;
- local endemism/a restricted distribution; and
- being poorly reserved (Environmental Protection Authority 2004).

Vegetation may be significant because the extent is below a threshold level and a range of other reasons, including:

- scarcity;
- unusual species;
- novel combinations of species;
- a role as a refuge;
- a role as a key habitat for threatened species or large populations representing a significant proportion of the local to regional total population of a species;
- being representative of the range of a unit (particularly, a good local and/or regional example of a unit in "prime" habitat, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- a restricted distribution (Environmental Protection Authority 2004).

Vegetation communities are locally significant if they contain Priority Flora species or contain a range extension of a particular taxon outside of the normal distribution. They may also be locally significant if they are very restricted to one or two locations or occur as small isolated communities. In addition, vegetation communities that exhibit unusually high structural and species diversity are also locally significant.

Vegetation communities are regionally significant where they are limited to specific landform types, are uncommon or restricted plant community types within the regional context, or support populations of threatened Flora.

Determining the significance of flora and vegetation may be applied at various scales, for example, a vegetation community may be nationally significant and governed by statutory protection as well as being locally and regionally significant.

3. OBJECTIVES

The aim of this survey was to complete a Level 2 flora and vegetation survey of the Thunderbird Project Area. Specifically, the objectives of the survey of the Thunderbird Project Area included:

- Undertake a desktop assessment to evaluate the botanical values of the local and broader area associated with the Thunderbird Project Area to identify any matters of botanical or conservation significance;
- Review previous literature and data, including undertaking a gap analysis with respect to previous flora and vegetation surveys of the Thunderbird Project Area;
- On the basis of the reviews, provide summaries to assist in the assessment of the potential range of values and the potential for conservation significant species and communities;
- Undertake botanical data collection in quadrats that are representative of all potential vegetation communities within the survey area of sufficient detail to permit appropriate statistical analyses;
- Collect and identify the vascular plant species present in vegetation survey quadrats, as well as opportunistically, within the Thunderbird Project Area;
- Record visual observations on the fire regimes, grazing pressures and overall health of the vegetation to allow for an assessment of the overall condition of the flora and vegetation within the Thunderbird Project Area;
- Identify and record the locations of any Declared Organisms within the Thunderbird Project Area;
- Review the conservation status of the vascular plant species recorded by reference to current literature and current listings by the DPaW (2016g) and plant collections held at the Western Australian State Herbarium, and listed by the Department of the Environment (DotE 2016a) under the *Environment Protection and Biodiversity Conservation Act 1999*;
- Define and prepare a vegetation map of the vegetation communities within the Thunderbird Project Area;
- Assess the condition of the vegetation communities within the Thunderbird Project Area;
- Provide descriptions of the vegetation communities present within the Thunderbird Project Area and evaluate their regional significance; and
- Prepare a report summarising the findings.

4. METHODS

The Thunderbird Project Area is approximately 18,886 ha in area. The coordinates delineating the boundaries of the Thunderbird Project Area are set out in Appendix B.

The survey was completed to the standards set out in *Guidance Statement 51 - Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004), *Position Statement No.3 – Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002), and *Technical Guide – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2015).

4.1 Desktop Survey

The desktop assessment for the Thunderbird Project Area was undertaken using the DPaW (2007-, 2016b, 2016e, 2016f) and DotE (2016a, 2016b, 2016c) databases. A 40 km search radius about the approximate centre point of the Thunderbird Project Area (499587 mE, 8070710 mN, MGA94 zone 51) was used as a search reference point. These databases were utilised to identify the possible occurrence of threatened and priority flora, threatened and priority ecological communities and any other matters protected under the EPBC Act within the vicinity of the Thunderbird Project Area.

4.2 Data from Flora and Vegetation Surveys of the Thunderbird Project Area Completed between 2012 and 2015

The Thunderbird Project Area has been the subject of three flora and vegetation surveys, completed by Ecologia Environment, between 2012 and 2015 (Ecologia 2012, 2014, 2015). Quadrat based survey data was made available by Sheffield from these surveys, in a range of formats. Species height and projected foliage cover was not made available for all three surveys. The data was transformed into a presence-absence format. Several of the survey quadrats established between 2012 and 2015 by Ecologia were re-assessed in June 2016 to verify species identifications and increase confidence in the supplied data for use in statistical analysis in 2016. The data from the 2012 to 2015 surveys was reviewed and the names and status of all species was updated to ensure currency with present taxonomic listings (DPaW 2016g).

4.3 Field Survey

The assessment of the flora and vegetation of the Thunderbird Project Area (Figures 1 and 2) was undertaken by four experienced botanists from Mattiske, from the 20th to 28th June 2016. All botanists held valid collection licences to collect flora for scientific purposes, issued under the *Wildlife Conservation Act 1950*. Additionally, at least one botanist held a valid permit to take Declared Rare Flora, issued under the *Wildlife Conservation Act 1950*.

The coordinates defining the boundaries of the Thunderbird Project Area were supplied by Sheffield (Appendix B). Aerial photographic maps at a 1:10,000 scale of the Thunderbird Project Area, based on

high resolution aerial imagery taken between October 2014 and September 2015 (0.15 m resolution overall, 0.05 m resolution in part), were prepared by CAD Resources of Carine, Western Australia. To sample all the apparent vegetation types across Thunderbird Project Area, the location of vegetation survey quadrats was made primarily on the basis of aerial photographic maps. Additional sites were selected *in situ*, based on observations of vegetation communities during the field survey. Wherever possible, replicate vegetation survey quadrats were established in the same but discontinuous vegetation community types. In addition to data recorded from vegetation survey quadrats, a more comprehensive species inventory of the Thunderbird Project Area was achieved using supplementary survey techniques - opportunistic collections, relevés and traverses - within the Thunderbird Project Area. This also enabled the visual confirmation of community boundaries during the field survey work.

All vegetation survey quadrats measured 50 m x 50 m in size. In situations where vegetation community shape (e.g. drainage channels) precluded establishing quadrats of the standard dimension, an area of equivalent size (i.e. 2,500 m^2) was surveyed. The flora and vegetation was described and sampled systematically at each vegetation survey quadrat, and additional opportunistic collecting was undertaken wherever previously unrecorded plants were observed. At each vegetation survey quadrat, the following floristic and environmental parameters were recorded:

- GPS location (GDA94 datum);
- soil type, colour and any additional observations;
- local site topography;
- presence of any outcropping rocks and their type;
- aspect of the hill-slopes;
- percentage of litter cover (logs, twigs and/or leaves);
- percentage of bare ground;
- time since fire;
- condition of the vegetation, based on Trudgeon's (1988) condition ratings; and
- alive and dead percentage of foliage cover and average height of each species recorded.

Searches for priority flora were undertaken concurrently with vegetation quadrat assessments. Preferred habitats of previously recorded priority species were traversed when encountered by botanists. When any suspected priority flora was encountered, counts were made in an appropriate area and field notes were made in relation to soil, topography and associated species. Some of the locations of priority flora recorded by Ecologia (2012, 21014, 2015) were re-visited and specimens collected to ensure the accuracy and consistency of identifications.

In addition to survey quadrats, targeted threatened and priority flora surveys were conducted concurrently. Preferred habitats of previously recorded priority species were traversed when encountered by botanists. When any suspected threatened or priority flora was encountered, counts were made in an appropriate area and anecdotal field notes were made in relation to soil, topography and associated

species. A selection of previous locations of species recorded by Ecologia were re-visited and specimens collected to ensure the accuracy and consistency of identifications between surveys and personnel.

All plant specimens collected during the field survey were dried and processed in accordance with the requirements of the Western Australian Herbarium (WAH). All plant specimens were identified through comparisons with pressed specimens housed at the Mattiske herbarium and WAH. Where appropriate, plant taxonomists with specialist skills were consulted. Nomenclature of the species recorded is in accordance with the WAH (DPaW 2016g).

4.4 Statistical Analysis of Data and Vegetation Mapping

A species accumulation curve, based on accumulated species versus number of quadrats surveyed was prepared, to evaluate the level of adequacy of the survey effort. The species accumulation curve was based on the species accumulation analysis of Colwell (2013).

Plymouth Routines in Multivariate Ecological Research version 6 (PRIMER v6) statistical analysis software was used to analyse species-by-site data and discriminate sites on the basis of their species composition (Clarke and Gorley 2006). To down-weight the relative contributions of quantitatively dominant species a presence/absence transformation of the data was used for statistical analysis. Introduced species, singletons (species recorded at only one site) and specimens that were not identified down to the species level were excluded from the analysis. Annuals were removed from the data in the analysis due to the likelihood of substantial differences between years based on seasonality of local rainfall events. Computation of similarity matrices was based on the Bray-Curtis similarity measure. Transformed data were analysed using a series of multivariate analysis routines including Hierarchical Clustering (CLUSTER), Similarity Profile (SIMPROF) and Similarity Percentages (SIMPER). Results were used to inform and support interpretation of aerial photography and delineation of individual vegetation communities.

4.5 Vegetation Descriptions

The description of the vegetation communities was based on Alpin's (1979) modification of the vegetation classification system of Specht (1970), to align with the NVIS. Vegetation communities were described at the association level of the NVIS classification framework, as defined by the Executive Steering Committee for Australian Vegetation Information (ESCAVI 2003).

5. DESKTOP SURVEY RESULTS

5.1 Climate

Beard (1990) described the climate of the West Kimberley, where the Thunderbird Project Area is situated, as having a semi-arid to dry hot tropical climate, with summer rainfall and annual precipitation of 250-800 mm. Much of the rain comes from thunderstorms. The heaviest and most widespread falls are associated with cyclonic disturbances. Derby Aero, which is located approximately 72 km to the east of the Thunderbird Project Area, has an average annual rainfall of 691 mm (Bureau of Meteorology, BOM 2016). Rainfall and temperature data for Derby Aero is illustrated in Figure 3. The rainfall and temperature data displayed covers the period January 2012 to June 2016, to span both the current survey being reported, as well as the three previous surveys (Ecologia 2012, 2014, 2015) of the Thunderbird Project Area. Rainfall in the four months preceding the June 2016 field survey was 190 mm, which is 51% of the long term average for the corresponding period. Table 1 lists the rainfall for the four months preceding each survey completed in the Thunderbird Project Area. Two of the surveys were completed after above average rainfall periods. The present survey was completed after the driest period preceding all four surveys.

Table 1: Rainfall at Derby Aero in the four months preceding flora and vegetation surveys in the Thunderbird Project Area.

Flora Survey Period	Surveying Company	Four-Month Rainfall[1]		Percent of Long Term Average Rainfall for CorrespondingMonths[1]
		Interval	Rainfall Total (mm)	
21st – 26th June 2012	Ecologia	Feb-May 2012	439.2	118
4th – 15th April 2013	Ecologia	Dec 2012 – Mar 2013	742.4	124
11th – 15th May 2015	Ecologia	Jan-Apr 2015	384.6	70
20th - 28th June 2016	Mattiske	Feb-May 2016	190.0	51

1. BOM 2016

5.2 IBRA7 Biogeographical Sub-regions

The Interim Biogeographic Regionalisation for Australia (IBRA) delineated 85 bioregions across Australia, based on a range of biotic and abiotic factors, including climate, vegetation, fauna, geology and landform (Thackway and Cresswell 1995; DotE 2016d). IBRA Version 7 refined the original 85 bioregions and 403 sub-regions described in IBRA 6.1, by expanding the number of regions to 89 and the number of sub-regions to 419. The sub-regions represent more localised and homogenous geomorphological units in each bioregion. IBRA7 includes four new oceanic bioregions, and seven new sub-regions in the oceanic bioregions and six new sub-regions in South Australia (DotE 2016d)

The Thunderbird Project Area is situated within the Dampierland 2 (DL2 – Pindanland) sub-region of the Dampierland (DAL) region. (Figure 4). Graham (2001) describes the Dampierland 2 (DLS – Pindanland) subregion as having a climate which is dry hot tropical and semi-arid with summer rainfall.

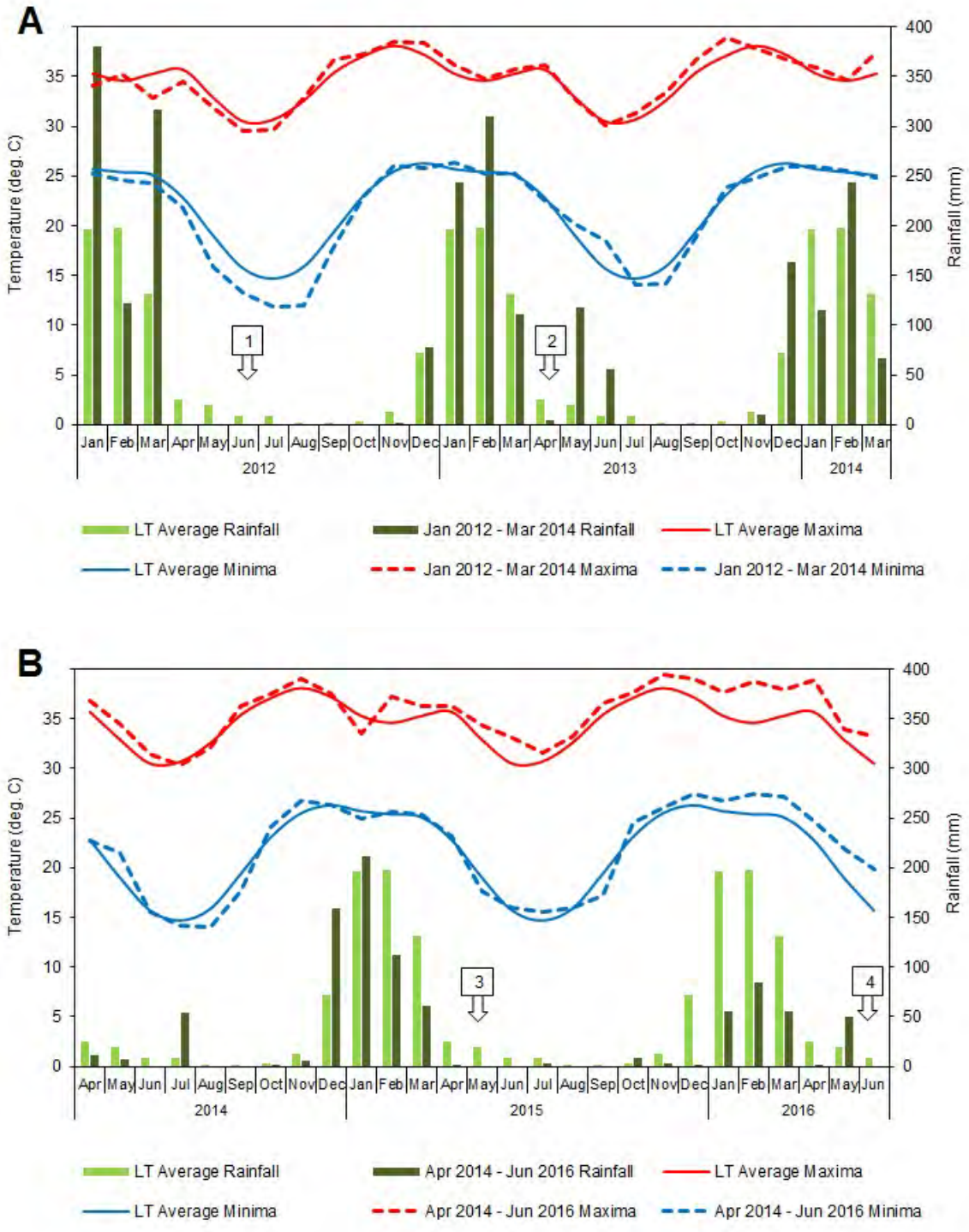


Figure 3: Rainfall and temperature data for Derby Aero
Long term average (LTA) rainfall and temperature data, together with monthly rainfall data for the period January 2012 to March 2014 (Fig. 2A) and April 2014 to June 2016 (Fig 2B) are shown (BOM 2016). The numbered markers indicate the timing of flora and vegetation surveys within the Thunderbird Project Area: 1 – June 2012 (Ecologia 2012); 2 – April 2013 (Ecologia 2014); 3 – May 2015 (Ecologia 2015); 4 - June 2016 (Mattiske, this report).

The Pindanland subregion comprises sandplains of the Dampier Peninsula and western part of Dampierland. Geologically, the subregion is dominated by:

- Quaternary sandplains overlying Jurassic and Mesozoic sandstones with pindan;
- Quaternary marine deposits on coastal plains; and
- Quaternary alluvial plains associated with Permian and Mesozoic sediments of the Fitzroy Trough.

The vegetation is described as primarily pindan (Graham 2001, Kenneally *et al*. 1996). The term pindan refers to both the soil type and its associated vegetation. The pindan soils comprise red earthy clayish sands, which form extensive undulating plains with little organised surface drainage. Pindan vegetation consists of a grassland with an upper layer composed of eucalypts, and a dense middle layer composed of *Acacia* species (Kenneally *et al*. 1996). Typical trees species include *Eucalyptus tectifica, Eucalyptus flavescens, Corymbia polycarpa, Corymbia greeniana* and *Corymbia zygophylla* (Graham 2001, Kenneally *et al*. 1996). Other common tree and large shrub species present include *Bauhinia cunninghamii, Ehretia saligna, Hakea macrocarpa, Hakea arborescens, Grevillea pyramidalis, Ventilago viminalis* and *Brachychiton diversifolius*. The grasses present are typically a mix of *Triodia*, *Chrysopogon* and *Sorghum* species (Graham 2001, Kenneally *et al*. 1996).

Table 2: Extent of IBRA sub-regions intersecting the Thunderbird Project Area.

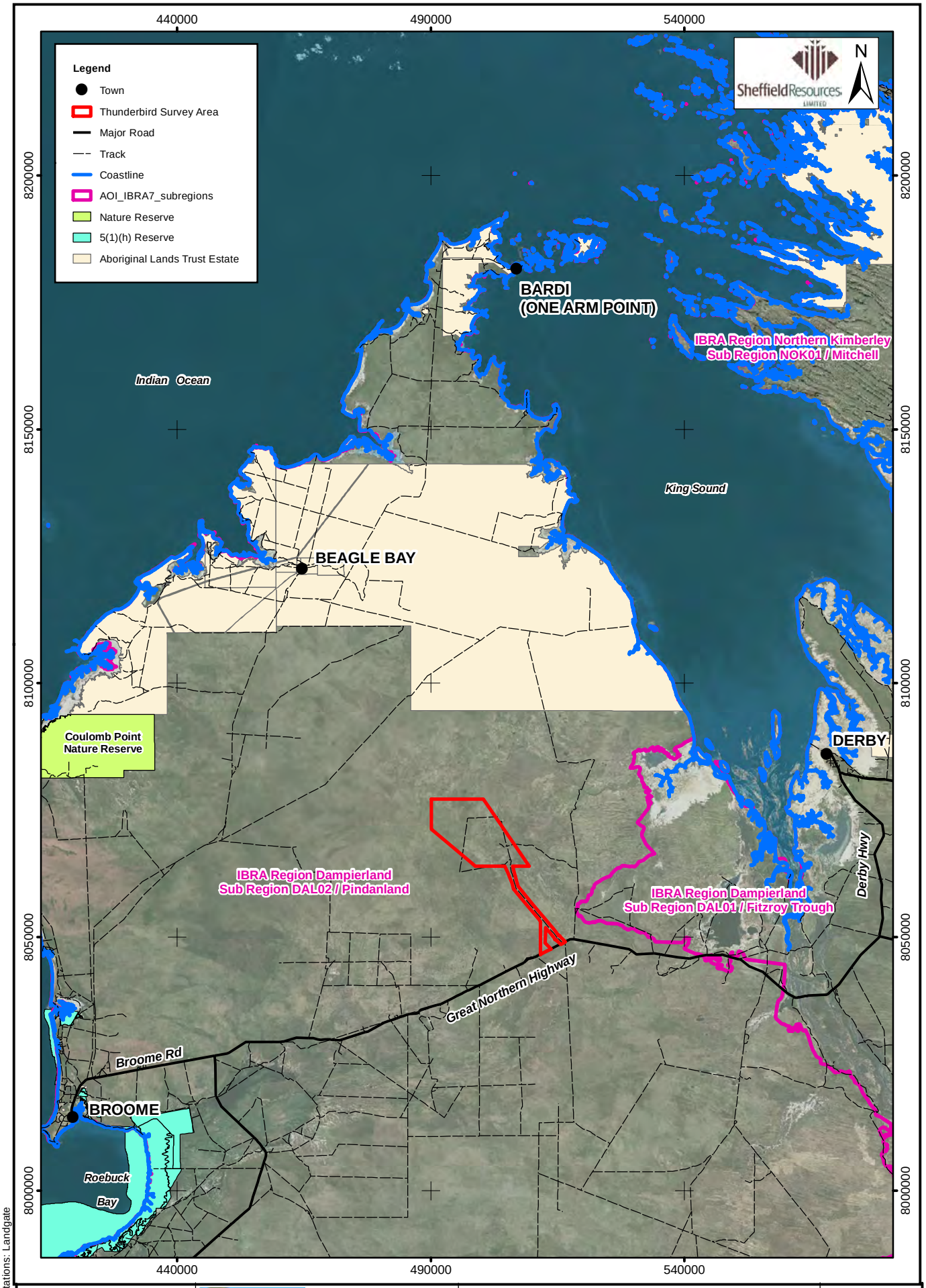
IBRA Sub-region	State-wide	Thunderbird Project Area	
	Current Extent (ha)	Area of Intersection (ha)	Proportion of Current Extent (%)
DL2 (Pindanland)	4,926,230	18,885.9195	0.38

5.3 Beard's Vegetation Mapping

Beard (1979, 1990) divided the northern province (Kimberley area) into four botanical districts, based on a combination of climate, landforms, geology, soils and vegetation patterns. The four botanical districts delineated in the northern province are the North Kimberley Region (Gardner Botanical District), Central Kimberley Region (Fitzgerald Botanical District), East Kimberley Region (Hall Botanical District) and the Dampierland Region (Dampier Botanical District) (Beard 1979, 1990). The Thunderbird Project Area falls within the Dampierland Region (Dampier Botanical District).

Geologically, Beard (1979) described the Dampier Region as being composed of quaternary sandplains and alluvia with outcrops of Phanerozoic sandstone and reef limestone. The country is low lying with little relief, except for local rugged sections on outcrops of either limestone or sandstone. The plains consist of sandy red earths, some yellow earths and lateritic podzolic soils. The region experiences summer (wet season) rainfall of 400-800 mm, with a dry season 8 months long. Much of the rain comes from thunderstorms. The heaviest and most widespread falls are associated with cyclonic disturbances.

The vegetation of the area is described as pindan, a term which incorporates the red sandy soils and the associated vegetation. The pindan is a grassland wooded by a sparse upper layer of trees and a dense thicket-forming layer of *Acacia*. Fires are a common occurrence, which periodically destroys the ground



Source: Pastoral Stations: Landgate

0 5 10 15 20 km

Scale: 1:1,000,000
MGA94 (Zone 51)

CAD Ref: a2409_f50_04

Date: Jul 2016 | Rev: B | A4

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Thunderbird Mineral Sands Project
IBRA Regions
Showing Managed Lands and Waters

Figure: **4**

layer and middle *Acacia* layer, leaving the trees intact. The grasses regenerate from seeds and rhizomes, the *Acacia* from seed. Over the succeeding years the *Acacias* grow taller, developing into a tall thicket or low forest, suppressing the grasses and herbs. Eventually a fire puts the succession back to the beginning, and the cycle repeats (Beard 1990). The common trees in the area are *Eucalyptus tectifica* and *Corymbia grandifolia*, typically 10-25 m in height. The pindan layer consists of *Acacia tumida*, with some *Acacia holosericea*, *Dolichandrone heterophylla*, *Gardenia pyriformis* subsp. *keartlandii* (formerly *Gardenia keartlandii*), *Grevillea refracta*, *Grevillea heliosperma*, *Hakea arborescens*, *Hakea macrocarpa*, *Petalostigma pubescens* and *Terminalia circumalata*. The grass layer is mainly *Triodia bitextura* (formerly *Plectrachne pungens*) with some *Chrysopogon* (Beard 1979). Within the Dampier Botanical District, the Thunderbird Project Area is situated within Beard's (1979) Dampier Peninsula sub-province, adjacent to Beard's (1979) Fitzroy Plains sub-province. Given the proximity of the latter to the Thunderbird Project Area, there is a likelihood that elements of both sub-provinces may be present. A summary of each of these sub-provinces is set out below.

Dampier Peninsula Sub-province

Gently undulating sandplain with red earthy sands. The sandplain is entirely covered by pindan-woodland vegetation type, which is comprised of an open layer of trees, 12-15 m in height, over a pindan layer of dense *Acacia*, up to 5 m, and a sparse grassy ground layer. Beard (1979) states that approximately 25 km north of Broome there is a gradual change in the vegetation, compared to that which is present in the more southern portion of the peninsula. The dominant tree species consist of *Eucalyptus tectifica* and *Corymbia grandiflora*, whilst *Acacia tumida* replaces *Acacia eriopoda* as the dominant pindan shrub. Other plant taxa commonly present include *Erythrophleum chlorostachys*, *Gyrocarpus americanus* and *Bauhinia cunninghamii*, mostly as smaller trees. The pindan layer consists of *Acacia tumida* with some *Acacia holosericea*, *Dolichandrone heterophylla*, *Gardenia pyriformis* subsp. *keartlandii*, Grevillea refract, *Grevillea heliosperma*, *Hakea arborescens*, *Hakea macrocarpa*, *Petalostigma pubescens* and *Terminalia circumalata*. The grass layer is mainly *Triodia pungens*. and *Chrysopogon* spp.

Fitzroy Plains Sub-province

Extensive sandplains, often with longitudinal sand ridges, usually without surface drainage. Broad saline mud-flats are present in bays and estuaries in coastal parts. The spoils consist of red earthy sands, sometimes with ironstone gravel. The vegetation is largely pindan. *Eucalyptus miniata*, *Eucalyptus tectifica* and *Corymbia confertifolia*, reaching 12-15 m in height. A smaller tree layer at 4-8 m is characterized by *Corymbia confertifolia*, with *Adansonia gregorii*, *Buchanania obovata*, *Erythrophleum chlorostachys*, *Grevillea* spp., *Bauhinia cunninghamii*, *Persoonia falcata* and *Terminalia canescens*. Acacia tumida is the principal Acacia dominating the pindan. The grassy ground layer is composed of *Triodia pungens.*, *Chrysopogon* spp. and annual *Sorghum*. In the middle section of the sandplains, numerous other shrubs, including *Acacia holosericea*, *Acacia monticola*, *Atalaya hemiglauca*, *Dolichandrone heterophylla*, *Grevillea* spp. and *Hakea* spp. are present. The grassy ground layer is composed of *Triodia pungens*, *Chrysopogon pallidus*, *Sorghum timorense*, *Sorghum stipoideum*, *Aristida holathera*, *Aristida hygrometrica*, *Eriachne ciliata*, *Eriachne obtusa*, *Eriachne eriopoda* and *Panicum* spp.

5.4 Land Systems

A land system is an area, or areas, through which there is a recurring pattern of topography, soils and vegetation (Christian and Stewart, 1953). The land systems approach to mapping has been used to map the arid rangelands in Western Australia since 1969. The regional land system mapping of the Kimberley by Schoknecht and Payne (2010) delineated a series of mapping units in the Kimberley region. The Thunderbird Project Area intersects four land systems (Figure 5). The four land systems that intersect the Thunderbird Project Area are the Fraser, Reeves, Wanganut and Yeeda land systems. The areas of each of these land systems together with their extent of intersection with the Thunderbird Project Area is set out in Table 3. A description of each of these land systems, summarised from Schoknecht and Payne (2010), is set following Table 3.

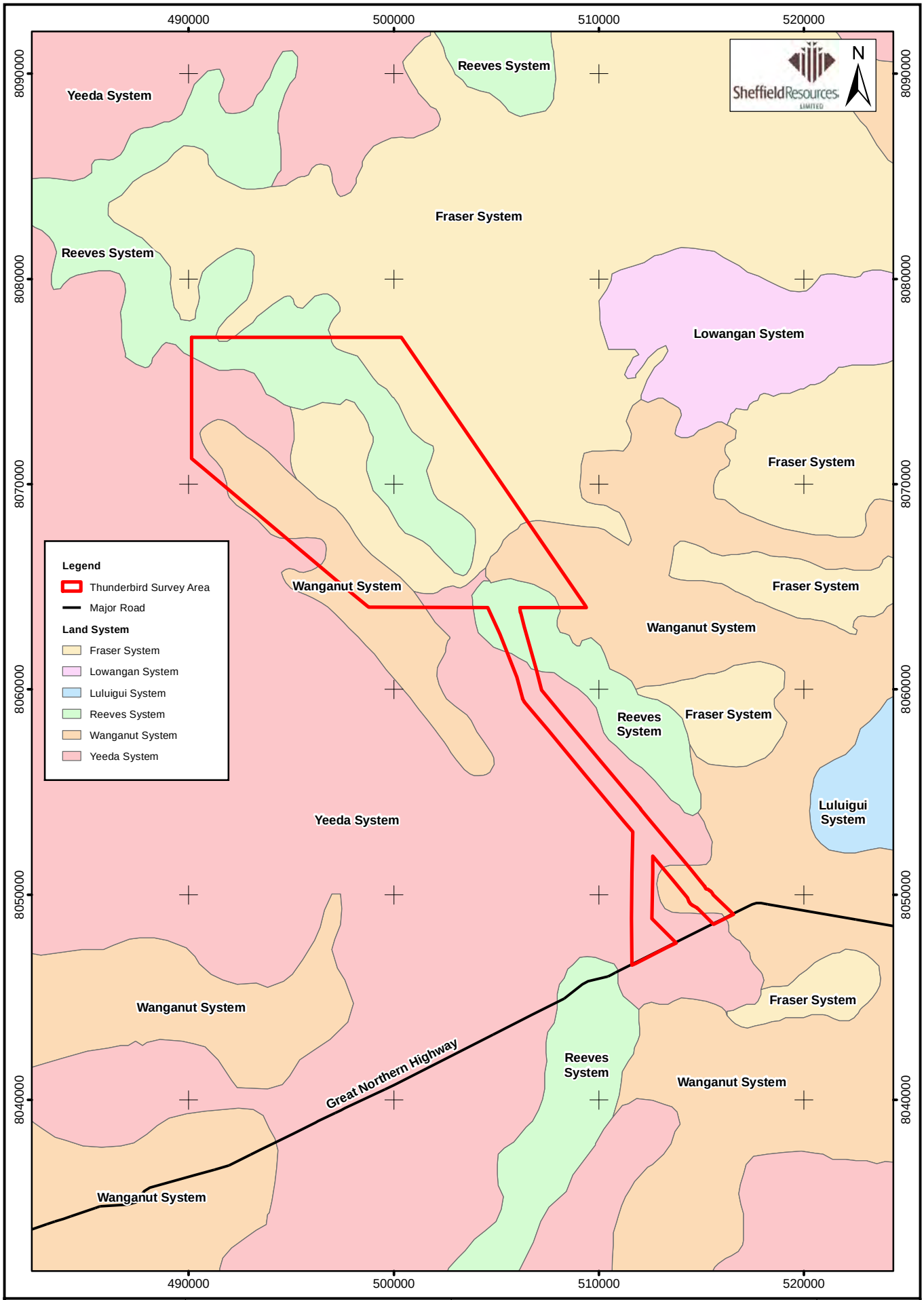
Table 3: Extent of Land Systems intersecting the Thunderbird Project Area.

Land System	State-wide	Thunderbird Project Area	
	Current Extent (ha)	Area of Intersection (ha)	Proportion of Current Extent (%)
Fraser	73,563.9768	5832.3473	7.928
Reeves	45,714.0627	5063.5019	11.076
Wanganut	706,433.7548	3967.8905	0.562
Yeeda	2,625,930.2681	4022.1528	0.153

Fraser Land System (Fra)

The Fraser land System consists of sandplains with irregular dunes and local stony surfaces, pindan and spinifex/tussock grasslands. The Fraser land system comprises six land units:

1. Sandplains up to 4.8 km in extent, of reddish sandy soils with brownish massive heavy clays in pans, supporting low woodland (pindan) with prominent *Acacia* shrub layer and *Triodia bitextura – Chrysopogon* spp. ground storey. *Corymbia dichromophloia - Corymbia zygophylla - Acacia* spp. community.
2. Sand dunes up to 6.4 km long and 9 m high, of deep red sands, supporting variable vegetation of low woodland (pindan) with prominent *Acacia* shrub layer and *Triodia bitextura – Chrysopogon* spp. ground storey, and more open woodlands with *Triodia pungens* and *Aristida browniana*. *Bauhinia cunninghamii* alliance.
3. Sandplains, up to 3,2 km in extent, with outcrops, on shallow, gravelly, reddish skeletal soil and some reddish sand soil, supporting open woodlands and patches of pindan with *Triodia bitextura - Chrysopogon* spp. ground storey. *Adansonia gregorii* and *Corymbia dichromophloia* alliances.
4. Low lying sandplains up to 1.6 km wide, with yellowish mottled sandy soils supporting a complex of grassy woodlands and pindan vegetation with *Chrysopogon* spp., and *Triodia bitextura*. *Bauhinia cunninghamii* and *Corymbia dichromophloia* alliances.
5. Drainage floors, up to 275 m wide, with sealed scalded surfaces and sand hummocks, on yellowish mottled loamy soils, supporting low grassy woodland with *Chrysopogon* spp. *Grevillea striata* and *Bauhinia cunninghamii* alliances.



Source: Land Systems: DoAF

0 1 2 3 4 5 km

Scale: 1:250,000
MGA94 (Zone 51)

CAD Ref: a2409_f50_05

Date: Jul 2016 | Rev: A | A4

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Thunderbird Mineral Sands Project
Land Systems

Figure: **5**

6. Drainage floors, up to 275 m wide, with sealed scalded surfaces and sand hummocks, on yellowish mottled loamy soils, supporting low grassy woodland with *Chrysopogon* spp. *Grevillea striata* and *Bauhinia cunninghamii* alliances.
7. Channels, up to 30 m wide and 3 m deep, on bed loads of deep sand with banks of brownish loamy alluvial soils, supporting fringing woodlands and forests. *Eucalyptus camaldulensis* - *Terminalia platyphylla* fringing communities.

The Fraser land system is generally stable with low susceptibility to erosion except for sand dunes (unit 2) which have moderate susceptibility immediately after fire but stabilise rapidly after rain. Fire history affects composition and density of pindan vegetation which is resilient under controlled grazing.

Reeves Land System (Rev)

The Reeves land system consists of sandplains with scattered hills and minor plateaux on reddish sandy soils, supporting pindan woodlands and spinifex/tussock grasslands. The Reeves land system comprises five land units:

1. Hills, up to 60 m high; flat or gently sloping rocky crests up to 800 m wide, with marginal escarpments, locally vertical, and basal scree slopes, supporting a depauperate woodland and spinifex grassland with scattered trees (*Corymbia confertifolia*) and scrubs.
2. Reddish sandy soil sandy surfaces with local outcropping, up to 1.6 km in extent, supporting a low woodland (pindan) with prominent *Acacia* tall shrub layer and *Triodia bitextura*, *Chrysopogon* spp. ground storey. *Corymbia dichromophloia*, *Corymbia zygophylla*, *Acacia* spp. community.
3. Sandplains up to 2.4 km wide, of reddish sandy soils, supporting a low woodland (pindan) with *Triodia bitextura*, *Chrysopogon* spp. ground storey; *Adansonia gregorii* and *Corymbia dichromophloia* alliances.
4. Pans and depressions, up to 800 m wide, with mottled sandy soils and greyish massive silty to heavy clays in pans, which are mostly bare, with paperbark fringing communities. *Melaleuca* spp. communities.
5. Channels, up to 9 m wide and 1.5 m deep, with bed loads ranging from deep sand to cobbles, and banks of brownish loamy alluvial soils, supporting fringing woodlands. *Eucalyptus camaldulensis* and *Melaleuca* spp. communities.

Pindan vegetation subject to fairly frequent fires which induce short term changes in botanical composition, density and structure; low to moderate pastoral value for a few years after fire. Sandplains (unit 3) have minor susceptibility to wind erosion immediately after fire but stabilise rapidly after rain; control of grazing pressure and frequency of burning is desirable.

Wanganut Land System (Wan)

The Wanganut land system consists of sandplains and dunes with pindan woodlands and spinifex/tussock grasslands. The Wanganut land System comprises six land units:

1. Sandplains, up to 4.8 km in extent, of deep red sands, supporting woodlands (pindan) with prominent *Acacia* shrub layer and *Triodia bitextura* – *Chrysopogon* spp. *Corymbia dichromophloia* alliance.

2. Linear dunes, up to 9 m high and 19 km long, of mainly deep red sands, supporting low woodlands (pindan) with patches of dense *Acacia* shrubs and *Triodia bitextura – Chrysopogon* spp. and *Aristida* spp. ground storeys. *Corymbia dichromophloia* and *Bauhinia cunninghamii* alliances.
3. Dune swales, up to 1.6 km wide, and low-lying sandplain of mainly yellowish sandy soils with minor amounts of reddish sandy soils, supporting grassy woodlands with patchy *Acacia* shrub layer. *Triodia bitextura* and *Triodia bitextura – Chrysopogon* spp. ground storeys. *Corymbia dichromophloia*, *Eucalyptus tectifica* and *Eucalyptus microtheca* alliances. The introduced **Cenchrus ciliaris* (buffel grass) was common in parts.
4. Pans and depressions, linear, up to 800 m wide and 4.8 km long, consisting of yellowish, strongly mottles loamy soils; brownish, massive intractable heavy clay in pans, supporting ribbon grass grasslands with patches of *Triodia bitextura* and fringing paperbark and bloodwood woodlands. *Corymbia polycarpa*, *Eucalyptus microtheca*, and *Melaleuca* spp. alliances.
5. Drainage floors composed of a complex of yellowish sandy soils and scalded greyish and brownish sands and loams over tough clay, supporting a complex of ribbon grass and paperbark trees. *Melaleuca* spp. community and *Chrysopogon* spp. community.
6. Channels, up to 30 m wide and 4.5 m deep, bed loads of deep sand, banks of brownish sandy and loamy alluvial soils, supporting fringing forests and woodlands. *Eucalyptus camaldulensis – Terminalia platyphylla* fringing community.

The Wanganut land system supports dense wattle scrub with pindan pastures and is subject to fairly frequent fires which induce short term changes in botanical composition, density and structure. Pindan pastures, depending on time since last fire, are poorly to moderately attractive and useful to cattle. Generally, not prone to degradation or erosion but control of grazing pressure and frequency of burning is desirable.

Yeeda Land System (Yed)

The Yeeda land system consists of sandplains and occasional dunes, with deep red and yellow sands, with shrubby spinifex grasslands or pindan woodlands. The Yeeda land system comprises four land units:

1. Sandplains of deep red sands, up to 16 km in extent, supporting woodlands (pindan) prominent *Acacia* shrub layer and *Triodia bitextura*, *Chrysopogon* spp. ground storey. *Corymbia dichromophloia* alliance.
2. Shallow valleys, up to 4.8 km wide, with reddish sandy soils or deep yellow sands, supporting grassy woodlands with patchy *Acacia* shrub layer and *Chrysopogon* spp., with *Eucalyptus tectifica* and *Eucalyptus argillacea*.
3. Plains with thin sand cover, of predominantly yellowish sandy soils, with scalded areas of greyish sands over tough loamy subsoils. The vegetation is composed of open patchy woodlands with *Chrysopogon* spp. and *Triodia bitextura*, patches of paperbark trees. *Grevillea striata*, *Bauhinia cunninghamii* and *Melaleuca* spp. alliances.
4. Pans, less than 800 m wide, of brownish, massive, intractable, silty to heavy clays, supporting various tall grasses with fringes of bloodwood and paperbark woodlands. *Corymbia polycarpa* and *Melaleuca* spp. alliances.

5.5 Geology, Soils and Topography

The Thunderbird Project Area is situated within Beard's (1990) Dampier Botanical District. Beard (1990) described the geology, soils and topography of the Dampier Botanical District as consisting of extensive sandplains on red earthy sands, low uplands of sandstone and limestone with shallow stony soils. Geologically, the area comprises Quaternary sandplain overlying Jurassic sandstones, with Quaternary marine deposits on the coastal plains, and Devonian reef limestones and extensive alluvial river plains.

In more recent times mapping of soils and landscapes has become available at a greater level of detail. The Department of Agriculture, in its "Soil-landscapes of Western Australia's Rangelands and Arid Interior" (Tille 2006), describes a range of soil-landscape mapping units. Tille (2006) describes the geology of the southern Kimberley, where the Thunderbird Project Area is situated, as comprising Devonian to Triassic sandstone, shale, siltstone and limestone of the Lennard Shelf and Fitzroy Trough (northern Canning Basin). The landforms present are sandplains and alluvial plains (with some hills) overlying the sedimentary rocks of the Canning Basin. The soils are red deep sands, with some yellow sandy earth and red sandy earths on sandplains.

Tille (2006) divided the Kimberley Region into three soil-landscape provinces (Figure 6A), with the Thunderbird Project Area being situated within the Fitzroy Province. Tille (2006) subdivides the Fitzroy Province into five soil-landscape zones (Figure 6B), with the Thunderbird Project Area being situated within Zone 335 – Dampier Sandplain Zone (Figure 7). The landform and soil data illustrated in Figure 7 was extracted from the soil datasets managed by the Department of Agriculture and Food (2012). The Dampier Sandplain Zone occupies an area of 27,000 km^2 and is located in the south-western Kimberley between Broome, Derby, Kimberley Downs Station and the Yampi Peninsula. It is composed of sandplains and dunes (with some sandy plateaux and coastal mud flats) on sedimentary rocks of the Canning Basin. The soils consist of red deep sands with some yellow sandy earths and some red and yellow sandy earths. The vegetation is described as consisting of pindan shrublands with spinifex/tussock grasslands (and some eucalypts).

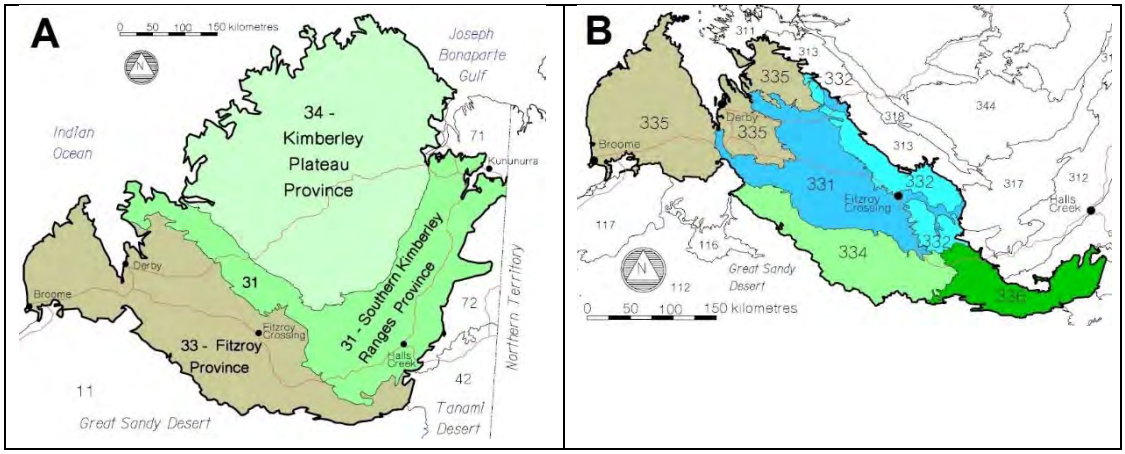


Figure 6: Soil-landscape provinces and zones of the Kimberley
Soil landscape-provinces of the Kimberley (Figure 6A) and soil-landscape zones of the Fitzroy Province (Figure 6B). Figures extracted from Tille (2006).

5.6 Pre-European Vegetation

The pre-European vegetation dataset, prepared through the National Land and Water Resources Audit, describes vegetation in relation to natural resource boundaries commonly used for environmental reporting (Shepherd *et al.* 2001). The pre-European vegetation dataset builds on the vegetation map database developed by G R Beeston and A J M Hopkins, based on 1: 250,000 scale mapping. A total of 819 vegetation types were recognised in Western Australia, ranging from tall forests, through to a wide variety of forests and woodlands, shrublands and grasslands, mostly with an overstorey of trees. The identification of the original pre-European and current extent of each of the vegetation types assist in providing baselines for managing issues such as land clearing. Although the extent of native vegetation remains largely intact within the inland areas of Western Australia, the structure and floristic composition have been altered since European settlement through grazing by introduced animals such as sheep, cattle, goats and rabbits, mining activities and by altered fire regimes (Shepherd *et al*. 2001).

In more recent years Hopkins, Beeston and Shepherd (2001) delineated a series of vegetation maps based primarily in this region on the previous work of Beard (1979). The pre-European vegetation associations occurring within the vicinity of the Thunderbird Project Area are illustrated in Figure 8. The Thunderbird Project Area intersects the six vegetation associations. These are:

Vegetation association 60.2: Grasslands, tall bunch grass savanna woodland. grey box and cabbage gum over ribbon grass;

Vegetation association 750.1: Shrublands, pindan; *Acacia tumida* shrubland with grey box and cabbage gum medium woodland over ribbon grass and curly spinifex;

Vegetation association 751: Shrublands, pindan; *Acacia eriopoda* and *Acacia tumida* shrubland with scattered low *Corymbia confertifolia* (formerly *Eucalyptus confertifolia*) over curly spinifex;

Vegetation association 752: Hummock grasslands, shrub steppe; *Acacia tumida* over *Acacia intermedia*

Vegetation association 755: Shrublands, pindan; *Acacia tumida* and *Acacia monticola* (formerly *Acacia impressa*) shrubland with scattered low bloodwood and *Eucalyptus setosa* over ribbon grass and curly spinifex; and

Vegetation association 762: Hummock grasslands, shrub steppe; *Acacia eriopoda* over soft spinifex.

Vegetation associations 60.2, 751, 752, 755 and 762 are restricted to the Dampierland system. Vegetation Association 762 occurs in the Dampierland and adjacent Fitzroy and North Fitzroy systems. The area of pre-European vegetation associations intersecting the Thunderbird Project Area are set out in Table 4.

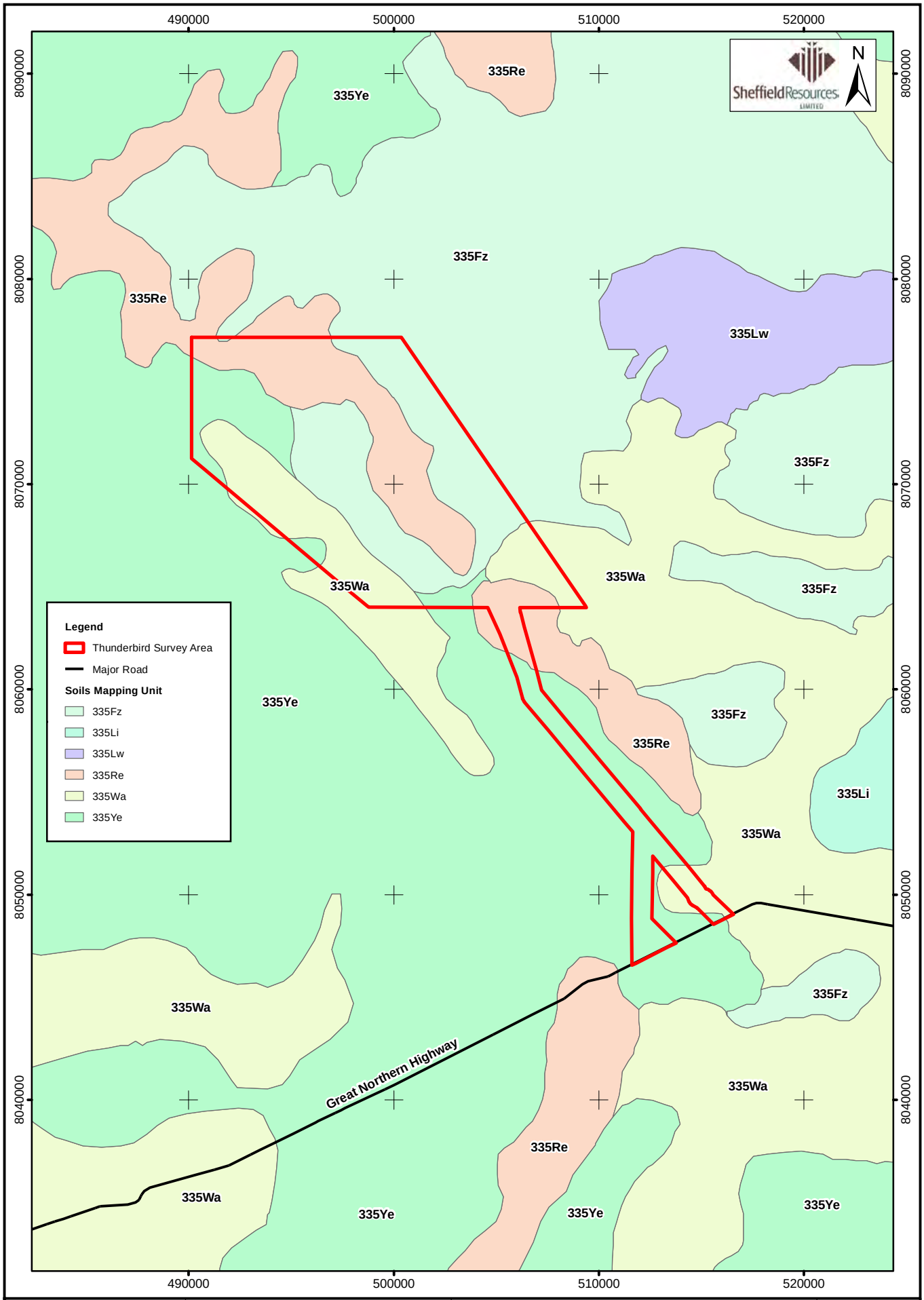
Table 4: Extent of pre-European vegetation associations intersecting the Thunderbird Project Area

Vegetation Association	State-wide[1]			Thunderbird Project Area	
	Pre-European Extent (ha)	Current Extent Impacted (ha)	Percent Remaining (%)	Area of Intersection (ha)	Proportion of Current Extent (%)
Dampierland_60.2	7748.85	7748.85	100.00	189.94	2.45
Dampierland_750.1	1,223,884.58	1,218,427.52	99.55	13,921.6866	1.14
Dampierland_751	16,045.28	15,994.73	99.68	1,332.2378	8.30
Dampierland_752	6,808.69	6,759.22	99.27	8.6597	0.13
Dampierland_755	183,168.83	183,058.23	99.94	738.7564	0.40
Dampierland_762 Fitzroy Sandplain_762 North Fitzroy Plains_762	6,811.39	6,807.35	99.94	2,694.6381	39.56

1. Government of Western Australia 2015

5.7 Current Land Use

The Dampierland bioregion is utilised for a range of purposes, including pastoralism, exploration / mining activities, native title and heritage areas, tourism and nature reserves. A large proportion of the Dampier Peninsula consists of pastoral leases, with the Thunderbird Project Area being situated across lands of the Mt Jowlaenga and Yeeda stations (Figure 1), which are currently grazed by cattle. Native title areas cover the majority of the Dampier Peninsula (Figure 9). The Dampier Peninsula has one area set aside as a nature reserve – the Coulomb Point Nature Reserve (Figure 4), which occupies an area of 28,676 ha (DotE 2016e).



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Scale: 1:250,000
MGA94 (Zone 51)

CAD Ref: a2409_f50_06

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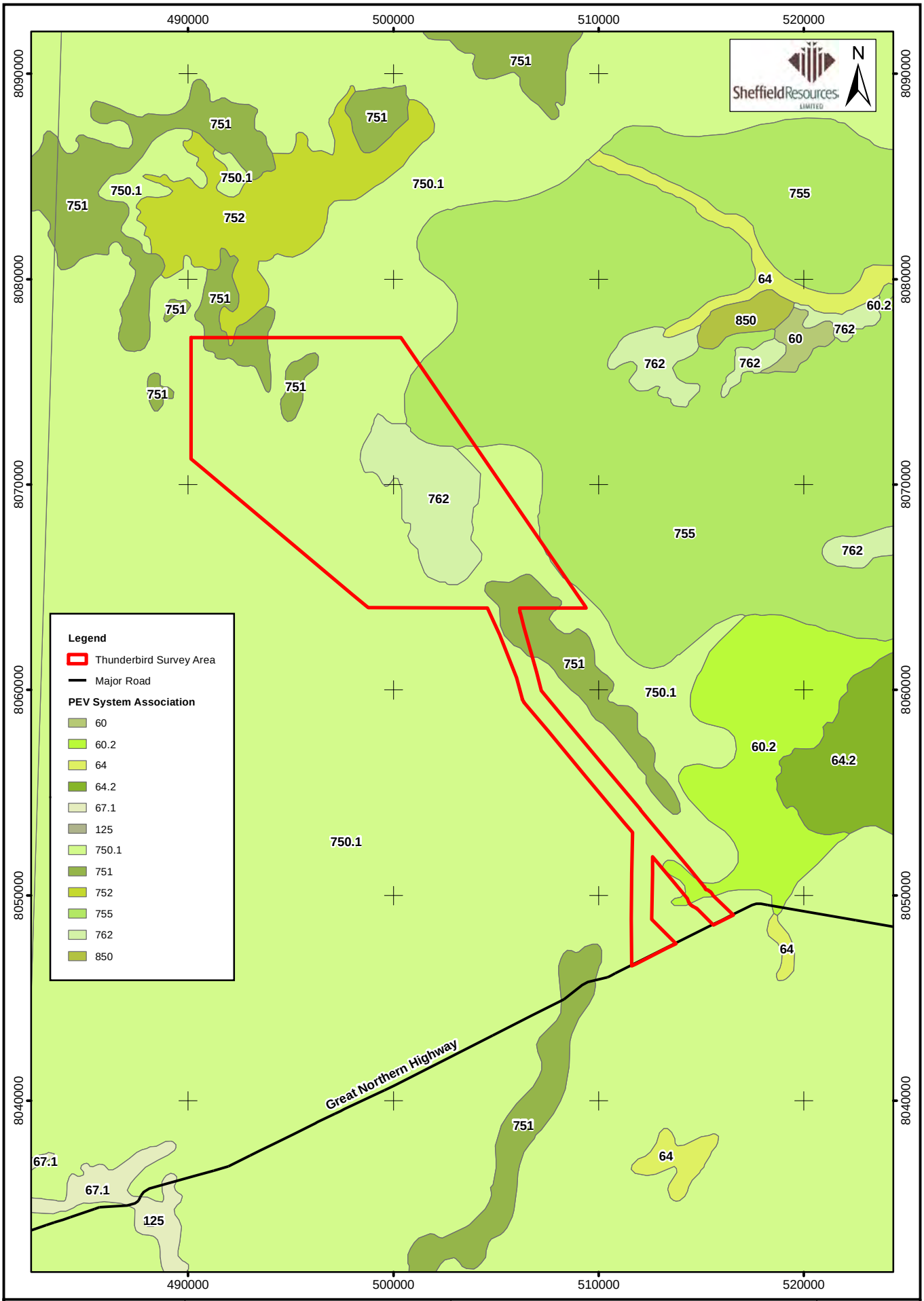
Thunderbird Mineral Sands Project
Soils

Figure: **7**

Source: Land Systems: DoAF



Source: Land Systems: DoAF

0 1 2 3 4 5 km

Scale: 1:250,000
MGA94 (Zone 51)

CAD Ref: a2409_f50_07

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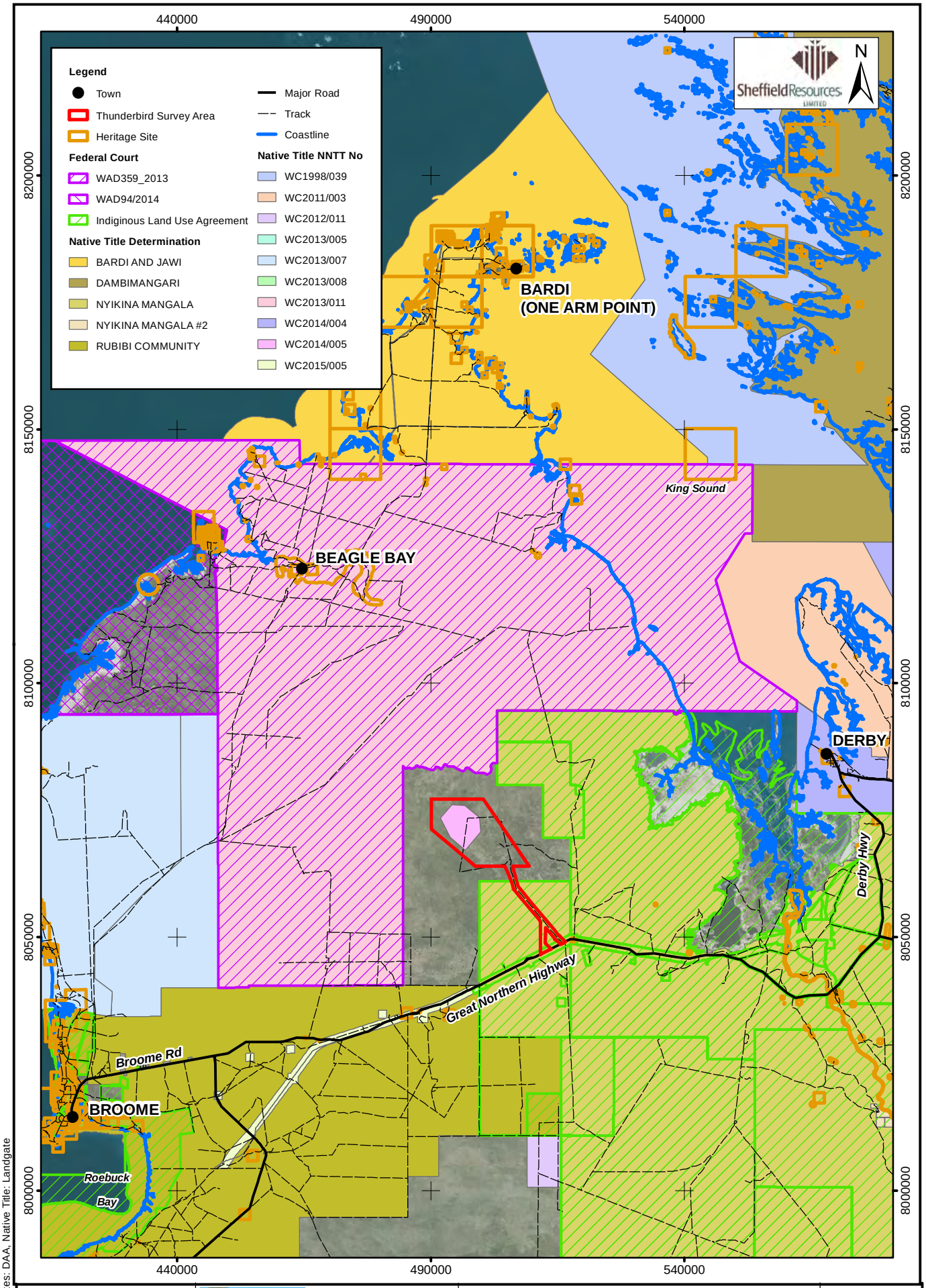
Thunderbird Mineral Sands Project
Pre-European Vegetation

Figure: **8**



Source:Heritage sites: DAA, Native Title: Landgate

0 5 10 15 20 km

Scale: 1:1,000,000
MGA94 (Zone 51)

CAD Ref: a2409_f50_09

Date: Jul 2016 | Rev: A | A4

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Thunderbird Mineral Sands Project
Heritage

Figure: **9**

5.8 Previous Surveys in the Thunderbird Project Area

Ecologia completed three surveys of the Thunderbird Project Area between 2012 and 2015 (Ecologia 2012, 2014, 2015). These surveys comprised a Level 1 flora survey (Ecologia 2012), a level 2 flora survey (Ecologia 2014) and a flora survey for a proposed haul road alignment (Ecologia 2015). The combined surveys recorded a total of 329 flora species (Appendix C). The majority of taxa recorded were representative of the Poaceae (54 taxa), Fabaceae (53 taxa), Cyperaceae (34 taxa), Malvaceae (22 taxa) and Asteraceae (11 taxa) families.

No threatened flora were recorded from the three surveys. Five priority flora taxa were recorded from the three surveys. These taxa are *Fuirena nodiflora* (P1), *Fuirena incrassata* (P3), *Pterocaulon intermedium* (P3), *Tephrosia valleculata* (P3) and *Triodia caelestialis* (P3). One taxon, *Eriachne* sp. Dampier Peninsula (K.F. Kennealy 5946), was a Priority 3 taxon at the time of the surveys, but has since been delisted as a priority taxon (DPaW 2016g). The locations of the priority flora recorded during the three surveys (Ecologia 2012, 2014, 2015) are set out in Appendix G and shown in Figure 11B.

Eight introduced flora tax were recorded from the three surveys. These taxa were *Cynodon dactylon*, *Digitaria ciliaris*, *Echinochloa colona*, *Malvastrum americanum*, *Sida acuta*, *Stylosanthes hamata*, Stylosanthes scabra and *Tridax procumbens*. *Sida acuta* is listed as a Declared Pest species pursuant to Section 22(2) of the *Biosecurity and Agriculture Management Act 2007*.

Eleven vegetation units were mapped in the Thunderbird Project Area by Ecologia across the three surveys (Ecologia 2012, 2014, 2015). These vegetation units are summarised in Table 5 and illustrated in Figure 10, and are based on data provided to Sheffield by Ecologia. The most commonly represented vegetation unit was EcAtSt (*Erythrophleum chlorostachys* low, open woodland, over *Acacia tumida* var. *tumida* mid, sparse shrubland, over *Sorghum timorense* open tussock grassland) which comprised 25.88% of the area surveyed. Four other vegetation units (BdEcAtSt, CgDhSt, EtApStCpEo and GpAmStTc) accounted for a further 48.05% of the mapped vegetation (Table 5). Within the surveyed area, there was considerable similarity between the species associated with these major vegetation units (Ecologia 2012, 2014, 2015), with the upper storey being dominated by a restricted range of species (*Corymbia greeniana*, *Eucalyptus tectifica*, *Corymbia dendromerinx*, *Brachychiton diversifolius* subsp. *diversifolius* and *Erythrophleum chlorostachys*). The mid storey was dominated by *Acacia* species, principally *Acacia tumida* var. *tumida*. The lower stratum was a mixed grassland comprising a mixture of *Triodia caelestialis* (P3), *Sorghum timorense* and *Chrysopogon pallidus*.

A 14.46 ha area of vegetation unit MaMvEtCPCc (*Melaleuca alsophila* or *Melaleuca viridiflora* and *Eucalyptus tectifica* low, open woodland, over *Chrysopogon pallidus* sparse tussock grassland and *Cyperus conicus* sparse sedgeland) was described as having similarities with the Lolly Well Springs wetland complex Priority 3 PEC assemblage (Ecologia 2014). The claimed similarity was based on the landform on which this portion of the vegetation unit is present being described as a low, large organic mound spring with moats. The presence of *Melaleuca viridiflora* and Cyperaceae species, also present in the Lolly Well Springs wetland complex are suggested to indicate that this vegetation unit may constitute

a potential PEC. No statistical analysis comparing the vegetation within the Thunderbird Project Area with comparative quadrats established at the Lolly Wells Springs is presented by Ecologia (2014).

Table 5: Vegetation units delineated by Ecologia within the Thunderbird Project Area

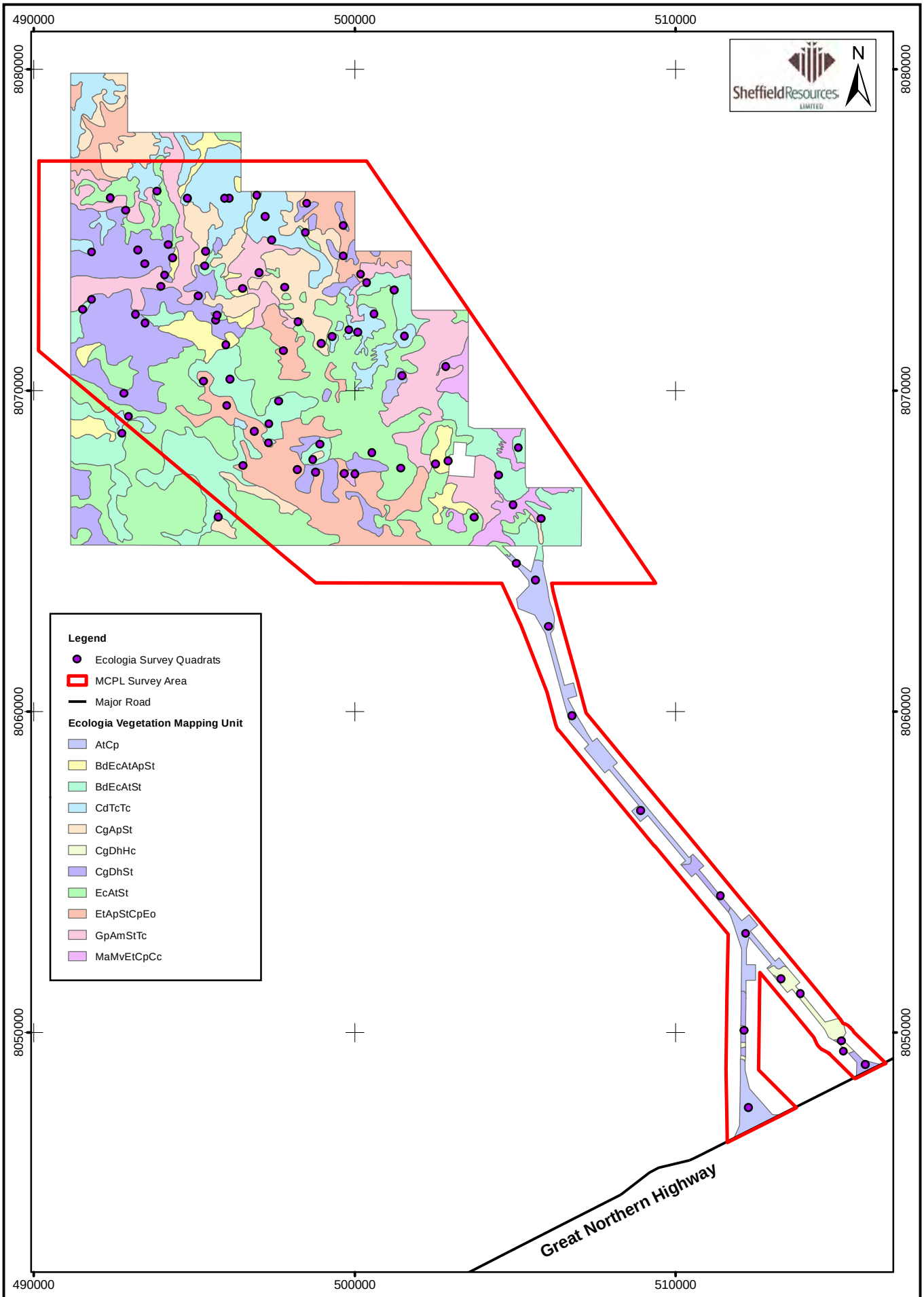
Ecologia Vegetation Unit	Description	Total Area Mapped (ha)	Proportion of Total Area Surveyed (%)
AtStCpHc	*Acacia tumida* var. *tumida* tall shrubland, over *Sorghum timorense*, *Chrysopogon pallidus* and *Heteropogon contortus* tussock grassland. Landform: Sandy plain	625.0644	3.98
BdEcAtApSt	*Brachychiton diversifolius* subsp. *diversifolius* and *Erythrophleum chlorostachys* low open woodland over *Acacia tumida* var. *tumida* and *Acacia platycarpa* tall, sparse shrubland over *Sorghum timorense* sparse tussock grassland. Landform: Sandy plain	541.1858	3.45
BdEcAtSt	*Brachychiton diversifolius* subsp. *diversifolius* and *Erythrophleum chlorostachys* low open woodland over *Acacia tumida* var. *tumida* sparse shrubland over *Sorghum timorense* sparse tussock grassland. Landform: Sandy plain	2,111.1677	13.44
CdTcTc	*Corymbia dendromerinx* and *Terminalia canescens* low, open woodland, over *Triodia caelestialis* (P3) open hummock grassland. Landform: Hillslope - midslope or ridgetop	1,307.6766	8.33
CgApSt	*Corymbia greeniana* mid, open woodland, over *Acacia platycarpa* tall, sparse shrubland, over *Sorghum timorense* open tussock grassland. Landform: Sandy plain	1,155.4066	7.36
CgDhHc	*Corymbia greeniana* low open forest over *Dolichandrone heterophylla* sparse shrubland, over *Heteropogon contortus* sparse tussock grassland. Landform: Floodplains adjacent to ephemeral waterways	110.6998	0.70
CgDhSt	*Corymbia greeniana* low open woodland over *Dolichandrone heterophylla* sparse shrubland over *Sorghum timorense* tussock grassland. Landform: Sandy plain	2,041.3534	13.00

Table 5: Vegetation units delineated by Ecologia within the Thunderbird Project Area

Ecologia Vegetation Unit	Description	Total Area Mapped (ha)	Proportion of Total Area Surveyed (%)
EcAtSt	*Erythrophleum chlorostachys* low, open woodland, over *Acacia tumida* var. *tumida* mid, sparse shrubland, over *Sorghum timorense* open tussock grassland. Landform: Sandy plain	4,064.4403	25.88
EtApStCpEo	*Eucalyptus tectifica* low, open woodland, over *Acacia platycarpa* tall, over *Sorghum timorense*, *Chrysopogon pallidus* and *Eriachne obtusa* open tussock grassland. Landform: Sandy floodplain	1,759.5221	11.21
GpAmStTc	*Grevillea pyramidalis* subsp. *pyramidalis* low, open woodland, over *Acacia monticola* mid, sparse shrubland, over *Sorghum timorense* sparse tussock grassland and *Triodia caelestialis* (P3) sparse hummock grassland. Landform: Gravelly plains	1,633.4877	10.40
MaMvEtCpCc	*Melaleuca alsophila* or *Melaleuca viridiflora* and *Eucalyptus tectifica* low open woodland, over *Chrysopogon pallidus* sparse tussock grassland and *Cyperus conicus* sparse sedgeland. Landform: Sandy floodplan	352.6004	2.25

5.9 Fire History

Parts of the Dampier peninsula had been burnt, both prior to, and over the period in which surveys of the Thunderbird Project Area have taken place (Landgate 2016). Specifically, various sections of the Thunderbird Project Area have been burnt between 2011 and 2016 (Landgate 2016). This has been confirmed through field observations and recordings by both Ecologia and Mattiske during the field surveys.



Source: Vegetation: ecologia environment

0 1 2 3 4 km

Scale: 1:160,000
MGA94 (Zone 51)

CAD Ref: a2409_f50_10

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Thunderbird Mineral Sands Project
Ecologia Mapped Vegetation

Figure: **10**

5.10 Threatened Ecological Communities

No TECs, pursuant to Schedule 1 of the *Wildlife Conservation Act 1950* and as listed by the DPaW (2016e) occur within the vicinity of the Thunderbird Project Area. No TECs, pursuant to the *EPBC Act* and as listed by the DotE (2016b) occur within the vicinity of the Thunderbird Project Area.

Two TECs, pursuant to Schedule 1 of the *Wildlife Conservation Act 1950* and as listed by the DPaW (2016e, DPaW Reference 01-0816EC) occur on the Dampier Peninsula. These are the Monsoon (vine) thickets on coastal sand dunes of the Dampier Peninsula (community identifier 67), and the Assemblages of Bunda Bunda organic mound spring (community identifier 85). Both TECs are classed as vulnerable (DPaW 2016d). Of the two TECs, the Monsoon (vine) thickets on coastal sand dunes of the Dampier Peninsula is listed as an endangered TEC according to the *EPBC Act* and as listed by the DotE (2016b). Both TECs are located on or close to coastal areas of the Dampier Peninsula, more than 50 km from the Thunderbird Project Area. Consequently, because of their restricted coastal location, none would be expected to occur within the Thunderbird Project Area.

5.11 Priority Ecological Communities

No PECs as listed by DPaW (2016f) currently intersect the Thunderbird Project Area. There are currently three Priority 1 and five Priority 3 PECs, as listed by DPaW (2016f, DPaW Reference 01-0816EC), which occur within 50 km of the Thunderbird Project Area (Figure 11A). These PECs are:

Dwarf pindan heath community of Broome coast (Priority 1)
Occurs between the racecourse and Gantheame Point lighthouse. Insufficient survey outside of Broome townsite area to determine full extent.
Threats: clearing, trampling, weed invasion, inappropriate fire regimes.

***Corymbia paractia* dominated community on dunes (Priority 1)**
Corymbia paractia behind dunes, Broome township area, Dampier Peninsula. Transition zone where coastal dunes (with vine thickets) merge with pindan (desert) vegetation. Also, port north of Broome.
Threats: clearing, trampling, weed invasion, inappropriate fire regimes.

Relict dune system dominated by extensive stands of Minyjuru (Mangarr - Sersalisia sericea) (Priority 1)
Contains frequent mature (100 years +) Sersalisia sericea or otherwise known as Minyjuru. Minyjurur is a culturally important and renowned local bush tucker species and does not occur in such frequency and longevity in other locations. The community is recorded as a Eucalyptus, Sersalisia low woodland unit that occurs on parallel dunes in the area south east of Gantheaume Point. The community also contains numerous woodland species such as: *Erythrophleum chlorostachys* (ironwood), *Eucalyptus* (*Corymbia*) *zygophylla* (Broome bloodwood), *Hakea macrocarpa* and *Corynotheca micrantha* (zig-zag Lilly). Some species are more reminiscent of desert and aridlands country including: *Solanum cunninghamii* (bush tomato), *Scaevola parvifolia*, *Goodenia sepalosa*, *Senna costata*, *Gyrostemon tepperi* and *Triodia* sp.

(spinifex). The extensive stands of Minyjuru occur in association with species more often found within the nearby threatened ecological community- Monsoon vine thicket.
Threats: weed invasion, grazing, inappropriate fire regime, proposed developments.

Assemblages of Disaster Bay organic mound springs (Priority 3)
Organic mounds springs on tidal flats with *Melaleuca acacioides*, *Timonius timon*, *Pandanus spiralis*, *Melaleuca viridiflora*, *Acacia neurocarpa* and *Lumnitzera racemosa* (mangrove) woodland with *Typha domingensis* and sedges, including *Schoenoplectus litoralis*.
Threats: soil compaction by cattle; potential changes in sea level due to climate change.

Assemblages of Lolly Well Springs wetland complex (Priority 3)
Wetland complex containing numerous low organic mound springs with moats.
Threats: recreational use, potential tourism developments, weed invasion, rubbish.

Kenneally *et al*. (1996) state that areas of permanent fresh water are rare on the Dampier Peninsula, but where they occur they support groves of *Melaleuca cajuputi* and *Melaleuca viridiflora*, together with aquatic species such as *Nymphaea violacea*, *Nymphoides indica* and *Nymphoides beaglensis*. Mound springs, sometimes raised two metres above the surrounding plain are situated near the Beagle Bay community, and support large fern colonies of *Cyclosorus interruptus* and *Lygodium microphyllum* (Kenneally *et al*. 1996). This is likely to represent vegetation which may be encountered at the Lolly Wells Spring wetland complex.

Kimberley vegetation Association 67 as defined by Beard (1979) (Priority 3)
Grasslands, tall bunch grass savanna, sparse low tree; ribbon grass & paperbarks.
Threats: extensive threatening processes acting at landscape scales, namely altered fire regimes, over grazing, and weed invasion.

Kimberley vegetation Association 73 as defined by Beard (1979) (Priority 3)
Grasslands, short bunch grass savanna, grass; salt water grassland (Sporobolus virginicus)
Threats: extensive threatening processes acting at landscape scales, namely altered fire regimes, over grazing, and weed invasion.

Kimberley Vegetation Association 759 as defined by Beard (1979) (Priority 3)
Grasslands, tall bunch grass savanna woodland, coolabah over ribbon/blue grass (*Bothriochloa* spp.)
Threats: extensive threatening processes acting at landscape scales, namely altered fire regimes, over grazing, and weed invasion.

Based on the desktop assessment, vegetation associations 67, 73, and 759 do not intersect the Thunderbird Project Area (Figure 8). The Dwarf pindan heath community of Broome coast, *Corymbia paractia* dominated community on dunes, Relict dune system dominated by extensive stands of Minyjuru, and Assemblages of Disaster Bay organic mound springs are associated with coastal areas of the Dampier Peninsula, and hence would not be expected to be recorded within the Thunderbird Project

Area. The Thunderbird Project Area, based on high resolution aerial imagery recorded in 2014 and 2015, does not contain obvious areas of vegetation consistent with permanent water associated with springs. Kenneally *et al*. (1996) state that areas of permanent fresh water are rare on the Dampier Peninsula, but where they occur they support groves of *Melaleuca cajuputi* and *Melaleuca viridiflora*, together with aquatic species such as *Nymphaea violacea*, *Nymphoides indica* and *Nymphoides beaglensis*. Mound springs, sometimes raised two metres above the surrounding plain are situated near the Beagle Bay community, and support large fern colonies of *Cyclosorus interruptus* and *Lygodium microphyllum* (Kenneally et al. 1996). This is likely to represent vegetation which may be encountered at the Lolly Wells Spring wetland complex. This type of vegetation is unlikely to be present within the Thunderbird project Area.

5.12 Threatened and Priority Flora

The desktop survey for threatened and priority flora which may potentially occur within the Thunderbird Project Area was undertaken using the resources of NatureMap (DPaW 2007-), the WAH (DPaW 2016g) and the DotE (2016a; 2016b), and included an application to the DPaW for a listing of threatened and priority flora known to occur on the broader Dampier Peninsula. In addition, the results of recent surveys of the Thunderbird Project Area (Ecologia 2012, 2014, 2015) were reviewed to provide a more complete inventory of species which may occur within the Thunderbird Project Area. Within the 40 km search radius about the vicinity of the Thunderbird Project Area there are no known threatened flora taxa and nine priority flora taxa. The nine priority flora taxa are comprised of two Priority 1 and seven Priority 3 (DPaW 2016g) taxa. These priority flora taxa are listed in Table 6 and their present distributions in the vicinity of the Thunderbird Project Area illustrated in Figure 11A and 11B.

Previous surveys of the Thunderbird Project Area, completed between 2012 and 2015 (Ecologia 2012, 2014, 2015) recorded five priority flora taxa. Four of the five taxa: *Fuirena nudiflora* (P1), *Fuirena incrassata* (P3), *Tephrosia valleculata* (P3), and *Pterocaulon intermedium* (P3) were recorded infrequently. The fifth taxon, *Triodia caelestialis* (P3) was recorded at 48 of the 65 quadrats surveyed, indicating that it was relatively common within the surveyed area.

Across the broader Dampier peninsula, one threatened and 30 priority flora taxa, which are in addition to those recorded within the 40 km search buffer previously described, have been recorded. The threatened taxon, *Seringia exastia*, is listed under its former name of *Keraudrenia exastia*, as critically endangered according to the EPBC Act (DotE 2016a). The 30 additional priority taxa are comprised of 13 Priority 1, 16 Priority 3 taxa, and one Priority 4 taxon (Table 6).

An assessment of the likelihood of recording any of the listed priority taxa within the Thunderbird Project Area, based on factors including known soil type, topography and distribution, is set out in Appendix D. Based on this assessment, five taxa have a high likelihood of being recorded within the Thunderbird Project Area. These taxa are *Fuirena incrassata* (P1), Pterocaulon intermedium (P3), *Stylidium pindanicum* (P3), *Tephrosia valleculata* (P3), and *Triodia caelestialis* (P3). With the exception of *Stylidium pindanicum* (P3), the other taxa have previously been recorded within the Thunderbird Project

Area. *Fuirena nudiflora* (P1) has previously been reported as being recorded within the Thunderbird Project Area (Ecologia 2014). A review of this taxon's distribution indicates that its presence within the Thunderbird Project Area would represent a range extension of more than 600 km west of its current known locations (DPaW 2016g). For this reason, and the fact that Ecologia (2014) do not state whether the identification was confirmed by a specialist taxonomist at the Western Australian Herbarium, it has been excluded from being considered likely to be present in the Thunderbird Project Area. A further 11 taxa are considered to have a medium probability of occurring within the Thunderbird Project Area (Table 6).

Table 6: Threatened and Priority flora taxa in the vicinity of the Thunderbird Project Area

Species	SCC[1]	Family	40 km buffer	Broader Dampier Peninsula	Likelihood to Record
Seringia exastia	T	Malvaceae		x	low
Aphyllodium parvifolium	P1	Fabaceae	x		medium
Bonamia oblongifolia	P1	Convolvulaceae		x	low
Byblis guehoi	P1	Byblidaceae		x	low
Corymbia paractia	P1	Myrtaceae		x	low
Cullen candidum	P1	Fabaceae		x	low
Cyperus haspan subsp. *haspan*	P1	Cyperaceae		x	low
Fuirena nudiflora[3]	P1	Cyperaceae	x		low
Haemodorum capitatum	P1	Haemodoraceae		x	medium
Ipomoea tolmerana subsp. occidentalis	P1	Convolvulaceae		x	low
Jacquemontia sp. Broome (A.A. Mitchell 3028)	P1	Convolvulaceae		x	low
Parsonsia kimberleyensis	P1	Apocynaceae		x	low
Polymeria sp. Broome (K.F. Kenneally 9759)	P1	Convolvulaceae		x	low
Thespidium basiflorum	P1	Asteraceae		x	low
Utricularia stellaris	P1	Lentibulariaceae		x	low
Utricularia tubulata	P1	Lentibulariaceae		x	low
Acacia monticola x *tumida* var. *kulparn*	P3	Fabaceae		x	medium
Aphyllodium glossocarpum	P3	Fabaceae		x	medium
Colocasia esculenta var. *aquatilis*	P3	Araceae		x	low
Dendrophthoe odontocalyx	P3	Loranthaceae		x	medium
Eriochloa fatmensis	P3	Poaceae		x	low
Fuirena incrassata	P3	Cyperaceae	x		high
Goodenia byrnesii	P3	Goodeniaceae		x	low
Goodenia sepalosa var. *glandulosa*	P3	Goodeniaceae	x		medium
Glycine pindanica	P3	Fabaceae		x	medium
Hibiscus panduriformis	P3	Malvaceae	x		low

Table 6: Threatened and Priority flora taxa in the vicinity of the Thunderbird Project Area

Species	SCC[1]	Family	40 km buffer	Broader Dampier Peninsula	Likelihood to Record
Lophostemon grandiflorus subsp. *grandiflorus*	P3	Myrtaceae		x	low
Nicotiana heterantha	P3	Solanaceae		x	low
Nymphoides beaglensis	P3	Menyanthaceae	x		low
Phyllanthus eremicus	P3	Phyllanthaceae		x	low
Pterocaulon intermedium[2, 3, 4]	P3	Asteraceae	x		high
Schoenus punctatus	P3	Cyperaceae		x	medium
Seringia katatona	P3	Malvaceae		x	medium
Stylidium costulatum	P3	Stylidiaceae		x	medium
Stylidium pindanicum	P3	Stylidiaceae		x	high
Tephrosia valleculata[3]	P3	Fabaceae	x		high
Terminalia kumpaja	P3	Combretaceae		x	low
Triodia acutispicula	P3	Poaceae		x	medium
Triodia caelestialis[2, 3, 4]	P3	Poaceae	x		high
Pittosporum moluccanum	P4	Pittosporaceae		x	low

1 - State Conservation Code (refer Appendix A); 2 - recorded by Ecologia within the Thunderbird Project Area (Ecologia 2012); 3 - recorded by Ecologia within the Thunderbird Project Area (Ecologia 2014); 4 - recorded by Ecologia within the Thunderbird Project Area (Ecologia 2015)

5.13 Introduced (Exotic) Plant Species

A total of eleven introduced (exotic) plant species were recorded from the desktop assessment utilising a 40 km search buffer about the Thunderbird Project Area. The introduced taxa are listed in Table 7. None of the species are listed as a Prohibited Organism pursuant to Section 12 of the *Biosecurity and Agriculture Management Act 2007* or listed as a Weed of National Significance (DotE 2016f).

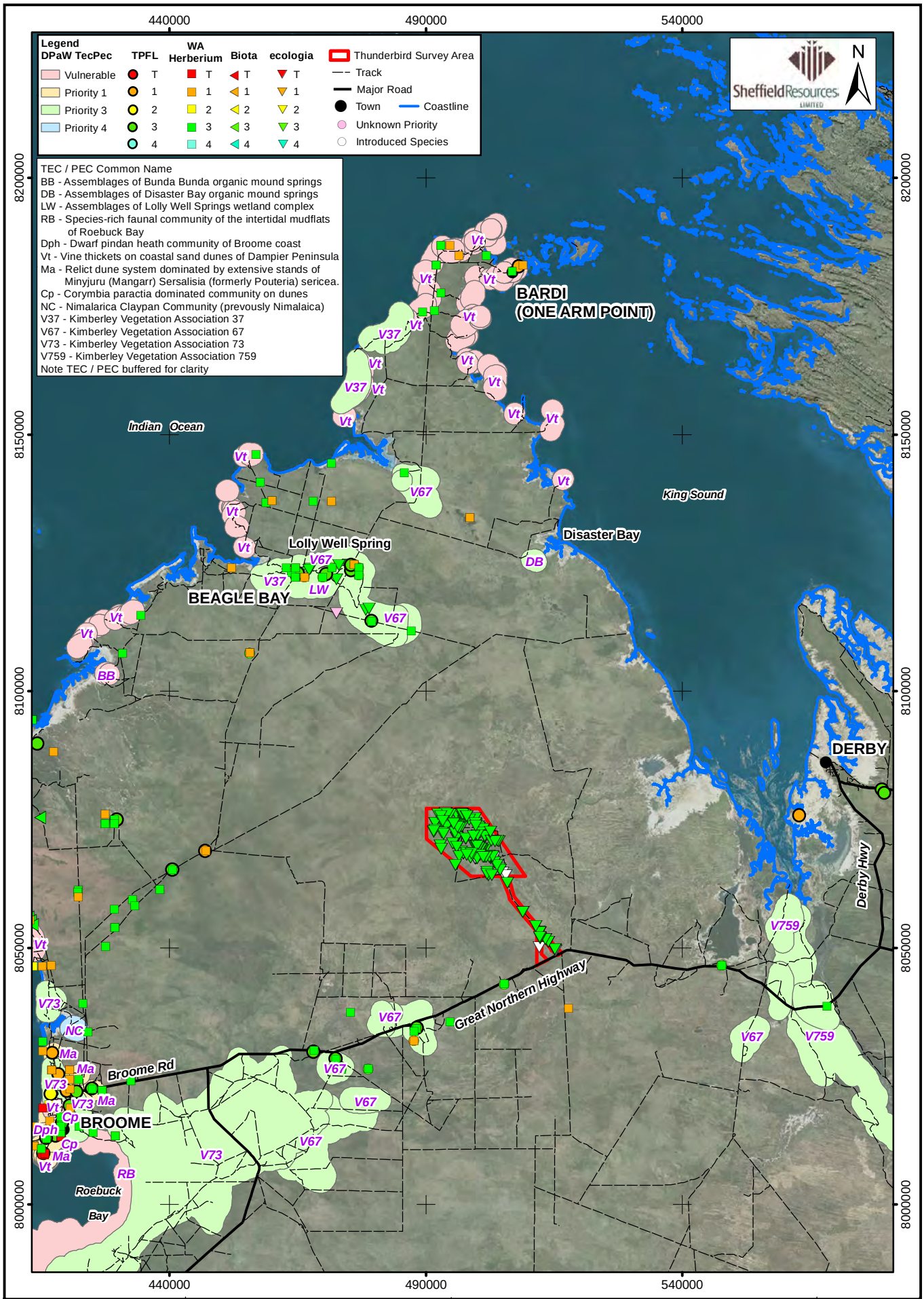
Table 7: Introduced plant species in the vicinity of the Thunderbird Project Area

Introduced Species	Common Name	Family	Potential /Recorded[6]
Cyanthillium cinereum [2]	-	Asteraceae	R
Cynodon dactylon [1, 2, 4]	couch grass	Poaceae	R
Digitaria ciliaris [3, 4]	summer grass	Poaceae	R
Echinochloa colona [3, 4]	awnless barnyard grass	Poaceae	R
Eragrostis minor [1, 4]	smaller stinkgrass	Poaceae	P
Flaveria trinervia [1]	speedy weed	Asteraceae	P
Moringa oleifera [1, 4]	-	Moringaceae	P
Sida acuta [3, 5]	spiny head sida	Malvaceae	R
Stylosanthes hamata [1, 2, 3, 4]	verano stylo	Fabaceae	R
Stylosanthes scabra [2, 3, 4]	-	Fabaceae	R
Tridax procumbens [3, 4]	tridax	Asteraceae	R

1 - recorded from NatureMap (DPaW 2007-); 2 - recorded by Ecologia (2012); 3 - Recorded by Ecologia (2014); 4 – Permitted (s11) under the BAM Act 2007; 5 – Declared Pest (s22(2) under the BAM Act 2007; 6 - P = Potential to occur, R = Recorded previously by Mattiske (2010, 2014).

One of the species is listed as a Declared Pest species pursuant to Section 22(2) of the *Biosecurity and Agriculture Management Act 2007*. The listed taxon is *Sida acuta* (Plate 1). *Sida acuta* is a common weed of the Kimberley, occurring in wasteland, creeks and riverine vine thickets (Hussey *et al*. 2007). *Sida acuta* is a densely branched perennial herb or small shrub to 1 m, with yellow flowers which are produced between March and September (DPaW 2016g). *Sida acuta* is subject to control/keeping category C3 (Management), under which such organisms should have some form of management applied that will alleviate the harmful impact of the organism, reduce the numbers or distribution of the organism or prevent or contain the spread of the organism (BAM Act 2007).

Plate 1: *Sida acuta* (DPaW 2016g)



Source: TecPec: DPaW, Flora: ecologia, DPaW (14-0716)

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MGA94 (Zone 51)

CAD Ref: a2409_f50_08a

Date: Oct 2016 | Rev: E | A4

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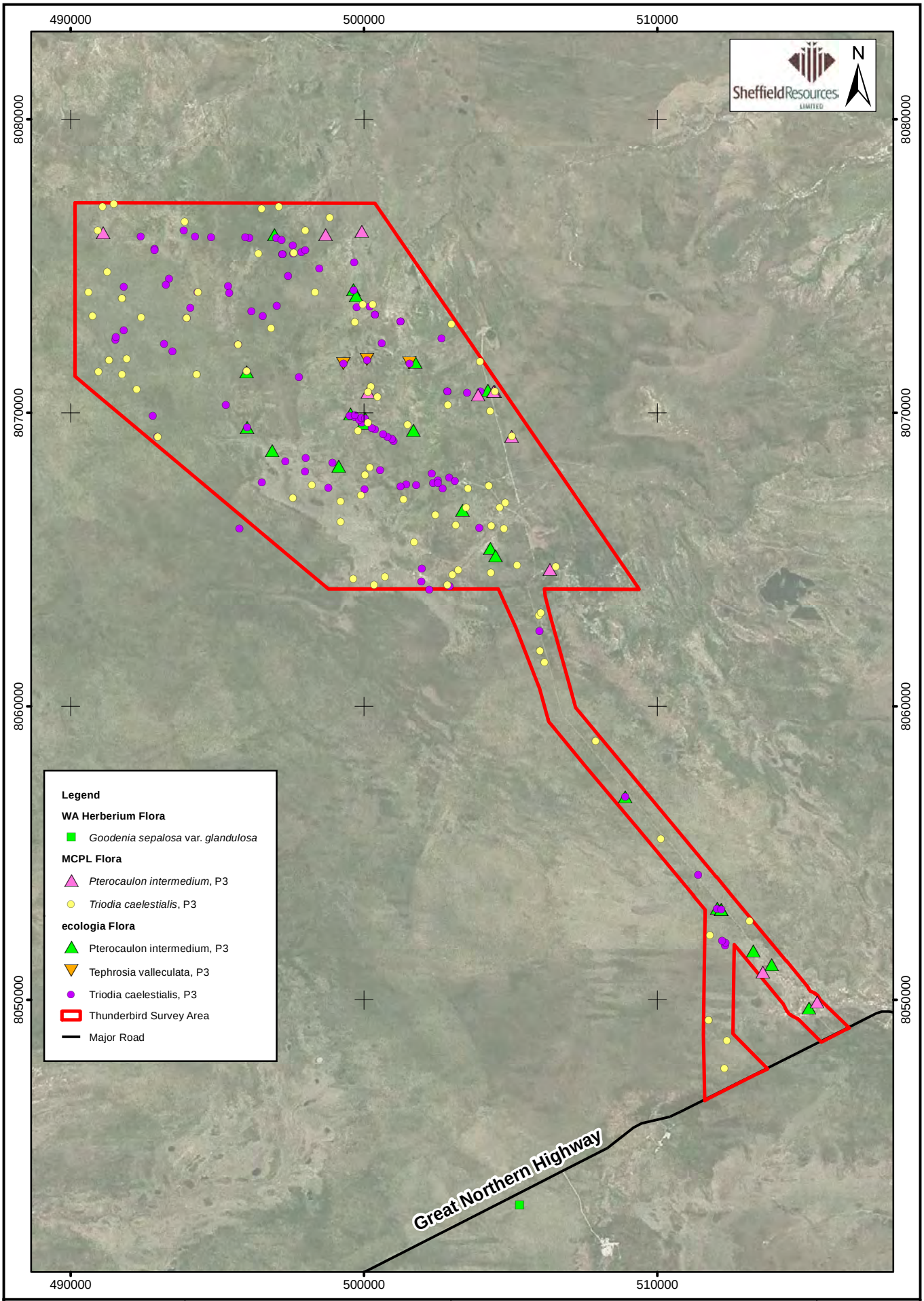
Thunderbird Mineral Sands Project
Priority Ecological Communities and Flora

Figure: **11A**



Source: Flora: ecologia, DPaW (14-0716)

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CAD Ref: a2409_f50_08d

Date: Oct 2016 | Rev: D | A4

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Thunderbird Mineral Sands Project
Conservation Significant Flora

Figure: **11B**

6. FIELD SURVEY RESULTS

A total of 155 survey quadrats were established by Mattiske in June 2016 to assess the flora and vegetation of the Thunderbird Project Area (Figure 12). Refer to Appendix E for a list of the geographic locations of the survey quadrats.

6.1 Field Survey Coverage, Limitations and Constraints

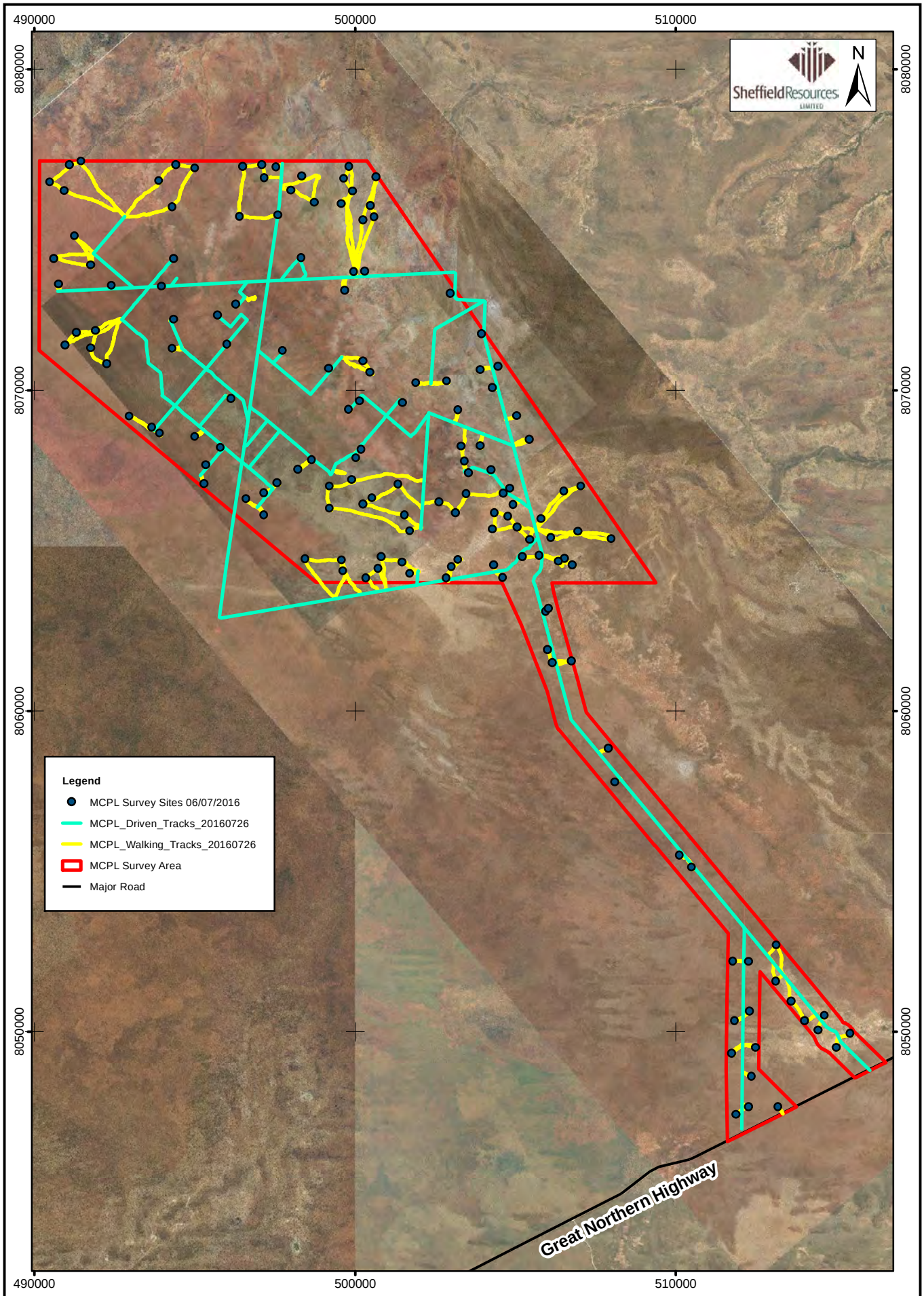
The coverage of the Thunderbird Project Area, based on survey quadrat locations, tracks and foot traverses is illustrated in Figure 12. An assessment of the survey against a range of factors which may have had an impact on the outcomes of the present survey was made (Table 8). Based on this assessment, the survey of the Thunderbird Project Area has not been subject to constraints which would affect the thoroughness of the survey and the conclusions which have been formed.

Table 8: Potential flora and vegetation survey limitations for the Thunderbird Project Area

Potential Survey Limitation	Impact on Survey
Sources of information and availability of contextual information (i.e. pre-existing background versus new material).	**Not a constraint.** Reference resources such as Beard's mapping, Land Systems mapping, online flora and vegetation information, provided an appropriate level of information for the current survey. In addition, the Thunderbird Project Area had been the subject of three previous surveys between 2012 and 2015 (Ecologia 2012, 2014, 2015). This material provided directly relevant information for the present survey.
Scope (i.e. what life forms, etc., were sampled).	**Not a constraint.** Vascular flora, which were the focus of the present survey, were thoroughly sampled.
Proportion of flora collected and identified (based on sampling, timing and intensity).	**Not a constraint.** The proportion of flora collected and identified was considered adequate. An analysis of the survey data demonstrated that approximately 80.13% of the potential flora species that may occur were recorded. This is based on both the present survey and surveys completed between 2012 and 2015 (Ecologia 2012, 2014, 2015). Of the 255 plant tax recorded in the current survey, approximately 16% were annual species. Additionally, a further approximately 16% of recorded taxa were classified as being annuals/short lived perennials. Any flora which could not be identified in the field was collected for subsequent identification. Of the 775 plants specimens collected, 60 could not be identified to the species level or could only be done so with some level of qualification. The reasons for this included the absence of fertile material required for accurate identification, the poor quality of the plant material available (senescent specimens) or the juvenile nature of the specimens available.
Completeness and further work which might be needed (i.e. was the relevant survey area fully surveyed).	**Not a constraint**. Survey quadrat locations were pre-selected using high resolution aerial photography to ensure all apparent vegetation communities identified were sampled, with multiple replications where possible. Quadrat locations, were in part, selected to complement past surveys (Ecologia 2012, 2014, 2015) and provide a greater degree of survey area coverage. Where necessary, additional sites were chosen in the field. Site selection and replication was considered adequate to accurately analyse and discriminate sites based on species composition and subsequently delineate vegetation community boundaries. The original haul road survey (Ecologia 2015) restricted vegetation community mapping strictly to the haul road width. In the present survey a 300 m buffer either side of the proposed haul road was surveyed.

Table 8: Potential flora and vegetation survey limitations for the Thunderbird Project Area

Potential Survey Limitation	Impact on Survey
Mapping reliability.	**Not a constraint**. Coverage of the survey area is considered to be good. High quality aerial maps (Scale: 1:10,000) were used for both the survey work and subsequent vegetation community mapping. Vegetation community boundaries were often discontinuous with interfaces resembling admixtures of one or more communities. This is a recognised and unavoidable limitation of vegetation mapping, particularly across mosaic Eucalyptus / Melaleuca and other shrubs associations and open woodland associations.
Timing, weather, season, cycle.	**Minor constraint**. The EPA (2004) recommends that flora and vegetation surveys in the Kimberley region (Northern Province) should be undertaken after the main rainfall period in the summer months. Rainfall in the four months preceding the June 2016 survey was well below average, with the area experiencing 51% of the long term average rainfall (Table 1, Figure 3). Compared to the three previous surveys of the Thunderbird Project Area (Table 1), the present survey was completed after one of the driest summer rainfall periods. This is likely to have affected the proportion of annual species likely to be recorded. In addition, identification of some taxa is likely to have been compromised due to the lack of, or poor quality of fertile material for plant identification.
Disturbances (fire, flood, accidental human intervention, etc.).	**Minor constraint**. Portions of the Thunderbird Project Area have been the subject of fires over the course of the surveys of the area undertaken since 2012 (refer to Section 5.9). Based on field observations, the vegetation has recovered rapidly, with the main species likely to be vegetation community defining, being readily identifiable from regrowth, even in areas which had been burnt within the 12 months preceding the present survey.
Intensity (in retrospect, was the intensity adequate).	N**ot a constraint**. The survey intensity was considered to have been thorough throughout the survey area with more than adequate replication being achieved via pre-planned quadrat locations, opportunistic field selection and relevé sites. The survey area was easily accessible by car and on foot.
Resources (i.e. were there adequate resources to complete the survey to the required standard).	**Not a constraint**. Resources, in terms of equipment, support and personnel were adequate.
Access problems (i.e. ability to access survey area).	**Not a constraint**. Vehicle access across the Thunderbird Project Area was via both existing Mt Jowlaenga station tracks and exploration tracks. These provided good access to the majority of the survey area. Some lengthy foot traverses were required to access parts of the survey area on the northern and eastern portions of the Thunderbird project Area (Figure 12).
Experience levels (e.g. degree of expertise in plant identification to taxon level).	**Not a constraint**. All botanists had extensive experience working in a range of botanical districts across the state. Two of the botanists on the present survey had previous experience working in the Kimberley region.



Source: Tracks: MCPL, Aerial Photography: Landgate and Sheffield Resources

0 1 2 3 4 km

Scale: 1:160,000
MGA94 (Zone 51)

CAD Ref: a2409_f50_11

Date: Jul 2016 | Rev: A | A4

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Thunderbird Mineral Sands Project
Tracks and Foot traverses

Figure: **12**

6.2 Flora

A total of 255 vascular plant taxa which are representative of 129 genera and 44 families were recorded in the Thunderbird Project Area during the 2016 survey. The majority of taxa recorded were representative of the Poaceae (46 taxa), Fabaceae (45 taxa), Malvaceae (18 taxa), Cyperaceae (14 taxa), Myrtaceae (14 taxa), Amaranthaceae (12 taxa) and Convolvulaceae (10 taxa) families. The taxa recorded during the survey are set out in Appendix C. A list of plant taxa recorded at each survey quadrat within the Thunderbird Project Area is set out in Appendix F.

Annual species represented 16.47% % of all recorded plant species within the Thunderbird Project Area during the 2016 survey. A further 16.08% of all recorded plant species recorded during the 2016 survey represented annual/short-lived perennial species The average species richness for the 155 quadrats surveyed during the 2016 survey was 20.51 ± 0.44 (mean ± s.e.m.), with a range of eight to 36 species per quadrat.

6.2.1 Proportion of Flora Surveyed

A species accumulation plot, based on accumulated species recorded versus sites surveyed within the Thunderbird Project Area was used to provide an indication as to the level of adequacy of the survey effort. As the number of survey sites increases, and correspondingly the size of the area surveyed increases, there should be a diminishing number of new species recorded. At some point, the number of new species recorded becomes essentially asymptotic. When the number of new species being recorded for survey effort expended approaches this asymptotic value, the survey effort can be considered to be adequate.

The species accumulation curve (Figure 13), based on the species accumulation analysis of Colwell (2013) was used to evaluate the adequacy of sampling. The asymptotic value was determined using Michaelis-Menten modelling. Using this analysis, the incidence based coverage estimator of species richness (ICE, Chao 2004) was calculated to be 534.11, based on data from the combination of surveys between 2012 and 2015 (Ecologia 2012, 2014, 2015) and the present survey. Based on this value, and the total of 419 species recorded across the 242 survey quadrats, approximately 80.13% of the flora species potentially present within the survey area were recorded.

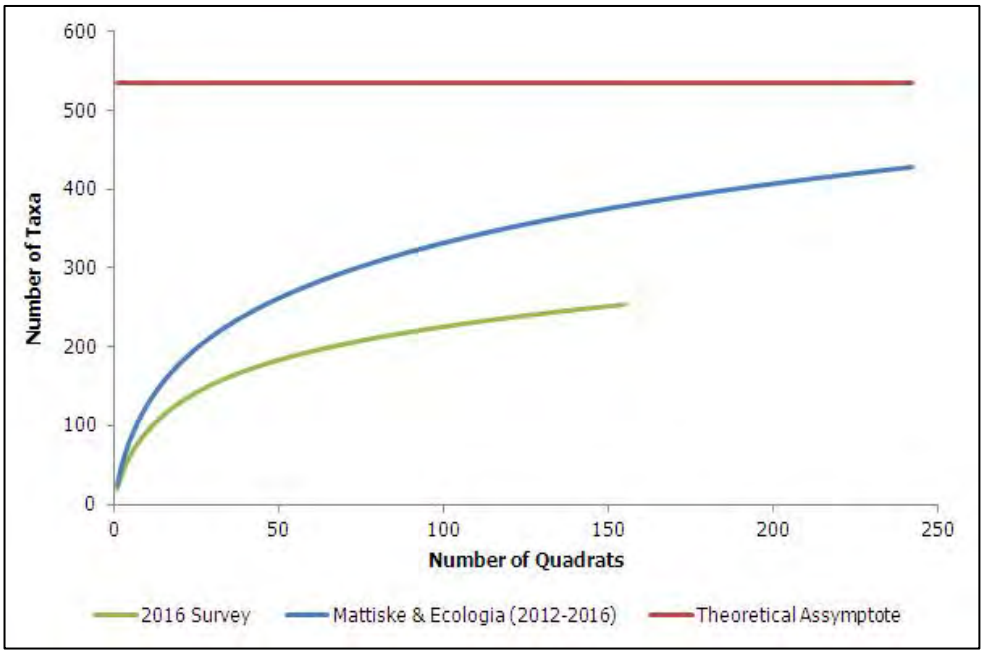


Figure 13: Average randomised species accumulation curve

6.2.2 Threatened and Priority Flora

No threatened flora pursuant to Schedule 1 of the *Wildlife Conservation Act 1950* and as listed by the DPaW (2016b) were recorded within the Thunderbird Project Area. No threatened flora pursuant to the *Environment Protection and Biodiversity Conservation Act 1999* and as listed by the DotE (2016a) were recorded within Thunderbird Project Area.

Two priority flora taxa, as listed by DPaW (2016g), were recorded within the Thunderbird Project Area during the present survey. The two priority flora recorded were *Pterocaulon intermedium* (P3) and Triodia *caelestialis* (P3) (Table 9). The geographical locations of priority flora recorded within the Thunderbird Project Area, together with their populations, are listed in Appendix G. The population of *Triodia caelestialis* (P3) within quadrats was highly variable, with a range of 1 to 13,000 plants in a 50 m x 50 m quadrat. The former indicates the presence of the taxon where a population count was not necessarily recorded. The larger population numbers were determined by counting plants in a 5 m x 5 m quadrat and then extrapolating this to the 50 m x 50 m quadrat area. This method was used where large numbers of plants were present and evenly distributed within the quadrat. Completed DPaW TPFL forms for the recorded priority taxa are presented as Appendix H.

In addition to the priority taxa recorded during the present survey, Ecologia (2012, 2014, 2015) recorded a range of priority taxa. These have been described in Section 5.8 of this report. The priority taxa recorded during previous surveys, together with their locations, are listed in Appendix G.

Table 9: Priority flora taxa recorded in the Thunderbird Project Area, June 2016

Species	SCC	Family	No. Of Survey Quadrats
Pterocaulon intermedium	P3	Asteraceae	11[1]
Triodia caelestialis	P3	Poaceae	81[2]

1 - Seven quadrats and four opportunistic records; 2 - 78 quadrats and three opportunistic records

6.2.3 Taxa with Extensions to their Range

One taxon recorded during the survey of the Thunderbird Project Area represented an extension to its currently known distribution. This taxon was *Aristida contorta.* The recording of *Aristida contorta* in the Thunderbird Project Area represents an approximately 300 km range extension from known records to either the east or south-west of the survey area (DPaW 2016g). This taxon is not considered to be of conservation significance. In this report, 150 km has been used as a basis to determine an extension to the currently known range for a taxon.

6.2.4 Introduced (Exotic) Plant Species

Five introduced (exotic) plant taxa were recorded during the survey of the Thunderbird Project Area. The introduced taxon recorded were **Cenchrus ciliaris,* **Portulaca pilosa,* **Stylosanthes hamata, Stylosanthes humilis and* **Stylosanthes scabra*. None of the recorded introduced species are Declared Pests pursuant to the *BAM Act 2007.*

**Cenchrus ciliaris* (buffel grass) is a tufted perennial grass to 1 m tall. It is a widespread weed of the pastoral regions (DPaW 2016g, Hussey *et al*. 2007). **Cenchrus ciliaris* is listed as Permitted (s11) pursuant to the *BAM Act 2007* according to the DAFWA (2016). **Cenchrus ciliaris* was recorded at four quadrats in the survey area, all situated on the upper slopes and ridges of hills.

**Portulaca pilosa* is a prostrate succulent annual to 20 cm high, producing pink or yellow flowers between January and July (DPaW 2016g, Hussey *et al*. 2007). **Portulaca pilosa* is listed as Permitted (s11) pursuant to the *BAM Act 2007* according to the DAFWA (2016). **Portulaca pilosa* was recorded at a single quadrat in the survey area.

Plate 2: *_Cenchrus ciliaris_ (DPaW 2016g)

Plate 3: *_Portulaca pilosa_ (DPaW 2016g)

**Stylosanthes hamata* is a softly hairy sprawling perennial herb to30 cm. The stems have hairs on one side only. Yellow flowers are produced from April to August, and the pods are hairy only on the lower half (DPaW 2016g, Hussey *et al*. 2007). **Stylosanthes hamata* is listed as Permitted (s11) pursuant to the *BAM Act 2007* according to the DAFWA (2016). **Stylosanthes hamata* was recorded at 12 quadrats in the survey area, across a range of different landforms.

**Stylosanthes humilis* is a hairy (a mix of soft and bristly hairs) sprawling perennial herb to30 cm. Yellow-orange flowers are produced from April to August, and the pods are sparsely hairy (DPaW 2016g, Hussey *et al*. 2007). **Stylosanthes humilis* is listed as Permitted (s11) pursuant to the *BAM Act 2007* according to the DAFWA (2016). **Stylosanthes humilis* was recorded at a single quadrat within the survey area, in a drainage channel. An identified image of **Stylosanthes humilis* is not available.

Plate 4: *Stylosanthes hamata* (DPaW 2016g)

**Stylosanthes scabra* is a sub-shurub to 1 m tall. The stems are hairy all over, giving the plant a rusty appearance. Yellow flowers are produced from February to June, and the pods are densely hairy (DPaW 2016g, Hussey *et al*. 2007). * *Stylosanthes scabra* is listed as Permitted (s11) pursuant to the *BAM Act 2007* according to the DAFWA (2016). **Stylosanthes scabra* was recorded at nine quadrats in the survey area, across a range of different landforms. An identified image of **Stylosanthes scabra* is not available.

The locations at which each of the introduced taxa were recorded within the Thunderbird Project Area are set out in Table 10. Population numbers at each location were not recorded.

Table 10: Locations of introduced species recorded within the Thunderbird Project Area

Survey Quadrat	GDA94_ZONE 51		Survey Quadrat	GDA94_ZONE 51	
	Easting (mE)	Northing (mN)		Easting (mE)	Northing (mN)
* *Cenchrus ciliaris*					
TB036	499684	8073106	TB071	403310	8068243
TB055	500466	8070546	TB114	506534	8064755
* *Portulaca pilosa*					
TB059	496133	8069735			
* *Stylosanthes hamata*					
TB008	495007	8076918	TB076	503414	8067780
TB010	500650	8076645	TB085	507050	8067000
TB011	497174	8076619	TB119	501468	8064631
TB044	503951	8071750	TB142	513606	8050948
TB059	496133	8069735	TB144	514650	8050502
TB071	503310	8068243	TB150	515012	8049496

Table 10: Locations of introduced species recorded within the Thunderbird Project Area

Survey Quadrat	GDA94_ZONE 51		Survey Quadrat	GDA94_ZONE 51	
* *Stylosanthes humilis*					
TB116	503218	8064713			
* *Stylosanthes scabra*					
TB017	499923	8076197	TB056	502860	8070275
TB018	498730	8075842	TB064	505040	8069200
TB038	496823	8072877	TB079	504247	8067511
TB052	504458	8070740	TB087	504821	8066933
TB054	503905	8070626			

6.3 Statistical Analysis of Data

Cluster analyses derived from a species-by-site resemblance matrix (Bray-Curtis similarity) grouped survey sites into discrete clusters based on species composition (dissimilarity/distance increased) (Clarke and Gorley 2006). Only taxa which could be identified to species level were included in the analysis. Classification and ordination analyses were conducted on a data matrix of perennial taxa, with singularly occurring species and annual taxa omitted prior to analysis. This was justified in that singleton taxa add little additional information, and annuals (desert ephemerals) exhibit high inter-annual variation in distribution and abundance (Mott 1972, 1973). In addition, the omission of annual species from the statistical analysis allows for comparison of data from surveys undertaken in different seasons or survey years (2012 to 2016 in the case of the present analysis). Hierarchical Clustering was used in conjunction with Analysis of Similarities (ANOSIM), Similarity Profile (SIMPROF), Similarity Percentages (SIMPER), site descriptions, site photos and aerial photographs; combining these methods increased the understanding of site inter-relations and thus the ability to accurately delineate those sites based on species composition.

Similarity Profile Analysis (SIMPROF) of the 242 vegetation quadrats - 155 Mattiske quadrats from the present survey and 87 quadrats assessed between 2012 and 2015 (Ecologia 2012, 2014, 2015) - identified significantly associated groups of quadrats. Based on this analysis, 14 significantly dissimilar vegetation communities were delineated within the Thunderbird Project Area (Global R = 0.759 p = <0.001). Where appropriate, outliers and small groupings were assigned to broader comparative vegetation units based on factors including species composition and site descriptions; this is particularly relevant where survey quadrats were established on ecotones. For the purposes of vegetation mapping, i.e. extrapolating quadrat data to generalised vegetation communities over broad areas, an inclusive rather than exclusive approach was adopted for outliers. The dendrogram representing the results of the cluster analysis, and the corresponding 14 statistically dissimilar vegetation types is illustrated in Figure 14.

6.4 Vegetation Mapping

Based on the statistical analysis (Section 6.3), 14 vegetation communities were defined and mapped within the Thunderbird Project Area. An overview of the mapped vegetation is presented in Figure 15. A detailed vegetation map is presented in Appendix I. In addition to the statistical analysis, survey quadrat physical data and aerial photographic maps were used to delineate the boundaries of the vegetation communities in the Thunderbird Project Area. The delineated vegetation communities are summarised below. A listing of species recorded within each vegetation community is set out in Appendix J. Detailed descriptions of each vegetation community together with representative photographs are presented in Appendix K.

Woodlands

W1 *Melaleuca viridiflora*, *Melaleuca alsophila* and *Eucalyptus tectifica* low sparse woodland over *Bauhinia cunninghamii*, *Carissa lanceolata* and *Atalaya hemiglauca* tall sparse shrubland over *Ectrosia schultzii*, *Eriachne sulcata* and *Cyperus conicus* low sparse grassland on grey-white to light brown sandy soils in drainage channels and low lying drainage areas.

W2 *Eucalyptus tectifica* mid open woodland over *Acacia plectocarpa* subsp. *plectocarpa* and *Grevillea pyramidalis* subsp. *pyramidalis* tall sparse shrubland over *Aristida holathera* subsp. *latifolia*, *Eriachne obtusa* and *Xerochloa laniflora* mid sparse grassland on light brown clayey sands in low lying drainage areas.

W3 *Corymbia dendromerinx*, *Eucalyptus tectifica* and *Corymbia greeniana* mid open woodland over *Dolichandrone heterophylla*, *Dodonaea hispidula* var. *arida* and *Grevillea pyramidalis* subsp. *pyramidalis* mid sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse hummock grassland on orange-brown clayey sands on flats and drainage areas.

W4 *Corymbia dendromerinx* mid open woodland over *Terminalia canescens*, *Calytrix exstipulata* and *Wrightia saligna* tall sparse shrubland over *Triodia caelestialis* (P3), *Triumfetta albida* and *Polycarpaea longiflora* mid open tussock grassland on brown sandy clay soils on mid-slopes to ridges of hills with sandstone outcropping.

W5 *Corymbia dendromerinx* mid open woodland over *Grevillea pyramidalis* subsp. *pyramidalis*, *Terminalia canescens* and *Waltheria indica* mid sparse shrubland over *Triodia caelestialis* (P3), *Sorghum plumosum* and *Hybanthus enneaspermus* subsp. *enneaspermus* low sparse tussock grassland on pale brown to orange-brown sandy clay loam soils on slopes and broad flat hill tops with sandstone outcropping.

W6 *Eucalyptus tectifica*, *Bauhinia cunninghamii* and *Brachychiton diversifolius* subsp. *diversifolius* mid open woodland over *Carissa lanceolata* and *Dolichandrone heterophylla* mid sparse shrubland

over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland on pale brown to grey brown sandy clay loams on flats.

W7 *Brachychiton diversifolius* subsp. *diversifolius* and *Eucalyptus tectifica* low open woodland over *Bauhinia cunninghamii*, *Acacia plectocarpa* subsp. *plectocarpa* and *Melaleuca viridiflora* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Aristida holathera* var. *holathera* mid sparse hummock grassland on pale orange-grey clayey sands on flats.

W8 *Erythrophleum chlorostachys*, *Brachychiton diversifolius* subsp. *diversifolius* and *Corymbia greeniana* mid open woodland over *Acacia tumida* var. *tumida*, *Bauhinia cunninghamii* and *Dodonaea hispidula* var. *arida* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland on orange brown to red fine sandy soils on flats.

W9 *Corymbia dendromerinx* low open woodland over *Grevillea pyramidalis* subsp. *pyramidalis*, *Microstachys chamaelea* and *Terminalia canescens* mid sparse shrubland over *Chrysopogon* sp. (*C. fallax* or *C. pallidus*), *Glycine tomentella* and *Sorghum plumosum* mid sparse grassland on orange-brown sandy clay with sandstone rocks and outcropping on hills.

W10 *Corymbia greeniana*, *Corymbia dendromerinx* and *Brachychiton diversifolius* subsp. *diversifolius* low open woodland over *Grevillea pyramidalis* subsp. *pyramidalis*, *Grevillea refracta* subsp. *refracta* and *Terminalia canescens* tall sparse shrubland over *Triodia caelestialis* (P3), *Solanum cunninghamii* and *Aristida hygrometrica* mid open tussock grassland on orange-brown clayey sands with occasional sandstone or ironstone rocks on flats and slopes associated with drainage areas.

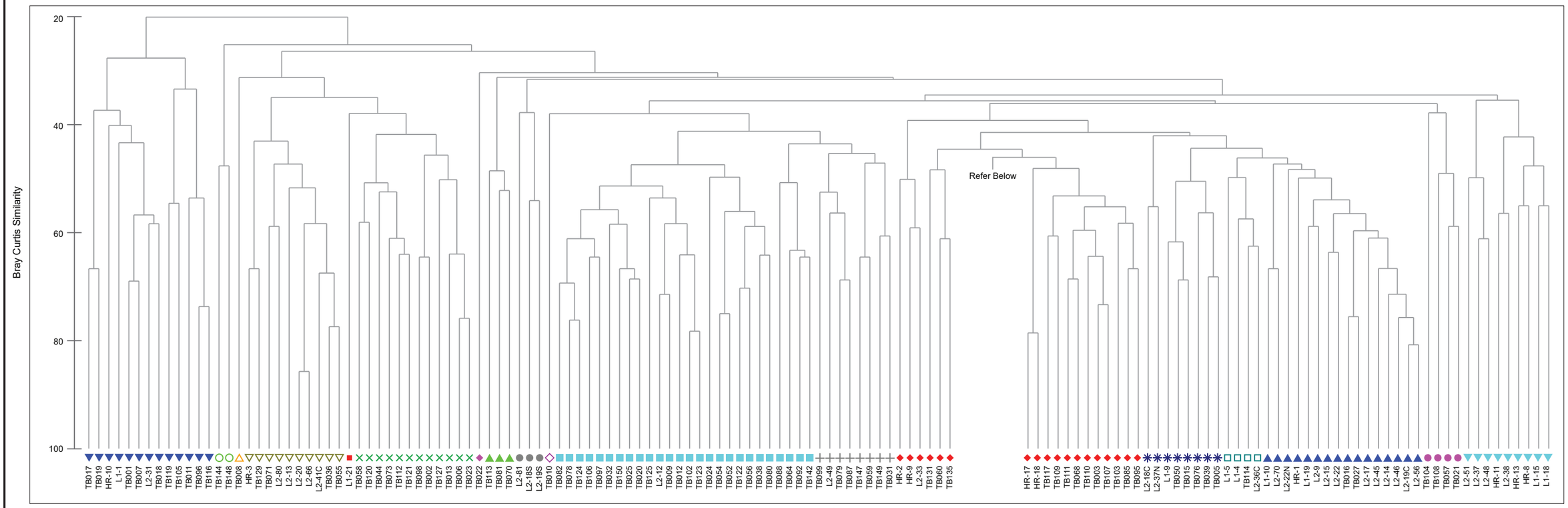
W11 *Corymbia zygophylla* low open woodland over *Acacia tumida* var. *tumida* and *Erythrophleum chlorostachys* tall sparse shrubland over *Triodia schinzii* and *Microstachys chamaelea* low sparse grassland on orange-brown clayey sands on flats and slopes.

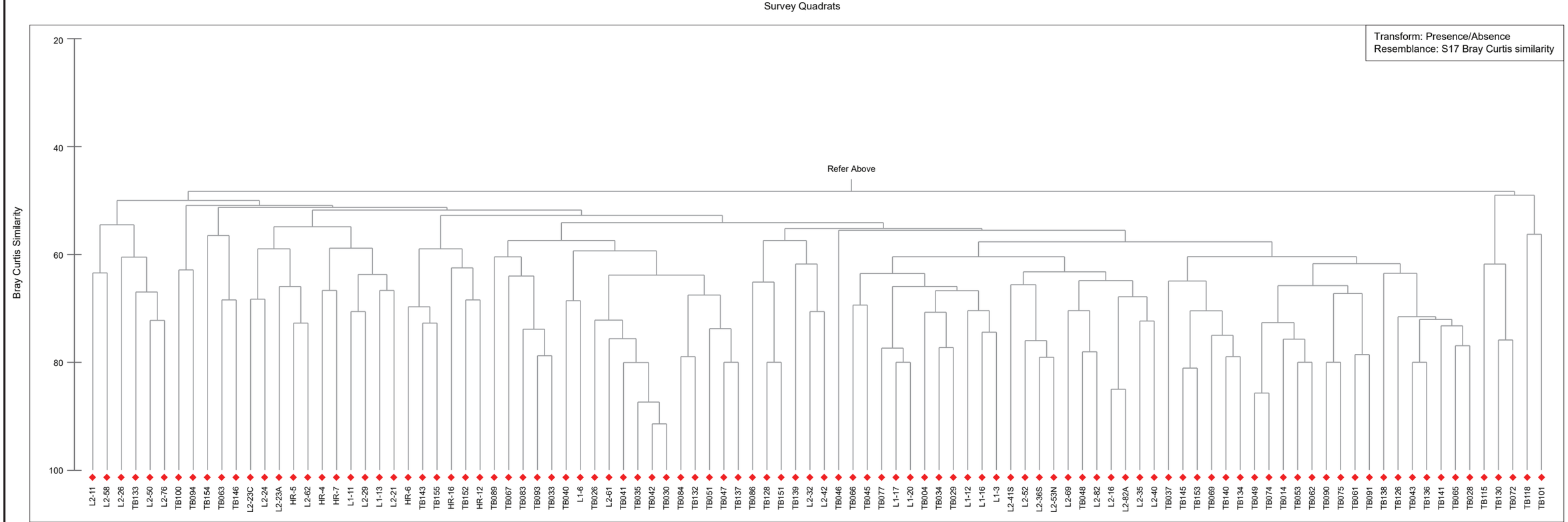
W12 *Corymbia greeniana*, *Eucalyptus tectifica* and *Corymbia dendromerinx* mid open woodland over *Dolichandrone heterophylla*, *Bauhinia cunninghamii* and *Acacia tumida* var. *tumida* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland, on brown clayey sands on flats and drainage channels.

W13 *Brachychiton diversifolius* subsp. *diversifolius, Erythrophleum chlorostachys* and *Corymbia dendromerinx* mid open woodland over *Grevillea refract* subsp. *refracta*, *Acacia monticola* and *Microstachys chamaelea* tall sparse shrubland over *Corchorus sidoides*, *Goodenia sepalosa* subsp. *sepalosa* and *Pterocaulon paradoxum* low sparse forbland on orange-brown clayey sands on flats.

Shrubland

S1 *Acacia tumida* var. *tumida* low sparse shrubland over *Waltheria indica* and *Bauhinia cunninghamii* low isolated shrubs over *Ectrosia schultzii*, *Eriachne obtusa* and *Corchorus pumilio* low sparse grassland on pale grey sandy clay loam soils on flats and slopes.





W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11 W12 W13 S1

Client: Sheffield Resources Limited
CAD Ref: g2409_Dend_F01
Date: Sept 2016 | Rev: B | A3

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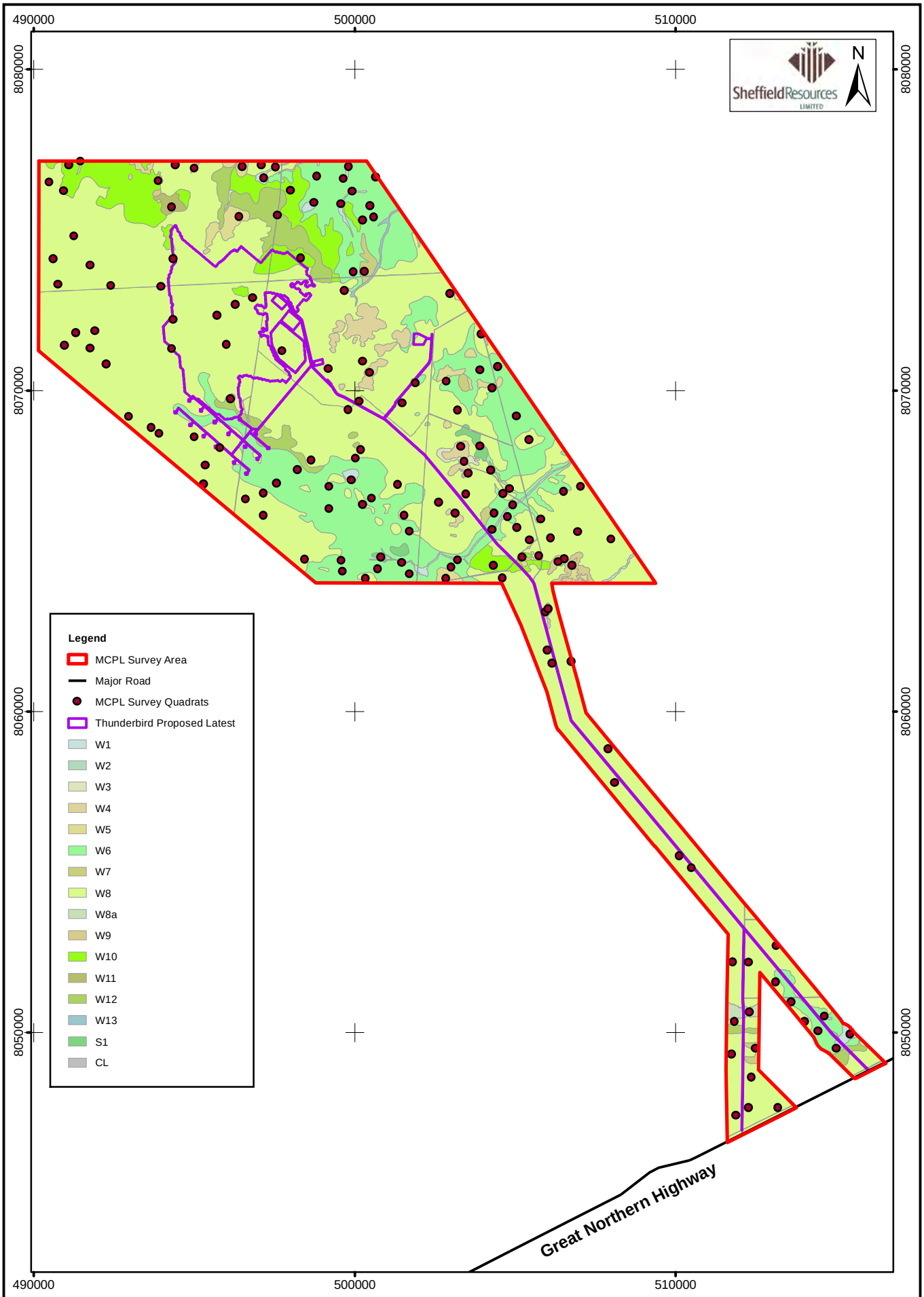
Thunderbird Mineral Sands Project
Hierarchical Cluster of Floristic Community Types
Group Average

Figure **14**



Source: Vegetation: MCPL, Site Layout: MBS

0 1 2 3 4 km

Scale: 1:160,000
MGA94 (Zone 51)

CAD Ref: a2409_f50_14

Date: Sep 2016 | Rev: B | A4

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Thunderbird Mineral Sands Project
Vegetation

Figure: **15**

6.5 Area Coverage of Vegetation Communities

The total areas mapped and percentage cover for each vegetation community delineated in the Thunderbird Project Area is set out in Table 11. In terms of area coverage, the woodland communities were the most commonly represented, accounting for 99.07% of the Thunderbird Project Area. In particular, two woodland communities - W6 and W8 (and W8a) - accounted for 86.32% of the Thunderbird Project Area. Vegetation community W8a is the same as vegetation community W8, but has been mapped as a sub-community based on its position in the landscape, being an area which is likely to be subject to seasonal inundation. Vegetation communities W2, W3 and W13 were the most restricted in terms of area coverage, occupying 0.02%, 0.19% and 0.13% respectively of the total area surveyed.

Average species richness across all 242 quadrats used for vegetation mapping (155 Mattiske quadrats and 87 Ecologia quadrats) was 25.40 ± 0.59 (mean ± s.e.m.). The W10 vegetation community exhibited the highest species richness (39.81 ± 2.85). The most species poor community delineated was the S1 community, with a mean species richness of 13.00 ± 0.74.

Table 11: Area coverage of each vegetation community in the Thunderbird Project Area.

Vegetation Community	Area (ha)	Percentage of Survey Area
S1	58.9207	0.31
W1	141.0203	0.75
W2	3.0769	0.02
W3	35.7049	0.19
W4	271.9573	1.44
W5	234.5105	1.24
W6	3,432.0202	18.17
W7	101.6397	0.54
W8	12,834.5447	67.95
W8a	36.9145	0.20
W9	67.8791	0.36
W10	964.2910	5.11
W11	40.9165	0.22
W12	519.7978	2.75
W13	25.1385	0.13
Cleared Land	117.5475	0.62
Totals	**18,885.8801**	**100.00**

6.6 Threatened Ecological Communities

No TECs, pursuant to Schedule 1 of the *Wildlife Conservation Act 1950* and as listed by the DPaW (2016e) were recorded within the Thunderbird Project Area. No TECs, pursuant to the *EPBC Act* and as listed by the DotE (2016b) were recorded within the Thunderbird Project Area.

6.7 Priority Ecological Communities

No PECs as listed by DPaW (2016f) were recorded within the Thunderbird Project Area.

6.8 Condition of the Vegetation

The condition of the vegetation within the Thunderbird Project Area ranged from good to excellent, according to Trudgeon (1988; Appendix A; Table A7). Some low level disturbance, associated with cattle was observed, predominantly in areas associated with drainage channels. Portions of the Thunderbird Project Area had been subjected to fires. The age since fire disturbance varied across the Thunderbird Project Area, with some areas having been burnt within the 12 months preceding the survey.

7. DISCUSSION

Mattiske was commissioned by Sheffield to undertake a Level 2 flora and vegetation survey of the Thunderbird Project Area. The Thunderbird Project Area occupies an area of 18,886 ha and is situated on the Dampier Peninsula, between Broome and Derby, across the Mt Jowlaenga and Yeeda Stations.

The Thunderbird Project Area has been the subject of three flora and vegetation surveys completed by Ecologia since 2012. These surveys were a Level 1 flora and fauna assessment (Ecologia 2012), a Level 2 flora and vegetation survey (Ecologia 2014) and a Haul Road and Accommodation Camp flora and fauna assessment (Ecologia 2015). These surveys recorded a range of flora species and vegetation communities which were broadly reflective of the pindan vegetation typical of the region, as described by Beard (1979), as well as the land systems described by Schoknecht & Payne (2010).

Prior to undertaking the field survey in June 2016, Mattiske reviewed the historical literature relating to the flora and vegetation of the region, as well as undertaking a gap analysis of the three surveys which had previously been completed in the Thunderbird Project Area (Ecologia 2012, 2014, 2015). The result of the gap analysis identified four principle areas which warranted additional survey work in the Thunderbird Project Area. These were:

1. A change in the boundary of the Thunderbird Project Area, as compared to the areas surveyed between 2012 and 2015 (Ecologia 2012, 2014, 2015), necessitating the establishment of survey quadrats in areas which previously did not fall within the present Thunderbird Project Area boundary (Figure 10);
2. The lower than desirable density of quadrats surveyed in the previous surveys to ensure adequate coverage for a Level 2 vegetation survey;
3. Mapping of the vegetation within the Thunderbird Project Area which did not reflect the landforms present; and
4. A review of the area within the 14.46 ha area of vegetation unit MaMvEtCPCc (*Melaleuca alsophila* or *Melaleuca viridiflora* and *Eucalyptus tectifica* low, open woodland, over *Chrysopogon pallidus* sparse tussock grassland and *Cyperus conicus* sparse sedgeland) which was described as having similarities with the Lolly Well Springs wetland complex Priority 3 PEC assemblage (Ecologia 2014).

In June 2016 Mattiske established 155 vegetation survey quadrats within the Thunderbird Project Area. Some of these quadrats were established in the sections of the Thunderbird Project Area which did not form part of the areas surveyed by Ecologia (2012, 2014, 2015). Other survey quadrats were established to provide higher survey quadrat density in areas previously surveyed (Ecologia 2012, 2014, 2015), to enable a higher level of confidence in the vegetation mapping. Several of the survey quadrats established by Ecologia between 2012 and 2015 were re-surveyed in 2016 to establish if there were any discrepancies between the species recorded between the different survey companies which would have an impact on utilising the data from previous surveys as part of the present data analysis. Quadrat based species data from the three previous surveys within the Thunderbird Project Area was made available by Sheffield. However, because of the variety of forms in which this data was provided, data from the previous surveys was reduced to a species presence-absence format to enable its incorporation

with data from the present survey. The data from 87 survey quadrats established between 2012 and 2015 (Ecologia 201, 2014, 2015) was merged with the data from the present survey (155 quadrats) for the purposes of statistical analysis and vegetation community delineation.

Flora

A total of 255 vascular plant taxa which are representative of 129 genera and 44 families were recorded in the Thunderbird Project Area during the 2016 survey. The majority of taxa recorded were representative of the Poaceae (46 taxa), Fabaceae (45 taxa), Malvaceae (18 taxa), Cyperaceae (14 taxa), Myrtaceae (14 taxa), Amaranthaceae (12 taxa) and Convolvulaceae (10 taxa) families (Appendix C). Species which were classified as strictly annual represented 16.47% of all taxa recorded. Overall, when data from the three previous flora surveys of the Thunderbird Project Area (Ecologia 2012, 2014, 2015) are assessed together with the data from the present survey, approximately 81% of the species potentially present within the Thunderbird Project Area have been recorded (Figure 13). This, together with the fact that four surveys have been completed over a four-year period, demonstrates that the area has been thoroughly assessed floristically, and that the conditions for a Level 2 survey have been satisfied.

Of the 775 plants specimens collected during the June 2016 survey, 60 could not be identified to the species level or could only be done so with some level of qualification. The reasons for this included the absence of fertile material required for accurate identification, the poor quality of the plant material available (senescent specimens) or the juvenile nature of the specimens available. Only five of the plant specimens collected (<1% of all plants collected) could only be identified to the family level. There were two reasons for the presence of relatively poor specimens. Firstly, the timing of the survey. The June 2016 survey was completed following the poorest rainfall season of all four surveys completed in the Thunderbird Project Area (Figure 3, Table 1). Rainfall in the four months preceding the 2016 survey was only 51% of the long term average. Consequently, it is unremarkable that there were a number of poor quality specimens available, many of which were annual species. Overall this is not considered to have constrained the survey of the Thunderbird Project Area because there have been four surveys in total, the first two of which (Ecologia 2012, 2014) were completed after very good rainfall seasons (Figure 3, Table 2). Secondly, some specimens which were collected from areas which had recently been the subject of bushfires (within 12 months of the survey), were of a juvenile nature and could not be positively identified to the species level.

The flora recorded during the June 2016 survey was consistent with species reported as being typical of the area (Appendix C, Beard 1979). Additionally, the species recorded were consistent with those previously reported within the Thunderbird Project Area (Ecologia 2012, 2014, 2015). The latter is particularly important, as it afforded a high level of confidence that the data from previous surveys could be merged with the present survey data for statistical analysis and vegetation community delineation.

No threatened flora were recorded within the Thunderbird Project Area during the June 2016 survey. This was also the case with the previous three surveys of the area (Ecologia 2012, 2014, 2015). Two priority flora taxa were recorded during the June 2016 survey of the Thunderbird Project Area. These

were *Triodia caelestialis* (P3) and *Pterocaulon intermedium* (P3). Specimens of both taxa collected by Mattiske in June 2016 – multiple specimens in the case of *Triodia caelestialis* (P3) – were submitted to the Western Australian Herbarium for re-identification. *Triodia caelestialis* (P3) was recorded at 78 of the 155 quadrats surveyed in June 2015. It was present in large numbers where it was recorded (Appendix G), and was recorded at locations spread across the entirety of the Thunderbird Project Area (Figure 11B, Appendix I).

Pterocaulon intermedium (P3) was recorded at 7 of the 155 quadrats surveyed in June 2016. It was recorded infrequently (Appendix G). The locations of both priority taxa within the Thunderbird Project Area does not, on the basis of all four surveys of the Thunderbird Project Area, appear to be associated with any specific landforms or soil types (Appendix I). Given the widespread distribution of both taxa, and the low level of surveys in the less accessible parts of the Dampier Peninsula, there is a reasonable expectation that they would be located beyond the Thunderbird Project Area boundary, and that impacts to these taxa from mine development would likely be low.

In addition to the aforementioned priority taxa, three other priority flora taxa have previously been recorded in the Thunderbird Project Area (Ecologia 2012, 2014, 2015). These taxa were *Fuirena incrassata* (P3), *Fuirena nudiflora* (P1), and *Tephrosia valleculata* (P3). An additional taxon, *Eriachne* sp. Dampier Peninsula (K.F. Kenneally 5946) was previously reported as a Priority 3 taxon in the Thunderbird Project Area (Ecologia 2014). This taxon is no longer listed as a priority taxon (DPaW 2016g). None of these three taxa were recorded by Mattiske during the June 2016 survey of the Thunderbird Project Area. All three taxa were recorded infrequently (Ecologia 2014). *Fuirena incrassata* (P3), which has been recorded in the region (DPaW 2016g), is an annual species. Given the poor rainfall conditions which preceded the present survey, the fact that it was not recorded during the June 2016 survey is not unsurprising. According to DPaW (2016g), the distribution of *Fuirena nudiflora* (P1) is restricted to the Victoria Bonaparte and Central Range IBRA regions, near to the borders of the Northern Territory and South Australia respectively. Its presence in the Thunderbird Project Area would represent a range extension of approximately 1,000 km to the west of its present known locations (DPaW 2016g). Unfortunately, Ecologia (2014) did not provide information as to whether or not the specimen of this taxon collected was confirmed by a specialist taxonomist, given the significance of it being recorded in the Thunderbird Project Area. However, given that it is an annual species, there would have been a low likelihood of recording this taxon given the poor rainfall season preceding the June 2016 survey. *Tephrosia valleculata* (P3) is known to occur within approximately 200 km of the Thunderbird Project Area (DPaW 2016g). Whether this species is annual or perennial is not indicated (DPaW 2016g). Its preferred habitat is on rock outcrops and soil around sandstone (DPaW 2016g), which occur within the Thunderbird Project Area. That it was not recorded during the June 2016 survey may be due to either it not being present due to the poor seasonal conditions, or given its infrequent recording by Ecologia (2014), such occurrences may be opportunistic. Again, no indication was provided as to verification of the identity of this taxon (Ecologia 2014). Notwithstanding this, given its preference for rocky outcrops (DPaW 2016g), it is unlikely to be impacted by mine development within the Thunderbird Project Area.

One taxon recorded during the June 2016 survey of the Thunderbird Project Area survey represented an extension to its currently known distribution. This taxon was *Aristida contorta.* The recording of *Aristida contorta* in the Thunderbird Project Area represents an approximately 300 km range extension from known records to either the east or south-west of the survey area (DPaW 2016g). This taxon is not considered to be of conservation significance, as it widespread throughout the State (DPaW 2016g). Ecologia (2014) reported that 26 of the taxa recorded during the Level 2 survey of the Thunderbird Project Area represented range extensions of more than 100 km from there then known range. As is the case with *Aristida contorta*, this is likely to be associated with the low level of survey of the less accessible areas of the Dampier Peninsula.

Five introduced (exotic) plant taxa were recorded during the survey of the Thunderbird Project Area (Table 10). The introduced taxon recorded were **Cenchrus ciliaris, *Portulaca pilosa, *Stylosanthes hamata and *Stylosanthes scabra*. None of the recorded introduced species are Declared Pests pursuant to the *BAM Act 2007.* All taxa were recorded infrequently, and were also reported by Ecologia during their three surveys of the Thunderbird Project Area (Ecologia 2012, 2014, 2015). Ecologia (2014) reported that the Declared Pest, **Sida aculeata*, was recorded during the then survey of the Thunderbird Project Area. Although this taxon was not recorded during the June 2016 survey, and given that it has previously been recorded within the Thunderbird Project Area, there may be a need to monitor the presence of this species.

Vegetation

Quadrat based species data was made available from the three preceding surveys of the Thunderbird Project Area (Ecologia 2012, 2014, 2015). Due to the different formats in which this data was made available, it was all converted into a species presence-absence matrix. A major concern when utilising data from previous surveys completed by different survey companies is the potential for there to be discrepancies between the data from the different surveys. A review of the previous data with that recorded during the present survey revealed that this would not pose a problem. Mattiske specifically re-surveyed several of the quadrats established by Ecologia (2012, 2014, 2015) to verify species identification. The results of this provided a high level of confidence in terms of merging the data from all four surveys.

Mattiske initially undertook a statistical analysis of the 2016 survey data in isolation. Plymouth Routines in Multivariate Ecological Research version 6 (PRIMER v6) statistical analysis software was used to analyse species-by-site data and discriminate sites on the basis of their species composition (Clarke and Gorley 2006). To down-weight the relative contributions of quantitatively dominant species a presence/absence transformation of the data was used for statistical analysis. Introduced species, singletons (species recorded at only one site) and specimens that were not identified down to the species level were excluded from the analysis. Annuals were removed from the data in analysis due to the differences between years based on seasonality of local rainfall events. Computation of similarity matrices was based on the Bray-Curtis similarity measure. Subsequently, data from 87 quadrats assessed during the previous surveys (Ecologia 2012, 2014, 2015) was merged with the data from the 155 quadrats surveyed during the June 2016 survey and the statistical analyses performed on the

merged data from 242 survey quadrats. The results of the statistical analysis are presented in the form of a dendrogram (Figure 14). With two exceptions (communities W12 and W13) there was no tendency for survey data from the four surveys to group, based on either survey type or survey company. Because of this, the aforementioned two communities were maintained as distinct communities rather than merging them into larger groupings.

Fourteen vegetation communities were defined and mapped across the Thunderbird Project Area based on the statistical analysis of the species data recorded across the combined 242 survey quadrats established in the Thunderbird Project Area between 2012 and 2016. The vegetation communities are summarised in Appendix K.

In broad terms, the vegetation of the Thunderbird Project Area consists of vegetation, where there is a sparse overstorey of *Eucalyptusl Corymbia* species – typically *Corymbia greenianal Eucalyptus tectifica* – over a mid-storey of *Acacia* species, dominated by *Acacia tumida* var. *tumida*, and a ground storey of mixed grasses, with *Triodia caelestialis* (P3), *Triodia schinzii*, and *Chrysopogon species* (*C. pallidus, C. timorense*) being dominant. Other common species in the upper storey included *Brachychiton diversifolius Corymbia zygophylla*, *Erythrophleum chlorostachys*, and *Eucalyptus flavescens*. *Atalaya hemiglauca*, *Bauhinia cunninghamii*, *Dolichandrone heterophylla*, *Ehretia saligna*, *Gardenia pyriformis* subsp. *keartlandii*, *Grevillea pyramidalis*, *Hakea arborescens*, and *Hakea macrocarpa* were common mid-storey species. Some of these, such as *Bauhinia cunninghamii*, were often of sufficient size as to form a component of the upper storey. The vegetation described here, based on the statistical analysis of the survey data, is essentially pindan. This is typical of the pindan vegetation and species described by Graham (2001), Kenneally *et al*. 1996, Beard (1979) and Schoknecht and Payne (2010) in their treatments of the IBRA region, vegetation mapping and land systems respectively. A more detailed review of these areas is presented in Section 5 of this report. In this respect, the vegetation of the Thunderbird Project Area is common and widespread through the broader Kimberley region.

Two of the 14 defined vegetation communities accounted for more than 86% of the Thunderbird Project Area (Table 11, Figure 15, Appendix I). The defined woodland communities accounted for more than 99% of the Thunderbird Project Area. Statistically, the average dissimilarity between the woodland communities was high, being typically greater than 70%. These differences were reflected in the relative presence/absence of the common range of species described in the preceding paragraph. Whilst the same species could be present at two communities (e.g. *Corymbia greenianal Eucalyptus tectifica*), one tended to be dominant at one community and not at the other, and vice versa. This tended to be reflected across the range of common species in all strata. The single defined shrubland (S1) represented 0.31% of the Thunderbird Project Area and was characterised by the absence of tree species.

From a vegetation mapping perspective, Mattiske has taken into account landform elements when allocating boundaries to vegetation communities. These include drainage channels and hills/breakaways. This was not a practice adopted in previous reports of surveys in the Thunderbird Project Area (Ecologia 2012, 2014, 2014). The high resolution aerial imagery taken since 2015 and

made available by Sheffield enabled a more accurate delineation of communities. The resulting vegetation map (Figure 15, Appendix I) is consequently more reflective of both the vegetation communities defined and the landforms present. Vegetation associated with the hills and drainage channels within the Thunderbird Project Area were statistically different from the vegetation communities defined on the flats (Appendices I and K). This also justified the decision to incorporate landform elements into the mapping.

The drainage channels (community W1) were dominated by *Melaleuca viridiflora* and *Melaleuca alsophila* (equivalent to Ecologia vegetation unit MaMvEtCpCc – refer to Table 5). The major drainage channel which traverses the southern portion of the Thunderbird Project Area polygon, just to the north of the proposed haul road junction with the main polygon, had *Eucalyptus camaldulensis* growing on its eastern section, where the drainage channel became wider and deeper. The Reeves land system (Schoknecht and Payne 2010) traverses this portion of the Thunderbird Project Area (Figure 5). One of its land units consists of channels supporting fringing woodlands of *Eucalyptus camaldulensis* and *Melaleuca* spp. communities. The major portion of the Thunderbird Project Area falls within the Fraser and Wanganut land systems (Figure 5). The vegetation recorded during both the present and previous three surveys (Ecologia 2012, 2014, 2015) recorded vegetation on soils consistent with these land systems. That is, sandplains composed of red sandy soils supporting low pindan woodland with a prominent *Acacia* shrub layer and *Triodia-Chrysopogon* ground layer (Schoknecht and Payne 2010). These were principally vegetation communities W6 and W8, which together accounted for approximately 86% of the Thunderbird Project Area. The hills and ridge communities (W4 and W5) tended to be very sparsely wooded and *Erythrophleum chlorostachys* was not present, unlike the flats where it was a common species. A section of vegetation community W8, located on one arm of the proposed access road near the great Northern Highway (Appendix I), has been delineated as a sub-community (W8a) because, unlike the remainder of the W8 community, this section is low lying in the landscape and is likely to become inundated during the wet season.

Two of the vegetation communities, W12 and W13, which comprised 2.75% and 0.13% respectively of the Thunderbird Project Area, comprised quadrats exclusively from previous surveys (Ecologia 2012, 2014, 2015). Both communities W12 and W13 did not contain any unusual species, compared to other communities of the flats. Statistically, *Triodia* spp. did not feature as defining elements of these two communities, although they were present in some quadrats. They did however statistically group together, and as such we have chosen to delineate them rather than merge them into broader groups. Community W12 was principally defined toward the Great Northern Highway end of the proposed haul road alignment and in the northern section of the Thunderbird Project Area. Community W13 was situated in areas in the north of the Thunderbird Project Area. Vegetation communities W12 and W13 are not regarded as comprising unusual vegetation or species assemblages (Appendix K), and the species present in both communities are components of the general pindan vegetation which is the dominant vegetation type in the Thunderbird Project Area. Neither community is situated in the indicative impact areas (Figure 15), and as such are unlikely to be affected by mine development.

Several of the defined vegetation communities (Table 11), represent 5% or less of the Thunderbird Project Area. However, they do not constitute communities which support either unusual species or species assemblages which would warrant special attention. As has been previously stated, the vegetation communities present, particularly on the flats, represent variations of the pindan vegetation which is the dominant vegetation of the region. Statistically, the differences between communities is related to the relative dominance in some areas of one or more of the commonly occurring species. At the time of compiling this report, Mattiske had access to indicative impact areas (Figure 15). Impacts associated with planned mining operations may impact the W6 and W8 communities, which constitute approximately 86% of the Thunderbird Survey Area. These communities are essentially the common pindan vegetation of the region, and hence impacts are likely considered to be low.

Ecologia (2014, 2014, 2015) mapped a range of vegetation communities, which show a higher level of community fragmentation than those mapped in the current report. It is likely that this, in part, is a function of the lower density of survey quadrats established – 87 from three Ecologia surveys. The communities defined and mapped in the present report are based on a total of 242 survey quadrats. In addition, the mapping presented in the present report takes into account landform elements present within the Thunderbird Project Area – for example, hills and drainage channels – which was not the case with previous mapping (Ecologia 2012, 2014, 2015). Notwithstanding this, the major communities defined by Ecologia (Figure 10, Table 5), and which are situated within the indicative impact areas (Figure 15), namely EtApStCpEo, BDEcAtSt, CdTcTc and CgDhSt, are comprised essentially of the species mix which form the broad pindan vegetation of the area. These species are the same as those used by Mattiske and which form the basis of the communities defined and mapped in the present report.

Ecologia (2014) reported that 'a 14.46 ha section of vegetation unit MaMvEtCpCc (*Melaleuca alsophila* or *Melaleuca viridiflora* and *Eucalyptus tectifica* low, open woodland, over *Chrysopogon pallidus* sparse tussock grassland and *Cyperus conicus* sparse sedgeland) closely resembles vegetation associated with a Priority Ecological Community (PEC) at Lolly Well Springs, 40 km to the north-west'. At no point in the document (Ecologia 2014) is any statistical analysis with the vegetation of Lolly Well Springs provided to support this claim. Furthermore, the author states, correctly, that 'Assemblages of Lolly Well Springs wetland complex (P3) contain numerous low organic mound springs with moats. *Melaleuca cajuputi* and/or *Timonius timon*, and *Eleocharis dulcis* are indicative of these types of wetlands'. The latter statement is uncited, but would appear to be a direct quote from Kenneally *et al*. (1996). Based on the discussion in the report (Ecologia 2014), another similarity claimed is that the area constitutes an ephemeral pool or spring which is not associated with the main drainage channel which occurs in the associated vegetation community.

During the June 2016 field survey, Mattiske revisited the area claimed to potentially constitute a PEC. The area at the time of the June 2016 survey was dry (Plates 5 & 6). The vegetation consisted of *Melaleuca viridiflora* and *Eucalyptus tectifica* low, open woodland, over *Chrysopogon pallidus* sparse tussock grassland and *Cyperus conicus* sparse sedgeland, as originally stated by Ecologia (2014). This area is not connected to the nearby main drainage channel (community W1), but statistically groups

with the W1 vegetation community described in this report. There was no evidence of a low organic mound spring. Given that Ecologia (2014) state that *Melaleuca cajuputi* and/or *Timonius timon*, and *Eleocharis dulcis* are indicative of these types of wetlands (low organic mound springs), and that none of these species was recorded during the 2014 survey by Ecologia, any claim that this portion of the Thunderbird Project Area may constitute a potential PEC is not scientifically valid, especially given the lack of statistical analysis with the Lolly Well Springs PEC. A review of the topography of the area demonstrates that the *Melaleuca viridiflora* community area is low lying relative to the surrounding land. Irrespective of whether or not this isolated *Melaleuca viridifloral Eucalyptus tectifical Cyperus conicus* community was connected to the main drainage channel nearby at some time in the past, it is nothing more than a low lying section of land which acts as a drainage area during periods of rainfall, thus maintaining conditions which continue to provide suitable habitat for the species present.

8. CONCLUSIONS

Overall, the vegetation communities mapped and species recorded in the Thunderbird Project Area are consistent with the historical mapping of Beard (1976, 1990) and more recent land systems mapping of Schoknecht and Payne (2010). The majority of the Thunderbird Project Area comprised red sandy flats supporting pindan vegetation. The priority taxon *Triodia caelestialis* (P3) was recorded widely across the survey area. A second priority taxon, *Pterocaulon intermedium* (P3), was recorded infrequently, and was not associated with any specific vegetation community delineated. Both taxa are expected to be recorded external to the Thunderbird Project Area boundary, and hence impacts within the project area are considered to be low.

With respect to the vegetation communities defined, the W6 and W8 communities comprised approximately 86% of the survey area. Indicative impact areas show that impacts associated with planned mining operations may impact these two communities. These communities are essentially the common pindan vegetation of the region, and hence impacts are considered to be low.

An area within the Thunderbird Project Area, which statistically groups with community W1, a drainage channel community consisting of *Melaleuca viridifloral Melaleuca alsophila*, was claimed by Ecologia (2014) to have some resemblance to the Lolly Wells Spring PEC. This claim was not supported by any statistical analysis or reasonable argument. A review by Mattiske indicates that the claimed area is simply an internal drainage area set in a low lying area amongst low slopes.

Plate 5: Photograph of *Melaleuca alsophila* or *Melaleuca viridiflora* and *Eucalyptus tectifica* low, open woodland, over *Chrysopogon pallidus* sparse tussock grassland and *Cyperus conicus* sparse sedgeland, facing south-east from quadrat north-west corner.

Plate 6: Photograph of *Melaleuca alsophila* or *Melaleuca viridiflora* and *Eucalyptus tectifica* low, open woodland, over *Chrysopogon pallidus* sparse tussock grassland and *Cyperus conicus* sparse sedgeland, facing north-west from quadrat north-west corner.

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10. LIST OF PERSONNEL

The following Mattiske Consulting Pty Ltd personnel were involved in this project:

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Mr B. Ellery	Botanist / Taxonomist	plant identification	N/A
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11. REFERENCES

Alpin, T.E.H. (1979)
The Flora. In Environment and Science. Editor B.J. O'Brien, University of Western Australia Press, Perth, Western Australia.

Beard J.S. (1979)
Vegetation Survey of Western Australia - Kimberley. 1:1,000,000 Vegetation Series. University of Western Australia Press, Nedlands, Western Australia.

Beard, J.S. (1990)
Plant Life of Western Australia. Kangaroo Press, Kenthurst NSW.

Biosecurity and Agriculture Management Act 2007

Biosecurity and Agriculture Management Regulations 2013

Bureau of Meteorology (2016)
Climate averages for specific sites. Accessed 11th July 2015.
<http://www.bom.gov.au/climate/data/>

Chao, A. (2004)
Species richness estimation. In Balakrisnan, N., Read, C.B. and Vidakovic, B, eds., *Encyclopaedia of Statistical Sciences*. Wiley, New York.

Christian, C.S. and Stewart, G.A. (1953)
Summary of general report on survey of Katherine-Darwin Region 1946. Commonwealth Scientific and Industrial Research Organisation, Land Research Series 1.

Clarke, K.R., and Gorley, R.N. (2006)
PRIMER v6: User Manual/Tutorial. PRIMER-E: Plymouth.

Colwell, R.K. (2013)
EstimateS: Statistical estimation of species richness and shared species from samples. Version 9. Persistent URL <purl.oclc.org/estimates>.

Department of Agriculture and Food (2012)
Western Australian Landform and Soil Mapping Data. Available from: Department of Agriculture and Food.

Department of Agriculture and Food (2016)
Western Australian Organism List. Accessed 11th July 2015.
<http://www.biosecurity.wa.gov.au/>

Department of Parks and Wildlife (2007-)
NatureMap, Mapping Western Australia's Biodiversity. Accessed 11th July 2016.
<http://naturemap.dec.wa.gov.au>

Department of Parks and Wildlife (2016a)
Western Australian Flora Statistics. Accessed 11th July 2016.
<http://florabase.dpaw.wa.gov.au/statistics/>

Department of Parks and Wildlife (2016b)
Wildlife Conservation (Threatened Flora Notice 2015) 3rd November 2015. Accessed 11th July 2015.
<http://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/2015_flora_notice.pdf>

Department of Parks and Wildlife (2016c)
Western Australian Flora Conservation taxa. Accessed 11th July 2016.
<http://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/conservation_code_definitions.pdf>

Department of Parks and Wildlife (2016d)
Definitions, Categories and Criteria for Threatened and Priority Ecological Communities. Accessed 11th July 2016.
<http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatened-ecological-communities>

Department of Parks and Wildlife (2016e)
List of Threatened Ecological Communities on the Department of Environment and Conservation's Threatened Ecological Community (TEC) Database endorsed by the Minister for the Environment, 25th June 2015. Accessed 11th July 2016.
<http://www.dpaw.wa.gov.au/images/plants-animals/threatened-species/threatened_ecological_communities_endorsed_by_the_minister_for_the_environment_june_2015.pdf>

Department of Parks and Wildlife (2016f)
Priority Ecological Communities for Western Australia (3rd December 2015). Accessed 11th July 2016.
<http://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/priority_ecological_communities_list_wa.pdf>

Department of Parks and Wildlife (2016g)
Florabase, the Western Australian Flora. Accessed 11th July 2016.
<http://florabase.dpaw.wa.gov.au>

Department of the Environment (2016a)
Environment Protection and Biodiversity Conservation Act 1999 List of Threatened Flora. Accessed 11th July 2016.
<http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=flora>

Department of the Environment (2016b)
Environment Protection Biodiversity Conservation Act 1999 List of Threatened Ecological Communities. Accessed 11th July 2016.
<http://www.environment.gov.au/cgi-bin/sprat/public/publiclookupcommunities.pl>

Department of the Environment (2016c)
Protected Matters Search Tool. Accessed 11th July 2016.
<https://www.environment.gov.au/epbc/protected-matters-search-tool>

Department of the Environment (2016d)
Australia's bioregions (IBRA). Accessed 11th July 2016.
<http://www.environment.gov.au/topics/land/national-reserve-system/science-maps-and-data/australias-bioregions-ibra>

Department of the Environment (2016e)
Collaborative Australian Protected Areas Database 2014. Accessed 14th July 2016.
<http://www.environment.gov.au/land/nrs/science/capad/2014>

Department of the Environment (2014f)
Weeds of National Significance. Accessed 14th July 2016.
<http://www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/wons.html>

Ecologia Environment (2012)
Sheffield Resources Ltd Thunderbird Dampier Peninsula Project Level 1 Flora and Fauna Assessment. Unpublished report prepared for Sheffield Resources Ltd. November 2012.

Ecologia Environment (2014)
Sheffield Resources Ltd Thunderbird Project Level 2 Flora and Vegetation Assessment. Unpublished report prepared for Sheffield Resources Ltd. March 2014

Ecologia Environment (2015)
Sheffield Resources Pty Ltd Thunderbird Haul Road and Accommodation Camp Flora and Fauna Assessment. Unpublished report prepared for Sheffield Resources Ltd. July 2015.

Environmental Protection Authority (2002)
Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3. Environmental Protection Authority, Perth, 2002.

Environmental Protection Authority (2004)
Guidance for the Assessment of Environmental Factors. Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. Environmental Protection Authority, Perth, 2004.

Environmental Protection Authority and Department of Parks and Wildlife (2015)
Technical Guide – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment. (eds. K Freeman, G Stack, S Thomas and N Woolfrey). Perth, Western Australia.

Environmental Protection Act 1986

Environment Protection and Biodiversity Conservation Act 1999

Environmental Protection (Clearing of Native Vegetation) Regulations 2004

Executive Steering Committee for Australian Vegetation Information (ESCAVI) (2003)
Australian Vegetation Attribute Manual: National Vegetation Information System, Version 6.0. Department of the Environment and Heritage, Canberra

Graham, G. (2001)
Dampierland 2 (DL2- Pindanland subregion). In *A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002.* Western Australian Government Department of Environment and Conservation, Perth, Western Australia.

Government of Western Australia (2015)
2015 Statewide vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of June 2015. WA Department of Parks and Wildlife, Perth.

Hopkins, A.J.M., Beeston, G.R. & Shepherd, D.P. (2001)
A database on the vegetation of Western Australia, stage 1, Technical Report No 251 (in press). Department of Agriculture.

Hussey, B.M.J., Keighery, G.J., Dodd, J., Lloyd S.G. and Cousens, R.D. (2007)
Western Weeds: a guide to the weeds of Western Australia (Second Edition). The Weeds Society of Western Australia, Perth.

Kenneally, K.F., Choules Edinger, D. and Willing, T. (1996)
Broome and Beyond. Plants and people of the Dampier Peninsula, Kimberley, Western Australia. Department of Conservations and Land Management.

Landgate (2016)
Firewatch. Accessed 28th July 2016.
<http://firewatch-pro.landgate.wa.gov.au/home.php#>

Mott, J.J. (1972)
Germination studies on some annual species from an arid region of Western Australia. Journal of Ecology 60, 293-304.

Mott, J.J. (1973)
Temporal and spatial distribution of an annual flora in an arid region of Western Australia. Tropical Grasslands 7, 89-97.

Myers, N., Mittermeier R. A., Mittermeier, C. G., da Fonseca, G. A. B., and Kent, J. (2000)
Biodiversity hotspots for conservation priorities. Nature 403, 853-858.

Schoknecht, N. and Payne, A.L. (2010)
Land systems of the Kimberley region, Western Australia. Department of Agriculture and Food, Western Australia. Technical Bulletin 98, 250p.

Shepherd, D.P., Beeston, G.R., Hopkins, A.J.M. (2001)
Native Vegetation in Western Australia, Technical Report 249. Department of Agriculture, Western Australia, South Perth.

Specht, R.L. (1970)
Vegetation. In Leeper, G.W. ed., *The Australian Environment*. 4th ed. Melbourne.

Thackway, R. and Cresswell, I. D. (1995)
An interim biogeographic regionalisation for Australia: a framework for establishing the national system of reserves. Australian Nature Conservation Agency, Canberra, Australian Capital Territory.

Tille, P. (2006)
Soil-landscapes of Western Australia's Rangelands and Arid Interior, Resource Management Technical Report 313. Department of Agriculture, Western Australia.

Trudgen, M.E. (1991)
Vegetation Condition Scale. In: Burke, G. (ed.) *Invasive weeds and regenerating ecosystems in Western Australia*. Proceedings of the conference held at Murdoch University.

Wildlife Conservation Act 1950

APPENDIX A1: STATE DEFINITION OF THREATENED AND PRIORITY FLORA SPECIES

Note: Adapted from DPaW (2016c).

Category	Definition
T – Threatened	Taxa that have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such (Schedules 1 to 4 of the *Wildlife Conservation (Rare Flora) Notice* under the WC Act). Threatened flora are further ranked by the DPaW to align with IUCN Red List categories and criteria: • CR: Critically Endangered – considered to be facing an extremely high risk of extinction in the wild (Schedule 1); • EN: Endangered – considered to be facing a very high risk of extinction in the wild (Schedule 2); or • VU: Vulnerable – considered to be facing a high risk of extinction in the wild (Schedule 3). • EX: Presumed Extinct – taxa that have been adequately searched for and there is no reasonable doubt that the last individual has died (Schedule 4)
P1 – Priority 1 (Poorly known taxa)	Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.
P2 – Priority 2 (Poorly known taxa)	Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.
P3 – Priority 3 (Poorly known taxa)	Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.
P4 – Priority 4 (Rare, Near Threatened and other taxa in need of monitoring)	1. Rare - Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands. 2. Near Threatened - Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. 3. Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

APPENDIX A2: DEFINITION OF THREATENED FLORA SPECIES (*Environment Protection and Biodiversity Conservation Act 1999*)

Category Code	Category
Ex	Extinct Taxa which at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
ExW	Extinct in the Wild Taxa which is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
CE	Critically Endangered Taxa which at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	Endangered Taxa which is not critically endangered and it is facing a very high risk of extinction in the wild in the immediate or near future, as determined in accordance with the prescribed criteria.
V	Vulnerable Taxa which is not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	Conservation Dependent Taxa which at a particular time if, at that time, the species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

APPENDIX A3: DEFINITION OF THREATENED ECOLOGICAL COMMUNITIES (DPaW 2016d)

Category Code	Category
PTD	Presumed Totally Destroyed An ecological community will be listed as Presumed Totally Destroyed if there are no recent records of the community being extant and either of the following applies: (i) records within the last 50 years have not been confirmed despite thorough searches or known likely habitats or; (ii) all occurrences recorded within the last 50 years have since been destroyed.
CE	Critically Endangered An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future, meeting any one of the following criteria: (i) The estimated geographic range and distribution has been reduced by at least 90% and is either continuing to decline with total destruction imminent, or is unlikely to be substantially rehabilitated in the immediate future due to modification; (ii) The current distribution is limited ie. highly restricted, having very few small or isolated occurrences, or covering a small area; (iii) The ecological community is highly modified with potential of being rehabilitated in the immediate future.
E	Endangered An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. The ecological community must meet any one of the following criteria: (i) The estimated geographic range and distribution has been reduced by at least 70% and is either continuing to decline with total destruction imminent in the short term future, or is unlikely to be substantially rehabilitated in the short term future due to modification; (ii) The current distribution is limited ie. highly restricted, having very few small or isolated occurrences, or covering a small area; (iii) The ecological community is highly modified with potential of being rehabilitated in the short term future.
V	Vulnerable An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing high risk of total destruction in the medium to long term future. The ecological community must meet any one of the following criteria: (i) The ecological community exists largely as modified occurrences that are likely to be able to be substantially restored or rehabilitated; (ii) The ecological community may already be modified and would be vulnerable to threatening process, and restricted in range or distribution; (iii) The ecological community may be widespread but has potential to move to a higher threat category due to existing or impending threatening processes.

APPENDIX A4: DEFINITION OF THREATENED ECOLOGICAL COMMUNITIES (Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*)

Three categories exist for listing threatened ecological communities under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

Listing Category	Explanation of Category
Critically endangered	If, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future.
Endangered	If, at that time, it is not critically endangered and is facing a very high risk of extinction in the wild in the near future.
Vulnerable	If, at that time, it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future.

APPENDIX A5: DEFINITION OF PRIORITY ECOLOGICAL COMMUNITIES (DPaW 2016d)

Category Code	Category
P1	Poorly-known ecological communities Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist.
P2	Poorly-known ecological communities Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, un-allocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation.
P3	Poorly known ecological communities (i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (iii) Communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing and inappropriate fire regimes.
P4	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.
P5	Conservation Dependent ecological communities Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

APPENDIX A6: CATEGORIES AND CONTROL OF DECLARED (PLANT) PESTS IN WESTERN AUSTRALIA (DAFWA 2016, *Biosecurity and Agriculture Management Regulations 2013*)

Control Category	Control Measures
C1 (Exclusion) '(a) Category 1 (C1) — Exclusion: if in the opinion of the Minister introduction of the declared pest into an area or part of an area for which it is declared should be prevented' Pests will be assigned to this category if they are not established in Western Australia and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.	In relation to a category 1 declared pest, the owner or occupier of land in an area for which an organism is a declared pest or a person who is conducting an activity on the land must take such of the control measures specified in subregulation (1) as are reasonable and necessary to destroy, prevent or eradicate the declared pest.
C2 (Eradication) '(b) Category 2 (C2) — Eradication: if in the opinion of the Minister eradication of the declared pest from an area or part of an area for which it is declared is feasible' Pests will be assigned to this category if they are present in Western Australia in low enough numbers or in sufficiently limited areas that their eradication is still a possibility.	In relation to a category 2 declared pest, the owner or occupier of land in an area for which an organism is a declared pest or a person who is conducting an activity on the land must take such of the control measures specified in subregulation (1) as are reasonable and necessary to destroy, prevent or eradicate the declared pest.
C3 (Management) '(c) Category 3 (C3) — Management: if in the opinion of the Minister eradication of the declared pest from an area or part of an area for which it is declared is not feasible but that it is necessary to — (i) alleviate the harmful impact of the declared pest in the area; or (ii) reduce the number or distribution of the declared pest in the area; or (iii) prevent or contain the spread of the declared pest in the area.' Pests will be assigned to this category if they are established in Western Australia but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.	In relation to a category 3 declared pest, the owner or occupier of land in an area for which an organism is a declared pest or a person who is conducting an activity on the land must take such of the control measures specified in subregulation (1) as are reasonable and necessary to — (a) alleviate the harmful impact of the declared pest in the area for which it is declared; or (b) reduce the number or distribution of the declared pest in the area for which it is declared; or (c) prevent or contain the spread of the declared pest in the area for which it is declared.

APPENDIX A7: DEFINITION OF VEGETATION CONDITION SCALE (adapted from Trudgen 1988)

Condition Rating	Description
Excellent (1)	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
Very Good (2)	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
Good (3)	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
Poor (4)	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.
Very Poor (5)	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species present including very aggressive species.
Completely Degraded (6)	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

APPENDIX B: COORDINATES DELINEATING THE BOUNDARY OF THE THUNDERBIRD PROJECT AREA

Waypoint	Location (MGA94, Zone 51)	
	Easting (mE)	Northing (mN)
1	490146	8071242
2	490646	8070822
3	497979	8064671
4	498696	8064070
5	498779	8064000
6	504580	8063995
7	505172	8062694
8	505989	8060605
9	505989	8060604
10	506266	8059586
11	506273	8059567
12	506277	8059552
13	506277	8059551
14	506287	8059526
15	506305	8059486
16	506306	8059486
17	506334	8059439
18	506334	8059438
19	506343	8059425
20	506343	8059425
21	506349	8059417
22	506365	8059396
23	507534	8057989
24	507535	8057989
25	507535	8057989
26	509344	8055814
27	509345	8055813
28	509345	8055813
29	511248	8053532
30	511250	8053530
31	511638	8053059
32	511607	8051069
33	511607	8051068
34	511577	8048848
35	511577	8048846
36	511612	8046563
37	511798	8046658
38	513324	8047427
39	513770	8047648
40	512585	8048835
41	512585	8048837
42	512614	8051053
43	512614	8051055
44	512627	8051872
45	513619	8050685

Waypoint	Location (MGA94, Zone 51)	
	Easting (mE)	Northing (mN)
46	514306	8049846
47	514385	8049677
48	514392	8049664
49	514403	8049644
50	514403	8049643
51	514422	8049612
52	514445	8049580
53	514446	8049579
54	514485	8049536
55	514497	8049523
56	514498	8049523
57	514546	8049485
58	514557	8049475
59	514558	8049475
60	514561	8049473
61	514561	8049473
62	514591	8049454
63	514739	8049370
64	514756	8049361
65	514770	8049353
66	514771	8049353
67	514796	8049342
68	514800	8049340
69	514800	8049340
70	514801	8049339
71	514815	8049324
72	514815	8049324
73	514816	8049323
74	515587	8048555
75	515638	8048581
76	516441	8048988
77	516552	8049039
78	515564	8050001
79	515516	8050074
80	515514	8050077
81	515494	8050104
82	515494	8050105
83	515452	8050153
84	515451	8050153
85	515445	8050160
86	515444	8050160
87	515421	8050179
88	515387	8050207
89	515387	8050208
90	515375	8050215

APPENDIX B: COORDINATES DELINEATING THE BOUNDARY OF THE THUNDERBIRD PROJECT AREA

Waypoint	Location (MGA94, Zone 51)	
	Easting (mE)	Northing (mN)
91	515375	8050216
92	515323	8050246
93	515323	8050246
94	515288	8050262
95	515255	8050275
96	515254	8050275
97	515213	8050286
98	515191	8050331
99	515188	8050337
100	515182	8050350
101	515182	8050350
102	515154	8050397
103	515154	8050397
104	515150	8050403
105	515150	8050404
106	515146	8050408
107	515125	8050436
108	514398	8051325
109	514396	8051327
110	514394	8051329
111	512532	8053559

Waypoint	Location (MGA94, Zone 51)	
	Easting (mE)	Northing (mN)
112	512026	8054173
113	512025	8054174
114	512024	8054176
115	510119	8056458
116	510119	8056459
117	508310	8058633
118	508310	8058633
119	507210	8059957
120	506961	8060870
121	506961	8060870
122	506961	8060870
123	506363	8063056
124	506176	8063742
125	506175	8063744
126	506175	8063747
127	506145	8063993
128	509381	8063991
129	509333	8064061
130	500371	8077144
131	490147	8077155
132	490146	8071242

APPENDIX C: VASCULAR PLANTS SPECIES RECORDED FROM THE DESKTOP SURVEY AND FROM SURVEYS WITHIN THE THUNDERBIRD PROJECT AREA BETWEEN 2012 AND 2016

Notes: NM denotes species recorded from desktop assessement (DPaW 2007-); L1 (Ecologia 2012); L2 (Ecologia 2014); HR (Ecologia 2015); Mattiske (present survey); * denotes introduced species; P1 - P5 denotes priority taxon (DPaW 2016g)

Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
PTERIDACEAE	*Cheilanthes brownii*	x		x	x	
	Cheilanthes caudata	x				
	Cheilanthes ?nudiuscula			x		
MARSILEACEAE	*Marsilea* sp.	x				
ALISMATACEAE	*Caldesia oligococca*	x				
HYDROCHARITACEAE	*Vallisneria annua*	x				
POACEAE	*Aristida contorta*					x
	Aristida holathera			x		
	Aristida holathera var. *holathera*	x	x	x	x	x
	Aristida holathera var. *latifolia*		x	x		x
	Aristida hygrometrica	x	x	x	x	x
	Aristida inaequiglumis		x		x	x
	Aristida aff. nitidula				x	
	Aristida sp.				x	x
	Bothriochloa bladhii	x				
	Bothriochloa sp.				x	
	* *Cenchrus ciliaris*					x
	Cenchrus elymoides		x	x		
	Cenchrus elymoides var. *elymoides*			x		
	Chloris lobata			x	x	
	Chrysopogon fallax				x	x
	Chrysopogon pallidus			x	x	x
	Chrysopogon sp.		x			x
	Cymbopogon ambiguus					x
	Cymbopogon bombycinus					x
	Cymbopogon procerus	x	x	x		x
	* *Cynodon dactylon*	x	x			
	Dactyloctenium radulans			x		x
	Digitaria bicornis		x			
	Digitaria brownii			x	x	x
	Ectrosia danesii	x				
	Ectrosia schultzii		x			x

APPENDIX C: VASCULAR PLANTS SPECIES RECORDED FROM THE DESKTOP SURVEY AND FROM SURVEYS WITHIN THE THUNDERBIRD PROJECT AREA BETWEEN 2012 AND 2016

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
POACEAE	*Ectrosia schultzii* var. *schultzii*			x	x	
(continued)	*Eragrostis cumingii*		x	x	x	x
	Eragrostis eriopoda	x	x	x	x	x
	Eragrostis exigua	x		x		
	* *Eragrostis minor*	x				
	Eragrostis speciosa	x				
	Eragrostis tenellula					x
	Eragrostis sp.		x		x	x
	Eriachne ciliata		x	x	x	x
	Eriachne melicacea		x	x	x	x
	Eriachne obtusa		x	x	x	x
	Eriachne pulchella subsp. *dominii*	x				
	Eriachne sp. Dampier Peninsula (K. F. Kenneally 5946)		x	x	x	x
	Eriachne sulcata		x	x		x
	Eriachne sp.					x
	Eulalia aurea					x
	Heteropogon contortus		x	x	x	x
	Iseilema ?fragile					x
	Mnesithea formosa			x		
	Panicum decompositum					x
	Paspalidium rarum		x	x		
	Perotis rara			x		
	Sacciolepis indica		x			
	Schizachyrium fragile			x	x	
	Sehima nervosum			x		x
	Setaria apiculata		x	x		
	Setaria surgens			x	x	x
	Sorghum plumosum		x	x	x	x
	Sorghum timorense			x	x	x
	Sporobolus actinocladus					x
	Sporobolus australasicus		x		x	
	Thaumastochloa major			x		
	Thaumastochloa pubescens			x		
	Triodia ?bynoei					x
	Triodia ?intermedia					x
	Triodia caelestialis (P3)		x	x	x	x

APPENDIX C: VASCULAR PLANTS SPECIES RECORDED FROM THE DESKTOP SURVEY AND FROM SURVEYS WITHIN THE THUNDERBIRD PROJECT AREA BETWEEN 2012 AND 2016

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
POACEAE	*Triodia schinzii*			x	x	x
(continued)	*Triodia* "schinzii group"					x
	Triodia sp.			x		x
	Urochloa piligera					x
	Urochloa praetervisa				x	
	Xerochloa barbata	x				x
	Xerochloa imberbis				x	
	Xerochloa laniflora			x		x
	Yakirra australiensis			x		x
	Yakirra australiensis var. *australiensis*			x	x	
	Yakirra australiensis var. *intermedia*		x	x	x	
	Yakirra pauciflora			x	x	
	Poaceae sp.					x
CYPERACEAE	*Abildgaardia schoenoides*			x	x	x
	Bulbostylis barbata		x	x	x	
	Crosslandia setifolia			x		
	Cyperus carinatus					x
	Cyperus concinnus	x				
	Cyperus conicus	x	x	x	x	x
	Cyperus latzii			x		
	Cyperus microcephalus		x			
	Cyperus ?microcephalus					x
	Cyperus microcephalus subsp. *microcephalus*			x	x	x
	Cyperus nervulosus			x		x
	Cyperus pulchellus			x		
	Cyperus tenuispica			x		x
	Cyperus sp.			x		
	Cyperus sp. A					x
	Cyperus sp. B					x
	Eleocharis geniculata		x			
	Fimbristylis ammobia			x	x	
	Fimbristylis caespitosa			x	x	
	Fimbristylis dichotoma		x			x
	Fimbristylis littoralis	x		x		x
	Fimbristylis macrantha			x		

APPENDIX C: VASCULAR PLANTS SPECIES RECORDED FROM THE DESKTOP SURVEY AND FROM SURVEYS WITHIN THE THUNDERBIRD PROJECT AREA BETWEEN 2012 AND 2016

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
CYPERACEAE	*Fimbristylis microcarya*			x		
(continued)	*Fimbristylis neilsonii*			x	x	
	Fimbristylis nuda			x		
	Fimbristylis oxystachya				x	x
	Fimbristylis punctata	x		x		
	Fimbristylis rara			x		
	Fimbristylis schultzii				x	
	Fimbristylis simulans		x	x		
	Fimbristylis tetragona			x		x
	Fimbristylis trigastrocarya			x		
	Fimbristylis sp.	x			x	
	Fuirena ciliaris		x	x		
	Fuirena incrassata (P3)			x		
	Fuirena nudiflora (P1)			x		
	Lipocarpha microcephala	x	x			
	Rhynchospora affinis	x				
	Scleria brownii		x	x		
	Cyperaceae sp.		x			x
RESTIONACEAE	*Leptocarpus crassipes* (P3)	x				
XYRIDACEAE	*Xyris complanata*		x	x		x
ERIOCAULACEAE	*Eriocaulon cinereum*	x				
	Eriocaulon sp. G Kimberley Flora (K.F. Kenneally 11374E	x				
COMMELINACEAE	*Murdannia graminea*			x		
ASPARAGACEAE	*Thysanotus chinensis*		x	x		
HEMEROCALLIDACEAE	*Corynotheca micrantha*					x
MORACEAE	*Ficus aculeata*					x
	Ficus aculeata var. *indecora*		x		x	
	Ficus platypoda		x	x		x

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
PROTEACEAE	*Grevillea pyramidalis*			x		
	Grevillea pyramidalis subsp. *pyramidalis*	x	x	x	x	x
	Grevillea refracta subsp. *refracta*	x	x	x	x	x
	Grevillea striata	x		x	x	x
	Grevillea sp.					x
	Hakea arborescens	x	x	x	x	x
	Hakea macrocarpa			x	x	x
	Hakea sp.					x
	Persoonia falcata		x	x	x	x
	Proteaceae sp.					x
SANTALACEAE	*Santalum lanceolatum*		x	x		x
OPILIACEAE	*Opilia amentacea*			x		
LORANTHACEAE	*Amyema sanguinea* var. *sanguinea*	x			x	
	Amyema sp.					x
	Dendrophthoe acacioides subsp. *acacioides*	x				
	Lysiana spathulata subsp. *spathulata*	x				
AMARANTHACEAE	*Achyranthes aspera*			x		
	Alternanthera angustifolia					x
	Gomphrena affinis					x
	Gomphrena brachystylis subsp. *pindanensis*	x				x
	Gomphrena canescens			x		
	Gomphrena canescens subsp. *canescens*	x	x	x	x	x
	Gomphrena flaccida	x	x	x	x	x
	Gomphrena lanata			x		
	Gomphrena leptoclada				x	
	Gomphrena leptoclada subsp. *leptoclada*			x		
	Gomphrena tenella	x				
	Gomphrena sp.					x
	Ptilotus corymbosus	x	x	x	x	x
	Ptilotus fusiformis			x		x
	Ptilotus lanatus			x		x
	Ptilotus murrayi	x				

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
AMARANTHACEAE	*Ptilotus nobilis* subsp. *nobilis*	x				x
(continued)	*Ptilotus polystachyus*	x		x	x	x
	Ptilotus sp.		x			x
NYCTAGINACEAE	*Boerhavia gardneri*			x		
GYROSTEMONACEAE	*Codonocarpus cotinifolius*		x			
AIZOACEAE	*Trianthema oxycalyptrum* var. *oxycalyptrum*	x		x		
	Trianthema pilosum		x	x	x	x
PORTULACACEAE	*Calandrinia quadrivalvis*	x			x	x
	Calandrinia strophiolata	x	x	x	x	x
	Calandrinia translucens				x	
	Calandrinia sp.	x				
	Portulaca bicolor			x		
	Portulaca aff. filifolia			x		
	* *Portulaca pilosa*					x
CARYOPHYLLACEAE	*Polycarpaea corymbosa*		x	x	x	
	Polycarpaea holtzei	x				
	Polycarpaea longiflora		x	x	x	x
	Polycarpaea spirostylis	x				
MENISPERMACEAE	*Tinospora smilacina*	x	x	x	x	x
LAURACEAE	*Cassytha capillaris*			x	x	
	Cassytha sp.					x
HERNANDIACEAE	*Gyrocarpus americanus*					x
	Gyrocarpus americanus subsp. *pachyphyllus*					x
CAPPARACEAE	*Capparis lasiantha*					x

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
CLEOMACEAE	*Cleome oxalidea*	x				
	Cleome tetrandra	x				
	Cleome tetrandra var. *tetrandra*	x		x		x
	Cleome viscosa			x	x	x
MORINGACEAE	* *Moringa oleifera*	x				
DROSERACEAE	*Drosera broomensis*	x		x		
	Drosera derbyensis		x	x	x	
	Drosera hartmeyerorum	x				
	Drosera indica	x	x	x		
	Drosera serpens	x				
BYBLIDACEAE	*Byblis filifolia*	x	x	x	x	x
	Byblis rorida	x				
	Byblis sp.	x				
FABACEAE	*Acacia acradenia*	x				
	Acacia adoxa	x				
	Acacia adoxa var. *adoxa*	x				
	Acacia ampliceps	x				
	Acacia bivenosa	x				
	Acacia colei	x				x
	Acacia colei var. *colei*	x	x	x	x	
	Acacia colei var. *ileocarpa*				x	
	Acacia drepanocarpa subsp. *drepanocarpa*				x	
	Acacia drepanocarpa subsp. *latifolia*		x			
	Acacia eriopoda	x		x		
	Acacia hippuroides	x	x	x		x
	Acacia monticola		x	x	x	x
	Acacia neurocarpa	x				
	Acacia platycarpa	x	x	x	x	x
	Acacia plectocarpa subsp. *plectocarpa*					x
	Acacia stigmatophylla	x		x		x
	Acacia stipuligera		x			
	Acacia synchronicia	x		x		

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
FABACEAE	*Acacia tumida*	x		x		x
(continued)	*Acacia tumida* var. *tumida*	x	x	x	x	x
	Acacia victoriae	x				
	Acacia sp.			x		x
	Aeschynomene indica					x
	Alysicarpus muelleri			x		
	Aphyllodium parvifolium (P1)	x				
	Bauhinia cunninghamii	x	x	x	x	x
	Cajanus cinereus			x		
	Cajanus marmoratus			x		x
	Cajanus reticulatus	x				
	Canavalia papuana	x				
	Canavalia rosea	x				
	Chamaecrista mimosoides		x			
	Chamaecrista moorei				x	
	Chamaecrista symonii	x	x	x		x
	Crotalaria brevis	x	x	x		x
	Crotalaria crispata		x	x	x	
	Crotalaria cunninghamii	x				
	Crotalaria ?*medicaginea*					x
	Crotalaria medicaginea var. *neglecta*	x	x	x	x	
	Crotalaria ramosissima	x				x
	Crotalaria sp.				x	x
	Cullen balsamicum					x
	Cullen corallum	x				
	Cullen leucanthum	x				
	Cullen pustulatum				x	
	Cullen sp.					x
	Desmodium brownii	x				x
	Desmodium filiforme		x	x	x	
	Erythrophleum chlorostachys	x	x	x	x	x
	Galactia tenuiflora		x	x	x	x
	Glycine tomentella	x	x	x	x	x
	Indigofera colutea			x		
	Indigofera haplophylla		x	x		x
	Indigofera hirsuta			x		

APPENDIX C: VASCULAR PLANTS SPECIES RECORDED FROM THE DESKTOP SURVEY AND FROM SURVEYS WITHIN THE THUNDERBIRD PROJECT AREA BETWEEN 2012 AND 2016

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
FABACEAE (continued)	*Indigofera linifolia*	x	x	x	x	x
	Indigofera linnaei					x
	Indigofera sp.					x
	Jacksonia aculeata	x				
	Neptunia dimorphantha	x				
	Neptunia sp.					x
	Rhynchosia minima					x
	Senna costata			x	x	x
	Senna notabilis	x				x
	Senna oligoclada		x		x	
	Sesbania erubescens	x				
*	*Stylosanthes hamata*	x	x	x	x	x
*	*Stylosanthes humilis*					x
*	*Stylosanthes scabra*		x		x	x
	Tephrosia brachyodon var. *longifolia*			x		
	Tephrosia crocea			x	x	
	Tephrosia aff. *croccea*					x
	Tephrosia forrestiana		x			
	Tephrosia leptoclada	x	x	x	x	x
	Tephrosia remotiflora		x	x	x	x
	Tephrosia simplicifolia		x	x		
	Tephrosia sp. B Kimberley Flora (C.A. Gardner 7300)					x
	Tephrosia sp. C Kimberley Flora (K.F. Kenneally 5599)				x	
	Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)			x	x	x
	Tephrosia sp. F Kimberley Flora (B.R. Maslin 5139)					x
	Tephrosia valleculata (P3)			x		
	Tephrosia sp.					x
	Uraria lagopodioides			x		x
	Vachellia pachyphloia subsp. *brevipinnula*					x
	Vachellia suberosa	x				
	Vigna lanceolata			x		
	Vigna lanceolata var. *filiformis*		x	x		
	Zornia chaetophora				x	x
	Zornia prostrata		x	x	x	
	Zornia prostrata var. *prostrata*		x	x	x	x

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
ZYGOPHYLLACEAE	*Tribulopis angustifolia*	x		x		x
	Tribulopis pentandra			x		
	Tribulus ranunculiflorus			x		
POLYGALACEAE	*Polygala galeocephala*			x		
	Polygala tepperi		x	x	x	x
EUPHORBIACEAE	*Euphorbia hassallii*			x	x	x
	Euphorbia mitchelliana	x		x		
	Euphorbia myrtoides		x			
	Euphorbia psilosperma			x		
	Euphorbia schultzii			x		
	Euphorbia schultzii var. *comans*			x		
	Euphorbia trigonosperma			x	x	x
	Euphorbia ?*vaccaria*					x
	Euphorbia vicina			x		
	Euphorbia sp.		x			x
	Microstachys chamaelea		x	x	x	x
PHYLLANTHACEAE	*Breynia cernua*			x		x
	Bridelia tomentosa		x			
	Flueggea virosa subsp. *melanthesoides*		x	x		x
	?*Phyllanthus baccatus*					x
	Phyllanthus exilis			x		
	Phyllanthus maderaspatensis			x		
	Phyllanthus rhytidospermus			x	x	x
	Phyllanthus virgatus		x	x		
	Phyllanthus sp.					x
CELASTRACEAE	*Denhamia cunninghamii*				x	x
	Stackhousia intermedia	x	x	x		
SAPINDACEAE	*Atalaya hemiglauca*	x	x	x	x	x
	Atalaya variifolia		x	x		x
	Atalaya sp.					x
	Dodonaea barklyana	x				

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
SAPINDACEAE	*Dodonaea hispidula*	x		x		
(continued)	*Dodonaea hispidula* var. *arida*	x	x	x	x	x
RHAMNACEAE	*Ventilago viminalis*		x	x		x
MALVACEAE	*Abutilon hannii*			x		x
	Abutilon otocarpum			x		
	Adansonia gregorii					x
	Brachychiton diversifolius			x		
	Brachychiton diversifolius subsp. *diversifolius*	x	x	x	x	x
	Corchorus aestuans			x		x
	Corchorus ?incanus					x
	Corchorus pumilio					x
	Corchorus sidoides				x	
	Corchorus sidoides subsp. *vermicularis*		x	x		x
	Corchorus tridens			x	x	
	Corchorus sp.					x
	Gossypium australe			x	x	x
	Grewia retusifolia	x				
	Hibiscus apodus	x				
	Hibiscus geranioides	x	x	x		x
	Hibiscus leptocladus					x
	Hibiscus panduriformis (P3)	x				
	Hibiscus sp.			x		x
	* *Malvastrum americanum*				x	
	Melhania oblongifolia		x	x		x
	Melochia corchorifolia		x			
	Seringia nephrosperma	x				
	Sida hackettiana		x	x		
	Sida rohlenae subsp. *occidentalis*			x		x
	Sida spinosa		x			
	Triumfetta albida	x		x	x	x
	Triumfetta breviaculeata		x			
	Triumfetta plumigera	x	x	x		x
	Triumfetta sp.		x			
	Waltheria indica		x	x	x	x

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
MALVACEAE (continued)	Malvaceae sp.					x
ELATINACEAE	*Bergia ammannioides*	x				
VIOLACEAE	*Hybanthus aurantiacus*	x	x	x	x	x
	Hybanthus enneaspermus subsp. *enneaspermus*	x		x		x
	?*Hybanthus* sp.					x
THYMELAEACEAE	*Thecanthes punicea*	x				x
LYTHRACEAE	*Ammannia muelleri*	x				
	Ammannia multiflora	x				
	Rotala occultiflora		x			
LECYTHIDACEAE	*Planchonia careya*					x
COMBRETACEAE	*Terminalia canescens*	x	x	x	x	x
	Terminalia ferdinandiana			x		
	Terminalia volucris	x				x
	Terminalia sp.		x	x		x
MYRTACEAE	*Calytrix exstipulata*		x	x	x	x
	Corymbia confertiflora	x				
	Corymbia dendromerinx	x	x	x		x
	Corymbia flavescens	x		x	x	x
	Corymbia greeniana	x	x	x	x	x
	Corymbia ?polycarpa					x
	Corymbia zygophylla	x	x	x	x	x
	Corymbia sp.	x				x
	Eucalyptus camaldulensis					x
	Eucalyptus tectifica	x	x	x		x
	Eucalyptus sp.					x
	Lophostemon grandiflorus	x				
	Melaleuca alsophila	x		x	x	x
	Melaleuca nervosa		x	x		x
	Melaleuca viridiflora		x	x		x

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
MYRTACEAE (continued)	*Melaleuca* sp.					x
ONAGRACEAE	*Ludwigia perennis*		x	x		
HALORAGACEAE	*Myriophyllum callitrichoides*	x				
ARALIACEAE	*Trachymene didiscoides*					x
	Trachymene microcephala		x	x		
	Trachymene oleracea subsp. *oleracea*				x	
OLEACEAE	*Jasminum molle*		x	x		
LOGANIACEAE	*Mitrasacme connata*			x		
	Mitrasacme exserta	x		x	x	
	Mitrasacme hispida			x		
	Mitrasacme lutea			x	x	
	Mitrasacme sp.			x		
MENYANTHACEAE	*Liparophyllum violifolium*	x				
	Nymphoides beaglensis (P3)	x				
	Nymphoides indica	x				
APOCYNACEAE	Apocynaceae sp.			x		
	Carissa lanceolata		x	x	x	x
	Cynanchum carnosum					x
	Ichnocarpus frutescens			x		
	Marsdenia angustata			x		
	?*Marsdenia viridiflora*					x
	Marsdenia viridiflora subsp. *tropica*		x	x		
	Wrightia saligna	x	x	x	x	x
CONVOLVULACEAE	*Bonamia linearis*		x	x	x	x
	Bonamia sp.					x
	Evolvulus alsinoides		x	x		x
	Evolvulus alsinoides var. *decumbens*		x	x	x	x
	Evolvulus alsinoides var. *villosicalyx*					x

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
CONVOLVULACEAE	*Evolvulus* sp.					x
(continued)	*Ipomoea coptica*			x	x	x
	Ipomoea muelleri	x				x
	Ipomoea pes-caprae	x				
	Ipomoea sp.					x
	Jacquemontia paniculata			x		
	Operculina brownii	x				
	Polymeria ambigua			x	x	
	Xenostegia tridentata		x	x		x
BORAGINACEAE	*Ehretia saligna*			x		x
	Ehretia saligna var. *saligna*		x	x	x	x
	Heliotropium cunninghamii		x		x	
	Heliotropium dichotomum		x			
	Heliotropium diversifolium	x				x
	Heliotropium foliatum	x		x		
	Heliotropium glabellum			x		x
	Heliotropium leptaleum			x	x	x
	Heliotropium sp. A					x
	Heliotropium sp. B					x
	Heliotropium sp. C					x
	Heliotropium sp.				x	
	Trichodesma zeylanicum	x		x		x
	Trichodesma zeylanicum var. *latisepalum*				x	
	Trichodesma zeylanicum var. *zeylanicum*	x	x	x		
LAMIACEAE	?*Clerodendrum floribundum*					x
	Clerodendrum floribundum var. *ovatum*			x		
	Clerodendrum tomentosum var. *tomentosum*				x	
	Premna acuminata		x	x		
SOLANACEAE	*Solanum beaugleholei*	x				
	Solanum cleistogamum				x	
	Solanum cunninghamii	x	x	x	x	x
	Solanum dioicum	x			x	x

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
SOLANACEAE	*Solanum diversiflorum*	x				
(continued)	*Solanum lucani*	x				x
	Solanum sp. A					x
	Solanum sp. B					x
SCROPHULARIACEAE	*Eremophila bignoniiflora*	x				
	Myoporum montanum	x				
BIGNONIACEAE	*Dolichandrone heterophylla*	x	x	x	x	x
OROBANCHACEAE	*Buchnera asperata*	x	x	x	x	x
	Buchnera linearis		x		x	
	Buchnera ramosissima	x			x	x
	Buchnera urticifolia				x	x
	Striga curviflora	x		x	x	
	Striga squamigera				x	
LENTIBULARIACEAE	*Utricularia gibba*	x				
	Utricularia sp.	x				
ACANTHACEAE	*Dicliptera armata*		x	x	x	x
PHRYMACEAE	*Glossostigma diandrum*	x				
	Glossostigma drummondii	x				
	Mimulus uvedaliae var. *lutea*	x	x			
	Peplidium muelleri	x				
PLANTAGINACEAE	*Bacopa floribunda*		x			
	Stemodia lathraia	x	x	x		x
	Stemodia lythrifolia		x	x		x
	?*Stemodia* sp.					x
LINDERNIACEAE	*Lindernia aplectra*	x				
	Lindernia chrysoplectra	x				
	Lindernia sp.	x				

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
RUBIACEAE	*Dentella asperata*	x				
	Dentella misera	x		x		
	Gardenia pyriformis subsp. *keartlandii*	x	x	x		x
	Oldenlandia galioides		x	x		
	Oldenlandia mitrasacmoides			x		
	Oldenlandia mitrasacmoides subsp. *mitrasacmoides*		x			
	Oldenlandia sp.	x				
	Spermacoce laevigata					x
	Spermacoce occidentalis	x	x	x	x	x
	Spermacoce sp.					x
	Synaptantha scleranthoides			x		
GOODENIACEAE	*Goodenia armitiana*	x		x	x	
	Goodenia bicolor	x				
	Goodenia lamprosperma	x				
	Goodenia scaevolina	x	x	x		x
	Goodenia sepalosa			x		
	Goodenia sepalosa var. *glandulosa* (P3)	x				
	Goodenia sepalosa var. *sepalosa*	x	x	x	x	x
	Goodenia sp. Dampier Peninsula (B.J. Carter 675)	x				
	Goodenia sp.	x				
	Velleia panduriformis	x		x		x
STYLIDIACEAE	*Stylidium adenophorum*	x				
	Stylidium desertorum	x				
	Stylidium leptorrhizum	x				
	Stylidium pindanicum (P3)	x				
ASTERACEAE	*Blumea integrifolia*	x	x			
	Calotis sp.	x				
	Centipeda minima subsp. *macrocephala*	x				
	Centipeda minima subsp. *minima*	x				
	Centipeda nidiformis	x				
	Cyanthillium cinereum					
	* *Flaveria trinervia*	x				
	Pluchea rubelliflora				x	

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Family	Species	Survey				
			Ecologia			Mattiske
		NM	L1	L2	HR	2016
ASTERACEAE	*Pluchea tetranthera*	x				x
(continued)	*Pterocaulon intermedium* (P3)		x	x	x	x
	Pterocaulon paradoxum	x		x	x	x
	Pterocaulon serrulatum			x		
	Pterocaulon serrulatum var. *velutinum*	x	x	x	x	x
	Pterocaulon sphacelatum		x	x	x	
	Pterocaulon tricholobum			x		
	Pterocaulon sp.				x	x
	Sphaeranthus indicus	x				
	Streptoglossa adscendens	x				
	Streptoglossa macrocephala	x				
	Streptoglossa odora	x				
	Streptoglossa ?odora					x
	* *Tridax procumbens*				x	
	Asteraceae sp.		x			x

APPENDIX D: ASSESSMENT OF THREATENED AND PRIORITY FLORA POTENTIALLY PRESENT IN THE THUNDERBIRD PROJECT AREA

Refer to Appendix A for State (SCC) and Federal (FCC; EPBC Act) conservation code definitions. IBRA Distribution: CK – Central Kimberley; CR – Central Ranges; DL – Dampierland; GSD – Great Sandy Desert; NK – North Kimberley; OVP – Ord Victoria Plain; PIL – Pilbara; VB – Victoria Bonaparte.

Taxon / Common Name	Family	SCC	FCC	Description and Habitat	Potential to Occur in Survey Area
Seringia exastia	Malvaceae	T	CE	Habit: erect shrub, to 0.6 m high Flowers: mauve-purple Flowering period: May-August (unconfirmed) Soils: sands IBRA Distribution: DL, GSD Florabase records: 18	Low Current known distribution is to the west and south of the survey area.
Aphyllodium parvifolium	Fabaceae	P1		Habit: trailing shrub to 0.3 m high Flowers: purple-pink Flowering period: April or June Soils: sands; sand hills IBRA Distribution: DL Florabase records: 5	Medium Preferred soil type & terrain likely to be present in survey area. Species has been recorded within 40 km of survey area.
Bonamia oblongifolia	Convolvulaceae	P1		Habit: perennial herb or shrub Flowers: blue Flowering period: February Soils: sandy or gravelly soils IBRA Distribution: DL, GSD Florabase records:	Low Preferred soil type & terrain likely to be present in survey area, but species has been recorded further to the west and south west of the survey area.
Byblis guehoi	Byblidaceae	P1		Habit: glandular herb Flowers: lilac-violet Flowering period: September (unconfirmed) Soils: sandy loam, waterlogged in wet season IBRA Distribution: DL Florabase records: 2	Low Preferred soil type & terrain unlikely likely to be present in survey area. Species has only been recorded near Beagle Bay Mission, more than 40 km from survey area.

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Refer to Appendix A for State (SCC) and Federal (FCC; EPBC Act) conservation code definitions. IBRA Distribution: CK – Central Kimberley; CR – Central Ranges; DL – Dampierland; GSD – Great Sandy Desert; NK – North Kimberley; OVP – Ord Victoria Plain; PIL – Pilbara; VB – Victoria Bonaparte.

Taxon / Common Name	Family	SCC	FCC	Description and Habitat	Potential to Occur in Survey Area
Corymbia paractia	Myrtaceae	P1		Habit: tree, 4-12 m high Flowers: white Flowering period: April to May or October to December Soils: skeletal soils in transition zone between coastal beach dunes and red pindan soils IBRA Distribution: DL Florabase records: 16	Low Preferred soil type & terrain unlikely likely to be present in survey area. Species has been recorded near Broome on the coast, more than 40 km from survey area.
Cullen candidum	Fabaceae	P1		Habit: shrub to 3 m high Flowers: white Flowering period: September to October Soils: clayey sand IBRA Distribution: CK, DL Florabase records: 5	Low Preferred soil type & terrain potentially present in survey area. Nearest recorded specimen is 100 km north of survey area. Species has been recorded more frequently in the central Kimberley area.
Cyperus haspan subsp. *haspan*	Cyperaceae	P1		Habit: sedge Flowers: unknown Flowering period: unknown Soils: peat, wet areas IBRA Distribution: DL Florabase records: 1	Low Preferred soil type & terrain not known in survey area. Only recorded specimen is near Beagle Bay Mission.
Fuirena nudiflora	Cyperaceae	P1		Habit: tufted annual, grass-like sedge, 0.05-0.2 m high Flowers: brown Flowering period: April to May or July Soils: sand; swamps, creek beds IBRA Distribution: CR, VB Florabase records: 2	Low Preferred soil type & terrain known to occur with survey area. Species previously recorded within survey area, but represents a large (>500 km) range extension from its currently known distribution.

APPENDIX D: ASSESSMENT OF THREATENED AND PRIORITY FLORA POTENTIALLY PRESENT IN THE THUNDERBIRD PROJECT AREA

Refer to Appendix A for State (SCC) and Federal (FCC; EPBC Act) conservation code definitions. IBRA Distribution: CK – Central Kimberley; CR – Central Ranges; DL – Dampierland; GSD – Great Sandy Desert; NK – North Kimberley; OVP – Ord Victoria Plain; PIL – Pilbara; VB – Victoria Bonaparte.

Taxon / Common Name	Family	SCC	FCC	Description and Habitat	Potential to Occur in Survey Area
Haemodorum capitatum	Haemodoraceae	P1		Habit: herb (to 0.5 m - unconfirmed) Flowers: red-maroon Flowering period: August, November (unconfirmed) Soils: sand, sandy clay IBRA Distribution: DL Florabase records: 4	Medium Preferred soil type & terrain likely to be present in survey area. Species has been recorded within 50 km of survey area.
Ipomoea tolmerana subsp. *occidentalis*	Convolvulaceae	P1		Habit: herb Flowers: mauve Flowering period: unknown (March) Soils: unknown IBRA Distribution: DL, NK Florabase records: 4	Low Preferred soil type & terrain unknown. Species has been recorded principally near Beagle Bay Mission, more than 40 km from survey area.
Jacquemontia sp. Broome (A.A. Mitchell 3028)	Convolvulaceae	P1		Habit: herb to 0.4 m Flowers: mauve (likely) Flowering period: unknown (April) Soils: pindan sands IBRA Distribution: DL Florabase records: 3	Low Preferred soil type & terrain present in survey area. Species has been recorded principally near Broome, more than 50 km from survey area.
Parsonsia kimberleyensis	Apocynaceae	P1		Habit: climber, to 3 m high Flowers: yellow/green Flowering period: May to June Soils: vine thickets IBRA Distribution: DL Florabase records: 2	Low Preferred habitat not known in survey area. Species associated with coastal vine thickets.

APPENDIX D: ASSESSMENT OF THREATENED AND PRIORITY FLORA POTENTIALLY PRESENT IN THE THUNDERBIRD PROJECT AREA

Refer to Appendix A for State (SCC) and Federal (FCC; EPBC Act) conservation code definitions. IBRA Distribution: CK – Central Kimberley; CR – Central Ranges; DL – Dampierland; GSD – Great Sandy Desert; NK – North Kimberley; OVP – Ord Victoria Plain; PIL – Pilbara; VB – Victoria Bonaparte.

Taxon / Common Name	Family	SCC	FCC	Description and Habitat	Potential to Occur in Survey Area
Polymeria sp. Broome (K.F. Kenneally 9759)	Convolvulaceae	P1		Habit: herb Flowers: unknown Flowering period: unknown Soils: sand, coastal plain IBRA Distribution: DL Florabase records: 3	Low Preferred soil type & terrain not known in survey area. Species has been recorded principally near Broome, more than 50 km from survey area.
Thespidium basiflorum	Asteraceae	P1		Habit: tufted, multi stemmed perennial herb, to 0.2 m high Flowers: green Flowering period: May to August Soils: sandy soils, creeks IBRA Distribution: DL Florabase records: 4	Low Preferred soil type & terrain present in survey area. Species has been recorded principally near Broome and Beagle Bay Settlement, more than 50 km from survey area.
Utricularia stellaris	Lentibulariaceae	P1		Habit: floating aquatic perennial herb Flowers: yellow Flowering period: June to July Soils: swamps, lagoons IBRA Distribution: DL, NK, VB Florabase records: 4	Low Preferred soil type & terrain not known in survey area. Species has a more coastal distribution.
Utricularia tubulata	Lentibulariaceae	P1		Habit: submerged aquatic perennial herb Flowers: purple-blue Flowering period: February to March or June Soils: ephemeral swamps IBRA Distribution: DL, NK, VB Florabase records: 4	Low Preferred soil type & terrain not known in survey area. Species has been recorded more than 50 km from survey area.

APPENDIX D: ASSESSMENT OF THREATENED AND PRIORITY FLORA POTENTIALLY PRESENT IN THE THUNDERBIRD PROJECT AREA

Refer to Appendix A for State (SCC) and Federal (FCC; EPBC Act) conservation code definitions. IBRA Distribution: CK – Central Kimberley; CR – Central Ranges; DL – Dampierland; GSD – Great Sandy Desert; NK – North Kimberley; OVP – Ord Victoria Plain; PIL – Pilbara; VB – Victoria Bonaparte.

Taxon / Common Name	Family	SCC	FCC	Description and Habitat	Potential to Occur in Survey Area
Acacia monticola × *tumida* var. *kulparn*	Fabaceae	P3		Habit: large shrub to 4 m tall Flowers: yellow Flowering period: May to August (unconfirmed) Soils: sand IBRA Distribution: DL Florabase records: 15	Medium Preferred soil type & terrain likely to be present in survey area. Species has been recorded within 50 km of survey area.
Aphyllodium glossocarpum	Fabaceae	P3		Habit: spreading or erect shrub, to 1.2 m high Flowers: pink-purple Flowering period: April to October Soils: sand, Pindan IBRA Distribution: DL Florabase records: 6	Medium Preferred soil type & terrain likely to be present in survey area. Species has been recorded within 50 km of survey area.
Colocasia esculenta var. *aquatilis*	Araceae	P3		Habit: aquatic herb (lily) Flowers: yellow Flowering period: March, April (unconfirmed) Soils: swamps, springs, creeks IBRA Distribution: CK, DL, NK, OVP Florabase records: 20	Low Preferred soil type & terrain may be in survey area. Species has a more north western distribution.
Dendrophthoe odontocalyx	Loranthaceae	P3		Habit: aerial shrub, hemiparasitic on stems Flowers: orange Flowering period: June to August Soils: parasitic on *Melaleuca* spp. IBRA Distribution: DL, NK Florabase records: 4	Medium Preferred host species present in survey area. Species has been recorded within 60 km of survey area.

APPENDIX D: ASSESSMENT OF THREATENED AND PRIORITY FLORA POTENTIALLY PRESENT IN THE THUNDERBIRD PROJECT AREA

Refer to Appendix A for State (SCC) and Federal (FCC; EPBC Act) conservation code definitions. IBRA Distribution: CK – Central Kimberley; CR – Central Ranges; DL – Dampierland; GSD – Great Sandy Desert; NK – North Kimberley; OVP – Ord Victoria Plain; PIL – Pilbara; VB – Victoria Bonaparte.

Taxon / Common Name	Family	SCC	FCC	Description and Habitat	Potential to Occur in Survey Area
Eriochloa fatmensis	Poaceae	P3		Habit: grass to 0.3 m high (unconfirmed) Flowers: unknown Flowering period: unknown Soils: unknown IBRA Distribution: DL, PIL Florabase records: 3	Low Current Kimberley distribution is near Derby area.
Fuirena incrassata	Cyperaceae	P3		Habit: annual, grass-like sedge, 0.1-0.3 m high Flowers: brown Flowering period: May to August Soils: sand, sandy clay; swamps, creek beds, claypans, semi-saline lakes IBRA Distribution: CK, DL, GSD, OVP, PIL Florabase records: 7	High Preferred habitat known to occur with survey area. Species previously recorded within survey area
Goodenia byrnesii	Goodeniaceae	P3		Habit: prostrate to decumbent herb to 0.3 m high Flowers: yellow Flowering period: January to February Soils: sand; creek edges IBRA Distribution: DL, NK, OVP, VB Florabase records: 16	Low Preferred soil type & terrain may be in survey area. Species has been recorded more than 50 km form survey area.
Goodenia sepalosa var. *glandulosa*	Goodeniaceae	P3		Habit: prostrate to sprawling shrub, 0.03-0.3 m high Flowers: yellow Flowering period: January – December (mainly April – July) Soils: red sand or loam IBRA Distribution: DL, NK, VB Florabase records: 8	Medium Preferred soil type & terrain likely to be present in survey area. Species has been recorded within 50 km of survey area.

APPENDIX D: ASSESSMENT OF THREATENED AND PRIORITY FLORA POTENTIALLY PRESENT IN THE THUNDERBIRD PROJECT AREA

Refer to Appendix A for State (SCC) and Federal (FCC; EPBC Act) conservation code definitions. IBRA Distribution: CK – Central Kimberley; CR – Central Ranges; DL – Dampierland; GSD – Great Sandy Desert; NK – North Kimberley; OVP – Ord Victoria Plain; PIL – Pilbara; VB – Victoria Bonaparte.

Taxon / Common Name	Family	SCC	FCC	Description and Habitat	Potential to Occur in Survey Area
Glycine pindanica	Fabaceae	P3		Habit: scrambling perennial herb or climber Flowers: pink, blue-purple Flowering period: February to March or June Soils: Pindan soils IBRA Distribution: DL Florabase records: 16	Medium Preferred soil type & terrain likely to be present in survey area. Species has been recorded within 50 km of survey area.
Hibiscus panduriformis	Malvaceae	P3		Habit: shrub to 2 m high Flowers: yellow Flowering period: unknown Soils: clay, sandy clay (unconfirmed) IBRA Distribution: VB Florabase records: 2	Low Preferred soil type & terrain may be in survey area. Species has been recorded more than 100 km form survey area, to the north west of the survey area.
Lophostemon grandiflorus subsp. *grandiflorus*	Myrtaceae	P3		Habit: tree to 8 m high Flowers: cream-white Flowering period: January to December Soils: damp habitats (swamps, seepages) IBRA Distribution: DL, VB Florabase records: 8	Low Preferred soil type & terrain not known in survey area. Species has been recorded more than 50 km from survey area.
Nicotiana heterantha	Solanaceae	P3		Habit: short lived annual herb to 0.5 high Flowers: white-cream Flowering period: March to June or September Soils: black clay; seasonally wet flats IBRA Distribution: DL, GSD, PIL Florabase records:	Low Preferred soil type & terrain not known in survey area. Species has been recorded more than 100 km to the south west of the survey area.

APPENDIX D: ASSESSMENT OF THREATENED AND PRIORITY FLORA POTENTIALLY PRESENT IN THE THUNDERBIRD PROJECT AREA

Refer to Appendix A for State (SCC) and Federal (FCC; EPBC Act) conservation code definitions. IBRA Distribution: CK – Central Kimberley; CR – Central Ranges; DL – Dampierland; GSD – Great Sandy Desert; NK – North Kimberley; OVP – Ord Victoria Plain; PIL – Pilbara; VB – Victoria Bonaparte.

Taxon / Common Name	Family	SCC	FCC	Description and Habitat	Potential to Occur in Survey Area
Nymphoides beaglensis	Menyanthaceae	P3		Habit: annual aquatic herb Flowers: white, white-pink-purple Flowering period: March - June Soils: edges of permanent waterholes IBRA Distribution: DL, NK Florabase records: 11	Low Preferred soil type & terrain may be in survey area. Species has been recorded more than 50 km form survey area.
Phyllanthus eremicus	Phyllanthaceae	P3		Habit: perennial herb to 1 m high Flowers: pale green Flowering period: June, July (unconfirmed) Soils: red Pindan sands IBRA Distribution: DL, GSD Florabase records: 8	Low Preferred soil type & terrain known in survey area. Species has been recorded more than 50 km to the south west of the survey area.
Pterocaulon intermedium	Asteraceae	P3		Habit: aromatic perennial herb, 0.2-0.6 m high Flowers: pink-violet Flowering period: March – November (likely) Soils: red sand, sandy clay IBRA Distribution: CK, DL, NK, PIL Florabase records: 24	High Preferred habitat known to occur with survey area. Species previously recorded within survey area
Schoenus punctatus	Cyperaceae	P3		Habit: tufted sedge to 0.6 m high Flowers: brown Flowering period: August Soils: watercourses IBRA Distribution: CK, DL, PIL, VB Florabase records: 6	Medium Preferred soil type & terrain likely to be present in survey area. Species has been recorded within 60 km of survey area.

APPENDIX D: ASSESSMENT OF THREATENED AND PRIORITY FLORA POTENTIALLY PRESENT IN THE THUNDERBIRD PROJECT AREA

Refer to Appendix A for State (SCC) and Federal (FCC; EPBC Act) conservation code definitions. IBRA Distribution: CK – Central Kimberley; CR – Central Ranges; DL – Dampierland; GSD – Great Sandy Desert; NK – North Kimberley; OVP – Ord Victoria Plain; PIL – Pilbara; VB – Victoria Bonaparte.

Taxon / Common Name	Family	SCC	FCC	Description and Habitat	Potential to Occur in Survey Area
Seringia katatona	Malvaceae	P3		Habit: shrub, to 1 m high (unconfirmed) Flowers: mauve, purple Flowering period: April to August (unconfirmed) Soils: red sand IBRA Distribution: DL, GSD Florabase records: 21	Medium Preferred soil type & terrain likely to be present in survey area. Species has been recorded within 100 km of survey area.
Stylidium costulatum	Stylidiaceae	P3		Habit: tufted annual herb to 0.2 m tall Flowers: yellow, orange & red Flowering period: April to August Soils: sandy or clayey soils; creeks or seasonally wet areas IBRA Distribution: CK, DL, NK Florabase records: 10	Medium Preferred soil type & terrain likely to be present in survey area. Species has been recorded within 60 km of survey area.
Stylidium pindanicum	Stylidiaceae	P3		Habit: annual herb to 0.25 m tall Flowers: pink Flowering period: May to September (unconfirmed) Soils: sand, clayey soils; creeks, damp areas IBRA Distribution: DL, NK, OVP Florabase records: 16	High Preferred habitat known to occur with survey area. Species previously recorded within 40 km of survey area.
Tephrosia valleculata	Fabaceae	P3		Habit: erect shrub, to 2m high Flowers: orange and green Flowering period: April to September Soils: sandy, often shallow soils around sandstone; rock outcrops IBRA Distribution: DL, NK Florabase records: 9	High Preferred habitat known to occur with survey area. Species previously recorded within survey area

APPENDIX D: ASSESSMENT OF THREATENED AND PRIORITY FLORA POTENTIALLY PRESENT IN THE THUNDERBIRD PROJECT AREA

Refer to Appendix A for State (SCC) and Federal (FCC; EPBC Act) conservation code definitions. IBRA Distribution: CK – Central Kimberley; CR – Central Ranges; DL – Dampierland; GSD – Great Sandy Desert; NK – North Kimberley; OVP – Ord Victoria Plain; PIL – Pilbara; VB – Victoria Bonaparte.

Taxon / Common Name	Family	SCC	FCC	Description and Habitat	Potential to Occur in Survey Area
Terminalia kumpaja	Combretaceae	P3		Habit: tree, to 6 m high Flowers: cream Flowering period: May, October (unconfirmed) Soils: sand, Pindan sand IBRA Distribution: DL, GSD Florabase records: 17	Low Preferred soil type & terrain known in survey area. Species has been recorded more than 50 km to the south west of the survey area.
Triodia acutispicula	Poaceae	P3		Habit: tussock-forming resinous perennial grass to 1.5 m high Flowers: cream-brown Flowering period: January to April Soils: sandy soils; Pindan plains, rocky hillslopes and outcrops IBRA Distribution: DL, NK Florabase records: 18	Medium Preferred soil type & terrain likely to be present in survey area. Species has been recorded within 100 km of survey area.
Triodia caelestialis	Poaceae	P3		Habit: tussock-forming non-resinous, non-caespitose perennial grass, to 0.4 m high Flowers: straw & purple Flowering period: January to March Soils: sands IBRA Distribution: CK, DL, NK Florabase records: 18	Highly likely Preferred habitat known to occur with survey area. Species previously recorded extensively within survey area
Pittosporum moluccanum	Pittosporaceae	P4		Habit: tree to 6 m high Flowers: white Flowering period: February to August Soils: white sand; sand dunes IBRA Distribution: DL, NK Florabase records: 18	Low Preferred soil type & terrain may be in survey area. Species has been recorded more than 50 km form survey area.

APPENDIX E: LOCATIONS OF VEGETATION SURVEY QUADRATS ESTABLISHED BY MATTISKE IN THE THUNDERBIRD PROJECT AREA, JUNE 2016

Quadrat	Location (GDA94, Zone 51)	
	Easting (mE)	Northing (mN)
TB001	491459	8077134
TB002	491087	8077033
TB003	497092	8077031
TB004	494402	8077029
TB005	499814	8076979
TB006	496500	8076972
TB007	497536	8076954
TB008	495007	8076918
TB009	498331	8076669
TB010	500650	8076645
TB011	497174	8076619
TB012	499652	8076597
TB013	493878	8076519
TB014	490482	8076490
TB015	497993	8076226
TB016	490921	8076219
TB017	499923	8076197
TB018	498730	8075842
TB019	499566	8075808
TB020	500480	8075752
TB021	494294	8075712
TB022	497596	8075454
TB023	496400	8075420
TB024	500599	8075405
TB025	500250	8075300
TB026	491250	8074800
TB027	498319	8074128
TB028	490600	8074100
TB029	494343	8074100
TB030	491751	8073892
TB031	500297	8073706
TB032	499959	8073689
TB033	490746	8073301
TB034	492397	8073255
TB035	493956	8073228
TB036	499684	8073106
TB037	502973	8073018
TB038	496823	8072877
TB039	496273	8072681
TB040	495709	8072344
TB041	494344	8072199
TB042	491903	8071849
TB043	491300	8071800

Quadrat	Location (GDA94, Zone 51)	
	Easting (mE)	Northing (mN)
TB044	503951	8071750
TB045	496000	8071428
TB046	490950	8071403
TB047	491751	8071303
TB048	494300	8071300
TB049	497737	8071232
TB050	500241	8070901
TB051	492250	8070824
TB052	504458	8070740
TB053	499183	8070676
TB054	503905	8070626
TB055	500466	8070546
TB056	502860	8070275
TB057	501902	8070222
TB058	504291	8070070
TB059	496133	8069735
TB060	500136	8069658
TB061	501478	8069607
TB062	499800	8069400
TB063	503211	8069390
TB064	505040	8069200
TB065	492955	8069182
TB066	493656	8068849
TB067	493900	8068651
TB068	495002	8068549
TB069	505430	8068468
TB070	503904	8068254
TB071	503310	8068243
TB072	495803	8068203
TB073	500190	8068149
TB074	500030	8067880
TB075	498645	8067832
TB076	503414	8067780
TB077	495340	8067668
TB078	498219	8067535
TB079	504247	8067511
TB080	503542	8067420
TB081	499893	8067199
TB082	497569	8067109
TB083	495291	8067077
TB084	501349	8067066
TB085	507050	8067000
TB086	499200	8066998

APPENDIX E: LOCATIONS OF VEGETATION SURVEY QUADRATS ESTABLISHED BY MATTISKE IN THE THUNDERBIRD PROJECT AREA, JUNE 2016

Quadrat	Location (GDA94, Zone 51)	
	Easting (mE)	Northing (mN)
TB087	504821	8066933
TB088	506516	8066853
TB089	497156	8066800
TB090	504626	8066787
TB091	503478	8066764
TB092	500532	8066633
TB093	496602	8066602
TB094	502618	8066509
TB095	500252	8066446
TB096	504941	8066426
TB097	499202	8066303
TB098	503134	8066177
TB099	504349	8066171
TB100	497156	8066100
TB101	501550	8066100
TB102	504774	8066063
TB103	505804	8065988
TB104	505060	8065728
TB105	504282	8065662
TB106	501710	8065607
TB107	506948	8065596
TB108	506112	8065404
TB109	507996	8065362
TB110	505455	8065333
TB111	505741	8064851
TB112	505222	8064801
TB113	500822	8064800
TB114	506534	8064755
TB115	498450	8064740
TB116	503218	8064713
TB117	499587	8064704
TB118	506340	8064660
TB119	501468	8064631
TB120	504323	8064554
TB121	506779	8064550

Quadrat	Location (GDA94, Zone 51)	
	Easting (mE)	Northing (mN)
TB122	503009	8064490
TB123	500719	8064436
TB124	499626	8064352
TB125	501715	8064284
TB126	504603	8064155
TB127	502842	8064142
TB128	500342	8064136
TB129	506031	8063200
TB130	505951	8063100
TB131	506000	8061900
TB132	506748	8061554
TB133	506152	8061498
TB134	507898	8058832
TB135	508100	8057780
TB136	510122	8055501
TB137	510508	8055113
TB138	513148	8052699
TB139	511789	8052190
TB140	512281	8052180
TB141	513128	8051564
TB142	513606	8050948
TB143	512310	8050630
TB144	514650	8050502
TB145	511851	8050340
TB146	514021	8050337
TB147	514444	8050042
TB148	515453	8049943
TB149	512500	8049500
TB150	515012	8049496
TB151	511756	8049321
TB152	512370	8048600
TB153	512281	8047660
TB154	513196	8047660
TB155	511889	8047411

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

Note - * denotes an introduced species; P1 - P5 denotes prioirty taxon (DPaW 2016g)

Species	Quadrat Reference																														
	TB001	TB002	TB003	TB004	TB005	TB006	TB007	TB008	TB009	TB010	TB011	TB012	TB013	TB014	TB015	TB016	TB017	TB018	TB019	TB020	TB021	TB022	TB023	TB024	TB025	TB026	TB027	TB028	TB029	TB030	TB031	TB032
Abildgaardia schoenoides			x																												
Abutilon hannii																															
Acacia colei										x	x																				
Acacia hippuroides																								x	x						x	
Acacia monticola								x																x								
Acacia platycarpa				x			x				x			x												x		x	x	x		
Acacia plectocarpa subsp. *plectocarpa*					x					x																					x	x
Acacia stigmatophylla																																
Acacia tumida			x			x								x	x	x							x				x				
Acacia tumida var. *tumida*				x																x	x							x	x	x		
Acacia sp.																																
Aeschynomene indica																																
Alternanthera angustifolia																																
Amyema sp.																							x									
Aristida contorta				x					x					x	x	x															x	
Aristida holathera var. *holathera*							x			x				x						x					x				x			
Aristida holathera var. *latifolia*										x																x		x	x			
Aristida hygrometrica														x	x	x											x				x	
Aristida inaequiglumis					x							x					x		x							x			x			
Aristida sp.																																
Asteraceae sp.																							x					x				
Atalaya hemiglauca										x					x					x					x				x			x
Atalaya variifolia																x																
Atalaya sp.			x																													
Bauhinia cunninghamii	x			x	x	x	x		x	x	x	x		x	x		x			x					x	x	x	x	x	x	x	x
Bonamia linearis			x		x																					x						
Bonamia sp.									x																						x	
Brachychiton diversifolius subsp. *diversifolius*						x			x		x			x		x								x		x	x	x	x	x		x
Breynia cernua																																
Buchnera asperata																																
Buchnera ramosissima																																
Buchnera urticifolia								x																								
Byblis filifolia																																
Cajanus marmoratus																																
Calandrinia quadrivalvis																			x													
Calandrinia strophiolata																																
Calytrix exstipulata								x																								
Capparis lasiantha																																
Carissa lanceolata					x				x	x		x					x		x	x		x		x	x							x
Cassytha sp.																																
* *Cenchrus ciliaris*																																
Chamaecrista symonii																																
Chrysopogon fallax						x		x												x			x	x	x			x	x			

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

Note - * denotes an introduced species; P1 - P5 denotes prioirty taxon (DPaW 2016g)

Species	Quadrat Reference																														
	TB001	TB002	TB003	TB004	TB005	TB006	TB007	TB008	TB009	TB010	TB011	TB012	TB013	TB014	TB015	TB016	TB017	TB018	TB019	TB020	TB021	TB022	TB023	TB024	TB025	TB026	TB027	TB028	TB029	TB030	TB031	TB032
Chrysopogon pallidus	x	x					x		x					x		x		x												x	
Chrysopogon sp.				x						x			x																		
Cleome tetrandra var. *tetrandra*																															
Cleome viscosa		x																													
?*Clerodendrum floribundum*																															
Corchorus aestuans																															
Corchorus ?incanus																															
Corchorus pumilio		x	x	x										x	x	x						x	x				x			x	
Corchorus sidoides subsp. *vermicularis*					x												x									x					
Corchorus sp.																															
Corymbia dendromerinx		x				x		x			x		x		x					x			x				x			x	
Corymbia flavescens																															
Corymbia greeniana			x	x	x		x	x						x		x						x				x	x	x	x	x	
Corymbia ?polycarpa																															
Corymbia sp.																														x	
Corymbia zygophylla																					x					x				x	
Crotalaria brevis																															
Crotalaria ?medicaginea																															
Crotalaria ramosissima																												x			
Crotalaria sp.	x						x																								
Cullen balsamicum																															
Cullen sp.																															
Cymbopogon ambiguus																															
Cymbopogon bombycinus																															
Cymbopogon procerus								x																							
Cynanchum carnosum										x																					
Cyperaceae sp.																															
Cyperus carinatus																															
Cyperus conicus	x				x		x					x					x	x	x												
Cyperus ?microcephalus																															
Cyperus microcephalus subsp. *microcephalus*		x																													
Cyperus nervulosus																															
Cyperus tenuispica																															
Cyperus sp. A												x					x														
Cyperus sp. B										x																					
Dactyloctenium radulans																															
Denhamia cunninghamii					x																					x					
Desmodium brownii																		x													
Dicliptera armata						x							x																		
Digitaria brownii																															
Digitaria ctenantha											x							x													
Dodonaea hispidula var. *arida*				x	x									x	x	x						x				x	x		x	x	
Dolichandrone heterophylla				x	x	x			x			x		x	x	x	x		x						x	x	x	x	x	x		x

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

Note - * denotes an introduced species; P1 - P5 denotes prioirty taxon (DPaW 2016g)

Species	Quadrat Reference																														
	TB001	TB002	TB003	TB004	TB005	TB006	TB007	TB008	TB009	TB010	TB011	TB012	TB013	TB014	TB015	TB016	TB017	TB018	TB019	TB020	TB021	TB022	TB023	TB024	TB025	TB026	TB027	TB028	TB029	TB030	TB031	TB032
Ectrosia schultzii	x						x				x							x														
Ehretia saligna																																
Ehretia saligna var. *saligna*										x																			x			
Eragrostis cumingii																			x													
Eragrostis eriopoda			x																													
Eragrostis tenellula																																
Eragrostis sp.																																
Eriachne ciliata																																
Eriachne melicacea														x		x															x	
Eriachne obtusa	x	x	x		x		x		x	x		x		x	x			x		x				x	x	x		x	x	x	x	x
Eriachne sulcata	x						x			x							x	x	x													
Eriachne sp. Dampier Peninsula (K. F. Kenneally 5946)		x				x								x									x				x				
Eriachne sp.																																
Erythrophleum chlorostachys			x	x										x	x	x					x					x		x	x	x		
Eucalyptus camaldulensis																																
Eucalyptus tectifica	x		x		x		x		x	x		x				x	x		x	x		x		x	x	x		x	x	x		x
Eucalyptus sp.		x																														
Eulalia aurea																																
Euphorbia hassallii																																
Euphorbia trigonosperma		x						x																			x					
Euphorbia ?*vaccaria*																																
Euphorbia sp.																																
Evolvulus alsinoides																																
Evolvulus alsinoides var. *decumbens*																											x					
Evolvulus alsinoides var. *villosicalyx*															x	x																
Evolvulus sp.																												x				
Ficus aculeata																																
Ficus platypoda																																
Fimbristylis dichotoma											x																					
Fimbristylis littoralis											x																					
Fimbristylis oxystachya																																
Fimbristylis tetragona																																
Flueggea virosa subsp. *melanthesoides*						x				x						x							x				x	x			
Galactia tenuiflora																																
Gardenia pyriformis subsp. *keartlandii*																												x				
Glycine tomentella		x											x				x					x	x							x		
Gomphrena affinis			x														x									x				x		
Gomphrena brachystylis subsp. *pindanensis*		x						x															x	x								
Gomphrena canescens subsp. *canescens*						x																	x					x	x			
Gomphrena flaccida		x						x						x																		
Gomphrena sp.													x																			
Goodenia scaevolina		x																				x			x		x				x	
Goodenia sepalosa var. *sepalosa*																																

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

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Species	Quadrat Reference																															
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Gossypium australe																								x	x						x	
Grevillea pyramidalis subsp. *pyramidalis*		x		x	x	x							x		x	x				x		x	x	x	x	x	x	x		x	x	x
Grevillea refracta subsp. *refracta*		x		x												x					x						x					
Grevillea striata																																
Grevillea sp.																																
Gyrocarpus americanus																																x
Gyrocarpus americanus subsp. *pachyphyllus*																																
Hakea arborescens						x				x										x				x								
Hakea macrocarpa																										x				x		
Hakea sp.																															x	
Heliotropium diversifolium								x																			x					
Heliotropium glabellum																																
Heliotropium leptaleum																								x	x			x				
Heliotropium sp. A																																
Heliotropium sp. B																																
Heliotropium sp. C																																
Heteropogon contortus	x						x	x		x																						
Hibiscus geranioides																																
Hibiscus leptocladus																																
Hibiscus sp.																	x															
Hybanthus aurantiacus										x												x		x	x					x		
Hybanthus enneaspermus subsp. *enneaspermus*		x				x							x	x		x						x	x				x			x		
?*Hybanthus* sp.																																
Indigofera haplophylla																																
Indigofera linifolia								x																								
Indigofera linnaei																																
Indigofera sp.														x																		
Ipomoea coptica																																
Ipomoea muelleri			x																													
Ipomoea sp.																																
Iseilema ?*fragile*																																
Malvaceae sp.	x	x	x				x											x				x									x	
?*Marsdenia viridiflora*																																x
Melaleuca alsophila								x			x							x														
Melaleuca nervosa																																
Melaleuca viridiflora	x						x	x	x		x	x					x	x	x													
Melaleuca sp.																																
Melhania oblongifolia																																
Microstachys chamaelea			x	x	x									x	x	x					x	x					x	x	x		x	
Neptunia sp.																																
Panicum decompositum																																
Persoonia falcata				x						x															x					x		
?*Phyllanthus baccatus*					x																											

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Phyllanthus rhytidospermus																															
Phyllanthus sp.								x																							
Planchonia careya				x																											
Pluchea ?tetranthera												x																			
Poaceae sp.			x											x																x	x
Polycarpaea longiflora		x											x																		
Polygala tepperi																															
**Portulaca pilosa*																															
Proteaceae sp.									x					x																	
Pterocaulon intermedium (P3)																	x														
Pterocaulon paradoxum																															
Pterocaulon serrulatum var. *velutinum*																															
Pterocaulon sp.															x																
Ptilotus corymbosus		x											x									x									
Ptilotus fusiformis																															
Ptilotus lanatus					x												x														
Ptilotus nobilis subsp. *nobilis*										x																					
Ptilotus polystachyus																						x									
Ptilotus sp.																						x									
Rhynchosia minima																															
Santalum lanceolatum				x																											
Sehima nervosum										x																				x	
Senna costata																						x						x			
Senna notabilis																															
Setaria surgens											x																				
Sida rohlenae subsp. *occidentalis*										x				x		x				x				x	x			x			
Solanum cunninghamii																x						x						x			
Solanum dioicum																															
Solanum lucani																													x		
Solanum sp. A																															
Solanum sp. B																										x					
Sorghum ?plumosum												x																			
Sorghum plumosum			x	x		x			x				x							x	x		x	x				x			x
Sorghum timorense	x				x				x					x	x	x	x		x			x			x		x	x	x	x	
Spermacoce laevigata																															
Spermacoce occidentalis																						x						x			
Spermacoce sp.																															
Sporobolus actinocladus																															
Stemodia lathraia																	x														
Stemodia lythrifolia																															
?*Stemodia* sp.																x															
Streptoglossa ?odora																			x												
**Stylosanthes hamata*								x		x	x																				

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* *Stylosanthes humilis*																															
* *Stylosanthes scabra*																	x	x													
Tephrosia aff. croccea			x											x		x															
Tephrosia leptoclada																															
Tephrosia remotiflora	x							x							x							x									
Tephrosia sp. B Kimberley Flora (C.A. Gardner 7300)																															
Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)																															
Tephrosia sp. F Kimberley Flora (B.R. Maslin 5139)																										x					
Tephrosia sp.		x																x										x			
Terminalia canescens	x	x		x		x	x	x	x	x			x	x	x	x	x		x	x			x		x		x		x	x	x	x
Terminalia volucris										x																					
Terminalia sp.																															
Tinospora smilacina											x																				
Trachymene didiscoides																						x									
Trianthema pilosum												x		x	x														x		
Tribulopis angustifolia																															
Trichodesma zeylanicum																															
Triodia ?bynoei																															
Triodia caelestialis (P3)	x	x	x			x			x				x		x	x						x	x			x	x	x	x	x	x	x
Triodia ?intermedia																															
Triodia schinzii				x	x							x		x					x		x										
Triodia "schinzii group"																				x					x							
Triodia sp.																																
Triumfetta albida		x						x																								
Triumfetta plumigera		x						x																								
Uraria lagopodioides							x										x			x					x							x
Urochloa piligera																																
Vachellia pachyphloia subsp. *brevipinnula*										x							x															
Velleia panduriformis																																
Ventilago viminalis												x	x			x													x			
Waltheria indica	x		x	x	x			x							x			x				x		x				x				
Wrightia saligna		x				x			x					x		x						x	x				x	x	x			
Xenostegia tridentata								x																								
Xerochloa barbata																																
Xerochloa laniflora																																
Xyris complanata	x																															
Yakirra australiensis					x																											
Zornia chaetophora																																
Zornia prostrata var. *prostrata*																																

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Abildgaardia schoenoides					x																				x							
Abutilon hannii																																
Acacia ?*colei*																																
Acacia hippuroides						x	x					x								x		x		x		x						x
Acacia monticola							x					x														x						
Acacia platycarpa		x	x							x	x		x	x	x	x	x		x		x					x			x	x	x	
Acacia plectocarpa subsp. *plectocarpa*			x				x													x		x					x					x
Acacia stigmatophylla				x														x					x									
Acacia ?*tumida*					x												x			x	x	x						x		x		
Acacia tumida var. *tumida*	x	x	x				x	x	x	x	x		x	x	x	x		x	x						x				x		x	x
Acacia sp.						x																		x								
Aeschynomene indica																																
Alternanthera angustifolia																																
Amyema sp.																																
Aristida contorta					x																x									x		x
Aristida holathera var. *holathera*						x					x		x			x	x			x												
Aristida holathera var. *latifolia*		x									x		x	x		x													x			
Aristida hygrometrica																											x					
Aristida ?*inaequiglumis*	x		x				x	x	x	x					x				x											x		
Aristida sp.																											x					
Asteraceae sp.							x				x																					
Atalaya hemiglauca				x		x							x					x					x	x								
Atalaya variifolia																				x	x	x								x		
Atalaya sp.																																
Bauhinia cunninghamii	x	x	x		x	x	x	x	x	x	x		x	x	x	x	x		x	x	x	x		x		x	x		x	x	x	
Bonamia linearis	x				x										x				x												x	x
Bonamia sp.														x																		
Brachychiton diversifolius subsp. *diversifolius*	x	x	x		x	x		x	x	x	x		x	x	x	x	x		x	x	x			x		x	x		x	x	x	x
Breynia cernua																																
Buchnera asperata																																
Buchnera ?*ramosissima*																																
Buchnera urticifolia																																
Byblis filifolia																																
Cajanus marmoratus																											x					
Calandrinia quadrivalvis																											x					
Calandrinia strophiolata																																
Calytrix exstipulata												x											x									
Capparis lasiantha																				x												
Carissa lanceolata	x					x	x					x		x						x		x		x					x			
Cassytha sp.																																
** Cenchrus ciliaris*				x																			x									
Chamaecrista symonii																															x	
Chrysopogon fallax		x				x					x			x		x													x	x		

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Chrysopogon pallidus																	x				x											
Chrysopogon sp.																																
Cleome tetrandra var. *tetrandra*																																
Cleome viscosa																																
?*Clerodendrum floribundum*						x								x		x															
Corchorus aestuans																																
Corchorus ?*incanus*																																
Corchorus pumilio					x								x	x			x			x		x						x		x		
Corchorus sidoides subsp. *vermicularis*	x						x			x		x			x			x	x						x	x						
Corchorus sp.																															x	
Corymbia dendromerinx				x			x	x										x	x	x			x			x		x				
Corymbia flavescens																											x					
Corymbia greeniana		x	x			x	x		x	x	x		x	x	x			x			x							x		x	x	
Corymbia ?*polycarpa*						x																										
Corymbia sp.																				x									x			
Corymbia zygophylla	x		x					x	x	x						x			x						x						x	
Crotalaria brevis																																
Crotalaria ?*medicaginea*																																
Crotalaria ramosissima																																
Crotalaria sp.																																
Cullen balsamicum																																
Cullen sp.																																
Cymbopogon ambiguus						x													x													
Cymbopogon bombycinus																				x												
Cymbopogon procerus				x																			x									
Cynanchum carnosum														x																		
Cyperaceae sp.																																
Cyperus carinatus																																
Cyperus ?*conicus*																																
Cyperus ?*microcephalus*																																
Cyperus microcephalus subsp. *microcephalus*																							x									
Cyperus nervulosus																																
Cyperus tenuispica																											x					
Cyperus sp. A																																
Cyperus sp. B																																
Dactyloctenium radulans		x																														
Denhamia cunninghamii							x																									
Desmodium brownii																															x	
Dicliptera armata																																
Digitaria brownii					x	x														x	x											
Digitaria ctenantha																											x					
Dodonaea hispidula var. *arida*	x	x	x				x	x	x	x	x	x		x	x	x	x	x	x		x					x		x	x	x	x	
Dolichandrone heterophylla		x	x				x			x			x			x	x	x			x	x		x				x		x		

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Ectrosia schultzii																																
?*Ehretia saligna*				x		x						x																				
Ehretia saligna var. *saligna*						x							x			x																
Eragrostis cumingii																											x					
Eragrostis eriopoda					x								x		x				x												x	
Eragrostis tenellula																																
Eragrostis sp.																												x				
Eriachne ciliata					x																											
Eriachne melicacea																																
Eriachne obtusa		x	x		x		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x		x
Eriachne sulcata																																
Eriachne sp. Dampier Peninsula (K. F. Kenneally 5946)				x																			x									
Eriachne sp.																									x							
Erythrophleum chlorostachys	x		x		x		x	x	x	x	x		x	x	x	x	x		x		x				x			x	x	x	x	
Eucalyptus camaldulensis																																
Eucalyptus tectifica		x	x	x		x	x		x	x	x	x		x	x		x		x	x		x	x	x		x	x	x		x		x
Eucalyptus sp.																																
Eulalia aurea																																
Euphorbia hassallii																																
Euphorbia trigonosperma																																
Euphorbia ?*vaccaria*																															x	
Euphorbia sp.																		x												x		
Evolvulus alsinoides																																
Evolvulus alsinoides var. *decumbens*											x										x	x					x			x		
Evolvulus alsinoides var. *villosicalyx*																					x									x	x	
Evolvulus sp.																																
Ficus aculeata																																
Ficus platypoda																																
Fimbristylis dichotoma																																
Fimbristylis littoralis																																
Fimbristylis oxystachya																																
Fimbristylis tetragona																																
Flueggea virosa subsp. *melanthesoides*				x		x								x						x		x	x	x								
Galactia tenuiflora																																
Gardenia pyriformis subsp. *keartlandii*			x				x						x																	x		
Glycine tomentella	x			x	x		x		x	x					x				x													
Gomphrena affinis	x		x						x										x													
Gomphrena brachystylis subsp. *pindanensis*																							x									
Gomphrena canescens subsp. *canescens*		x		x							x			x																		
Gomphrena flaccida																							x									
Gomphrena sp.																																
Goodenia scaevolina												x																				
Goodenia sepalosa var. *sepalosa*																															x	

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Gossypium australe																				x		x		x		x						
Grevillea pyramidalis subsp. *pyramidalis*	x	x		x		x	x	x		x	x	x	x	x	x	x		x		x	x	x	x	x		x				x		
Grevillea refracta subsp. *refracta*	x					x	x	x					x				x											x				
Grevillea striata																																
Grevillea sp.										x																						
Gyrocarpus americanus																				x												
Gyrocarpus americanus subsp. *pachyphyllus*																																
Hakea arborescens		x				x	x							x						x		x		x						x		x
Hakea macrocarpa	x		x							x												x										
Hakea sp.																																
Heliotropium diversifolium																																
Heliotropium glabellum																							x									
Heliotropium leptaleum		x				x															x								x			
Heliotropium sp. A																																
Heliotropium sp. B																																
Heliotropium sp. C												x																				
Heteropogon contortus																																
Hibiscus geranioides																																
Hibiscus leptocladus						x														x		x										
Hibiscus sp.																																
Hybanthus aurantiacus						x							x										x									
Hybanthus enneaspermus subsp. *enneaspermus*																				x												
?*Hybanthus* sp.												x						x								x						
Indigofera haplophylla												x																				
Indigofera linifolia																											x					
Indigofera linnaei																																
Indigofera sp.																																
Ipomoea coptica																																
Ipomoea muelleri																																
Ipomoea sp.																																
Iseilema ?*fragile*																																
Malvaceae sp.																	x									x						
?*Marsdenia viridiflora*																						x								x		
Melaleuca alsophila					x																											
Melaleuca nervosa																																x
Melaleuca viridiflora								x																x			x					
Melaleuca sp.																				x	x											
Melhania oblongifolia												x		x																		
Microstachys chamaelea	x	x			x	x	x						x		x						x				x					x		
Neptunia sp.																																
Panicum decompositum																																
Persoonia falcata		x							x		x				x				x								x	x				
?*Phyllanthus baccatus*							x																									

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Phyllanthus rhytidospermus							x		x		x																					
Phyllanthus sp.													x	x														x				
Planchonia careya																																
Pluchea ?tetranthera																						x			x							
Poaceae sp.																							x				x					
Polycarpaea longiflora																																
Polygala tepperi																																
**Portulaca pilosa*																											x					
Proteaceae sp.																																
Pterocaulon intermedium (P3)																				x		x										x
Pterocaulon paradoxum																																
Pterocaulon serrulatum var. *velutinum*												x																				
Pterocaulon sp.																																
Ptilotus corymbosus																		x														
Ptilotus fusiformis																																
Ptilotus lanatus																																
Ptilotus nobilis subsp. *nobilis*																																
Ptilotus polystachyus	x								x										x													
Ptilotus sp.																																
Rhynchosia minima																																
?*Santalum lanceolatum*																																
Sehima nervosum																				x		x									x	
Senna costata																			x													
Senna notabilis																																
Setaria surgens																																
Sida rohlenae subsp. *occidentalis*											x																x					
Solanum cunninghamii		x			x						x		x			x											x					
Solanum dioicum																																
Solanum lucani																																
Solanum sp. A																															x	
Solanum sp. B	x														x																	
Sorghum ?plumosum				x																												
Sorghum plumosum		x				x						x		x									x									
Sorghum timorense	x		x		x				x	x	x		x		x	x	x		x		x			x			x	x	x	x		x
Spermacoce laevigata																																
Spermacoce occidentalis																																
Spermacoce sp.																																
Sporobolus actinocladus																																
Stemodia lathraia		x											x	x																		
Stemodia lythrifolia																																
?*Stemodia* sp.																																
Streptoglossa ?odora																																
**Stylosanthes hamata*												x															x					

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

Note - * denotes an introduced species; P1 - P5 denotes prioirty taxon (DPaW 2016g)

Species	Quadrat Reference																															
	TB033	TB034	TB035	TB036	TB037	TB038	TB039	TB040	TB041	TB042	TB043	TB044	TB045	TB046	TB047	TB048	TB049	TB050	TB051	TB052	TB053	TB054	TB055	TB056	TB057	TB058	TB059	TB060	TB061	TB062	TB063	TB064
* *Stylosanthes humilis*																																
* *Stylosanthes scabra*						x														x		x		x								x
Tephrosia aff. croccea					x		x																		x			x		x	x	
Tephrosia leptoclada						x	x																							x		
Tephrosia remotiflora						x					x							x							x							
Tephrosia sp. B Kimberley Flora (C.A. Gardner 7300)				x																												
Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)																																
Tephrosia sp. F Kimberley Flora (B.R. Maslin 5139)																																
Tephrosia sp.		x				x																										
Terminalia canescens		x	x			x	x	x	x			x	x					x		x		x	x	x						x		
Terminalia volucris																																
Terminalia sp.																																
Tinospora smilacina		x												x																		
Trachymene didiscoides																																
Trianthema pilosum																																
Tribulopis angustifolia																											x					
?*Trichodesma zeylanicum*																																
Triodia ?*bynoei*																													x			
Triodia caelestialis (P3)	x	x	x	x	x	x		x		x	x	x	x	x	x	x		x	x	x			x	x		x		x	x	x		x
Triodia ?*intermedia*																																
Triodia schinzii							x		x	x					x	x	x				x										x	
Triodia "schinzii group"																									x							
Triodia sp.											x					x						x										
Triumfetta albida				x																			x									
Triumfetta plumigera																							x									
Uraria lagopodioides																	x				x							x				
Urochloa piligera																																
Vachellia pachyphloia subsp. *brevipinnula*																																
Velleia panduriformis																																
Ventilago viminalis						x												x			x									x		
Waltheria indica	x	x			x	x	x			x	x	x		x	x		x	x		x	x			x		x	x					
Wrightia saligna		x		x		x					x		x	x		x	x				x	x	x					x	x	x		
Xenostegia tridentata																																
Xerochloa barbata																																
Xerochloa laniflora																																
Xyris complanata																																
Yakirra australiensis																																
Zornia chaetophora																															x	
Zornia prostrata var. *prostrata*																											x					

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

Note - * denotes an introduced species; P1 - P5 denotes prioirty taxon (DPaW 2016g)

Species	Quadrat Reference																														
	TB065	TB066	TB067	TB068	TB069	TB070	TB071	TB072	TB073	TB074	TB075	TB076	TB077	TB078	TB079	TB080	TB081	TB082	TB083	TB084	TB085	TB086	TB087	TB088	TB089	TB090	TB091	TB092	TB093	TB094	TB095	TB096
Abildgaardia schoenoides																																
Abutilon hannii							x																									
Acacia ?colei																																
Acacia hippuroides						x						x			x	x							x								
Acacia monticola							x		x			x				x							x								
Acacia platycarpa	x	x		x		x				x	x		x	x	x											x	x			x	
Acacia plectocarpa subsp. *plectocarpa*										x	x				x						x		x	x		x		x			
Acacia stigmatophylla																																
Acacia ?tumida	x	x			x					x	x		x	x												x	x			x	
Acacia tumida var. *tumida*						x						x				x	x	x	x	x	x	x		x	x			x	x		x	
Acacia sp.																																
Aeschynomene indica																																
Alternanthera angustifolia																																
Amyema sp.																																
Aristida contorta					x				x		x				x											x						
Aristida holathera var. *holathera*				x	x			x		x						x							x				x			x		
Aristida holathera var. *latifolia*		x		x				x					x						x	x					x			x			x	
Aristida hygrometrica	x																	x														
Aristida ?inaequiglumis																					x											
Aristida sp.																																
Asteraceae sp.	x							x					x																			
Atalaya hemiglauca									x							x		x									x					x
Atalaya variifolia																																
Atalaya sp.														x																		
Bauhinia cunninghamii	x	x	x		x	x		x				x	x	x	x	x	x	x	x		x	x	x			x	x	x		x	x	
Bonamia linearis												x			x					x	x									x		
Bonamia sp.																																
Brachychiton diversifolius subsp. *diversifolius*			x	x	x	x		x		x	x		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x		
Breynia cernua																																
Buchnera asperata							x																									
Buchnera ?ramosissima																																
Buchnera urticifolia			x																													
Byblis filifolia																																
Cajanus marmoratus																																
Calandrinia quadrivalvis																			x													x
Calandrinia strophiolata				x																												
Calytrix exstipulata							x					x																				
Capparis lasiantha																																
Carissa lanceolata			x						x			x				x			x						x				x			
Cassytha sp.																							x									
**Cenchrus ciliaris*							x																									
Chamaecrista symonii																																
Chrysopogon fallax	x	x		x				x		x				x		x		x												x		

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

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Species	Quadrat Reference																																
	TB065	TB066	TB067	TB068	TB069	TB070	TB071	TB072	TB073	TB074	TB075	TB076	TB077	TB078	TB079	TB080	TB081	TB082	TB083	TB084	TB085	TB086	TB087	TB088	TB089	TB090	TB091	TB092	TB093	TB094	TB095	TB096
Chrysopogon pallidus																																
Chrysopogon sp.																						x					x					
Cleome tetrandra var. *tetrandra*																																
Cleome viscosa																																
?*Clerodendrum floribundum*																x																
Corchorus aestuans																																
Corchorus ?*incanus*																																
Corchorus pumilio		x		x	x	x		x		x	x		x		x	x		x											x			
Corchorus sidoides subsp. *vermicularis*																			x	x	x			x	x					x		x	
Corchorus sp.			x			x													x						x					x			
Corymbia dendromerinx			x				x	x	x			x				x				x		x		x								
Corymbia flavescens																																
Corymbia greeniana	x	x		x							x		x				x		x		x	x			x	x	x	x	x	x	x	
Corymbia ?*polycarpa*																																
Corymbia sp.																										x						
Corymbia zygophylla	x	x	x		x															x										x		
Crotalaria brevis						x																										
Crotalaria ?*medicaginea*																																
Crotalaria ramosissima																																
Crotalaria sp.																																
Cullen balsamicum																																
Cullen sp.																																
Cymbopogon ambiguus																x																
Cymbopogon bombycinus																																
Cymbopogon procerus							x					x																				
Cynanchum carnosum																										x						
Cyperaceae sp.																																
Cyperus carinatus																																
Cyperus ?*conicus*																																
Cyperus ?*microcephalus*							x																									
Cyperus microcephalus subsp. *microcephalus*																																
Cyperus nervulosus																																
Cyperus tenuispica																																
Cyperus sp. A																																
Cyperus sp. B																																
Dactyloctenium radulans																																
Denhamia cunninghamii																																
Desmodium brownii						x																										
Dicliptera armata																																
Digitaria brownii																x																
Digitaria ctenantha																																
Dodonaea hispidula var. *arida*		x	x					x	x	x	x	x	x			x			x	x						x	x		x	x	x	
Dolichandrone heterophylla		x			x		x			x		x	x	x		x						x										

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

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Species	Quadrat Reference																														
	TB065	TB066	TB067	TB068	TB069	TB070	TB071	TB072	TB073	TB074	TB075	TB076	TB077	TB078	TB079	TB080	TB081	TB082	TB083	TB084	TB085	TB086	TB087	TB088	TB089	TB090	TB091	TB092	TB093	TB094	TB095	TB096
Ectrosia schultzii						x											x															x
?*Ehretia saligna*																																
Ehretia saligna var. *saligna*							x	x														x										
Eragrostis cumingii																																x
Eragrostis eriopoda				x	x																x					x				x		
Eragrostis tenellula																																
Eragrostis sp.																																
Eriachne ciliata																																x
Eriachne melicacea															x								x									
Eriachne obtusa	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x		x		
Eriachne sulcata															x								x									x
Eriachne sp. Dampier Peninsula (K. F. Kenneally 5946)																																
Eriachne sp.																																
Erythrophleum chlorostachys	x	x	x	x	x			x			x		x						x	x		x			x	x	x		x	x		
Eucalyptus camaldulensis																																x
Eucalyptus tectifica							x			x		x		x	x	x	x	x	x					x				x				
Eucalyptus sp.																																
Eulalia aurea																																
Euphorbia hassallii																																
Euphorbia trigonosperma																																
Euphorbia ?*vaccaria*																																
Euphorbia sp.							x																									
Evolvulus alsinoides																																
Evolvulus alsinoides var. *decumbens*											x				x	x									x	x			x			
Evolvulus alsinoides var. *villosicalyx*					x																											
Evolvulus sp.																																
Ficus aculeata		x	x																										x			
Ficus platypoda							x																									
Fimbristylis dichotoma																																
Fimbristylis littoralis																																x
Fimbristylis oxystachya															x																	
Fimbristylis tetragona																																x
Flueggea virosa subsp. *melanthesoides*							x					x																				
Galactia tenuiflora							x																									
Gardenia pyriformis subsp. *keartlandii*	x	x																		x				x	x			x				
Glycine tomentella			x																x						x							
Gomphrena affinis																			x													
Gomphrena brachystylis subsp. *pindanensis*																																
Gomphrena canescens subsp. *canescens*																																
Gomphrena flaccida							x																									
Gomphrena sp.																																
Goodenia scaevolina																							x									
Goodenia sepalosa var. *sepalosa*																																

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

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Species	Quadrat Reference																														
	TB065	TB066	TB067	TB068	TB069	TB070	TB071	TB072	TB073	TB074	TB075	TB076	TB077	TB078	TB079	TB080	TB081	TB082	TB083	TB084	TB085	TB086	TB087	TB088	TB089	TB090	TB091	TB092	TB093	TB094	TB095	TB096
Gossypium australe			x												x	x																
Grevillea pyramidalis subsp. *pyramidalis*	x	x	x						x					x		x		x		x				x					x	x		
Grevillea refracta subsp. *refracta*		x	x	x	x			x			x		x			x			x	x	x			x	x				x	x		
Grevillea striata								x					x																			
Grevillea sp.								x					x																			
Gyrocarpus americanus																																
Gyrocarpus americanus subsp. *pachyphyllus*																																
Hakea arborescens		x		x								x	x									x										
Hakea macrocarpa																											x					
Hakea sp.																							x									
Heliotropium diversifolium															x																	
Heliotropium glabellum							x		x							x																
Heliotropium leptaleum																																
Heliotropium sp. A						x																										
Heliotropium sp. B																																
Heliotropium sp. C																																
Heteropogon contortus																																
Hibiscus geranioides							x																									
Hibiscus leptocladus																x														x		
Hibiscus sp.																																
Hybanthus aurantiacus																x																
Hybanthus enneaspermus subsp. *enneaspermus*									x																							
?*Hybanthus* sp.																																
Indigofera haplophylla																																
Indigofera linifolia																																
Indigofera linnaei																																
Indigofera sp.																											x					
Ipomoea coptica																																
Ipomoea muelleri																																
Ipomoea sp.																																
Iseilema ?*fragile*																							x									
Malvaceae sp.					x	x																	x							x		
?*Marsdenia viridiflora*																																
Melaleuca alsophila																																x
Melaleuca nervosa																																
Melaleuca viridiflora															x		x						x					x				
Melaleuca sp.						x				x								x					x									
Melhania oblongifolia							x					x																				
Microstachys chamaelea		x	x	x	x			x	x	x		x	x						x	x	x				x				x	x		
Neptunia sp.																																
Panicum decompositum												x																				
Persoonia falcata			x																x						x							
?*Phyllanthus baccatus*																																

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

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Species	Quadrat Reference																															
	TB065	TB066	TB067	TB068	TB069	TB070	TB071	TB072	TB073	TB074	TB075	TB076	TB077	TB078	TB079	TB080	TB081	TB082	TB083	TB084	TB085	TB086	TB087	TB088	TB089	TB090	TB091	TB092	TB093	TB094	TB095	TB096
Phyllanthus rhytidospermus																											x					
Phyllanthus sp.																																
Planchonia careya	x			x		x																										
Pluchea ?tetranthera																																
Poaceae sp.																																
Polycarpaea longiflora							x																									
Polygala tepperi		x											x																			
**Portulaca pilosa*																																
Proteaceae sp.																																
Pterocaulon intermedium (P3)																																
Pterocaulon paradoxum												x									x			x							
Pterocaulon serrulatum var. *velutinum*																																
Pterocaulon sp.																																
Ptilotus corymbosus							x																									
Ptilotus fusiformis		x																														
Ptilotus lanatus					x																				x							
Ptilotus nobilis subsp. *nobilis*																																
Ptilotus polystachyus			x	x															x						x				x			
Ptilotus sp.																																
Rhynchosia minima													x																			
?*Santalum lanceolatum*																																
Sehima nervosum																	x	x				x										
Senna costata	x																			x	x											
Senna notabilis																																
Setaria surgens																																
Sida rohlenae subsp. *occidentalis*				x						x					x															x		
Solanum cunninghamii	x	x		x	x								x																			
Solanum dioicum																																
Solanum lucani																																
Solanum sp. A																																
Solanum sp. B																					x								x		x	
Sorghum ?plumosum																					x			x							x	
Sorghum plumosum				x				x	x				x										x									
Sorghum timorense	x	x	x		x	x	x			x	x	x			x	x			x	x			x		x	x	x	x	x			
Spermacoce laevigata																																
Spermacoce occidentalis																					x											
Spermacoce sp.																																
Sporobolus actinocladus																																
Stemodia lathraia		x				x												x														
Stemodia lythrifolia																																
?*Stemodia* sp.																																
Streptoglossa ?odora																																
**Stylosanthes hamata*							x					x									x											

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* *Stylosanthes humilis*																																
* *Stylosanthes scabra*															x								x									
Tephrosia aff. croccea												x	x								x									x		
Tephrosia leptoclada							x									x																
Tephrosia remotiflora		x							x							x																
Tephrosia sp. B Kimberley Flora (C.A. Gardner 7300)																																
Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)																																
Tephrosia sp. F Kimberley Flora (B.R. Maslin 5139)																																
Tephrosia sp.						x										x																
Terminalia canescens									x			x			x				x	x										x		
Terminalia volucris																																
Terminalia sp.					x											x																
Tinospora smilacina			x				x																									x
Trachymene didiscoides																																
Trianthema pilosum	x	x																														
Tribulopis angustifolia																																
?*Trichodesma zeylanicum*					x																											
Triodia ?bynoei																																
Triodia caelestialis (P3)	x								x	x				x	x	x	x	x		x		x	x			x	x					
Triodia ?intermedia																																
Triodia schinzii			x		x			x			x								x		x			x				x	x		x	
Triodia "schinzii group"																																
Triodia sp.		x		x		x							x										x								
Triumfetta albida							x																									
Triumfetta plumigera							x																									
Uraria lagopodioides									x	x																						
Urochloa piligera																																
Vachellia pachyphloia subsp. *brevipinnula*																																
Velleia panduriformis																																
Ventilago viminalis																																
Waltheria indica					x	x			x	x	x	x			x	x	x	x		x	x		x			x			x	x		x
Wrightia saligna	x								x	x	x		x																			
Xenostegia tridentata																																
Xerochloa barbata																							x									
Xerochloa laniflora																																x
Xyris complanata																																
Yakirra australiensis				x																												
Zornia chaetophora																																
Zornia prostrata var. *prostrata*																																

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Species	Quadrat Reference																														
	TB097	TB098	TB099	TB100	TB101	TB102	TB103	TB104	TB105	TB106	TB107	TB108	TB109	TB110	TB111	TB112	TB113	TB114	TB115	TB116	TB117	TB118	TB119	TB120	TB121	TB122	TB123	TB124	TB125	TB126	TB127	TB128
Abildgaardia schoenoides																																
Abutilon hannii																																
Acacia ?colei	x									x																			x			
Acacia hippuroides																										x						
Acacia monticola		x	x													x								x	x					x		
Acacia platycarpa				x							x											x		x								x
Acacia plectocarpa subsp. *plectocarpa*							x																									
Acacia stigmatophylla																																
Acacia ?tumida																											x				x	x
Acacia tumida var. *tumida*				x	x		x	x			x	x	x	x	x		x	x	x		x	x								x		
Acacia sp.										x																		x				x
Aeschynomene indica																				x												
Alternanthera angustifolia																							x									
Amyema sp.		x																						x								
Aristida contorta		x	x			x											x									x	x					
Aristida holathera var. *holathera*	x									x																				x		
Aristida holathera var. *latifolia*				x	x																											
Aristida hygrometrica												x	x		x			x			x									x		
Aristida ?inaequiglumis												x	x		x				x		x	x								x		
Aristida sp.																			x			x										
Asteraceae sp.																																
Atalaya hemiglauca	x	x								x								x		x		x			x		x					
Atalaya variifolia						x																					x				x	
Atalaya sp.																																
Bauhinia cunninghamii	x				x	x	x		x	x	x	x	x						x	x	x	x	x	x		x	x	x	x			x
Bonamia linearis				x			x				x				x																	
Bonamia sp.			x																												x	
Brachychiton diversifolius subsp. *diversifolius*	x		x		x		x	x		x	x		x	x	x				x		x	x				x	x	x	x	x		x
Breynia cernua																	x															
Buchnera asperata																x																
Buchnera ?ramosissima																		x														
Buchnera urticifolia																																
Byblis filifolia												x																				
Cajanus marmoratus																																
Calandrinia quadrivalvis									x										x	x												
Calandrinia strophiolata							x								x																	
Calytrix exstipulata																								x	x	x					x	
Capparis lasiantha																							x									
Carissa lanceolata			x		x	x			x	x									x		x		x				x	x	x			
Cassytha sp.		x																x									x					
** Cenchrus ciliaris*																		x														
Chamaecrista symonii							x					x																			x		
Chrysopogon fallax		x		x						x					x			x			x		x			x	x	x		x	x	x

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

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Species	Quadrat Reference																														
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Chrysopogon pallidus																																
Chrysopogon sp.								x						x																		
Cleome tetrandra var. *tetrandra*																																
Cleome viscosa																x		x														
?*Clerodendrum floribundum*																					x										x	
Corchorus aestuans																																
Corchorus ?*incanus*																x								x	x							
Corchorus pumilio				x							x				x		x				x					x					x	
Corchorus sidoides subsp. *vermicularis*			x				x	x						x								x		x								
Corchorus sp.																			x						x							
Corymbia dendromerinx		x			x					x						x		x	x			x		x	x						x	
Corymbia flavescens																																
Corymbia greeniana			x	x	x		x	x			x	x		x	x							x								x		x
Corymbia ?*polycarpa*																																
Corymbia sp.																																x
Corymbia zygophylla								x			x	x	x		x															x		
Crotalaria brevis																																
Crotalaria ?*medicaginea*							x																									
Crotalaria ramosissima																				x												
Crotalaria sp.																																
Cullen balsamicum																																
Cullen sp.																																
Cymbopogon ambiguus																																
Cymbopogon bombycinus																																
Cymbopogon procerus																		x														
Cynanchum carnosum													x		x						x											
Cyperaceae sp.																				x												
Cyperus carinatus																							x									
Cyperus ?*conicus*																																
Cyperus ?*microcephalus*																x																
Cyperus microcephalus subsp. *microcephalus*		x																x														
Cyperus nervulosus																				x												
Cyperus tenuispica																																
Cyperus sp. A																																
Cyperus sp. B																																
Dactyloctenium radulans																																
Denhamia cunninghamii																								x								
Desmodium brownii																																
Dicliptera armata													x																		x	
Digitaria brownii																										x					x	
Digitaria ctenantha																				x			x									
Dodonaea hispidula var. *arida*				x	x														x												x	
Dolichandrone heterophylla	x									x	x							x									x	x				x

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Ectrosia schultzii																	x			x			x									
?*Ehretia saligna*																																
Ehretia saligna var. *saligna*				x						x																						
Eragrostis cumingii																				x			x									
Eragrostis eriopoda					x		x				x		x	x	x						x	x								x		x
Eragrostis tenellula																																
Eragrostis sp.																																
Eriachne ciliata																																
Eriachne melicacea																																
Eriachne obtusa		x	x	x		x	x	x	x	x	x		x	x	x	x	x	x	x		x	x		x		x	x	x	x	x		x
Eriachne sulcata			x																	x												
Eriachne sp. Dampier Peninsula (K. F. Kenneally 5946)																									x							
Eriachne sp.																																
Erythrophleum chlorostachys				x	x		x				x	x	x	x	x				x			x				x				x		
Eucalyptus camaldulensis																																
Eucalyptus tectifica	x	x				x				x						x										x	x	x	x			
Eucalyptus sp.																		x														
Eulalia aurea																				x												
Euphorbia hassallii																x								x								
Euphorbia trigonosperma							x	x					x		x					x	x		x							x		
Euphorbia ?*vaccaria*							x												x													
Euphorbia sp.																x																
Evolvulus alsinoides																																
Evolvulus alsinoides var. *decumbens*			x																							x	x			x		
Evolvulus alsinoides var. *villosicalyx*								x						x					x										x			
Evolvulus sp.																																
Ficus aculeata																																
Ficus platypoda																																
Fimbristylis dichotoma																				x												
Fimbristylis littoralis																				x			x									
Fimbristylis oxystachya																																
Fimbristylis tetragona																				x												
Flueggea virosa subsp. *melanthesoides*																		x								x				x		
Galactia tenuiflora																x									x							
Gardenia pyriformis subsp. *keartlandii*																								x						x		
Glycine tomentella					x													x						x								
Gomphrena affinis																								x	x							
Gomphrena brachystylis subsp. *pindanensis*		x																								x				x		
Gomphrena canescens subsp. *canescens*																																
Gomphrena flaccida																				x												
Gomphrena sp.																																
Goodenia scaevolina																						x										
Goodenia sepalosa var. *sepalosa*							x	x											x													

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Gossypium australe																						x										
Grevillea pyramidalis subsp. *pyramidalis*		x	x							x			x			x		x				x		x	x	x				x	x	
Grevillea refracta subsp. *refracta*		x		x						x			x					x				x										
Grevillea striata																													x			
Grevillea sp.																																x
Gyrocarpus americanus																																
Gyrocarpus americanus subsp. *pachyphyllus*													x																			
Hakea arborescens	x			x		x				x																x	x		x			
Hakea macrocarpa																								x								
Hakea sp.																																
Heliotropium diversifolium																																
Heliotropium glabellum		x																						x	x							
Heliotropium leptaleum											x																					
Heliotropium sp. A																																
Heliotropium sp. B																																
Heliotropium sp. C																					x											
Heteropogon contortus																																
Hibiscus geranioides																																
Hibiscus leptocladus																								x							x	
Hibiscus sp.										x																						
Hybanthus aurantiacus			x															x														
Hybanthus enneaspermus subsp. *enneaspermus*																									x						x	
?*Hybanthus* sp.																																
Indigofera haplophylla		x														x															x	
Indigofera linifolia																																
Indigofera linnaei																																
Indigofera sp.																																
Ipomoea coptica																							x									
Ipomoea muelleri																																
Ipomoea sp.													x																			
Iseilema ?*fragile*																																
Malvaceae sp.																		x									x					
?*Marsdenia viridiflora*																		x														
Melaleuca alsophila																					x											
Melaleuca nervosa	x							x																								
Melaleuca viridiflora			x			x	x		x												x		x			x	x					
Melaleuca sp.													x																			
Melhania oblongifolia																																
Microstachys chamaelea				x							x	x	x					x				x								x		
Neptunia sp.									x																							
Panicum decompositum																																
Persoonia falcata				x																												
?*Phyllanthus baccatus*																																

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

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Phyllanthus rhytidospermus					x																											
Phyllanthus sp.																																
Planchonia careya										x					x																	
Pluchea ?tetranthera																																
Poaceae sp.																				x												
Polycarpaea longiflora																		x														
Polygala tepperi							x					x																				
**Portulaca pilosa*																																
Proteaceae sp.																																
Pterocaulon intermedium (P3)																						x										
Pterocaulon paradoxum												x																				
Pterocaulon serrulatum var. *velutinum*																																
Pterocaulon sp.																																
Ptilotus corymbosus																x		x				x		x							x	
Ptilotus fusiformis																																
Ptilotus lanatus																																
Ptilotus nobilis subsp. *nobilis*																																
Ptilotus polystachyus																						x										
Ptilotus sp.																																
Rhynchosia minima																																
?*Santalum lanceolatum*																																
Sehima nervosum	x			x						x																		x				
Senna costata													x											x								
Senna notabilis																																
Setaria surgens									x							x		x		x			x		x							
Sida rohlenae subsp. *occidentalis*												x	x		x						x			x						x	x	
Solanum cunninghamii													x																		x	
Solanum dioicum																																
Solanum lucani																																
Solanum sp. A																			x													
Solanum sp. B							x																									
Sorghum ?plumosum																						x		x	x							
Sorghum plumosum											x	x	x	x	x	x		x														
Sorghum timorense					x		x																								x	
Spermacoce laevigata							x																									
Spermacoce occidentalis								x				x	x																			
Spermacoce sp.																																
Sporobolus actinocladus																																
Stemodia lathraia																																
Stemodia lythrifolia												x																				
?*Stemodia* sp.																																
Streptoglossa ?odora																																
**Stylosanthes hamata*																							x									

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* *Stylosanthes humilis*																				x												
* *Stylosanthes scabra*																																
Tephrosia aff. croccea							x					x		x	x															x		
Tephrosia leptoclada		x																								x					x	
Tephrosia remotiflora													x			x		x						x							x	
Tephrosia sp. B Kimberley Flora (C.A. Gardner 7300)																																
Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)																																x
Tephrosia sp. F Kimberley Flora (B.R. Maslin 5139)					x																											
Tephrosia sp.		x																							x							
Terminalia canescens		x	x							x						x		x				x		x	x	x			x		x	
Terminalia volucris																																
Terminalia sp.																																
Tinospora smilacina							x								x										x							
Trachymene didiscoides																																
Trianthema pilosum								x							x																	
Tribulopis angustifolia																																
?*Trichodesma zeylanicum*																																
Triodia ?bynoei																																
Triodia caelestialis (P3)	x	x	x			x				x						x		x						x		x	x	x			x	x
Triodia ?intermedia																																
Triodia schinzii				x			x	x			x	x	x	x							x				x							
Triodia "schinzii group"																													x			
Triodia sp.															x				x											x		
Triumfetta albida		x																														
Triumfetta plumigera		x																														
Uraria lagopodioides																																
Urochloa piligera																				x			x									
Vachellia pachyphloia subsp. *brevipinnula*																																
Velleia panduriformis																																
Ventilago viminalis																	x												x			
Waltheria indica			x		x		x			x	x		x	x		x	x			x	x	x		x	x	x				x	x	x
Wrightia saligna																		x							x							
Xenostegia tridentata																																
Xerochloa barbata																																
Xerochloa laniflora									x																							
Xyris complanata																																
Yakirra australiensis															x				x	x												
Zornia chaetophora								x				x							x													
Zornia prostrata var. *prostrata*																																

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Abildgaardia schoenoides																											
Abutilon hannii																											
Acacia ?colei																				x		x					
Acacia hippuroides																											
Acacia monticola				x																							
Acacia platycarpa				x	x			x	x		x		x					x					x			x	
Acacia plectocarpa subsp. *plectocarpa*														x		x			x	x	x						
Acacia stigmatophylla																											
Acacia ?tumida	x	x				x	x				x	x			x		x						x	x	x		x
Acacia tumida var. *tumida*					x			x	x	x			x	x				x								x		
Acacia sp.																											
Aeschynomene indica																											
Alternanthera angustifolia																											
Amyema sp.																											
Aristida contorta						x					x	x					x				x		x	x	x		x
Aristida holathera var. *holathera*			x					x					x						x							x		
Aristida holathera var. *latifolia*			x		x									x		x		x		x		x						
Aristida hygrometrica													x															
Aristida ?inaequiglumis				x																							
Aristida sp.																											
Asteraceae sp.								x		x																	
Atalaya hemiglauca																						x					
Atalaya variifolia											x																
Atalaya sp.							x								x												
Bauhinia cunninghamii		x	x			x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
Bonamia linearis			x	x			x		x		x														x	x		
Bonamia sp.																											
Brachychiton diversifolius subsp. *diversifolius*		x		x		x		x	x	x	x	x	x	x			x	x			x		x		x	x	x
Breynia cernua																											
Buchnera asperata																											
Buchnera ?ramosissima																											
Buchnera urticifolia	x																										
Byblis filifolia																											
Cajanus marmoratus															x						x						
Calandrinia quadrivalvis					x							x				x		x									
Calandrinia strophiolata													x						x								
Calytrix exstipulata	x																										
Capparis lasiantha																											
Carissa lanceolata																						x					
Cassytha sp.	x																										
** Cenchrus ciliaris*																											
Chamaecrista symonii			x																								
Chrysopogon fallax		x	x		x	x	x	x		x		x	x		x				x		x	x		x			x

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Chrysopogon pallidus																	x						x		x		
Chrysopogon sp.																											
Cleome tetrandra var. *tetrandra*								x																			
Cleome viscosa																											
?*Clerodendrum floribundum*																											
Corchorus aestuans																x											
Corchorus ?incanus																											
Corchorus pumilio		x				x	x			x							x	x						x	x		
Corchorus sidoides subsp. *vermicularis*				x																							
Corchorus sp.									x																		
Corymbia dendromerinx	x	x		x							x			x							x		x				
Corymbia flavescens																			x								
Corymbia greeniana					x	x	x	x		x		x	x		x		x	x	x				x	x	x	x	x
Corymbia ?polycarpa																											
Corymbia sp.																	x										
Corymbia zygophylla								x	x	x					x			x								x	x
Crotalaria brevis																											
Crotalaria ?medicaginea																											
Crotalaria ramosissima												x			x												
Crotalaria sp.																											
Cullen balsamicum																	x										
Cullen sp.																					x						
Cymbopogon ambiguus																											
Cymbopogon bombycinus																											
Cymbopogon procerus																											
Cynanchum carnosum																											
Cyperaceae sp.																											
Cyperus carinatus																											
Cyperus ?conicus																	x										
Cyperus ?microcephalus																											
Cyperus microcephalus subsp. *microcephalus*	x																										
Cyperus nervulosus																											
Cyperus tenuispica																											
Cyperus sp. A																											
Cyperus sp. B																											
Dactyloctenium radulans																x											
Denhamia cunninghamii																											
Desmodium brownii																x											
Dicliptera armata	x																										
Digitaria brownii																											
Digitaria ctenantha																x											
Dodonaea hispidula var. *arida*		x		x			x	x		x								x						x			
Dolichandrone heterophylla			x	x		x	x			x	x	x	x	x	x		x	x					x	x		x	x

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Ectrosia schultzii																											
?*Ehretia saligna*																											
Ehretia saligna var. *saligna*																											
Eragrostis cumingii																											
Eragrostis eriopoda						x			x	x				x			x	x					x	x	x	x	
Eragrostis tenellula																						x					
Eragrostis sp.		x					x																				
Eriachne ciliata																											
Eriachne melicacea																											
Eriachne obtusa		x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Eriachne sulcata																											
Eriachne sp. Dampier Peninsula (K. F. Kenneally 5946)																								x	x		
Eriachne sp.																											
Erythrophleum chlorostachys		x	x	x	x	x	x	x	x		x	x			x		x						x	x	x		x
Eucalyptus camaldulensis																											
Eucalyptus tectifica		x	x	x		x			x					x		x			x	x	x	x					
Eucalyptus sp.																											
Eulalia aurea																											
Euphorbia hassallii																											
Euphorbia trigonosperma											x								x					x			
Euphorbia ?*vaccaria*					x				x							x		x									
Euphorbia sp.	x																			x							
Evolvulus alsinoides																	x										
Evolvulus alsinoides var. *decumbens*												x			x												
Evolvulus alsinoides var. *villosicalyx*		x				x	x	x		x			x			x		x	x							x	
Evolvulus sp.																											
Ficus aculeata																											
Ficus platypoda																											
Fimbristylis dichotoma																											
Fimbristylis littoralis																											
Fimbristylis oxystachya																											
Fimbristylis tetragona																											
Flueggea virosa subsp. *melanthesoides*																											
Galactia tenuiflora																											
Gardenia pyriformis subsp. *keartlandii*			x	x			x					x		x			x							x	x	x	
Glycine tomentella	x								x																		
Gomphrena affinis																											
Gomphrena brachystylis subsp. *pindanensis*	x																					x					
Gomphrena canescens subsp. *canescens*																											
Gomphrena flaccida																											
Gomphrena sp.																x											
Goodenia scaevolina																											
Goodenia sepalosa var. *sepalosa*																x		x									

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

Note - * denotes an introduced species; P1 - P5 denotes prioirty taxon (DPaW 2016g)

Species	Quadrat Reference																									
	TB129	TB130	TB131	TB132	TB133	TB134	TB135	TB136	TB137	TB138	TB139	TB140	TB141	TB142	TB143	TB144	TB145	TB146	TB147	TB148	TB149	TB150	TB151	TB152	TB153	TB154	TB155
Gossypium australe																											
Grevillea pyramidalis subsp. *pyramidalis*			x	x			x		x	x			x			x				x	x			x		x	
Grevillea refracta subsp. *refracta*				x	x	x	x					x			x					x							x
Grevillea striata																											
Grevillea sp.																											
Gyrocarpus americanus																											
Gyrocarpus americanus subsp. *pachyphyllus*																											
Hakea arborescens														x													
Hakea macrocarpa																		x									
Hakea sp.																											
Heliotropium diversifolium																											
Heliotropium glabellum														x													
Heliotropium leptaleum			x																								
Heliotropium sp. A												x															
Heliotropium sp. B					x			x																			
Heliotropium sp. C																											
Heteropogon contortus																											
Hibiscus geranioides																											
Hibiscus leptocladus										x																	
Hibiscus sp.																											
Hybanthus aurantiacus		x																	x								
Hybanthus enneaspermus subsp. *enneaspermus*																											
?*Hybanthus* sp.																											
Indigofera haplophylla																											
Indigofera linifolia																x											
Indigofera linnaei																x											
Indigofera sp.						x														x						x	
Ipomoea coptica																x											
Ipomoea muelleri																											
Ipomoea sp.																											
Iseilema ?*fragile*																											
Malvaceae sp.													x														
?*Marsdenia viridiflora*																										x	
Melaleuca alsophila																				x	x						
Melaleuca nervosa																											
Melaleuca viridiflora																											
Melaleuca sp.																				x							
Melhania oblongifolia																											
Microstachys chamaelea		x		x		x		x	x	x		x			x		x									x	
Neptunia sp.																											
Panicum decompositum																											
Persoonia falcata															x							x					
?*Phyllanthus baccatus*																											

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

Note - * denotes an introduced species; P1 - P5 denotes prioirty taxon (DPaW 2016g)

Species	Quadrat Reference																										
	TB129	TB130	TB131	TB132	TB133	TB134	TB135	TB136	TB137	TB138	TB139	TB140	TB141	TB142	TB143	TB144	TB145	TB146	TB147	TB148	TB149	TB150	TB151	TB152	TB153	TB154	TB155
Phyllanthus rhytidospermus								x																			
Phyllanthus sp.																											
Planchonia careya										x			x													x	
Pluchea ?tetranthera																											
Poaceae sp.																				x							
Polycarpaea longiflora	x																										
Polygala tepperi																			x								
**Portulaca pilosa*																											
Proteaceae sp.																											
Pterocaulon intermedium (P3)														x						x							
Pterocaulon paradoxum																											
Pterocaulon serrulatum var. *velutinum*																											
Pterocaulon sp.																											
Ptilotus corymbosus	x																										
Ptilotus fusiformis																											
Ptilotus lanatus								x						x													
Ptilotus nobilis subsp. *nobilis*																											
Ptilotus polystachyus					x	x	x				x														x		
Ptilotus sp.																											
Rhynchosia minima																											
?Santalum lanceolatum																											
Sehima nervosum																				x			x			x	
Senna costata												x	x				x	x							x		
Senna notabilis									x																		
Setaria surgens																											
Sida rohlenae subsp. *occidentalis*								x		x			x						x			x					
Solanum cunninghamii					x		x	x		x	x	x	x		x				x		x			x			x
Solanum dioicum																x								x			
Solanum lucani																		x									
Solanum sp. A																											
Solanum sp. B																											
Sorghum ?plumosum																				x							
Sorghum plumosum		x								x					x									x			x
Sorghum timorense	x		x	x	x	x	x	x	x		x	x	x	x			x	x	x		x		x		x		
Spermacoce laevigata																											
Spermacoce occidentalis													x					x									
Spermacoce sp.																									x		
Sporobolus actinocladus																						x					
Stemodia lathraia														x													
Stemodia lythrifolia																											
?Stemodia sp.																											
Streptoglossa ?odora																											
**Stylosanthes hamata*														x		x						x					

APPENDIX F: VASCULAR PLANT SPECIES RECORDED AT EACH SURVEY QUADRAT WITHIN THE THUNDERBIRD PROJECT AREA, JUNE 2016

Note - * denotes an introduced species; P1 - P5 denotes prioirty taxon (DPaW 2016g)

Species	Quadrat Reference																										
	TB129	TB130	TB131	TB132	TB133	TB134	TB135	TB136	TB137	TB138	TB139	TB140	TB141	TB142	TB143	TB144	TB145	TB146	TB147	TB148	TB149	TB150	TB151	TB152	TB153	TB154	TB155
* *Stylosanthes humilis*																											
* *Stylosanthes scabra*																											
Tephrosia aff. croccea													x					x									
Tephrosia leptoclada	x		x											x					x				x	x			
Tephrosia remotiflora																	x										
Tephrosia sp. B Kimberley Flora (C.A. Gardner 7300)																											
Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)																											
Tephrosia sp. F Kimberley Flora (B.R. Maslin 5139)											x																
Tephrosia sp.			x																								
Terminalia canescens	x	x							x					x				x			x		x			x	x
Terminalia volucris																											
Terminalia sp.																											
Tinospora smilacina										x	x		x				x									x	
Trachymene didiscoides																											
Trianthema pilosum			x		x			x	x				x		x			x						x	x		
Tribulopis angustifolia								x										x									
?*Trichodesma zeylanicum*																											
Triodia ?*bynoei*																											
Triodia caelestialis (P3)	x	x	x		x	x		x		x	x												x	x	x		
Triodia ?*intermedia*																						x					
Triodia schinzii				x					x					x				x				x				x	
Triodia "schinzii group"									x																		
Triodia sp.					x		x	x				x	x		x				x		x						x
Triumfetta albida	x																										
Triumfetta plumigera																											
Uraria lagopodioides							x														x						
Urochloa piligera																											
Vachellia pachyphloia subsp. *brevipinnula*																											
Velleia panduriformis					x							x															
Ventilago viminalis																	x										
Waltheria indica				x		x		x	x	x		x	x	x	x	x	x	x					x	x	x		
Wrightia saligna	x		x			x	x			x	x															x	
Xenostegia tridentata																											
Xerochloa barbata																											
Xerochloa laniflora																x				x		x					
Xyris complanata																											
Yakirra australiensis					x			x																			
Zornia chaetophora							x																				
Zornia prostrata var. *prostrata*			x																								

APPENDIX G: LOCATIONS AND POPULATIONS OF PRIORITY FLORA RECORDED WITHIN THE THUNDERBIRD PROJECT AREA

Mattiske Consulting Pty Ltd – June 2016 Survey

Notes: 1 – number of plants is per 50 m x 50 m quadrat;
2 – plant numbers estimated by extrapolation, based on a 5 m x 5 m subset of the quadrat.

Species	Quadrat Reference	Location (GDA94, Zone 51)		Number of Plants[1]
		Easting (mE)	Northing (mN)	
Pterocaulon intermedium (P3)	Opportunistic	504415	8070743	1
	Opportunistic	500141	8070719	1
	Opportunistic	491113	8076144	1
	Opportunistic	498700	8076078	1
	TB017	499923	8076197	13
	TB052	504458	8070740	5
	TB054	503905	8070626	25
	TB064	505040	8069200	3
	TB118	506340	8064660	5
	TB142	513606	8050948	2
	TB148	515453	8049943	5
Triodia caelestialis (P3)	Opportunistic	502431	8066522	10,000[2]
	Opportunistic	503209	8064645	10,500[2]
	Opportunistic	500141	8070719	1
	TB001	491459	8077134	4
	TB002	491087	8077033	3,000[2]
	TB003	497092	8077031	3,000[2]
	TB006	496500	8076972	5,000[2]
	TB009	498831	8076669	1
	TB013	493878	8076519	200
	TB015	497993	8076226	2,500[2]
	TB016	490921	8076219	12,000[2]
	TB022	497596	8075454	10,000[2]
	TB023	496400	8075420	250
	TB026	491250	8074800	3,000[2]
	TB027	498319	8074128	51
	TB028	490600	8074100	26
	TB029	494343	8074100	50
	TB030	491751	8073892	150
	TB031	500297	8073706	1
	TB032	499959	8073689	1
	TB033	490746	8073301	150
	TB034	492397	8073255	26
	TB035	493956	8073228	100
	TB036	499684	8073106	1
	TB037	502973	8073018	3,000[2]
	TB038	496823	8072877	100
	TB040	495709	8072344	26

APPENDIX G: LOCATIONS AND POPULATIONS OF PRIORITY FLORA RECORDED WITHIN THE THUNDERBIRD PROJECT AREA

Mattiske Consulting Pty Ltd – June 2016 Survey

Notes: 1 – number of plants is per 50 m x 50 m quadrat;
2 – plant numbers estimated by extrapolation, based on a 5 m x 5 m subset of the quadrat.

Species	Quadrat Reference	Location (GDA94, Zone 51)		Number of Plants[1]
		Easting (mE)	Northing (mN)	
Triodia caelestialis (P3)	TB042	491903	8071849	1
	TB043	491300	8071800	26
	TB044	503951	8071750	1
	TB045	496000	8071428	26
	TB046	490950	8071403	26
	TB047	491751	8071303	100
	TB048	494300	8071300	26
	TB050	500241	8070901	11
	TB051	492250	8070824	10,000[2]
	TB052	504458	8070740	150
	TB055	500466	8070546	150
	TB056	502860	8070275	1
	TB058	504291	8070070	1,000[2]
	TB060	500136	8069658	1,000[2]
	TB061	501478	8069607	3,000[2]
	TB062	499800	8069400	100
	TB064	505040	8069200	700
	TB065	492955	8069182	1,000[2]
	TB073	500190	8068149	26
	TB074	500030	8067880	11,000[2]
	TB078	498219	8067535	90
	TB079	504247	8067511	200
	TB080	503542	8067420	5,000[2]
	TB081	499893	8067199	100
	TB082	497569	8067109	11
	TB084	501349	8067066	51
	TB086	499200	8066998	250
	TB087	504821	8066933	51
	TB090	504626	8066787	700
	TB091	503478	8066764	55
	TB097	499202	8066303	200
	TB098	503134	8066177	100
	TB099	504349	8066171	1
	TB102	504774	8066063	13,000[2]
	TB106	501710	8065607	1,500[2]
	TB112	505222	8064801	150
	TB114	506534	8064755	11
	TB120	504323	8064554	150

APPENDIX G: LOCATIONS AND POPULATIONS OF PRIORITY FLORA RECORDED WITHIN THE THUNDERBIRD PROJECT AREA

Mattiske Consulting Pty Ltd – June 2016 Survey

Notes: 1 – number of plants is per 50 m x 50 m quadrat;
2 – plant numbers estimated by extrapolation, based on a 5 m x 5 m subset of the quadrat.

Species	Quadrat Reference	Location (GDA94, Zone 51)		Number of Plants[1]
		Easting (mE)	Northing (mN)	
Triodia caelestialis (P3)	TB122	503009	8064490	130
	TB123	500719	8064436	1,200[2]
	TB124	499626	8064352	100
	TB127	502842	8064142	100
	TB128	500342	8064136	1,000[2]
	TB129	506031	8063200	1
	TB130	505951	8063100	150
	TB131	506000	8061900	100
	TB133	506152	8061498	26
	TB134	507898	8058832	2,000[2]
	TB136	510122	8055501	11
	TB138	513148	8052699	51
	TB139	511789	8052190	1,500[2]
	TB151	511756	8049321	900[2]
	TB152	512370	8048600	1
	TB153	512281	8047660	120

APPENDIX G: LOCATIONS AND POPULATIONS OF PRIORITY FLORA RECORDED WITHIN THE THUNDERBIRD PROJECT AREA

Ecologia Environment: 2012 - 2015 Surveys

Notes: Data extracted from Ecologia (2014, 2015); Survey – 1 and 2 (Ecologia 2014), 3 (Ecologia 2015)

Species	Location (GDA94, Zone 51)		Number of Plants	Survey
	Easting (mE)	Northing (mN)		
Fuirena nudiflora (P1)	498513	8075814	n/a	2
Fuirena incrassata (P3)	498513	8075814	n/a	2
Pterocaulon intermedium (P3)	496948	8076082	n/a	2
	496014	8069515	n/a	2
	496874	8068718	n/a	2
	501746	8071736	n/a	2
	499645	8074211	n/a	2
	499736	8074001	n/a	2
	499143	8068184	n/a	2
	504227	8070776	n/a	2
	495997	8071402	n/a	1
	499972	8069648	1	3
	500041	8069802	1	3
	499540	8069960	1	3
	512043	8053129	1	3
	504309	8065397	1	3
	515172	8049723	1	3
	508905	8056914	1	3
	513902	8051201	1	3
	504489	8065127	1	3
	512185	8053074	1	3
	512185	8053074	1	3
	513285	8051678	1	3
	503365	8066681	1	3
	501697	8069412	1	3
Tephrosia valleculata (P3)	501559	8071691	n/a	2
	500103	8071806	n/a	2
	499300	8071679	n/a	2
Triodia caelestialis (P3)	494788	8075983	n/a	2
	499653	8075125	n/a	2
	495360	8074330	n/a	2
	498468	8074919	n/a	2
	497024	8073661	n/a	2
	500377	8073356	n/a	2
	500377	8073356	n/a	2
	492865	8075608	n/a	2
	501241	8073130	n/a	2
	501241	8073130	n/a	2
	493844	8076206	n/a	2

APPENDIX G: LOCATIONS AND POPULATIONS OF PRIORITY FLORA RECORDED WITHIN THE THUNDERBIRD PROJECT AREA

Ecologia Environment: 2012 - 2015 Surveys

Notes: Data extracted from Ecologia (2014, 2015); Survey – 1 and 2 (Ecologia 2014), 3 (Ecologia 2015)

Species	Location (GDA94, Zone 51)		Number of Plants	Survey
	Easting (mE)	Northing (mN)		
Triodia caelestialis (P3)	491518	8072513	n/a	2
	499645	8074186	n/a	2
	500610	8072377	n/a	2
	491802	8072820	n/a	2
	493180	8072364	n/a	2
	501559	8071691	n/a	2
	502849	8070745	n/a	2
	502849	8070745	n/a	2
	495292	8070277	n/a	2
	492804	8069895	n/a	2
	492954	8069182	n/a	2
	496014	8069515	n/a	2
	502909	8067801	n/a	2
	501441	8067567	n/a	2
	498783	8067452	n/a	2
	496522	8067652	n/a	2
	495748	8066057	n/a	2
	492382	8076000	n/a	2
	493471	8072099	n/a	2
	500103	8071806	n/a	2
	495707	8072341	n/a	2
	497215	8075412	n/a	2
	497215	8075412	n/a	2
	497215	8075412	n/a	2
	499300	8071679	n/a	2
	496547	8073307	n/a	2
	494237	8076007	n/a	2
	502361	8067614	n/a	2
	501977	8064692	n/a	2
	502224	8063975	n/a	2
	496166	8073465	n/a	2
	495405	8074098	n/a	2
	499749	8073601	n/a	2
	492865	8075563	n/a	2
	498021	8068475	n/a	2
	498914	8068318	n/a	2
	497584	8075440	n/a	2
	503967	8070730	n/a	2
	503519	8070695	n/a	2

APPENDIX G: LOCATIONS AND POPULATIONS OF PRIORITY FLORA RECORDED WITHIN THE THUNDERBIRD PROJECT AREA

Ecologia Environment: 2012 - 2015 Surveys

Notes: Data extracted from Ecologia (2014, 2015); Survey – 1 and 2 (Ecologia 2014), 3 (Ecologia 2015)

Species	Location (GDA94, Zone 51)		Number of Plants	Survey
	Easting (mE)	Northing (mN)		
Triodia caelestialis (P3)	497574	8075714	n/a	2
	497004	8075953	n/a	2
	497183	8075890	n/a	2
	493341	8074570	n/a	2
	491539	8072602	n/a	2
	497985	8068005	n/a	2
	497865	8075466	n/a	2
	498001	8075549	n/a	2
	503097	8067697	n/a	2
	501772	8067538	n/a	2
	501241	8067496	n/a	2
	501960	8064274	n/a	2
	502916	8064085	n/a	2
	502636	8072555	n/a	2
	502523	8067699	n/a	1
	493955	8073234	n/a	1
	500545	8068053	n/a	1
	496085	8075978	n/a	1
	495950	8075987	n/a	1
	493242	8074375	n/a	1
	494332	8074125	n/a	1
	495997	8071422	n/a	1
	497314	8068357	n/a	1
	497776	8071234	n/a	1
	494080	8073582	n/a	1
	497409	8074676	n/a	1
	500192	8073619	n/a	1
	491807	8074300	n/a	1
	500022	8067396	n/a	1
	512037	8053110	300	3
	499689	8069847	1500	3
	501015	8069032	100	3
	502678	8067418	50	3
	512322	8051853	200	3
	512324	8051958	1000	3
	512185	8053074	50	3
	505982	8062571	1	3
	511403	8054250	20	3
	508905	8056914	50	3

APPENDIX G: LOCATIONS AND POPULATIONS OF PRIORITY FLORA RECORDED WITHIN THE THUNDERBIRD PROJECT AREA

Ecologia Environment: 2012 - 2015 Surveys

Notes: Data extracted from Ecologia (2014, 2015); Survey – 1 and 2 (Ecologia 2014), 3 (Ecologia 2015)

Species	Location (GDA94, Zone 51)		Number of Plants	Survey
	Easting (mE)	Northing (mN)		
Triodia caelestialis (P3)	503921	8066082	100	3
	500946	8069120	200	3
	500798	8069186	100	3
	500656	8069273	100	3
	500373	8069441	50	3
	500273	8069488	100	3
	499926	8069682	100	3
	499834	8069766	1000	3
	512216	8052028	1000	3
	499512	8069908	100	3
	499685	8069931	500	3
	499908	8069827	1000	3
	500036	8069802	500	3
	502526	8067594	50	3
	502306	8067938	100	3

APPENDIX H

Department of Parks and Wildlife

Threatened and Priority Flora Report Forms

Pterocaulon intermedium (p3)

Triodia caelestialis (P3)

Department of Parks and Wildlife

Threatened and Priority Flora Report Form

Version 1.2 August 2013

Please complete as much of the form as possible.
For information on how to complete the form please refer to the Threatened & Priority Flora Report Form (TPRF) manual on the DPaW website at http://www.dpaw.wa.gov.au/

TAXON: Pterocaulon intermedium **TPFL Pop. No:**

OBSERVATION DATE: 21-26/06/2016 **CONSERVATION STATUS:** P3 New population ☒

OBSERVER/S: David Angus, Natalie Murdock, Jeffry Cargill **PHONE:** 08 9257 1625

ROLE: Botanist / Ecologist **ORGANISATION:** Mattiske Consulting Pty Ltd

DESCRIPTION OF LOCATION (Provide at least nearest town/named locality, and the distance and direction to that place)**:**

Survey area located on Dampier Peninsula, within Mt. Jowlaenga Station and Yeeda Stations, approximately midway between Broome and Derby. The survey area was approximately 19,000 ha.

Reserve No:

DISTRICT: Kimberley **LGA:** Broome Land manager present: ☐

DATUM:
GDA94 / MGA94 ☒
AGD84 / AMG84 ☐
WGS84 ☐
Unknown ☐

COORDINATES: (If UTM coords provided, **Zone** is also required)
DecDegrees ☐ DegMinSec ☐ UTMs ☒
Lat / Northing: see attcahed list
Long / Easting: see attcahed list
Zone: 51

METHOD USED:
GPS ☒ Differential GPS ☐ Map ☐
No. satellites: Map used:
Boundary polygon captured: ☐ Map scale:

LAND TENURE:
Nature reserve ☐ Timber reserve ☐ Private property ☐ Rail reserve ☐ Shire road reserve ☐
National park ☐ State forest ☐ Pastoral lease ☒ MRWA road reserve ☐ Other Crown reserve ☐
Conservation park ☐ Water reserve ☐ UCL ☐ SLK/Pole _____ to _____ Specify other: _____

AREA ASSESSMENT: Edge survey ☐ Partial survey ☒ Full survey ☐ Area observed (m²): _____

EFFORT: Time spent surveying (minutes): _____ No. of minutes spent / 100 m²: _____

POP'N COUNT ACCURACY: Actual ☒ Extrapolation ☐ Estimate ☐

Count method: (Refer to field manual for list) _____

WHAT COUNTED: Plants ☒ Clumps ☐ Clonal stems ☐

TOTAL POP'N STRUCTURE:

	Mature:	Juveniles:	Seedlings:	Totals:
Alive	62			62
Dead				

Area of pop (m²): 17,500

Note: Pls record count as numbers (not percentages) for database.

QUADRATS PRESENT: No. 7 Size 50 x 50 m Data attached ☐ Total area of quadrats (m²): 17,500

Summary Quad. Totals: Alive				

REPRODUCTIVE STATE: Clonal ☐ Vegetative ☐ Flowerbud ☒ Flower ☒
Immature fruit ☐ Fruit ☐ Dehisced fruit ☐ Percentage in flower: approx 90%

CONDITION OF PLANTS: Healthy ☒ Moderate ☒ Poor ☐ Senescent ☐

COMMENT:

THREATS - type, agent and supporting information: E.g. clearing, too frequent fire, weed, disease. Refer to field manual for list of threats & agents. **Specify agent** where relevant. **Rate current and potential threat impact:** N=Nil, L=Low, M=Medium, H=High, E=Extreme **Estimate time to potential impact:** S=Short (<12mths), M=Medium (<5yrs), L=Long (5yrs+)	**Current impact (N-E)**	**Potential Impact (L-E)**	**Potential Threat Onset (S-L)**
• Fire Parts of entire survey area burnt within last 12 months, parts unburint for more than 10 years. Fire events occur every year on portion of the survey area	L	M	M
• Mining Sheffield Resources mineral sand mining operation - potential for vegetation clearing leading to some direct and indiret imopacts to local populations	L	L-M	M
•			

Please return completed form to **Species And Communities Branch** DPaW,
Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983
RECORDS: Please forward to **Flora Administrative Officer,** Species and Communities Branch.

Record entered by:_____ **Sheet No.:**_____ **Record Accepted in Database** ☐

Department of Parks and Wildlife

Threatened and Priority Flora Report Form

Version 1.2 August 2013

HABITAT INFORMATION: (Check more than one box for combinations or where necessary)

LANDFORM:	ROCK TYPE:	LOOSE ROCK:	SOIL TYPE:	SOIL COLOUR:	DRAINAGE:
Crest ☐	Granite ☐	(on soil surface; e.g. gravel, quartz fields)	Sand ☒	Red ☒	Well drained ☒
Hill ☐	Dolerite ☐		Sandy loam ☐	Brown ☒	Seasonally inundated ☐
Ridge ☐	Laterite ☐	0-10% ☒	Loam ☐	Yellow ☐	Permanently inundated ☐
Outcrop ☐	Ironstone ☐	10-30% ☐	Clay loam ☐	White ☐	Tidal ☐
Slope ☐	Limestone ☐	30-50% ☐	Light clay ☐	Grey ☒	
Flat ☒	Quartz ☐	50-100% ☐	Peat ☐	Black ☐	
Open depression ☐					
Drainage line ☒	Specify other:		Specify other:	Specify other:	Specify other:
Closed depression ☐					
Wetland ☐					

Specific Landform Element: (Refer to field manual for additional values)

CONDITION OF SOIL:

Dry ☐ Moist ☒ Waterlogged ☐ Inundated ☐ Cracked ☐ Saline ☐ Other:

VEGETATION CLASSIFICATION:* E.g. **1**. Banksia woodland (B. attenuata, B. ilicifolia); **2**. Open shrubland (Hibbertia sp., Acacia spp.) **3**. Isolated clumps of sedges (Mesomelaena tetragona)	1. Erythrophleum chlorostachys, Brachychiton diversifolius subsp. diversifolius and Corymbia greeniana low-mid open woodland
	2. Acacia tumida var. tumida, Bauhinia cunninghamii and Dodonaea hispidula var. arida tall sparse shrubland
	3. Triodia caelestialis (P3), Triodia schinzii and Eriachne obtusa mid sparse tussock grassland
	4.
ASSOCIATED SPECIES: Other (non-dominant) spp	Corymbia zygophylla, Dolichandrone heterophylla
	Grevillea pyramidalis subsp. pyramidalis, Grevillea refracta subsp. refracta,
	Microstachys chamaelea, Solanum cunninghamii, Waltheria indica
	Chrysopogon fallax, Chrysopogon pallidus, Eragrostis eriopoda, Sorghum timorense

* Please record up to four of the most representative vegetation layers (with up to three dominant species in each layer). Structural Formations should follow 2009 *Australian Soil and Land Survey Field Handbook* guidelines – refer to field manual for further information and structural formation table.

CONDITION OF HABITAT: Pristine ☐ Excellent ☒ Very good ☒ Good ☐ Degraded ☐ Completely degraded ☐

COMMENT:

FIRE HISTORY: **Last Fire:** Season/Month: _____ Year: ~2010 **Fire Intensity:** High ☒ Medium ☒ Low ☐ No signs of fire ☒

FENCING: Not required ☒ Present ☐ Replace / repair ☐ Required ☐ Length req'd: _____

ROADSIDE MARKERS: Not required ☒ Present ☐ Replace / reposition ☐ Required ☐ Quantity req'd: _____

OTHER COMMENTS: (Please include recommended management actions and/or implemented actions - include date. Also include details of additional data available, and how to locate it.)

List of co-ordinates and associated site information attached from multiple locations recorded in the survey area

Please return completed form to **Species And Communities Branch** DPaW,
Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983
RECORDS: Please forward to **Flora Administrative Officer,** Species and Communities Branch.

Record entered by:_____ **Sheet No.:**_____ **Record Accepted in Database** ☐

Department of Parks and Wildlife

Threatened and Priority Flora Report Form

Version 1.2 August 2013

DRF PERMIT/ LICENCE No: SLO11706, SLO11719, SLO11715

Note if only observing plants (i.e. no specimens or plant matieral is taken) then no permit/licence is required. For further information on permit and licening requirements see the Threatened Flora and Wildlife Licensing pages on DPaW's website. Any actions carried out under licence/permit should be recorded above in the OTHER COMMENTS section.

SPECIMEN: Collectors No: WA Herb. ☐ Regional Herb. ☐ District Herb. ☐ Other:

ATTACHED: Map ☐ Mudmap ☐ Photo ☐ GIS data ☒ Field notes ☐ Other:

COPY SENT TO: Regional Office ☐ District Office ☐ Other:

Submitter of record: David Angus **Role:** Senior Botanist

Signature: DA **Date submitted:** 9/09/2016

Please return completed form to **Species And Communities Branch** DPaW,
Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983
RECORDS: Please forward to **Flora Administrative Officer,** Species and Communities Branch.

Record entered by:_____ **Sheet No.:**_____ **Record Accepted in Database** ☐

Threatened and Priority Flora report Form – Attachment – *Pterocaulon intermedium* (P3)

Species	Quadrat Reference	Location (GDA94, Zone 51)		Number of Plants[1]
		Easting (mE)	Northing (mN)	
Pterocaulon intermedium (P3)	Opportunistic	504415	8070743	1
	Opportunistic	500141	8070719	1
	Opportunistic	491113	8076144	1
	Opportunistic	498700	8076078	1
	TB017	499923	8076197	13
	TB052	504458	8070740	5
	TB054	503905	8070626	25
	TB064	505040	8069200	3
	TB118	506340	8064660	5
	TB142	513606	8050948	2
	TB148	515453	8049943	5

Department of Parks and Wildlife

Threatened and Priority Flora Report Form

Version 1.2 August 2013

Please complete as much of the form as possible.
For information on how to complete the form please refer to the Threatened & Priority Flora Report Form (TPRF) manual on the DPaW website at http://www.dpaw.wa.gov.au/

TAXON: Triodia caelestialis **TPFL Pop. No:**

OBSERVATION DATE: 21-26/06/2016 **CONSERVATION STATUS:** P3 New population ☒

OBSERVER/S: David Angus, Natalie Murdock, Jeffry Cargill, Adrian Barrett **PHONE:** 08 9257 1625

ROLE: Botanist / Ecologist **ORGANISATION:** Mattiske Consulting Pty Ltd

DESCRIPTION OF LOCATION (Provide at least nearest town/named locality, and the distance and direction to that place)**:**

Survey area located on Dampier Peninsula, within Mt. Jowlaenga Station and Yeeda Stations, approximately midway between Broome and Derby. The survey area was approximately 19,000 ha.

Reserve No:

DISTRICT: Kimberley **LGA:** Broome Land manager present: ☐

DATUM:
GDA94 / MGA94 ☒
AGD84 / AMG84 ☐
WGS84 ☐
Unknown ☐

COORDINATES: (If UTM coords provided, **Zone** is also required)
DecDegrees ☐ DegMinSec ☐ UTMs ☒
Lat / Northing: see attcahed list
Long / Easting: see attcahed list
Zone: 51

METHOD USED:
GPS ☒ Differential GPS ☐ Map ☐
No. satellites: Map used:
Boundary polygon captured: ☐ Map scale:

LAND TENURE:
Nature reserve ☐ Timber reserve ☐ Private property ☐ Rail reserve ☐ Shire road reserve ☐
National park ☐ State forest ☐ Pastoral lease ☒ MRWA road reserve ☐ Other Crown reserve ☐
Conservation park ☐ Water reserve ☐ UCL ☐ SLK/Pole _____ to _____ Specify other: _____

AREA ASSESSMENT: Edge survey ☐ Partial survey ☒ Full survey ☐ Area observed (m²): _____

EFFORT: Time spent surveying (minutes): _____ No. of minutes spent / 100 m²: _____

POP'N COUNT ACCURACY: Actual ☒ Extrapolation ☐ Estimate ☐

Count method: (Refer to field manual for list) _____

WHAT COUNTED: Plants ☒ Clumps ☒ Clonal stems ☐

TOTAL POP'N STRUCTURE:

	Mature:	Juveniles:	Seedlings:	Totals:
Alive	120,492			120,492
Dead				

Area of pop (m²): 202,500

Note: Pls record count as numbers (not percentages) for database.

QUADRATS PRESENT: No. 81 Size 50 x 50 m Data attached ☐ Total area of quadrats (m²): 202,500

Summary Quad. Totals: Alive				

REPRODUCTIVE STATE: Clonal ☐ Vegetative ☐ Flowerbud ☐ Flower ☒
Immature fruit ☐ Fruit ☐ Dehisced fruit ☐ Percentage in flower: approx 20%

CONDITION OF PLANTS: Healthy ☒ Moderate ☒ Poor ☒ Senescent ☐

COMMENT:

THREATS - type, agent and supporting information: E.g. clearing, too frequent fire, weed, disease. Refer to field manual for list of threats & agents. **Specify agent** where relevant. **Rate current and potential threat impact:** N=Nil, L=Low, M=Medium, H=High, E=Extreme **Estimate time to potential impact:** S=Short (<12mths), M=Medium (<5yrs), L=Long (5yrs+)	**Current impact (N-E)**	**Potential Impact (L-E)**	**Potential Threat Onset (S-L)**
• Fire Parts of entire survey area burnt within last 12 months, parts unburint for more than 10 years. Fire events occur every year on portion of the survey area	L	M	M
• Mining Sheffield Resources mineral sand mining operation - potential for vegetation clearing leading to some direct and indiret imopacts to local populations	L	L-M	M
•			

Please return completed form to **Species And Communities Branch** DPaW,
Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983
RECORDS: Please forward to **Flora Administrative Officer,** Species and Communities Branch.

Record entered by:_____ **Sheet No.:**_____ **Record Accepted in Database** ☐

Department of Parks and Wildlife

Threatened and Priority Flora Report Form

Version 1.2 August 2013

HABITAT INFORMATION: (Check more than one box for combinations or where necessary)

LANDFORM:	ROCK TYPE:	LOOSE ROCK:	SOIL TYPE:	SOIL COLOUR:	DRAINAGE:
Crest ☐	Granite ☐	(on soil surface; e.g. gravel, quartz fields)	Sand ☒	Red ☒	Well drained ☒
Hill ☒	Dolerite ☐		Sandy loam ☐	Brown ☒	Seasonally inundated ☐
Ridge ☒	Laterite ☐	0-10% ☒	Loam ☐	Yellow ☐	Permanently inundated ☐
Outcrop ☐	Ironstone ☐	10-30% ☒	Clay loam ☐	White ☐	Tidal ☐
Slope ☐	Limestone ☐	30-50% ☐	Light clay ☐	Grey ☒	
Flat ☒	Quartz ☐	50-100% ☐	Peat ☐	Black ☐	
Open depression ☐					
Drainage line ☒					
Closed depression ☐	Specify other: Sandstone		Specify other: clayey sand	Specify other:	Specify other:
Wetland ☐					

Specific Landform Element: (Refer to field manual for additional values)

CONDITION OF SOIL:

Dry ☐ Moist ☒ Waterlogged ☐ Inundated ☐ Cracked ☐ Saline ☐ Other:

VEGETATION CLASSIFICATION:* E.g. **1**. Banksia woodland (B. attenuata, B. ilicifolia); **2**. Open shrubland (Hibbertia sp., Acacia spp.) **3**. Isolated clumps of sedges (Mesomelaena tetragona)	1. Erythrophleum chlorostachys, Brachychiton diversifolius subsp. diversifolius and Corymbia greeniana low-mid open woodland
	2. Acacia tumida var. tumida, Bauhinia cunninghamii and Dodonaea hispidula var. arida tall sparse shrubland
	3. Triodia caelestialis (P3), Triodia schinzii and Eriachne obtusa mid sparse tussock grassland
	4.
ASSOCIATED SPECIES: Other (non-dominant) spp	Corymbia zygophylla, Dolichandrone heterophylla
	Grevillea pyramidalis subsp. pyramidalis, Grevillea refracta subsp. refracta,
	Microstachys chamaelea, Solanum cunninghamii, Waltheria indica
	Chrysopogon fallax, Chrysopogon pallidus, Eragrostis eriopoda, Sorghum timorense

* Please record up to four of the most representative vegetation layers (with up to three dominant species in each layer). Structural Formations should follow 2009 *Australian Soil and Land Survey Field Handbook* guidelines – refer to field manual for further information and structural formation table.

CONDITION OF HABITAT: Pristine ☐ Excellent ☒ Very good ☒ Good ☒ Degraded ☐ Completely degraded ☐

COMMENT:

FIRE HISTORY: **Last Fire:** Season/Month: ~2005 Year: ~2015 **Fire Intensity:** High ☒ Medium ☒ Low ☐ No signs of fire ☒

FENCING: Not required ☒ Present ☐ Replace / repair ☐ Required ☐ Length req'd: _____

ROADSIDE MARKERS: Not required ☒ Present ☐ Replace / reposition ☐ Required ☐ Quantity req'd: _____

OTHER COMMENTS: (Please include recommended management actions and/or implemented actions - include date. Also include details of additional data available, and how to locate it.)

List of co-ordinates and associated site information attached from multiple locations recorded in the survey area

Specimens were submitted to WAHERB for paid ID for verification purposes

Please return completed form to **Species And Communities Branch** DPaW,
Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983
RECORDS: Please forward to **Flora Administrative Officer,** Species and Communities Branch.

Record entered by:_____ **Sheet No.:**_____ **Record Accepted in Database** ☐

Department of Parks and Wildlife

Threatened and Priority Flora Report Form

Version 1.2 August 2013

DRF PERMIT/ LICENCE No: SLO11706, SLO11719, SLO11715, SLO11707

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SPECIMEN: Collectors No: WA Herb. ☐ Regional Herb. ☐ District Herb. ☐ Other:

ATTACHED: Map ☐ Mudmap ☐ Photo ☐ GIS data ☒ Field notes ☐ Other:

COPY SENT TO: Regional Office ☐ District Office ☐ Other:

Submitter of record: David Angus **Role:** Senior Botanist

Signature: DA **Date submitted:** 9/09/2016

Please return completed form to **Species And Communities Branch** DPaW,
Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983
RECORDS: Please forward to **Flora Administrative Officer,** Species and Communities Branch.

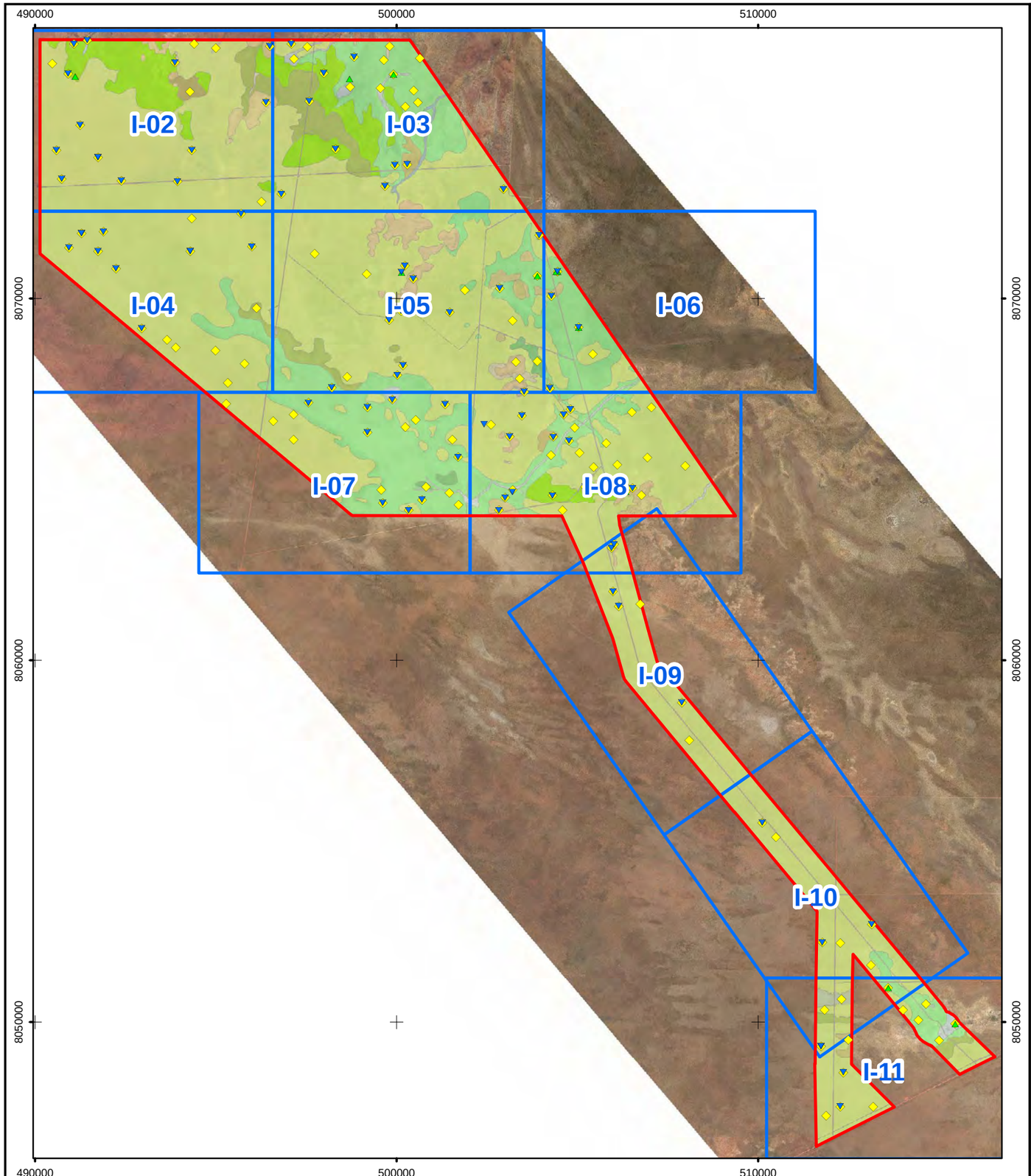
Record entered by:_____ **Sheet No.:**_____ **Record Accepted in Database** ☐

Threatened and Priority Flora report Form – Attachment – *Triodia caelestialis* (P3)

Species	Quadrat Reference	Location (GDA94, Zone 51)		Number of Plants
		Easting (mE)	Northing (mN)	
Triodia caelestialis (P3)	Opportunistic	502431	8066522	$10,000^2$
	Opportunistic	503209	8064645	$10,500^2$
	Opportunistic	500141	8070719	1
	TB001	491459	8077134	4
	TB002	491087	8077033	$3,000^2$
	TB003	497092	8077031	$3,000^2$
	TB006	496500	8076972	$5,000^2$
	TB009	498831	8076669	1
	TB013	493878	8076519	200
	TB015	497993	8076226	$2,500^2$
	TB016	490921	8076219	$12,000^2$
	TB022	497596	8075454	$10,000^2$
	TB023	496400	8075420	250
	TB026	491250	8074800	$3,000^2$
	TB027	498319	8074128	51
	TB028	490600	8074100	26
	TB029	494343	8074100	50
	TB030	491751	8073892	150
	TB031	500297	8073706	1
	TB032	499959	8073689	1
	TB033	490746	8073301	150
	TB034	492397	8073255	26
	TB035	493956	8073228	100
	TB036	499684	8073106	1
	TB037	502973	8073018	$3,000^2$
	TB038	496823	8072877	100
	TB040	495709	8072344	26
	TB042	491903	8071849	1
	TB043	491300	8071800	26
	TB044	503951	8071750	1
	TB045	496000	8071428	26
	TB046	490950	8071403	26
	TB047	491751	8071303	100
	TB048	494300	8071300	26
	TB050	500241	8070901	11
	TB051	492250	8070824	$10,000^2$
	TB052	504458	8070740	150
	TB055	500466	8070546	150
	TB056	502860	8070275	1
	TB058	504291	8070070	$1,000^2$
	TB060	500136	8069658	$1,000^2$
	TB061	501478	8069607	$3,000^2$
	TB062	499800	8069400	100

	TB064	505040	8069200	700
	TB065	492955	8069182	1,000[2]
	TB073	500190	8068149	26
	TB074	500030	8067880	11,000[2]
	TB078	498219	8067535	90
	TB079	504247	8067511	200
	TB080	503542	8067420	5,000[2]
	TB081	499893	8067199	100
	TB082	497569	8067109	11
	TB084	501349	8067066	51
	TB086	499200	8066998	250
	TB087	504821	8066933	51
	TB090	504626	8066787	700
	TB091	503478	8066764	55
	TB097	499202	8066303	200
	TB098	503134	8066177	100
	TB099	504349	8066171	1
	TB102	504774	8066063	13,000[2]
	TB106	501710	8065607	1,500[2]
	TB112	505222	8064801	150
	TB114	506534	8064755	11
	TB120	504323	8064554	150
	TB122	503009	8064490	130
	TB123	500719	8064436	1,200[2]
	TB124	499626	8064352	100
	TB127	502842	8064142	100
	TB128	500342	8064136	1,000[2]
	TB129	506031	8063200	1
	TB130	505951	8063100	150
	TB131	506000	8061900	100
	TB133	506152	8061498	26
	TB134	507898	8058832	2,000[2]
	TB136	510122	8055501	11
	TB138	513148	8052699	51
	TB139	511789	8052190	1,500[2]
	TB151	511756	8049321	900[2]
	TB152	512370	8048600	1
	TB153	512281	8047660	120

2 – population extrapolated by counting a 5 m x 5 m subset of 50 x 50 m quadrat



Vegetation Legend

W1 *Melaleuca viridiflora*, *Melaleuca alsophila* and *Eucalyptus tectifica* low sparse woodland over *Bauhinia cunninghamii*, *Carissa lanceolata* and *Atalaya hemiglauca* tall sparse shrubland over *Ectrosia schultzii*, *Eriachne sulcata* and *Cyperus conicus* low sparse grassland on grey-white to light brown sandy soils in drainage channels and low lying drainage areas.

W2 *Eucalyptus tectifica* mid open woodland over *Acacia plectocarpa* subsp. *plectocarpa* and *Grevillea pyramidalis* subsp. *pyramidalis* tall sparse shrubland over *Aristida holathera* subsp. *latifolia*, *Eriachne obtusa* and *Xerochloa laniflora* mid sparse grassland on light brown clayey sands in low lying drainage areas.

W3 *Corymbia dendromerinx*, *Eucalyptus tectifica* and *Corymbia greeniana* mid open woodland over *Dolichandrone heterophylla*, *Dodonaea hispidula* var. *arida* and *Grevillea pyramidalis* subsp. *pyramidalis* mid sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse hummock grassland on orange-brown clayey sands on flats and drainage areas.

W4 *Corymbia dendromerinx* mid open woodland over *Terminalia canescens*, *Calytrix exstipulata* and *Wrightia saligna* tall sparse shrubland over *Triodia caelestialis* (P3), *Triumfetta albida* and *Polycarpaea longiflora* mid open tussock grassland on brown sandy clay soils on mid-slopes to ridges of hills with sandstone outcropping.

W5 *Corymbia dendromerinx* mid open woodland over *Grevillea pyramidalis* subsp. *pyramidalis*, *Terminalia canescens* and *Waltheria indica* mid sparse shrubland over *Triodia caelestialis* (P3), *Sorghum plumosum* and *Hybanthus enneaspermus* subsp. *enneaspermus* low sparse tussock grassland on pale brown to orange-brown sandy clay loam soils on slopes and broad flat hill tops with sandstone outcropping.

W6 *Eucalyptus tectifica*, *Bauhinia cunninghamii* and *Brachychiton diversifolius* subsp. *diversifolius* mid open woodland over *Carissa lanceolata* and *Dolichandrone heterophylla* mid sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland on pale brown to grey brown sandy clay loams on flats.

W7 *Brachychiton diversifolius* subsp. *diversifolius* and *Eucalyptus tectifica* low open woodland over *Bauhinia cunninghamii*, *Acacia plectocarpa* subsp. *plectocarpa* and *Melaleuca viridiflora* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Aristida holathera* var. *holathera* mid sparse hummock grassland on pale orange-grey clayey sands on flats.

W8 *Erythrophleum chlorostachys*, *Brachychiton diversifolius* subsp. *diversifolius* and *Corymbia greeniana* mid open woodland over *Acacia tumida* var. *tumida*, *Bauhinia cunninghamii* and *Dodonaea hispidula* var. *arida* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland on orange-brown to red fine sandy soils on flats.

W8a *Erythrophleum chlorostachys*, *Brachychiton diversifolius* subsp. *diversifolius* and *Corymbia greeniana* mid open woodland over *Acacia tumida* var. *tumida*, *Bauhinia cunninghamii* and *Dodonaea hispidula* var. *arida* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland on orange-brown to red fine sandy soils in swale area subject to seasonal inundation.

W9 *Corymbia dendromerinx* low open woodland over *Grevillea pyramidalis* subsp. *pyramidalis*, *Microstachys chamaelea* and *Terminalia canescens* mid sparse shrubland over *Chrysopogon* sp. (*C. fallax* or *C. pallidus*), *Glycine tomentella* and *Sorghum plumosum* mid sparse grassland on orange-brown sandy clay with sandstone rocks and outcropping on hills.

W10 *Corymbia greeniana*, *Corymbia dendromerinx* and *Brachychiton diversifolius* subsp. *diversifolius* low open woodland over *Grevillea pyramidalis* subsp. *pyramidalis*, *Grevillea refracta* subsp. *refracta* and *Terminalia canescens* tall sparse shrubland over *Triodia caelestialis* (P3), *Solanum cunninghamii* and *Aristida hygrometrica* mid open tussock grassland on orange-brown clayey sands with occasional sandstone or ironstone rocks on flats and slopes associated with drainage areas.

W11 *Corymbia zygophylla* low open woodland over *Acacia tumida* var. *tumida* and *Erythrophleum chlorostachys* tall sparse shrubland over *Triodia schinzii* and *Microstachys chamaelea* low sparse grassland on orange-brown clayey sands on flats and slopes.

W12 *Corymbia greeniana*, *Eucalyptus tectifica* and *Corymbia dendromerinx* mid open woodland over *Dolichandrone heterophylla*, *Bauhinia cunninghamii* and *Acacia tumida* var. *tumida* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland, on brown clayey sands on flats and drainage channels.

W13 *Brachychiton diversifolius* subsp. *diversifolius*, *Erythrophleum chlorostachys* and *Corymbia dendromerinx* mid open woodland over *Grevillea refract* subsp. *refracta*, *Acacia monticola* and *Microstachys chamaelea* tall sparse shrubland over *Corchorus sidoides*, *Goodenia sepalosa* subsp. *sepalosa* and *Pterocaulon paradoxum* low sparse for bland on orange-brown clayey sands on flats

S1 *Acacia tumida* var. *tumida* low sparse shrubland over *Waltheria indica* and *Bauhinia cunninghamii* low isolated shrubs over *Ectrosia schultzii*, *Eriachne obtusa* and *Corchorus pumilio* low sparse grassland on pale grey sandy clay loam soils on flats and slopes.

CL *cleared*

Legend
- ▲ *Pterocaulon intermedium*
- ▼ *Triodia caelestialis*
- ◆ MCPL Sites 01/09/2016
- Thunderbird Survey Area
- Sheet_Layout_20160906_A3

Vegetation Communities
W1 W5 W8a W12
W2 W6 W9 W13
W3 W7 W10 S1
W4 W8 W11 CL

Note
Aerial Photography: Sheffield Resources (09/2015)
Quadrats: MCPL
Flora: MCPL
Vegetation: MCPL (08/2016)
Refer figure 2 for detailed vegetation

Client: Sheffield Resources Limited

N

0 1,000 2,000 m
Scale: 1:125,000
MGA94 (Zone 51)
CAD Ref: a2409_f50_12
Date: Sep 2016 | Rev: A | A3

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Thunderbird Mineral Sands Project
Vegetation
Legend and Sheet Layout

Appendix
I-01

490000 492000 494000 496000

8076000 8074000

TB001 TB002 TB006 TB013 TB016 Oppo3 TB023 TB026 TB028 TB029 TB030 TB030 TB033 TB034 TB035

W1 W3 W4 W5 W8 W9 W10 W11 W12 CL

490000 492000 494000 496000

Legend ▲ *Pterocaulon intermedium* ▼ *Triodia caelestialis* ◇ MCPL Sites 01/09/2016 □ ecologia Quadrats ▭ Thunderbird Survey Area	Note Aerial Photography: Sheffield Resources (09/2015) Quadrats: MCPL, ecologia Flora: MCPL, ecologia Vegetation: MCPL (08/2016) Refer figure 1 for detailed vegetation legend	Sheet Layout:	Client: Sheffield Resources Limited	N	0 200 400m Scale: 1:20,000 MGA94 (Zone 51) CAD Ref: a2409_f50_13 Date: Sep 2016 | Rev: A | A3

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Thunderbird Mineral Sands Project
Vegetation
Sheet 1 of 10

Appendix: **I-02**

498000 500000 502000 504000

8076000

8074000

TB003 TB009 TB015 TB017 Oppo TB022 TB027 TB032 TB031 TB036 TB037 TB038

W1 W3 W4 W5 W6 W7 W8 W10 W12 W13 CL

Legend
- *Pterocaulon intermedium*
- *Triodia caelestialis*
- MCPL Sites 01/09/2016
- ecologia Quadrats
- Thunderbird Survey Area

Note
Aerial Photography: Sheffield Resources (09/2015)
Quadrats: MCPL, ecologia
Flora: MCPL, ecologia
Vegetation: MCPL (08/2016)
Refer figure 1 for detailed vegetation legend

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Scale: 1:20,000
MGA94 (Zone 51)

CAD Ref: a2409_f50_13
Date: Sep 2016 | Rev: A | A3

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Thunderbird Mineral Sands Project
Vegetation
Sheet 2 of 10

Appendix:
I-03

490000 492000 494000 496000

8072000 8070000 8068000

TB040 TB043 TB043 TB042 TB046 TB047 TB045 TB048 TB048 TB051 TB065

W8 W7 CL W8 W12 W6 CL W6 W6

490000 492000 494000 496000

Legend
- *Pterocaulon intermedium*
- *Triodia caelestialis*
- MCPL Sites 01/09/2016
- ecologia Quadrats
- Thunderbird Survey Area

Note
Aerial Photography: Sheffield Resources (09/2015)
Quadrats: MCPL, ecologia
Flora: MCPL, ecologia
Vegetation: MCPL (08/2016)
Refer figure 1 for detailed vegetation legend

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Scale: 1:20,000
MGA94 (Zone 51)

CAD Ref: a2409_f50_13
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Thunderbird Mineral Sands Project
Vegetation
Sheet 3 of 10

Appendix:
I-04

498000 500000 502000 504000

8072000 8070000 8068000

W4 W6 W8 W5 W12 W1 W3 W7 S1 CL

TB044 TB050 Oppo Oppo2 TB054 TB055 TB056 TB060 TB061 TB062 TB073 TB074 TB078 TB080

Legend
- *Pterocaulon intermedium*
- *Triodia caelestialis*
- MCPL Sites 01/09/2016
- ecologia Quadrats
- Thunderbird Survey Area

Note
Aerial Photography: Sheffield Resources (09/2015)
Quadrats: MCPL, ecologia
Flora: MCPL, ecologia
Vegetation: MCPL (08/2016)
Refer figure 1 for detailed vegetation legend

Sheet Layout:

Client: Sheffield Resources Limited

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Scale: 1:20,000
MGA94 (Zone 51)
CAD Ref: a2409_f50_13
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Thunderbird Mineral Sands Project
Vegetation
Sheet 4 of 10

Appendix:
I-05

Legend

- *Pterocaulon intermedium*
- *Triodia caelestialis*
- MCPL Sites 01/09/2016
- ecologia Quadrats
- Thunderbird Survey Area

Note
Aerial Photography: Sheffield Resources (09/2015)
Quadrats: MCPL, ecologia
Flora: MCPL, ecologia
Vegetation: MCPL (08/2016)
Refer figure 1 for detailed vegetation legend

Sheet Layout:

Client: Sheffield Resources Limited

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Scale: 1:20,000
MGA94 (Zone 51)

CAD Ref: a2409_f50_13
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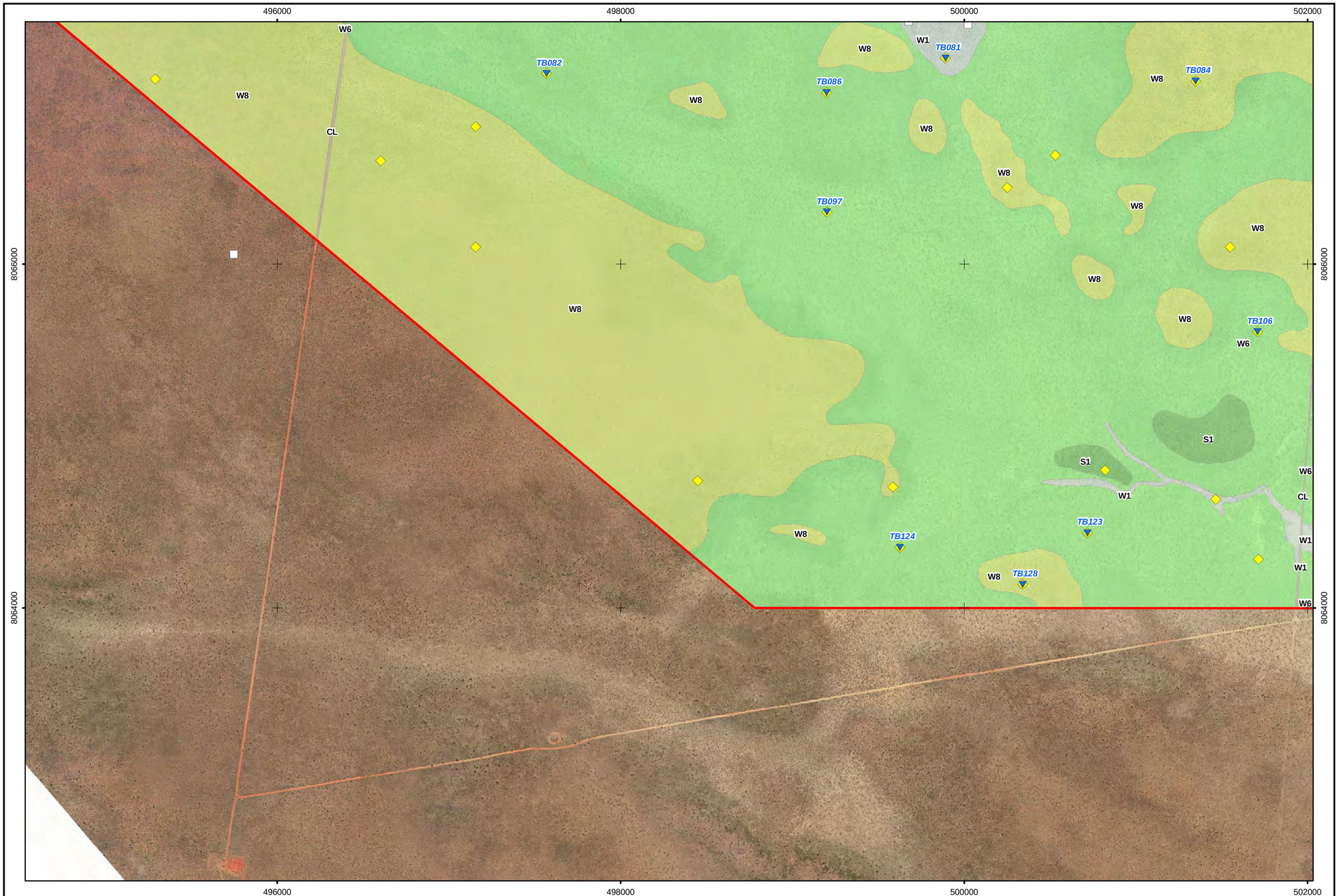
Thunderbird Mineral Sands Project
Vegetation
Sheet 5 of 10

Appendix:
I-06



Legend
- *Pterocaulon intermedium*
- *Triodia caelestialis*
- MCPL Sites 01/09/2016
- ecologia Quadrats
- Thunderbird Survey Area

Note
Aerial Photography: Sheffield Resources (09/2015)
Quadrats: MCPL, ecologia
Flora: MCPL, ecologia
Vegetation: MCPL (08/2016)
Refer figure 1 for detailed vegetation legend

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0 200 400m
Scale: 1:20,000
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Thunderbird Mineral Sands Project
Vegetation
Sheet 6 of 10

Appendix:
I-07

504000 506000 508000

8066000 8064000

W4 CL W9 W6 W7 W6 W6 W8 W8 W8 W6 W1 W8 W6 W6 W8 W6 W6 W8 W6 W6 W1 W6 W8 W8 W4 W4 W7 W6 W8 W4 W6 W8 CL W6 W8 W5 W10 W5 W10 W10 W1 W5 W8 W5 W6 W5 W6 W8 W8 W9 W1 W8 W7 W5 W5 W8 W9 W8 W8

TB091 TB087 TB090 TB098 TB099 TB102 TB112 TB114 TB118 TB120 TB122 TB127 TB129 TB130 Oppo Oppo

W4

Legend
- *Pterocaulon intermedium*
- *Triodia caelestialis*
- MCPL Sites 01/09/2016
- ecologia Quadrats
- Thunderbird Survey Area

Note
Aerial Photography: Sheffield Resources (09/2015)
Quadrats: MCPL, ecologia
Flora: MCPL, ecologia
Vegetation: MCPL (08/2016)
Refer figure 1 for detailed vegetation legend

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Scale: 1:20,000
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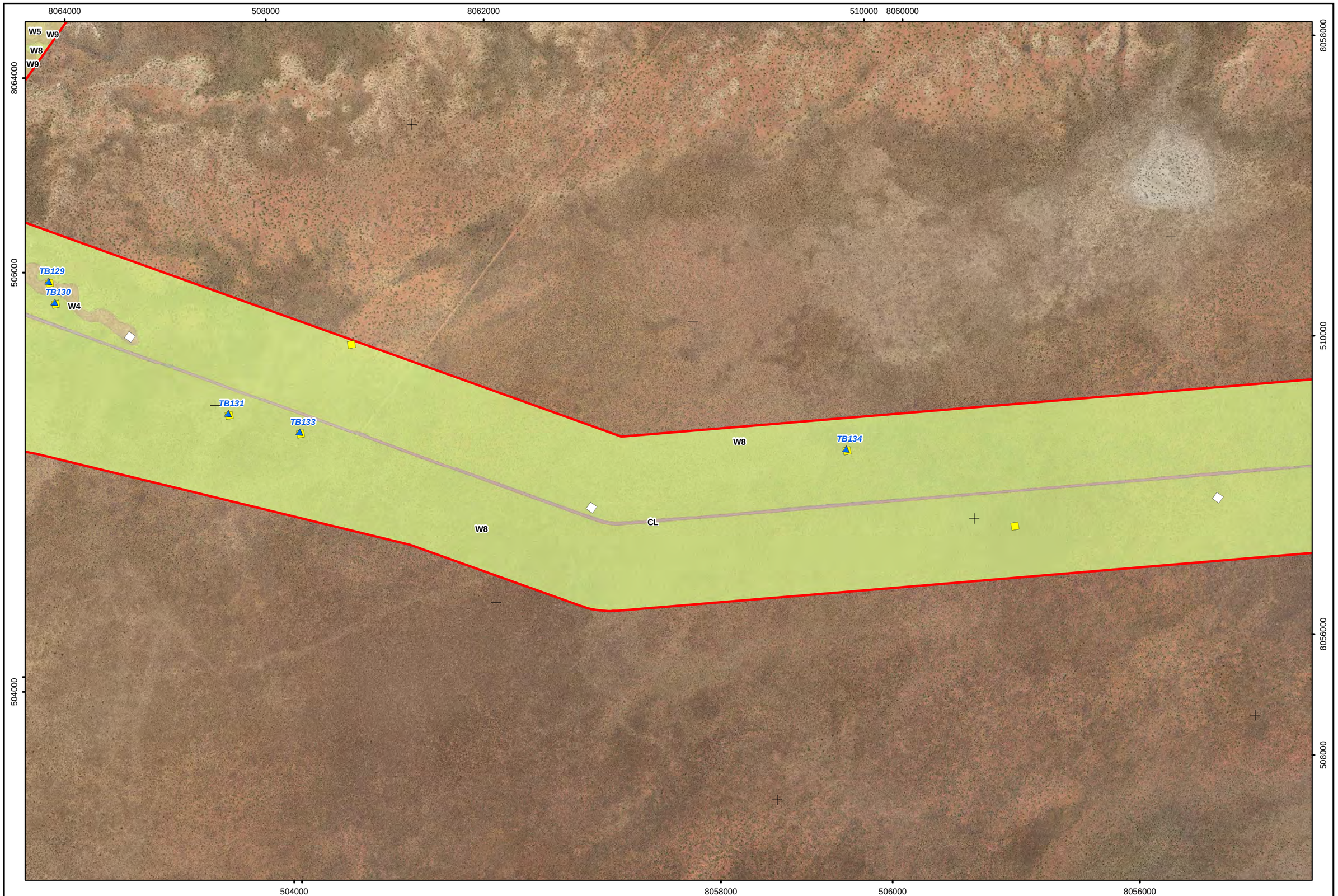
Thunderbird Mineral Sands Project
Vegetation
Sheet 7 of 10

Appendix:
I-08



Legend
- *Pterocaulon intermedium*
- *Triodia caelestialis*
- MCPL Sites 01/09/2016
- ecologia Quadrats
- Thunderbird Survey Area

Note
Aerial Photography: Sheffield Resources (09/2015)
Quadrats: MCPL, ecologia
Flora: MCPL, ecologia
Vegetation: MCPL (08/2016)
Refer figure 1 for detailed vegetation legend

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Scale: 1:20,000
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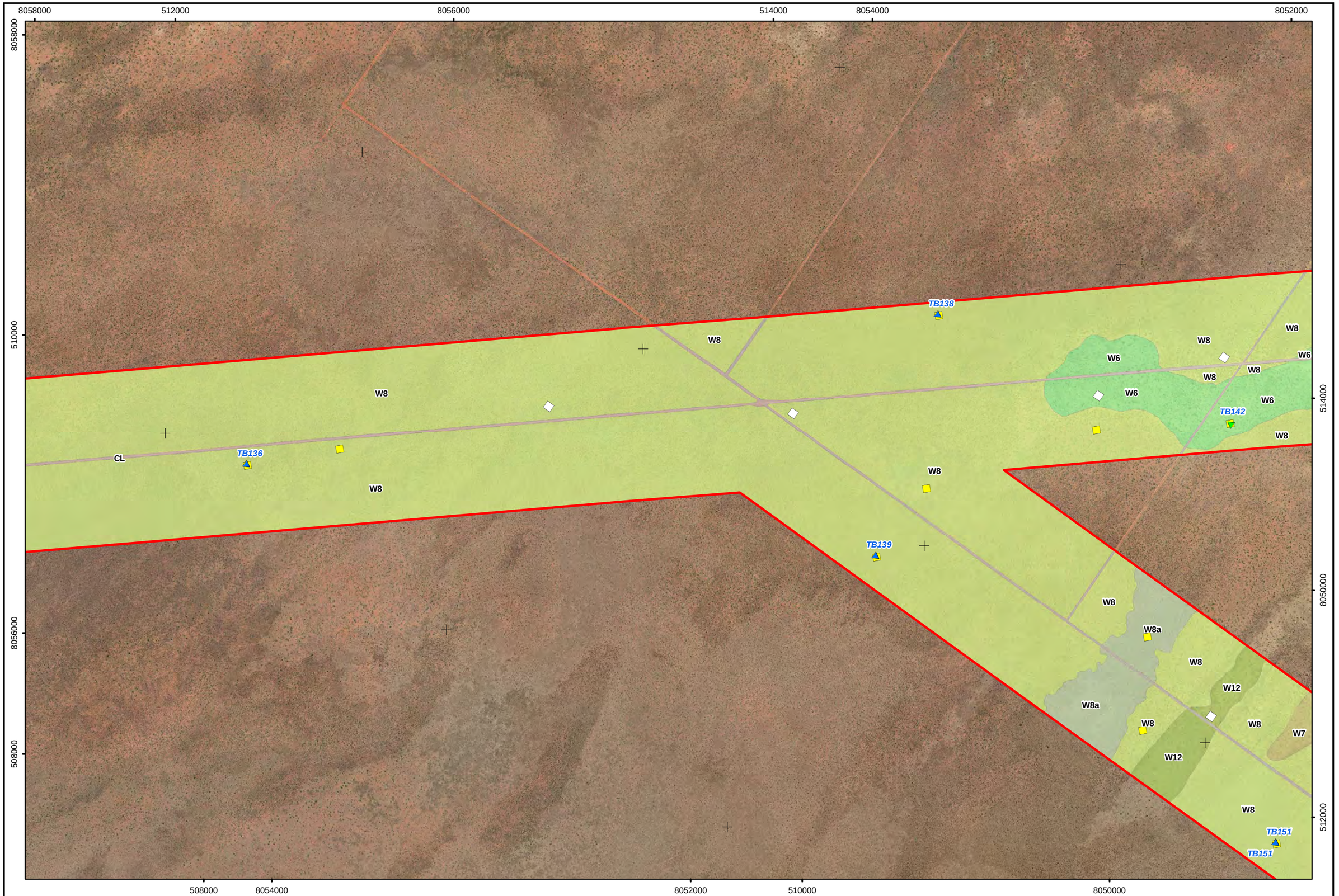
Vegetation
Sheet 8 of 10

Appendix:
I-09



Legend
- *Pterocaulon intermedium*
- *Triodia caelestialis*
- MCPL Sites 01/09/2016
- ecologia Quadrats
- Thunderbird Survey Area

Note
Aerial Photography: Sheffield Resources (09/2015)
Quadrats: MCPL, ecologia
Flora: MCPL, ecologia
Vegetation: MCPL (08/2016)
Refer figure 1 for detailed vegetation legend

Sheet Layout:

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0 200 400m
Scale: 1:20,000
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Thunderbird Mineral Sands Project
Vegetation
Sheet 9 of 10

Appendix:
I-10

512000 514000 516000

8050000 8048000

W8 W8 CL W8 W8 W6 W8 W8 TB142 W8 W8 W8a W8a W8 W8 W2 W6 W12 W12 W6 TB148 W1 CL W1 W6 W12 TB151 TB151 W12 W8 W7 W8 W8 W8 W8 TB152 W8 W8 W8 TB153 W8 W8

Note
Aerial Photography: Sheffield Resources (09/2015)
Quadrats: MCPL, ecologia
Flora: MCPL, ecologia
Vegetation: MCPL (08/2016)
Refer figure 1 for detailed vegetation legend

Sheet Layout:

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0 200 400m
Scale: 1:20,000
MGA94 (Zone 51)

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Thunderbird Mineral Sands Project
Vegetation
Sheet 10 of 10

Appendix:
I-11

APPENDIX J: VASCULAR PLANT SPECIES RECORDED IN EACH VEGETATION COMMUNITY IN THE THUNDERBIRD PROJECT AREA

Notes: * denotes introduced species; P1 - P5 denotes prioirty species

Species	Vegetation Community													
	S1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Abildgaardia schoenoides									x		x	x	x	
Abutilon hannii					x						x			
Abutilon otocarpum									x					
Acacia ?colei		x	x				x							
Acacia colei var. *colei*		x							x				x	x
Acacia colei var. *ileocarpa*													x	
Acacia drepanocarpa subsp. *drepanocarpa*									x				x	
Acacia drepanocarpa subsp. *latifolia*										x				
Acacia eriopoda											x		x	x
Acacia hippuroides	x			x		x	x	x	x	x	x		x	x
Acacia monticola				x	x	x	x	x	x	x	x		x	x
Acacia platycarpa	x	x		x	x	x	x	x	x	x	x		x	
Acacia plectocarpa subsp. *plectocarpa*			x	x			x	x	x					
Acacia stigmatophylla				x	x				x					x
Acacia stipuligera											x			
Acacia synchronicia							x							
Acacia ?tumida		x		x	x	x	x		x		x		x	
Acacia tumida var. *tumida*	x			x	x		x	x	x	x	x	x	x	
Acacia sp.							x		x					
Achyranthes aspera													x	
Adansonia gregorii											x			
Aeschynomene indica		x												
Alternanthera angustifolia		x												
Alysicarpus muelleri									x					
Amyema sanguinea var. *sanguinea*									x					
Amyema sp.						x								
Apocynaceae sp.		x												
Aristida contorta	x			x		x	x	x	x		x			
Aristida holathera									x		x		x	
Aristida holathera var. *holathera*		x			x		x	x	x		x		x	
Aristida holathera var. *latifolia*			x				x		x		x		x	
Aristida hygrometrica		x		x	x		x	x	x	x	x	x	x	
Aristida inaequiglumis		x		x			x		x				x	
Aristida aff. nitidula									x				x	
Aristida sp.								x			x		x	
Asteraceae sp.		x		x		x			x		x			
Atalaya hemiglauca		x		x	x	x	x		x	x	x		x	
Atalaya variifolia				x		x	x		x	x	x		x	
Atalaya sp.							x		x					
Bacopa floribunda													x	
Bauhinia cunninghamii	x	x	x	x	x	x	x	x	x		x	x	x	x
Blumea integrifolia		x											x	
Boerhavia gardneri									x					

APPENDIX J: VASCULAR PLANT SPECIES RECORDED IN EACH VEGETATION COMMUNITY IN THE THUNDERBIRD PROJECT AREA

Notes: * denotes introduced species; P1 - P5 denotes prioirty species

Species	Vegetation Community													
	S1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Bonamia linearis				x	x		x	x	x	x	x			
Bonamia sp.						x	x	x	x					
Bothriochloa sp.									x					
Brachychiton diversifolius								x			x		x	
Brachychiton diversifolius subsp. *diversifolius*	x	x		x		x	x	x	x	x	x	x	x	x
Breynia cernua	x										x			
Bridelia tomentosa											x			
Buchnera asperata		x		x	x	x			x	x	x		x	x
Buchnera linearis									x	x	x			
Buchnera ramosissima		x			x				x	x	x		x	
Buchnera urticifolia		x			x				x					
Bulbostylis barbata		x		x	x			x	x		x		x	
Byblis filifolia		x			x		x	x	x		x	x	x	x
Cajanus cinereus									x					
Cajanus marmoratus					x			x	x		x		x	
Calandrinia quadrivalvis		x	x					x	x		x			
Calandrinia strophiolata		x			x		x	x	x		x		x	
Calandrinia translucens									x					
Calytrix exstipulata				x	x	x	x		x	x	x			x
Capparis lasiantha		x					x							
Carissa lanceolata		x		x		x	x	x	x		x		x	
Cassytha capillaris					x				x					
Cassytha sp.					x	x	x	x		x				
* *Cenchrus ciliaris*					x					x				
Cenchrus elymoides									x	x				
Cenchrus elymoides var. *elymoides*									x					
Chamaecrista mimosoides		x												
Chamaecrista moorei									x					
Chamaecrista symonii					x			x	x		x	x	x	
Cheilanthes brownii					x									
Cheilanthes ?*nudiuscula*							x							
Chloris lobata		x											x	
Chrysopogon fallax		x				x	x	x	x	x				
Chrysopogon pallidus		x		x	x	x	x	x	x		x		x	x
Chrysopogon sp.		x				x			x	x	x	x		
Cleome tetrandra var. *tetrandra*									x		x			
Cleome viscosa					x	x			x	x				x
?*Clerodendrum floribundum*						x	x		x					
Clerodendrum floribundum var. *ovatum*											x			
Clerodendrum tomentosum var. *tomentosum*									x					
Codonocarpus cotinifolius									x					
Corchorus aestuans			x								x		x	
Corchorus ?*incanus*						x								

APPENDIX J: VASCULAR PLANT SPECIES RECORDED IN EACH VEGETATION COMMUNITY IN THE THUNDERBIRD PROJECT AREA

Notes: * denotes introduced species; P1 - P5 denotes prioirty species

Species	Vegetation Community													
	S1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Corchorus pumilio	x			x		x	x	x	x		x			
Corchorus sidoides									x		x			
Corchorus sidoides subsp. *vermicularis*		x		x	x	x	x	x	x		x	x	x	x
Corchorus tridens		x			x				x					
Corchorus sp.	x					x			x					
Corymbia dendromerinx		x		x	x	x	x	x	x	x	x		x	x
Corymbia flavescens					x			x			x		x	
Corymbia greeniana	x	x		x	x		x	x	x		x	x	x	x
Corymbia ?*polycarpa*							x							
Corymbia zygophylla		x			x				x		x	x		
Corymbia sp.							x	x	x					
Corynotheca micrantha											x			
Crosslandia setifolia									x					
Crotalaria brevis	x	x		x			x	x	x		x		x	x
Crotalaria crispata									x				x	
Crotalaria ?*medicaginea*									x					
Crotalaria medicaginea var. *neglecta*					x			x	x	x	x		x	x
Crotalaria ramosissima		x							x					
Crotalaria sp.		x											x	
Cullen balsamicum									x					
Cullen pustulatum													x	
Cullen sp.			x											
Cyanthillium cinereum											x			x
Cymbopogon ambiguus							x		x					
Cymbopogon bombycinus							x							
Cymbopogon procerus				x	x				x	x	x		x	x
Cynanchum carnosum									x					
**Cynodon dactylon*									x					
Cyperaceae sp.		x							x					
Cyperus carinatus		x												
Cyperus conicus		x		x			x		x				x	x
Cyperus latzii					x				x					x
Cyperus microcephalus					x	x				x				
Cyperus microcephalus subsp. *microcephalus*					x	x			x	x			x	
Cyperus nervulosus		x							x					
Cyperus pulchellus							x		x		x		x	
Cyperus tenuispica				x				x	x					
Cyperus sp. A		x					x							
Cyperus sp.									x					
Dactyloctenium radulans			x						x				x	
Denhamia cunninghamii				x		x			x		x			
Dentella misera									x		x			
Desmodium brownii	x	x	x						x					

APPENDIX J: VASCULAR PLANT SPECIES RECORDED IN EACH VEGETATION COMMUNITY IN THE THUNDERBIRD PROJECT AREA

Notes: * denotes introduced species; P1 - P5 denotes prioirty species

Species	Vegetation Community													
	S1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Desmodium filiforme					x		x		x		x		x	x
Dicliptera armata				x	x	x			x	x	x		x	x
Digitaria bicornis		x												
Digitaria brownii		x				x	x		x		x		x	
Digitaria ctenantha		x	x					x						
Dodonaea hispidula				x									x	
Dodonaea hispidula var. *arida*		x		x	x	x	x	x	x	x	x		x	
Dolichandrone heterophylla		x		x	x	x	x	x	x	x	x		x	
Drosera broomensis							x		x		x		x	x
Drosera derbyensis									x				x	
Drosera indica		x							x					
Ectrosia schultzii	x	x							x					
Ectrosia schultzii var. *schultzii*									x		x		x	
Ehretia saligna				x	x	x		x	x		x		x	x
Ehretia saligna var. *saligna*					x		x		x	x	x		x	
Eleocharis geniculata		x												
Eragrostis cumingii		x		x				x	x		x		x	
Eragrostis eriopoda		x			x		x		x		x		x	
Eragrostis exigua											x			
Eragrostis sp.									x				x	
Eragrostis tenellula							x							
Eriachne ciliata		x		x	x				x	x	x		x	
Eriachne melicacea					x		x	x	x	x	x			x
Eriachne obtusa	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Eriachne sulcata		x		x				x					x	
Eriachne sp. Dampier Peninsula (K. F. Kenneally 5946)					x	x			x	x	x		x	x
Eriachne sp.												x		
Erythrophleum chlorostachys		x		x	x		x	x	x		x	x	x	x
Eucalyptus camaldulensis		x												
Eucalyptus tectifica	x	x	x	x	x	x	x	x	x	x	x		x	x
Eucalyptus sp.						x				x				
Eulalia aurea		x												
Euphorbia hassallii					x	x	x		x				x	x
Euphorbia mitchelliana											x			
Euphorbia myrtoides				x							x			
Euphorbia psilosperma					x				x		x			
Euphorbia schultzii													x	
Euphorbia schultzii var. *comans*									x		x			
Euphorbia trigonosperma		x		x	x	x		x	x		x	x		
Euphorbia ?vaccaria			x						x					
Euphorbia vicina											x			
Euphorbia sp.			x	x	x	x			x				x	
Evolvulus alsinoides									x		x		x	

APPENDIX J: VASCULAR PLANT SPECIES RECORDED IN EACH VEGETATION COMMUNITY IN THE THUNDERBIRD PROJECT AREA

Notes: * denotes introduced species; P1 - P5 denotes prioirty species

Species	Vegetation Community													
	S1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Evolvulus alsinoides var. *decumbens*		x			x	x	x	x	x		x		x	
Evolvulus alsinoides var. *villosicalyx*			x	x				x	x		x	x		
Evolvulus sp.									x					
Ficus aculeata									x					
Ficus aculeata var. *indecora*									x		x			
Ficus platypoda					x				x	x				
Fimbristylis ammobia					x			x	x		x		x	
Fimbristylis caespitosa		x							x					
Fimbristylis dichotoma		x											x	
Fimbristylis littoralis		x											x	
Fimbristylis macrantha									x		x		x	
Fimbristylis microcarya									x		x			
Fimbristylis neilsonii					x				x		x		x	
Fimbristylis nuda													x	
Fimbristylis oxystachya								x	x					
Fimbristylis punctata							x						x	
Fimbristylis rara													x	
Fimbristylis schultzii		x												
Fimbristylis simulans				x					x	x	x		x	
Fimbristylis tetragona		x							x				x	
Fimbristylis trigastrocarya							x				x			
Fimbristylis sp.													x	
Flueggea virosa subsp. *melanthesoides*		x		x	x	x	x		x	x	x		x	x
Fuirena ciliaris		x							x				x	
Fuirena incrassata (P3)									x					
Fuirena nudiflora (P1)									x					
Galactia tenuiflora				x	x	x			x		x			x
Gardenia pyriformis subsp. *keartlandii*				x		x	x		x		x		x	
Glycine tomentella		x		x	x	x		x	x	x	x		x	
Gomphrena affinis		x				x			x					
Gomphrena brachystylis subsp. *pindanensis*					x	x	x							
Gomphrena canescens											x			x
Gomphrena canescens subsp. *canescens*		x		x	x	x	x	x	x	x	x		x	x
Gomphrena flaccida		x		x	x	x			x	x	x		x	
Gomphrena lanata					x				x				x	
Gomphrena leptoclada					x									
Gomphrena leptoclada subsp. *leptoclada*											x			x
Gomphrena sp.			x			x								
Goodenia armitiana									x		x		x	
Goodenia scaevolina						x	x	x	x		x		x	x
Goodenia sepalosa														x
Goodenia sepalosa var. *sepalosa*			x	x	x			x	x		x	x	x	x
Gossypium australe				x	x	x	x	x	x		x			x

APPENDIX J: VASCULAR PLANT SPECIES RECORDED IN EACH VEGETATION COMMUNITY IN THE THUNDERBIRD PROJECT AREA

Notes: * denotes introduced species; P1 - P5 denotes prioirty species

Species	Vegetation Community													
	S1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Grevillea pyramidalis					x				x		x			x
Grevillea pyramidalis subsp. *pyramidalis*			x	x	x	x	x	x	x	x	x		x	
Grevillea refracta subsp. *refracta*			x	x	x	x	x	x	x	x	x	x	x	x
Grevillea striata		x					x						x	
Grevillea sp.									x					
Gyrocarpus americanus							x							
Gyrocarpus americanus subsp. *pachyphyllus*									x					
Hakea arborescens				x		x	x		x		x		x	
Hakea macrocarpa						x	x		x		x		x	x
Hakea sp.								x						
Heliotropium cunninghamii									x				x	
Heliotropium dichotomum										x	x			
Heliotropium diversifolium								x			x			
Heliotropium foliatum									x		x			
Heliotropium glabellum					x	x	x		x					
Heliotropium leptaleum		x			x		x	x	x		x		x	
Heliotropium sp. A	x								x					
Heliotropium sp. B									x					
Heliotropium sp. C						x			x					
Heliotropium sp.													x	
Heteropogon contortus		x		x	x				x		x		x	x
Hibbertia gracilipes													x	
Hibiscus geranioides					x				x		x		x	x
Hibiscus leptocladus						x	x		x					
Hibiscus sp.		x					x		x					
Hybanthus aurantiacus				x	x		x	x	x	x	x		x	
Hybanthus enneaspermus subsp. *enneaspermus*					x	x	x	x	x		x			
?*Hybanthus* sp.				x		x								
Ichnocarpus frutescens					x									
Indigofera colutea									x		x			
Indigofera haplophylla				x	x	x			x		x			x
Indigofera hirsuta									x					
Indigofera linifolia			x		x		x	x	x		x		x	x
Indigofera linnaei			x											
Indigofera sp.			x						x					
Ipomoea coptica		x	x										x	
Ipomoea muelleri									x					
Ipomoea sp.									x					
Iseilema ?*fragile*								x						
Jacquemontia paniculata					x									
Jasminum molle				x					x				x	
Lipocarpha microcephala		x												
Ludwigia perennis		x		x										

APPENDIX J: VASCULAR PLANT SPECIES RECORDED IN EACH VEGETATION COMMUNITY IN THE THUNDERBIRD PROJECT AREA

Notes: * denotes introduced species; P1 - P5 denotes prioirty species

Species	Vegetation Community													
	S1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Malvaceae sp.	x	x				x	x	x	x	x				
**Malvastrum americanum*											x			
Marsdenia angustata									x		x			
?*Marsdenia viridiflora*							x		x	x				
Marsdenia viridiflora subsp. *tropica*									x		x		x	
Melaleuca alsophila		x	x					x	x				x	
Melaleuca nervosa							x		x		x	x	x	
Melaleuca viridiflora	x	x					x	x	x				x	
Melaleuca sp.	x		x				x		x					
Melhania oblongifolia				x	x	x			x					
Melochia corchorifolia		x												
Microstachys chamaelea				x	x	x	x	x	x	x	x	x	x	x
Mimulus uvedaliae var. *lutea*		x												
Mitrasacme connata									x				x	
Mitrasacme exserta							x		x		x			
Mitrasacme hispida													x	
Mitrasacme lutea									x		x			
Mitrasacme sp.							x							
Mnesithea formosa				x					x		x		x	
Murdannia graminea					x				x		x		x	x
Neptunia sp.		x												
Oldenlandia galioides		x									x		x	
Oldenlandia mitrasacmoides					x		x	x	x		x		x	x
Oldenlandia mitrasacmoides subsp. *mitrasacmoides*				x					x	x	x		x	
Opilia amentacea									x					
Panicum decompositum				x										
Paspalidium rarum									x					
Perotis rara				x							x		x	
Persoonia falcata					x		x	x	x		x			
?*Phyllanthus baccatus*				x										
Phyllanthus exilis									x		x			
Phyllanthus maderaspatensis									x					
Phyllanthus rhytidospermus				x					x		x		x	
Phyllanthus virgatus		x											x	
Phyllanthus sp.									x					
Planchonia careya	x						x		x					
Pluchea rubelliflora		x												
Pluchea ?tetranthera							x							
Poaceae sp.		x	x				x	x	x			x		
Polycarpaea corymbosa		x		x				x	x	x	x		x	
Polycarpaea longiflora					x	x			x	x	x		x	x
Polygala galeocephala									x		x			x
Polygala tepperi		x			x		x	x	x		x	x	x	

APPENDIX J: VASCULAR PLANT SPECIES RECORDED IN EACH VEGETATION COMMUNITY IN THE THUNDERBIRD PROJECT AREA

Notes: * denotes introduced species; P1 - P5 denotes prioirty species

Species	Vegetation Community													
	S1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Polymeria ambigua									x		x		x	
Portulaca bicolor									x		x			
Portulaca aff. *filifolia*									x					
**Portulaca pilosa*								x						
Premna acuminata				x					x	x	x		x	
Proteaceae sp.							x		x					
Pterocaulon intermedium (P3)		x	x	x			x		x		x		x	
Pterocaulon paradoxum				x			x		x		x	x	x	x
Pterocaulon serrulatum											x			
Pterocaulon serrulatum var. *velutinum*				x	x	x			x		x		x	
Pterocaulon sphacelatum				x				x	x	x	x		x	
Pterocaulon tricholobum					x				x		x		x	
Pterocaulon sp.				x									x	
Ptilotus corymbosus				x	x	x		x	x	x	x			
Ptilotus fusiformis									x		x			
Ptilotus lanatus		x		x			x		x		x			
Ptilotus polystachyus		x							x		x		x	
Ptilotus sp.													x	
Rhynchosia minima									x					
Rotala occultiflora		x												
Sacciolepis indica		x												
Santalum lanceolatum									x	x	x			x
Schizachyrium fragile				x	x		x	x	x		x		x	
Scleria brownii							x		x		x		x	x
Sehima nervosum	x		x				x	x	x					
Senna costata									x					
Senna notabilis									x					
Senna oligoclada				x					x					
Setaria apiculata									x	x	x		x	
Setaria surgens		x				x			x	x			x	
Sida hackettiana		x							x					
Sida rohlenae subsp. *occidentalis*					x	x	x	x	x		x	x		
Sida spinosa									x	x				
Solanum cleistogamum									x					
Solanum cunninghamii		x			x			x	x	x	x		x	x
Solanum dioicum		x	x						x					
Solanum lucani									x					
Solanum sp. A									x					
Solanum sp. B									x					
Sorghum plumosum		x	x	x	x	x	x		x	x	x	x	x	
Sorghum timorense	x	x		x	x		x	x	x		x		x	x
Spermacoce laevigata									x					
Spermacoce occidentalis				x	x		x		x		x	x	x	x

APPENDIX J: VASCULAR PLANT SPECIES RECORDED IN EACH VEGETATION COMMUNITY IN THE THUNDERBIRD PROJECT AREA

Notes: * denotes introduced species; P1 - P5 denotes prioirty species

Species	Vegetation Community													
	S1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Spermacoce sp.									x					
Sporobolus actinocladus							x							
Sporobolus australasicus		x		x					x					
Stackhousia intermedia		x							x		x		x	
Stemodia lathraia	x	x		x			x		x		x		x	
Stemodia lythrifolia				x	x				x		x	x	x	x
?*Stemodia* sp.											x			
Streptoglossa ?odora		x												
Striga curviflora		x			x		x		x		x		x	x
Striga squamigera									x					
**Stylosanthes hamata*		x	x	x	x	x	x	x	x		x		x	x
**Stylosanthes humilis*		x												
**Stylosanthes scabra*		x					x	x	x		x		x	
Synaptantha scleranthoides											x		x	
Tephrosia brachyodon var. *longifolia*									x					
Tephrosia crocea									x					
Tephrosia aff. *croccea*				x					x		x	x		
Tephrosia forrestiana													x	
Tephrosia leptoclada				x	x	x	x	x	x		x		x	x
Tephrosia remotiflora		x		x	x	x	x	x	x	x	x	x	x	
Tephrosia simplicifolia								x	x		x			x
Tephrosia sp. B Kimberley Flora (C.A. Gardner 7300)					x									
Tephrosia sp. C Kimberley Flora (K.F. Kenneally 5599)									x					
Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)		x							x		x		x	
Tephrosia sp. F Kimberley Flora (B.R. Maslin 5139)									x					
Tephrosia valleculata (P3)									x					x
Tephrosia sp.	x	x				x	x		x					
Terminalia canescens		x		x	x	x	x	x	x	x	x		x	x
Terminalia ferdinandiana									x		x			
Terminalia volucris														
Terminalia sp.					x		x		x	x				
Thaumastochloa major									x		x			
Thaumastochloa pubescens													x	
Thecanthes punicea											x			
Thysanotus chinensis		x					x							
Tinospora smilacina		x			x	x			x	x	x		x	x
Trachymene microcephala					x				x		x			
Trachymene oleracea subsp. *oleracea*									x					
Trianthema oxycalyptrum var. *oxycalyptrum*													x	
Trianthema pilosum		x		x	x		x	x	x		x	x	x	
Tribulopis angustifolia					x			x	x		x		x	x
Tribulopis pentandra									x					
Tribulus ranunculiflorus													x	

APPENDIX J: VASCULAR PLANT SPECIES RECORDED IN EACH VEGETATION COMMUNITY IN THE THUNDERBIRD PROJECT AREA

Notes: * denotes introduced species; P1 - P5 denotes prioirty species

Species	Vegetation Community													
	S1	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Trichodesma zeylanicum									x				x	
Trichodesma zeylanicum var. *latisepalum*									x					
Trichodesma zeylanicum var. *zeylanicum*		x							x		x		x	
* *Tridax procumbens*		x												
Triodia ?bynoei									x					
Triodia ?intermedia							x							
Triodia caelestialis (P3)	x	x		x	x	x	x	x	x	x	x		x	x
Triodia schinzii		x		x	x	x	x		x		x	x	x	x
Triodia "schinzii group"							x		x			x		
Triodia sp	x				x		x	x	x		x		x	
Triumfetta albida				x	x	x			x					
Triumfetta breviaculeata										x			x	
Triumfetta plumigera					x	x			x	x	x			
Triumfetta sp.				x										
Uraria lagopodioides		x				x	x	x	x					
Urochloa piligera		x												
Urochloa praetervisa									x					
Vachellia pachyphloia subsp. *brevipinnula*		x												
Velleia panduriformis									x					
Ventilago viminalis	x			x	x	x	x		x	x	x		x	
Vigna lanceolata									x		x			
Vigna lanceolata var. *filiformis*								x	x	x	x			
Waltheria indica	x	x	x	x	x	x	x	x	x	x	x	x	x	
Wrightia saligna		x		x	x	x	x	x	x	x	x		x	
Xenostegia tridentata				x										x
Xerochloa barbata								x						
Xerochloa imberbis		x												
Xerochloa laniflora		x	x				x						x	
Xyris complanata		x							x					
Yakirra australiensis		x		x	x			x	x				x	
Yakirra australiensis var. *australiensis*									x				x	
Yakirra australiensis var. *intermedia*					x				x		x			x
Yakirra pauciflora									x				x	
Zornia chaetophora									x			x		
Zornia prostrata								x	x		x		x	
Zornia prostrata var. *prostrata*					x			x	x	x	x		x	

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description

Vegetation map code: W1

Description

Melaleuca viridiflora, *Melaleuca alsophila* and *Eucalyptus tectifica* low sparse woodland over *Bauhinia cunninghamii*, *Carissa lanceolata* and *Atalaya hemiglauca* tall sparse shrubland over *Ectrosia schultzii*, *Eriachne sulcata* and *Cyperus conicus* low sparse grassland.

Statistically associated species

Shrubs: *Waltheria indica*

Grasses: *Aristida* sp., *Chrysopogon fallax, Chrysopogon pallidus, Eriachne obtusa*

Soils and Landforms: grey-white to light brown sandy soils in drainage channels and low lying drainage areas.

Outcropping: not present

Condition: poor to excellent

Area: 141.0203 ha

Proportion of survey area: 0.75 %

Number of Quadrats: 13

Average species richness: 21.15 ± 2.84 (s.e.m.)

Range of species richness: 8 to 43

Similarity Percentage: 35.69 %

Representative Photograph

Quadrat TB116

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description

Vegetation map code: W2

Description

Eucalyptus tectifica mid open woodland over *Acacia plectocarpa* subsp. *plectocarpa* and *Grevillea pyramidalis* subsp. *pyramidalis* tall sparse shrubland over *Aristida holathera* subsp. *latifolia*, *Eriachne obtusa* and *Xerochloa laniflora* mid sparse grassland.

Statistically associated species

no applicable

Soils and Landforms: light brown clayey sands in low lying drainage areas.

Outcropping: not present

Condition: very good

Area: 3.0769 ha

Proportion of survey area: 0.02 %

Number of Quadrats: 2

Average species richness: 20.00 ± 2.00 (s.e.m.)

Range of species richness: 18to 22

Similarity Percentage: 47.62 %

Representative Photograph

Quadrat TB144

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description

Vegetation map code: W3

Description

Corymbia dendromerinx, *Eucalyptus tectifica* and *Corymbia greeniana* mid open woodland over *Dolichandrone heterophylla*, *Dodonaea hispidula* var. *arida* and *Grevillea pyramidalis* subsp. *pyramidalis* mid sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse hummock grassland.

Statistically associated species

Trees: *Erythrophleum chlorostachys*

Shrubs: *Acacia tumida* var. *tumida, Bauhinia cunninghamii, Carissa lanceolata, Tephrosia remotiflora, Terminalia canescens, Waltheria indica*

Forbs: *Corchorus sidoides, Microstachys chamaelea*

Grasses: *Sorghum timorense*

Soils and Landforms: orange-brown clayey sands on flats and drainage areas.

Outcropping: not present

Condition: very good - excellent

Area: 35.7049 ha

Proportion of survey area: 0.19 %

Number of Quadrats: 8

Average species richness: 29.38 ± 3.44 (s.e.m.)

Range of species richness: 18 to 45

Similarity Percentage: 47.79 %

Representative Photograph

Quadrat TB005

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description

Vegetation map code: W4

Description

Corymbia dendromerinx mid open woodland over *Terminalia canescens*, *Calytrix exstipulata* and *Wrightia saligna* tall sparse shrubland over *Triodia caelestialis* (P3), *Triumfetta albida* and *Polycarpaea longiflora* mid open tussock grassland.

Statistically associated species

Trees: *Ehretia saligna* var. *saligna, Flueggea virosa* subsp. *melanthesoides*

Shrubs: *Acacia stigmatophylla, Grevillea pyramidalis* subsp. *pyramidalis*

Forbs: Glycine tomentella, Hybanthus aurantiacus

Grasses: *Cymbopogon procerus, Eriachne obtusa, Eriachne* sp. Dampier Peninsula (K.F.Kenneally 5946), *Sorghum timorense*

Sedges: *Cyperus microcephalus* subsp. *microcephalus*

Soils and Landforms: brown sandy clay soils on mid-slopes to ridges of hills with sandstone outcropping.

Outcropping: sandstone

Condition: excellent

Area: 271.9573 ha

Proportion of survey area: 1.44 %

Number of Quadrats: 10

Average species richness: 29.90 ± 2.69 (s.e.m.)

Range of species richness: 17 to 44

Similarity Percentage: 50.83 %

Representative Photograph

Quadrat TB129

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description

Vegetation map code: W5

Description

Corymbia dendromerinx mid open woodland over *Grevillea pyramidalis* subsp. *pyramidalis*, *Terminalia canescens* and *Waltheria indica* mid sparse shrubland over *Triodia caelestialis* (P3), *Sorghum plumosum* and *Hybanthus enneaspermus* subsp. *enneaspermus* low sparse tussock grassland.

Statistically associated species

Trees: *Eucalyptus tectifica, Wrightia saligna*

Shrubs: *Calytrix exstipulata*

Grasses: *Chrysopogon fallax, Eriachne obtusa, Eriachne* sp. Dampier Peninsula (K. F. Kenneally 5946)

Soils and Landforms: pale brown to orange-brown sandy clay loam soils on slopes and broad flat hill tops with sandstone outcropping.

Outcropping: sandstone

Condition: excellent

Area: 234.5105 ha

Proportion of survey area: 1.24 %

Number of Quadrats: 12

Average species richness: 21.17 ± 1.39 (s.e.m.)

Range of species richness: 14 to 27

Similarity Percentage: 46.90 %

Representative Photograph

Quadrat TB006

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description

Vegetation map code: W6

Description

Eucalyptus tectifica, *Bauhinia cunninghamii* and *Brachychiton diversifolius* subsp. *diversifolius* mid open woodland over *Carissa lanceolata* and *Dolichandrone heterophylla* mid sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland.

Statistically associated species

Trees: *Hakea arborescens, Melaleuca viridiflora*

Shrubs: *Acacia tumida* var. *tumida, Atalaya hemiglauca, Grevillea pyramidalis* subsp. *pyramidalis, Terminalia canescens*

Grasses: *Chrysopogon fallax, Chrysopogon pallidus*

Soils and Landforms: pale brown to grey brown sandy clay loams on flats.

Outcropping: not present

Condition: very good to excellent

Area: 3,432.0202 ha

Proportion of survey area: 18.17 %

Number of Quadrats: 26

Average species richness: 19.35 ± 1.62 (s.e.m.)

Range of species richness: 9 to 39

Similarity Percentage: 49.41 %

Representative Photograph

Quadrat TB025

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description

Vegetation map code: W7

Description

Brachychiton diversifolius subsp. *diversifolius* and *Eucalyptus tectifica* low open woodland over *Bauhinia cunninghamii*, *Acacia plectocarpa* subsp. *plectocarpa* and *Melaleuca viridiflora* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Aristida holathera* var. *holathera* mid sparse hummock grassland.

Statistically associated species

Shrubs: *Acacia hippuroides, Solanum cunninghamii, Waltheria indica*

Forbs: *Evolvulus alsinoides* var. *decumbens*

Grasses: *Chrysopogon fallax, Eriachne sulcata, Sorghum timorense*

Soils and Landforms: pale orange-grey clayey sands on flats.

Outcropping: not present

Condition: very good to excellent

Area: 101.6397 ha

Proportion of survey area: 0.54 %

Number of Quadrats: 8

Average species richness: 23.75 ± 2.92 (s.e.m.)

Range of species richness: 16 to 41

Similarity Percentage: 49.19 %

Representative Photograph

Quadrat TB059

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description

Vegetation map code: W8 (combination of communities W8 and W8a)

Description

Erythrophleum chlorostachys, *Brachychiton diversifolius* subsp. *diversifolius* and *Corymbia greeniana* mid open woodland over *Acacia tumida* var. *tumida*, *Bauhinia cunninghamii* and *Dodonaea hispidula* var. *arida* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland.

Statistically associated species

Trees: *Corymbia zygophylla, Dolichandrone heterophylla*

Shrubs: *Grevillea pyramidalis* subsp. *pyramidalis, Grevillea refracta* subsp. *refracta, Microstachys chamaelea, Solanum cunninghamii, Waltheria indica*

Grasses: *Chrysopogon fallax, Chrysopogon pallidus, Eragrostis eriopoda, Sorghum timorense*

Soils and Landforms: orange brown to red fine sandy soils on flats.

Outcropping: not present

Condition: good to excellent

Area: 12,871.4592 ha

Proportion of survey area: 68.15 %

Number of Quadrats: 120

Average species richness: 25.06 ± 0.61 (s.e.m.)

Range of species richness: 14 to 43

Similarity Percentage: 51.52 %

Representative Photograph

Quadrat TB014

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description

Vegetation map code: W9

Description

Corymbia dendromerinx low open woodland over *Grevillea pyramidalis* subsp. *pyramidalis*, *Microstachys chamaelea* and *Terminalia canescens* mid sparse shrubland over *Chrysopogon* sp. (*C. fallax* or *C. pallidus*), *Glycine tomentella* and *Sorghum plumosum* mid sparse grassland.

Statistically associated species

Trees: *Dolichandrone heterophylla, Flueggea virosa* subsp*. melanthesoides*

Shrubs: *Acacia tumida* var*. tumida , Dodonaea hispidula* var*. arida , Grevillea refracta* subsp*. refracta, Waltheria indica*

Forbs: *Hybanthus aurantiacus, Polycarpaea longiflora*

Grasses: *Aristida hygrometrica*

Soils and Landforms: orange-brown sandy clay with sandstone rocks and outcropping on hills.

Outcropping: sandstone

Condition: very good to excellent

Area: 67.8791 ha

Proportion of survey area: 0.36 %

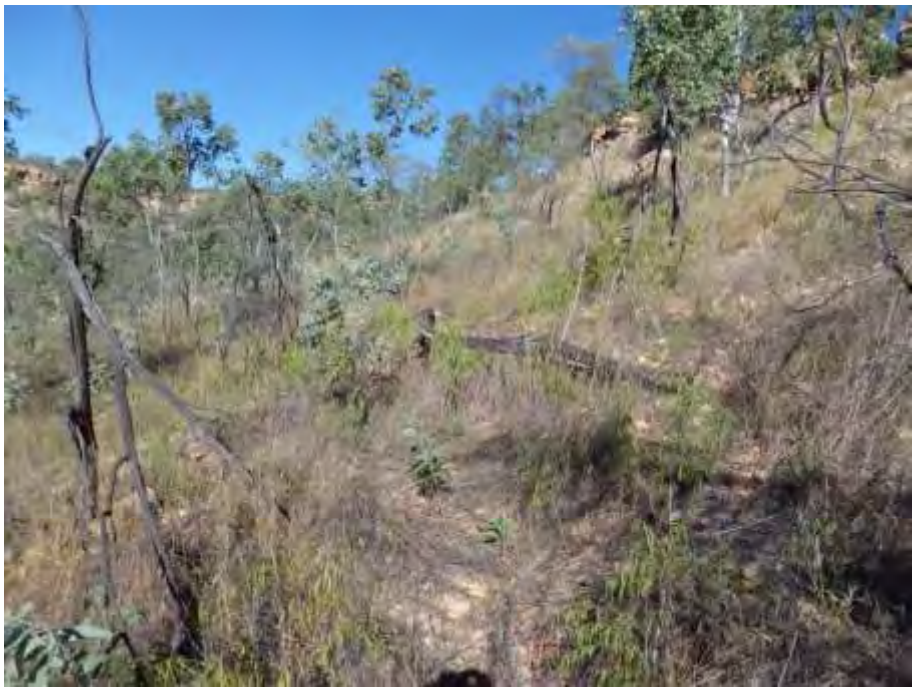
Number of Quadrats: 4

Average species richness: 39.00 ± 3.49 (s.e.m.)

Range of species richness: 31 to 47

Similarity Percentage: 54.45 %

Representative Photograph



Quadrat TB114

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description

Vegetation map code: W10

Description

Corymbia greeniana, *Corymbia dendromerinx* and *Brachychiton diversifolius* subsp. *diversifolius* low open woodland over *Grevillea pyramidalis* subsp. *pyramidalis*, *Grevillea refracta* subsp. *refracta* and *Terminalia canescens* tall sparse shrubland over *Triodia caelestialis* (P3), *Solanum cunninghamii* and *Aristida hygrometrica* mid open tussock grassland.

Statistically associated species

Trees: *Dolichandrone heterophylla, Wrightia saligna*

Shrubs: *Acacia tumida* var*. tumida, Bauhinia cunninghamii, Corchorus sidoides, Dodonaea hispidula* var*. arida, Microstachys chamaelea, Waltheria indica*

Forbs: *Goodenia sepalosa var. sepalosa*

Grasses: *Chrysopogon pallidus, Sorghum timorense*

Soils and Landforms: orange-brown clayey sands with occasional sandstone or ironstone rocks on flats and slopes associated with drainage areas.

Outcropping: not present

Condition: very good to excellent

Area: 964.2910 ha

Proportion of survey area: 5.11 %

Number of Quadrats: 16

Average species richness: 39.81 ± 2.85 (s.e.m.)

Range of species richness: 24 to 68

Similarity Percentage: 54.41 %

Representative Photograph

Quadrat TB027

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description

Vegetation map code: W11

Description

Corymbia zygophylla low open woodland over *Acacia tumida* var. *tumida* and *Erythrophleum chlorostachys* tall sparse shrubland over *Triodia schinzii* and *Microstachys chamaelea* low sparse grassland.

Statistically associated species

Shrubs: *Corchorus sidoides* subsp. *vermicularis*

Grasses: *Eriachne obtusa, Sorghum plumosum*

Soils and Landforms: orange-brown clayey sands on flats and slopes.

Outcropping: not present

Condition: excellent

Area: 40.9165 ha

Proportion of survey area: 0.22 %

Number of Quadrats: 4

Average species richness: 13.50 ± 2.22 (s.e.m.)

Range of species richness: 8 to 18

Similarity Percentage: 45.03 %

Representative Photograph

Quadrat TB057

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description	
Vegetation map code: W12	
Description	
Corymbia greeniana, *Eucalyptus tectifica* and *Corymbia dendromerinx* mid open woodland over *Dolichandrone heterophylla*, *Bauhinia cunninghamii* and *Acacia tumida* var. *tumida* tall sparse shrubland over *Triodia caelestialis* (P3), *Triodia schinzii* and *Eriachne obtusa* mid sparse tussock grassland.	
Statistically associated species	
Trees: *Brachychiton diversifolius* subsp. *diversifolius*	
Shrubs: *Acacia colei* var. *colei, Acacia platycarpa*	
Forbs: *Glycine tomentella, Polygala tepperi*	
Grasses: *Chrysopogon pallidus, Eriachne* sp. Dampier Peninsula (K.F.Kenneally 5946)*, Heteropogon contortus, Sorghum plumosum*	
Soils and Landforms: brown clayey sands on flats and drainage channels.	
Outcropping: not present	
Condition: good to excellent	
Area: 519.7978 ha	Proportion of survey area: 2.75 %
Number of Quadrats: 9	Average species richness: 31.22 ± 1.70 (s.e.m.)
Range of species richness: 25 to 38	Similarity Percentage: 41.49 %
Representative Photograph	
No photograph available	

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description	
Vegetation map code: W13	
Description	
Brachychiton diversifolius subsp. *diversifolius, Erythrophleum chlorostachys* and *Corymbia dendromerinx* mid open woodland over *Grevillea refract* subsp. *refracta*, *Acacia monticola* and *Microstachys chamaelea* tall sparse shrubland over *Corchorus sidoides*, *Goodenia sepalosa* subsp. *sepalosa* and *Pterocaulon paradoxum* low sparse forbland.	
Statistically associated species	
Shrubs: *Acacia hippuroides*	
Forbs: *Solanum cunninghamii*	
Soils and Landforms: orange-brown clayey sands on flats.	
Outcropping: not present	
Condition: very good to excellent	
Area: 25.1385 ha	Proportion of survey area: 0.13 %
Number of Quadrats: 3	Average species richness: 28.67 ± 2.62 (s.e.m.)
Range of species richness: 24 to 36	Similarity Percentage: 43.17 %
Representative Photograph	
No photograph available	

APPENDIX K: SUMMARY OF VEGETATION COMMUNITIES DEFINED IN THE THUNDERBIRD PROJECT AREA

Vegetation Community Description

Vegetation map code: S1

Description

Acacia tumida var. *tumida* low sparse shrubland over *Waltheria indica* and *Bauhinia cunninghamii* low isolated shrubs over *Ectrosia schultzii*, *Eriachne obtusa* and *Corchorus pumilio* low sparse grassland.

Statistically associated species

No other statistically associated species

Soils and Landforms: pale grey sandy clay loam soils on flats and slopes.

Outcropping: not present

Condition: very good to excellent

Area: 58.9207 ha

Proportion of survey area: 0.31 %

Number of Quadrats: 6

Average species richness: 13.00 ± 2.86 (s.e.m.)

Range of species richness: 8 to 21

Similarity Percentage: 49.74 %

Representative Photograph

Quadrat TB113

APPENDIX 2 LEVEL 1 FLORA AND FAUNA ASSESSMENT, ECOLOGIA 2012

SHEFFIELD RESOURCES LTD
THUNDERBIRD DAMPIER PENINSULA PROJECT
LEVEL 1 FLORA AND FAUNA ASSESSMENT

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THUNDERBIRD DAMPIER PENINSULA PROJECT

LEVEL 1 FLORA AND FAUNA ASSESSMENT

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TABLE OF CONTENTS

1 INTRODUCTION 9
1.1 PROJECT OVERVIEW 9
1.2 LEGISLATIVE FRAMEWORK 9
1.3 SURVEY OBJECTIVES 10
2 BIOPHYSICAL CLIMATE 13
2.1 CLIMATE 13
2.2 SOILS AND GEOLOGY 14
2.3 VEGETATION 15
2.4 LAND SYSTEMS 17
2.5 BIOGEOGRAPHY 18
3 SURVEY METHODS 21
3.1 LITERATURE REVIEW AND DATABASE SEARCHES 21
3.2 CONSERVATION SIGNIFICANT SPECIES 22
3.3 SURVEY TIMING 24
3.4 QUADRAT SELECTION 25
3.5 SAMPLING METHODS 29
3.6 ANIMAL ETHICS 30
3.7 VEGETATION MAPPING 30
3.8 TAXONOMY AND NOMENCLATURE 30
3.9 SURVEY ADEQUACY AND ANALYSIS 31
3.10 SURVEY TEAM 31
3.11 SURVEY LIMITATIONS AND CONSTRAINTS 33
4 RESULTS 35
4.1 SURVEY LIMITATIONS 35
4.2 VEGETATION RESULTS 37
4.3 FLORA RESULTS 48
4.4 FAUNA RESULTS 62
4.5 FAUNA HABITATS 69

5 DISCUSSION 79
5.1 VEGETATION COMMUNITIES CONSERVATION ASSESSMENT 79
5.2 FLORA CONSERVATION ASSESSMENT 82
5.3 CONSERVATION SIGNIFICANT FAUNA WITH A MEDIUM OR HIGH LIKELIHOOD 84
6 FURTHER INVESTIGATIONS 89
6.1 STATE ASSESSMENT PROCESS 89
6.2 COMMONWEALTH ASSESSMENT PROCESS 89
6.3 SHEFFIELD RESOURCES THUNDERBIRD DAMPIER PENINSULA PROJECT 90
7 REFERENCES 91

TABLES

Table 2.1 – Climate Data for Broome Airport and Derby Aero Weather Station (BoM, 2012). 14
Table 2.2 – Representation of Broad Scale Vegetation Units within the Study Area. 15
Table 2.3 – Land Systems of the Study Area 17
Table 3.1 – Flora, Fauna and Ecological Community Database Searches 21
Table 3.2 – Previous Biological Survey Reports near the Study Area. 22
Table 3.3 – Likelihood of Occurrence Categories. 23
Table 3.4 – Regional Impact to the Conservation Significant Species. 23
Table 3.5 – Rainfall received at Derby and Broome preceeding the survey. 24
Table 3.6 – Location of Flora Quadrats. 25
Table 3.7 – Location of Fauna Survey Sites. 26
Table 3.8 – References used for Fauna Identification. 31
Table 3.9 – Project Staff and Qualifications. 32
Table 3.10 – Relevent DEC Licence Details. 32
Table 4.1 – Flora Survey Limitations and Constraints 35
Table 4.2 – Fauna Survey Limitations and Constraints 36
Table 4.3 – Taxonomic Composition of the Flora of the Study Area. 48
Table 4.4 – Most Frequently Recorded Families, Genera and Taxa in the Study Area. 48
Table 4.5 – Assessment of Potential of Priority Flora to Occur in the Study Area. 50
Table 4.6 – Priority Flora Recorded in the Study Area. 56

Table 4.7 – Taxa with Range Extensions Greater than 100 km. 57
Table 4.8 – Introduced Species Recorded in the Study Area and their Location. 58
Table 4.9 – Attributes of Introduced Flora in the Study Area. 60
Table 4.10 – Characteristics of Introduced Flora Recorded in the Study Area..... 61
Table 4.11 – Comparison of Results of Previous Fauna Surveys. 62
Table 4.12 – Vertebrate Fauna Species Recorded During Current Survey Within Study Area. 63
Table 4.13 – Fauna Habitat area Calculations of the Study Area. 69
Table 4.14 – Conservation Significant Fauna Occurring or Potentially Occurring in the Study Area. ... 74
Table 5.1 – Regional Distribution of Priority Flora Recorded during the Current Survey 84

FIGURES

Figure 1.1 – Location of the Study Area. 12
Figure 2.1 – Climate Data for Broome Airport and Derby Aero Weather Stations (BoM, 2012). 13
Figure 2.2 – Shepherd Vegetation Associations of the Study Area. 16
Figure 2.3 – Land Systems of the Study Area. 19
Figure 2.4 – Biogeographic Regions of the Study Area. 20
Figure 3.1 – Location of Flora Sites within the Study Area. 27
Figure 3.2 – Location of Fauna Sites within the Study Area. 28
Figure 4.1 – Representative Photograph of Vegetation Unit CdAdCpGt. 38
Figure 4.2 – Representative Photograph of Vegetation Unit CgApTcAh. 39
Figure 4.3 – Representative Photograph of Vegetation Unit CzAtSpTc. 40
Figure 4.4 – Representative Photograph of Vegetation Unit GpSpTc. 41
Figure 4.5 – Representative Photograph of Vegetation Unit MnMvAcEoTc. 42
Figure 4.6 – Representative Photograph of Vegetation Unit EtMvSi. 43
Figure 4.7 – Vegetation Units of Thunderbird Study Area Map A. 44
Figure 4.8 – Vegetation Units of Thunderbird Study Area Map B. 45
Figure 4.9 – Vegetation Units of Thunderbird Study Area Map C. 46
Figure 4.10 – Average Randomised SAC for the Study Area. 49
Figure 4.11 – Priority Flora of the Thunderbird Study Area 59
Figure 4.12 – Locations of Conservation Significant Fauna Recorded During the Survey. 67
Figure 4.13 – Regional *EPBC Act* Threatened Fauna Records on the Dampier Peninsula. 68

Figure 4.14 – The Burrowing Skink *Lerista apoda* Recorded During the Level 1 Survey in Rocky Hills. 70

Figure 4.15 – Representative Photo of Rocky Hills Habitat Type. 70

Figure 4.16 – Representative Photo of Pindan Plains Habitat Type. 71

Figure 4.17 – Representative Photo of Savannah woodlands Habitat Type. 72

Figure 4.18 – Fauna Habitats of the Thunderbird Study Area. 73

Figure 5.1 – Suggested Buffer Zones on Creeklines and the Temporary Pool 81

Figure 5.2 – Rainbow Bee-eater (EPBC Migratory, WC Schedule 3) Recorded During the Survey. 86

Figure 5.3 – Australian Bustard (DEC Priority 4) Recorded During the Level 1 Survey. 87

APPENDICES

Appendix A Explanation of Conservation Codes 95

Appendix B Flora Quadrat Descriptions 101

Appendix C Dendrogram and Species x Quadrat Matrix 119

Appendix D Vascular Flora within Thunderbird Study Area 121

Appendix E Fauna site descriptions 129

Appendix F Regional fauna records 139

Appendix G Rare Flora Report Forms 161

ACRONYMS

ARRP Act	*Agriculture and Related Resources Protection Act 1976*
BIF	Banded Iron Formation
BOM	Bureau of Meteorology
CALM	Department of Conservation and Land Management (now DEC)
DAFWA	Department of Agriculture and Food Western Australia
DEC	Department of Environment and Conservation
DEFL	Department of Environment and Conservation Threatened Flora Database
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FMG	Fortescue Metals Group Limited
IBRA	**I**nterim Biogeographic Regionalisation for Australia
NHMRC	National Health and Medical Research Council
NVIS	National Vegetation Information System
PRI	Pilbara Regional Inventory
PEC	Priority Ecological Community
SAC	Species Accumulation Curve
TEC	Threatened Ecological Community
UCL	Unallocated Crown Land
WAHERB	Western Australian Herbarium
WC Act	*Wildlife Conservation Act 1950*
WONS	Weeds of National Significance

EXECUTIVE SUMMARY

Sheffield Resources Limited (Sheffield) has commissioned *ecologia* Environment (*ecologia*) to undertake a desktop assessment, a Level 1 Survey, and Cultural Heritage Survey of its Thunderbird Project, located 70 kilometres west of Derby on the Dampier Peninsula. Sheffield seeks to gain an understanding of the flora and vertebrate fauna of the Study Area, and the environmental assessment implications of the Thuderbird Project. The Cultural Heritage Survey was completed by *ecologia* and Environmental, Heritage & Social Impact Services following the Flora and Fauna Assessment and will be provided to Sheffield in a separate report.

A single phase Level 1 flora and vertebrate fauna assessment was undertaken which combined the following methodological approaches:

- Desktop Assessment: to gather background information on the footprint or target area (i.e. search of literature, data and map-based information);
- Level 1 Survey: to enhance the level of knowledge of the flora and vegetation at the local scale and its local context or significance (if the broader scale is well known), and to ground truth the predicted fauna habitat types present in the Study Area and confirm the likelihood of occurrence for species of conservation significance; and
- Assess the proposed 2 km buffer (avoidance) zones surrounding creeklines and the temporary pool that have been recommended by the Traditional Owners.

A total of 155 flora taxa were recorded, including subspecies, varieties and hybrids. The highest species richness in the Study Area was recorded in quadrats 5 and 9. Lower species richness values were recorded in quadrats 11, 6 and 21. The sites with highest and lowest species richness were distributed across a range of vegetation types with no one vegetation unit having the highest or lowest species richness. Using Species Accumualtion Curve (SAC) analysis and extrapolation of the curve to the asymptote using Michaelis-Menten modelling, the incidence-based coverage estimator of species richness 245 (ICE Mean) and 249 (Chao 2 Mean). The 155 taxa recorded in the Study Area, represent between 60 and 67 % of the estimated flora species present. This level of survey effort may not satisfy the requirements of formal Environmental Impact Assessments, but is sufficient to meet the objectives of the current survey, primarily the requirements of the Traditional Owners. The optimal timing for flora and vegetation surveys in the Kimberley is directly following the wet season (generally March - April), which would increase the number of taxa recorded through the increased presence of annual and ephemeral taxa.

No *EPBC Act* listed flora species were recorded in the Study Area. No Threatened flora taxa were recorded in the Study Area. A database search of the DEC's Threatened (Declared Rare) Flora Database and the DEC's WAHERB Specimen Database indicates that 40 Priority Flora taxa have previously been recorded within a 50 km of the Study Area. Three Priority taxa were recorded by *ecologia* within the Study Area; *Eriachne* sp. Dampier Peninsula (P3), *Pterocaulon intermedium* (P3) and *Triodia caelestialis* (P3). Previously, *Triodia caelestialis* was only known from three records in the central and western Kimberely and on the very eastern edge of Dampierland. *Triodia caelestialis* has been recently described (2008) and is thought to occur widely in and around the Thunderbird Study Area. A regional survey for this species would assist in determining its extent in the eastern Dampier Peninsula.

The creeklines of the Thunderbird Study Area have been identified by the Traditional Owners as areas that have environmental cultural significance and a 2 km buffer surrounding each creekline has been suggested as adequate to protect these values. Multi-variate analysis of the quadrat data from this

survey did not distinguish the creeklines as separate vegetation units from the surrounding vegetation. The current drilling program is low intensity, with the drilling holes separated from each other by approximately 500-1000 m. As the soils of the Thunderbird Study Area are sand-based soils, it is thought that the drill holes will collapse following drilling and not affect the drainage of surface flow or alter the water table. To avoid disturbance to the drainage lines in the current drilling program, it is recommended that buffer (avoidance) zones of 150 m would be sufficient to prevent disturbance to the creekline vegetation composition, structure and function.

The vegetation of the ephemeral pool (EtMvSi) is dominated by *Eucalyptus tectifica* and *Melaleuca viridiflora* open woodland, over dense tussock grassland (*Sacciolepis indica*, *Sorghum plumosum*, *Fruiena ciliaris*). Many species of *Melaleuca* are known to be phreatophytic; that rely on the groundwater at least some of the year for survival. The vegetation unit EtMvSi appears to be localised to the ephemeral pool with a gradation to the vegetation unit MnMvAcEoTc (*Corymbia greeniana* and *Melaleuca nervosa* or *M. viridiflora* oopen woodland, over *Acacia colei* var. *colei* tall shrubland, over *Eriachne obtusa* tussock grassland and *Triodia caelestialis* hummock grassland) over a distance of approximately 250 m. The current drilling program maintains a buffer zone of 2 km from the temporary pool which is adequate to ensure that there is no adverse impact to this vegetation unit.

The impact to the *Melaleuca* vegetation communities (EtMvSi and MnMvAcEoTc) from the current drilling program should be minimal given the drilling program is of low intensity and the soils appear to largely be sandy and thought to collapse rapidly following drilling. The impact to the vegetation units ETMvSi and MnMvAcEoTc from an altered water table if the Thunderbird project is developed could be assessed through a seperate hydrological assessment.

The vertebrate fauna assessment, incorporating database searches and records of previous surveys from within 100 km of the Study Area, identified a total of 358 terrestrial vertebrate fauna species with potential to occur in the Study Area. This includes 33 native and 6 introduced mammal species, 232 bird species, 78 reptile species and 9 amphibian species. During the Level 1 Survey, 8 mammals (five native, three introduced), 59 birds, seven reptiles and one amphibian were recorded within the Study Area.

Results from the desktop assessment and Level 1 field survey indicate that 69 fauna species of conservation significance may potentially occur in the Study Area. Of these, one mammal and five birds have a medium to high likelihood of occurring in the Study Area.

During the current survey, three conservation significant species were recorded: Rainbow Bee-eater (EPBC Act Migratory, WC Act Schedule 3), Australian Bustard (DEC Priority 4) and Bush-stone Curlew (DEC Priority 4).

The habitat assessment revealed three main fauna habitat types within the Study Area:

- Rocky Hills;
- Pindan Plains; and,
- Savannah Woodlands.

This desktop assessment has identified that 20 flora taxa and six vertebrate fauna species of conservation significance have a medium to high likelihood of occuring within the Study Area. Further investigations to assess the impacts to these species are recommended to support future Environmental Impact Assessment of a development proposal at Thunderbird.

If the Thunderbird project is to be developed, it is recommended that Sheffield undertake;

- A single phase Level 2 Vertebrate Fauna Assessment which incorporates targeted conservation significant fauna surveys;
- A Level 2 Vegetation and Flora Assessment;
- A baseline Short-Range Endemic Fauna Assessment; and,
- A baseline Subterranean Fauna Assessment for Troglofauna and Stygofauna.

1 INTRODUCTION

1.1 PROJECT OVERVIEW

Sheffield Resources Limited (Sheffield) has commissioned *ecologia* Environment (*ecologia*) to undertake a Level 1 Flora and Fauna Survey of its Thunderbird Project, located 70 kilometres west of Derby on the Dampier Peninsula (Figure 1.1). Sheffield seeks to gain an understanding of the flora and vertebrate fauna of the Thunderbird area (Study Area) and identify the environmental assessment implications that the Project may have and address conditions 6 and 7 from the Work Program Clearance Heritage Survey Report.

1.2 LEGISLATIVE FRAMEWORK

The *Environmental Protection Act 1986* (*EP Act*) is "an Act to provide for an Environmental Protection Authority, for the prevention, control and abatement of environmental pollution, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing." Section 4a of this Act outlines five principles that are required to be addressed to ensure that the objectives of the Act are satisfied. Three of these principles are relevant to native fauna and flora:

- *The Precautionary Principle*

  Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;

- *The Principles of Intergenerational Equity*

  The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations; and,

- *The Principle of the Conservation of Biological Diversity and Ecological Integrity*

  Conservation of biological diversity and ecological integrity should be a fundamental consideration.

In addition to these principles, projects undertaken as part of the Environmental Impact Assessment (EIA) process are required to address guidelines produced by the Environmental Protection Authority (EPA), in this case Guidance Statement No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004b), principles outlined in EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002) and the *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010).

Native flora and fauna in Western Australia that are formally recognised as rare, threatened with extinction, or as having high conservation value are protected at a federal level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and at a state level under the *Wildlife Conservation Act 1950* (WC Act). International agreements include the Japan-Australian Migratory Bird Agreement (JAMBA) and the China-Australia Migratory Bird Agreement (CAMBA).

The *EPBC Act* was developed to provide for the protection of the environment, particularly those aspects of the environment that are matters of national environmental significance, to promote ecologically sustainable development through the conservation and ecologically sustainable use of

natural resources, and to promote the conservation of biodiversity. The *EPBC Act* includes provisions to protect native species (and in particular to prevent the extinction and promote the recovery of threatened species) and to ensure the conservation of migratory species. In addition to the principles outlined in Section 4a of the *EPBC Act*, Section 3a of the *EPBC Act* includes a principle of ecologically sustainable development dictating that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. Schedule 1 of the *EPBC Act* contains a list of species that are considered Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable and Conservation Dependent. Definitions of categories relevant to fauna occurring or potentially occurring in the Study Area are provided in Appendix A.

The *WC Act* was developed to provide for the conservation and protection of wildlife in Western Australia. Under Section 14 of this Act, all flora and fauna within Western Australia is protected; however, the Minister may, via a notice published in the *Government Gazette*, declare a list of fauna identified as rare, likely to become extinct, or otherwise in need of special protection (Appendix A). The current listing was gazetted in February 2012.

In addition, the Department of Environment and Conservation (DEC) maintains a Threatened and Priority species list. Threatened flora and fauna that are listed under Schedule 1 of the WC Act are further ranked by the DEC according to their level of threat using IUCN Red List criteria. Species can be listed as Critically Endangered (CR), Endangered (EN) and Vulnerable (VU). Species that have not yet been adequately surveyed to be listed under Schedule 1 or 2 are listed as Priorities 1, 2 or 3, which are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as Threatened species. Species that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are listed as Priority 4. These species require regular monitoring. Conservation Dependent species are listed as Priority 5. The three Threatened and five Priority codes are summarised in Appendix A.

Ecological communities are naturally occurring biological assemblages located in a particular type of habitat. At a national level, Threatened Ecological Communities (TECs) are protected under the *EPBC Act*. The DEC also maintains a list of TECs that are classified as being either 'Presumed Totally Destroyed', 'Critically Endangered', 'Endangered' or 'Vulnerable'. Definitions of these categories are given below. The DEC also maintains an additional list of Priority Ecological Communities (PECs), for communities that could potentially be classified as TECs, but are not currently adequately defined or surveyed. Communities are placed in this category while consideration can be given to their declaration as a TEC. The TEC and PEC codes are defined further in Appendix A.

1.3 SURVEY OBJECTIVES

Sheffield commissioned *ecologia* to undertake a desktop assessment and Level 1 Survey of the vertebrate fauna, vegetation and flora of the Thunderbird Study Area as part of an agreement with the Nyikina Mangala Native Title Claim Group (Traditional Owners). Specifically, *ecologia* was commissioned to address the following conditions from the Work Program Clearance Heritage Survey Report produced by Cox Anthropology (2012):

- **Condition 6**: Prior to the commencement of the proposed activity above, the team has instructed that a thorough flora and fauna study be conducted with advice and input from Traditional Owners; and,
- **Condition 7:** The survey team is concerned with regard to the proximity of the track-clearing and drill holes to water sources and waterways in the Study Area. The survey teams advise Sheffield Resources that they do not wish them to conduct any exploration activity involving

track clearing or drilling within two kilometers of waterways and water sources marked on government maps in the Study Area. Nor do they wish them to conduct these activities within areas that are two kilometers in proximity to water courses and water sources that are not marked on maps (e.g. a spring at E 0499665; N 8067419).

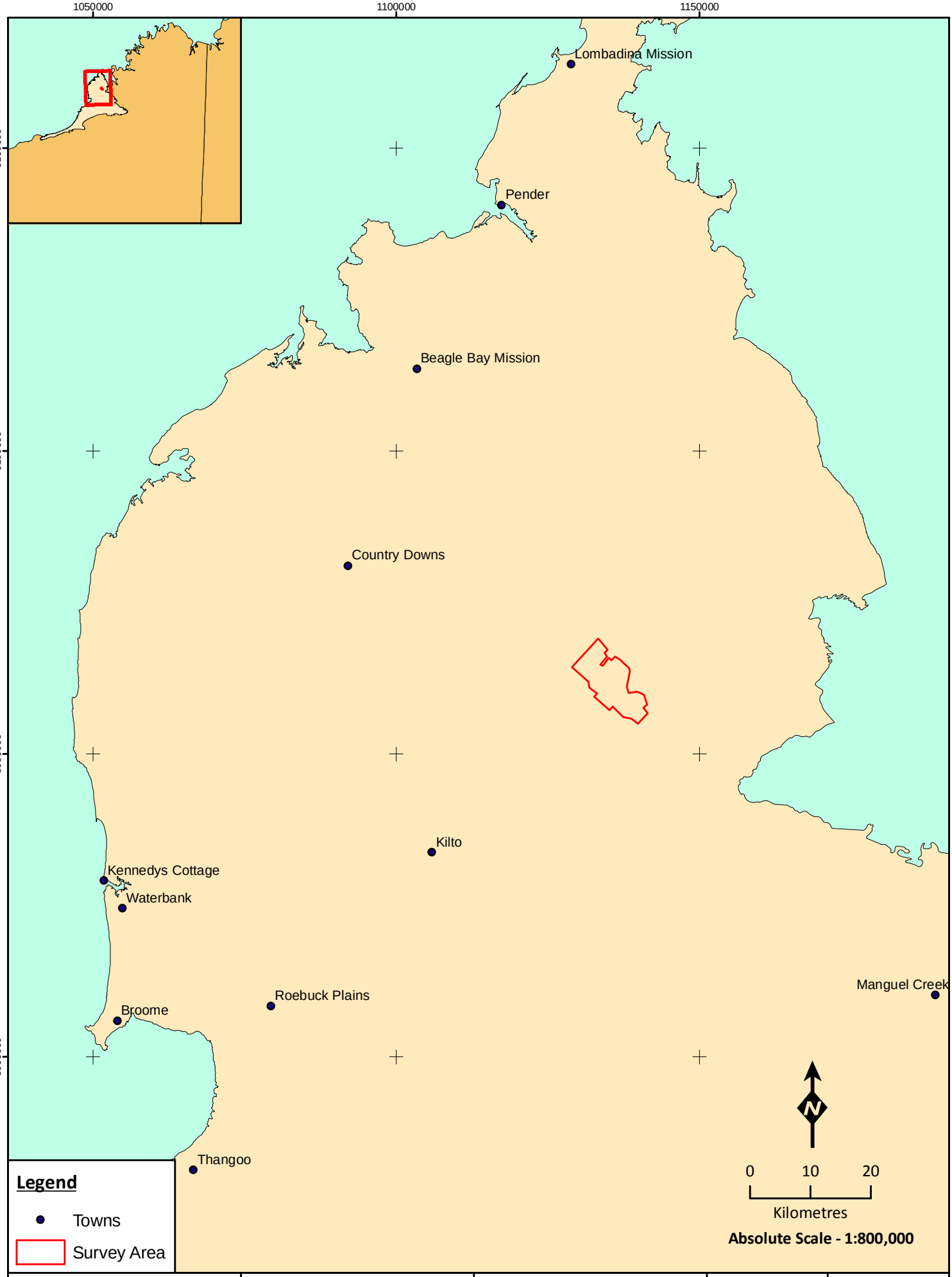
To address these conditions *ecologia* completed a Level 1 flora, vegetation and fauna assessment in line with the EPA's objectives. The EPA's objectives with regards to biological management are to:

- Avoid adverse impacts on biological diversity comprising the different plants and animals and the ecosystems they form, at the levels of genetic, species and ecosystem diversity;
- Maintain the abundance, species diversity, geographic distribution and productivity of terrestrial fauna and vegetation communities;
- Protect Threatened Flora (DRF) consistent with the provisions of the *WC Act*;
- Protect Specially Protected (Threatened) fauna, consistent with the provisions of the *WC Act*; and,
- Protect other flora species of conservation significance.

Further, the desktop assessment and Level 1 biological surveys will provide initial survey information to Sheffield to allow potential environmental issues that relate to flora and vertebrate fauna and potential impacts of the development the Study Area identified.

This survey was undertaken in a manner that complies with the requirements documented in the EPA's Guidance Statements 51 and 56, and Position Statement No. 3, thus providing:

- A review of background information, including literature and database searches;
- An inventory of species of biological and conservation significance (Flora and Fauna) recorded or likely to occur within the Study Area and surrounds;
- An inventory of vegetation types and flora species occurring in the Study Area, incorporating recent published and unpublished records;
- An inventory of species of biological and conservation significance recorded or likely to occur within the Study Area and surrounds;
- An inventory of vertebrate fauna species potentially occurring in the Study Area, incorporating recent published and unpublished records;
- A map and detailed description of vegetation types occurring in the Study Area;
- A description of fauna habitats occurring in the Study Area;
- An appraisal of the current knowledge base for the area, including a review of previous surveys conducted in the area relevant to the current study;
- A review of regional and biogeographical significance, including the conservation status of species recorded in the Study Area; and,
- A risk assessment to determine likely impacts of threatening processes on vegetation and flora within the Study Area.



ecologia ENVIRONMENT

Sheffield Resources LIMITED

Location of Thunderbird Study Area

Figure: 1.1
Project ID: 1462

Drawn: RY
Date: 31/07/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: RY111

A4

2 BIOPHYSICAL CLIMATE

2.1 CLIMATE

The Study Area is situated in the Kimberley region of WA at the south-east edge of the Dampier Peninsula. The area has a dry, hot, tropical climate with two distinct seasons: the 'wet' from around December to March, and the 'dry' for the rest of the year. Rainfall is highly variable in the region due to the inconsistent nature of the movement and occurrence of thunderstorms and tropical systems. Tropical cyclones can occur as late as April, but are most common in January and February. Rainfall during the cooler months is usually associated with cloud bands originating from tropical waters to the north-west (BoM 2011). The average temperature over summer is over 33 °C, with warm overnight minima of around 26 °C (BoM 2011). Winter temperatures are quite mild, with average maximum and minimum temperatures in July being 26.9 °C and 12.0 °C respectively (BoM 2011).

The closest Bureau of Meteorology (BoM) weather stations (with full data sets) to the Study Area is Derby Aero (BoM Station 3032) and Broome Airport (BoM Station 3003). Derby Aero is located 70 km east of the Study Area with Broome Airport located 95 km to the south-west. These stations were selected as a reference to provide the best indication of the local climatic conditions of the Study Area (Figure 2.1).

The mean annual rainfall for Broome is 607 mm, but highly variable with over 75% of the annual rainfall usually falling between January and March (BoM 2011). The mean number of rainfall days (≥1 mm) a year is only 35.1. Generally, the wettest month is February, with a mean of 179.1 mm falling over an average of 9.1 rainfall days. The hottest month is April and the coldest is July, with means of 34.3 °C and 28.8 °C respectively (Table 2.1).

The mean annual rainfall for Derby is 676.9 mm, with over 75% of the annual rainfall usually falling between January and March (BOM 2012). The mean number of rainfall days (≥1 mm) a year is 38.0. January and February are generally the wettest months of the year, with a mean of 196.3 and 199.8 mm over an average of 10.1 and 9.7 rain days resepctively. The hottest month is October and the coldest is June, with means of 37.0°C and 30.4 °C respectively (Table 2.1).

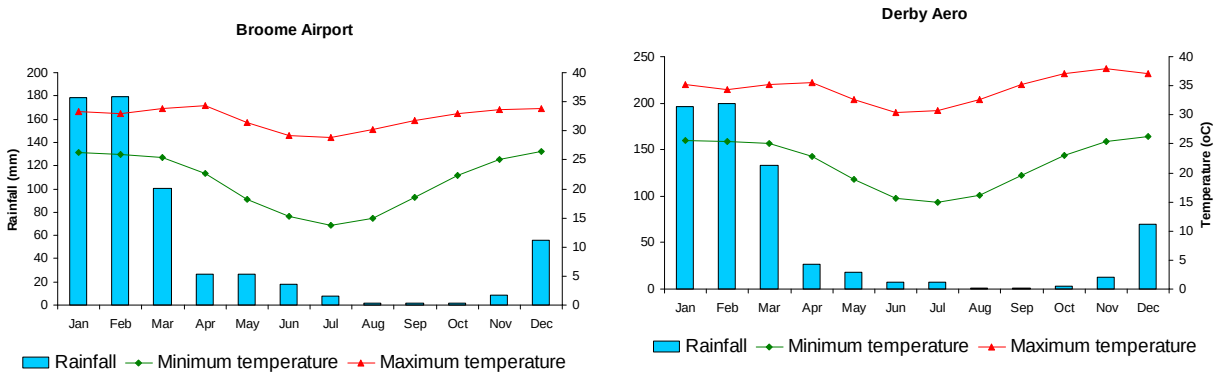


Figure 2.1 – Climate Data for Broome Airport and Derby Aero Weather Stations (BoM, 2012).

Table 2.1 – Climate Data for Broome Airport and Derby Aero Weather Station (BoM, 2012).

Broome Airport (003003)					**Commenced: 1939**						**Last record: 2012**		
Latitude: 17.95 °S					**Longitude: 122.24 °E**						**Elevation: 7m**		
Derby Aero (003032)					**Commenced: 1951**						**Last record: 2012**		
Latitude: 17.37 °S					**Longitude: 123.66 °E**						**Elevation: 6m**		
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Mean maximum temperature (°C)													
BME	33.3	32.9	33.9	34.3	31.5	29.1	28.8	30.3	31.8	32.9	33.6	33.8	32.3
DBY	35.2	34.3	35.2	35.5	32.7	30.4	30.7	32.6	35.2	37.0	38.0	37.1	34.5
Mean minimum temperature (°C)													
BME	26.3	26.0	25.4	22.6	18.2	15.2	13.7	14.9	18.5	22.3	25.1	26.5	21.2
DBY	25.6	25.4	25.0	22.8	18.9	15.6	14.9	16.2	19.6	23.0	25.4	26.3	21.6
Mean rainfall (mm)													
BME	178.5	179.1	100.8	26.7	26.4	17.8	7.3	1.7	1.4	1.4	8.9	56.0	602.1
DBY	196.3	199.8	132.6	26.5	18.1	7.9	7.8	0.8	1.1	2.7	13.0	69.9	676.9
Mean number of rain days													
BME	9.2	9.3	6.5	2.0	1.7	1.2	0.2	0.3	0.2	0.2	0.8	3.8	35.7
DBY	10.1	9.7	7.5	1.8	1.1	0.7	0.4	0.1	0.1	0.5	1.2	4.8	38
Mean 9am relative humidity (%)													
BME	70	74	69	56	48	47	46	45	49	54	58	64	57
DBY	71	75	69	52	42	40	38	37	43	47	51	61	52
Mean 9am wind speed (km/h)													
BME	13.8	12.9	11.4	11.7	13.9	14.3	14.3	13.9	13.9	13.9	14.2	14.5	13.6
DBY	13.1	11.8	11.2	10.9	13.7	14.6	14.0	13.0	12.9	13.0	12.7	12.7	12.8

Source: Bureau of Meteorology (August 2012)

2.2 SOILS AND GEOLOGY

The Dampier Peninsula is underlain by the Pre-Cambrian rocks of the Canning Basin. The major soil type on the Peninsula is pindan, which developed during the Quaternary period (the past two million years) on desert dune sandstone. The pindan soils form extensive undulating plains with little or no organised surface drainage. When the pindan soils dry out, they become very hard with a dusty

surface, and become soft and greasy when wet, with the potential to erode rapidly and form deep, steep-sided gullies (Kenneally *et al.* 1996).

2.3 VEGETATION

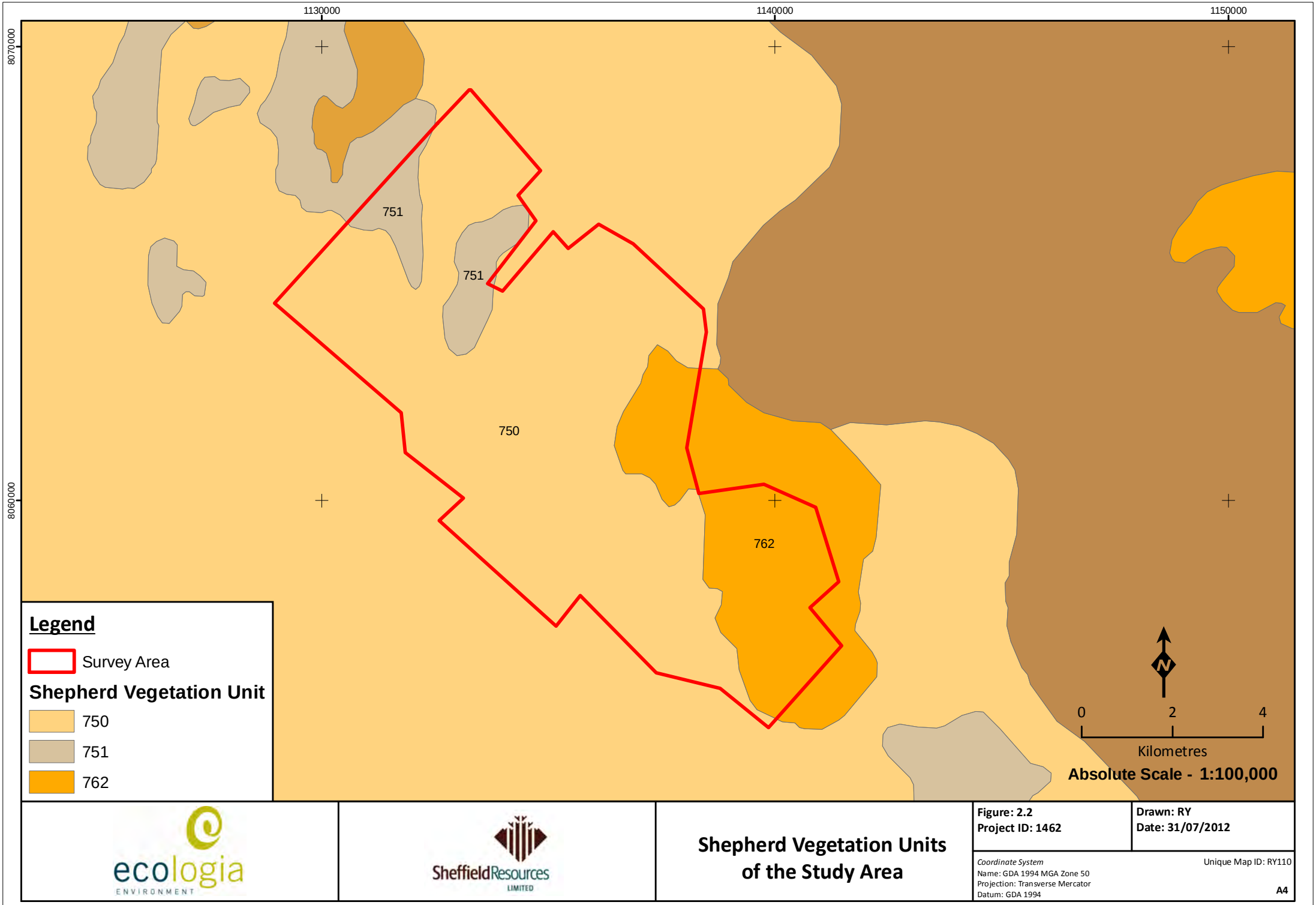
The Dampier Peninsula in which the Study Area s located lies within the Northern Botanical Province. The vegetation of Western Australia was originally mapped at the 1:1,000,000 scale by Beard (1979), and was subsequently reinterpreted and updated to reflect the National Vegetation Information System (NVIS) standards (Shepherd *et al.* 2002). Three of the vegetation types identified by Shepherd *et al.* (2002) are found within the Study Area: Vegetation Associations 750, 751 and 762. The majority of the the Study Area (76.27%) consists of vegetation type 750 (Table 2.2, Figure 2.2), which is described as Shrublands, pindan; *Acacia tumida* shrubland with grey box & cabbage gum medium woodland over ribbon grass & curly spinifex (Shepherd *et al.* 2002). The remaining area is comprised of Hummock grasslands, shrub steppe; *Acacia eriopoda* over soft spinifex (17.51 %) and Shrublands, pindan; *Acacia eriopoda* & *A. tumida* shrubland with scattered low *Eucalyptus confertifolia* over curly spinifex (6.22 %).

Table 2.2 – Representation of Broad Scale Vegetation Units within the Study Area.

Vegetation Association	Description	Total Area in the Dampierland Bio-region (ha)	Total Area in the Thunderbird Study Area (ha)	Percentage of the Thunderbird Study Area	Percentage of Vegetation Unit in Dampierland Impacted
750	Shrublands, pindan; Acacia tumida shrubland with grey box & cabbage gum medium woodland over ribbon grass & curly spinifex	1,232,039.34	5,641.91	76.27%	0.53%
751	Hummock grasslands, shrub steppe; Acacia eriopoda over soft spinifex	16,193.97	1,502.38	17.51%	9.28%
762	Shrublands, pindan; Acacia eriopoda & A. tumida shrubland with scattered low Eucalyptus confertifolia over curly spinifex	5,401.67	533.58	6.22%	9.88%

In a regional context, although over 76% of the Study Area comprises vegetation unit 750: Shrublands, pindan; *Acacia tumida* shrubland with grey box & cabbage gum medium woodland over ribbon grass & curly spinifex (Beard $e_{50,\ 51}$ Mi a_{29} Sc cp_3 Gi), this is a common and widespread vegetation unit, and represents 0.5% of the total area of the vegetation type within the Dampierland Bioregion.

Vegetation unit 751 comprises 17.5 % of the Study Area: Hummock grasslands, shrub steppe; *Acacia eriopoda* over soft spinifex (Beard a_{28} Sr t_1 Hi). This unit occurs throughout the Dampierland with 9.28 % found in the Study Area. Similarly, the remaining 6.22 % of the Study Area is comprised of vegetation unit 762: Shrublands, pindan; *Acacia eriopoda* & *A. tumida* shrubland with scattered low *Eucalyptus confertifolia* over curly spinifex (Beard e_{59} Lr $a_{28,\ 29}$ Sc p_3 Gi). This unit is less common on the Dampier Peninsula, with 9.88 % occuring within the Study Area (Figure 2.2).



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Sheffield Resources LIMITED

Shepherd Vegetation Units of the Study Area

Figure: 2.2
Project ID: 1462

Drawn: RY
Date: 31/07/2012

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: RY110

A4

2.4 LAND SYSTEMS

Land systems are described using the biophysical characteristic of geology, landform, vegetation and soils. The Study Area falls across four of these land systems (Figure 2.3), of which details are provided in Table 2.3 below.

Table 2.3 – Land Systems of the Study Area

Land System	Description	Total Area in Dampierland (ha)	Total Area within Thunderbird Study Area (ha)	Percentage of Land System in Thunderbird Study Area	Percentage of Land System in Dampierland Impacted
Fraser	Sand plain with irregular dunes and local stony surfaces, pindan and low grassy woodlands.	73,275	2801	36.49	3.82
Reeves	Sand plain with scattered hills and minor plateaux, reddish sandy soils, pindan.	44,794	3359	43.75	7.50
Waganut	Low lying sandplains and dune fields with through going drainage supporting pindan acacia shrublands with emergent eucalypt trees.	518,511	461	6.00	0.09
Yeeda	Sandplains with red and yellow sands supporting pindan acacia shrublands with emergent eucalypt trees.	1,653,086	1056	13.76	0.06

2.4.1 Fraser Land System

The Fraiser land system is characterised by sandplains and dunes with pindan woodlands and spinifex/tussock grasslands. Geologically, it is comprised of quanternary Aeolian sand with minor outcrops of gentle dipping Creataceous sandstone.

2.4.2 Reeves Land System

The Reeves land system is characterised by sandplaiins and scattered hills and minor plateaux, with pindan woodlands and spinifex/tussock grasslands. The geological formation is subhorizontal or gently dipping sandstone, sandy siltstone and silicified quartz sandstone of Creataceous age, with Quaternary Aeolian sand. Pindan vegetation can be subject to frequent fires, which induce short term changes in botanical composition, density and structure. The sandplains have minor susceptibility to wind erosion immediately after fire but stabilise rapidly after rain.

2.4.3 Waganut Land System

The Waganut land system is characterised by low-lying sandplains and dunefields qith through-going drainage, with pindan woodlands and spinifex/tussock grasslands. Its geological formation is made up of quaternary Aeolian sands. Vegetation is primarily dense wattle shrub with pindan pastures and is subject to fairly frequent fires, which induce short term changes in botanical composistion, density and structure.

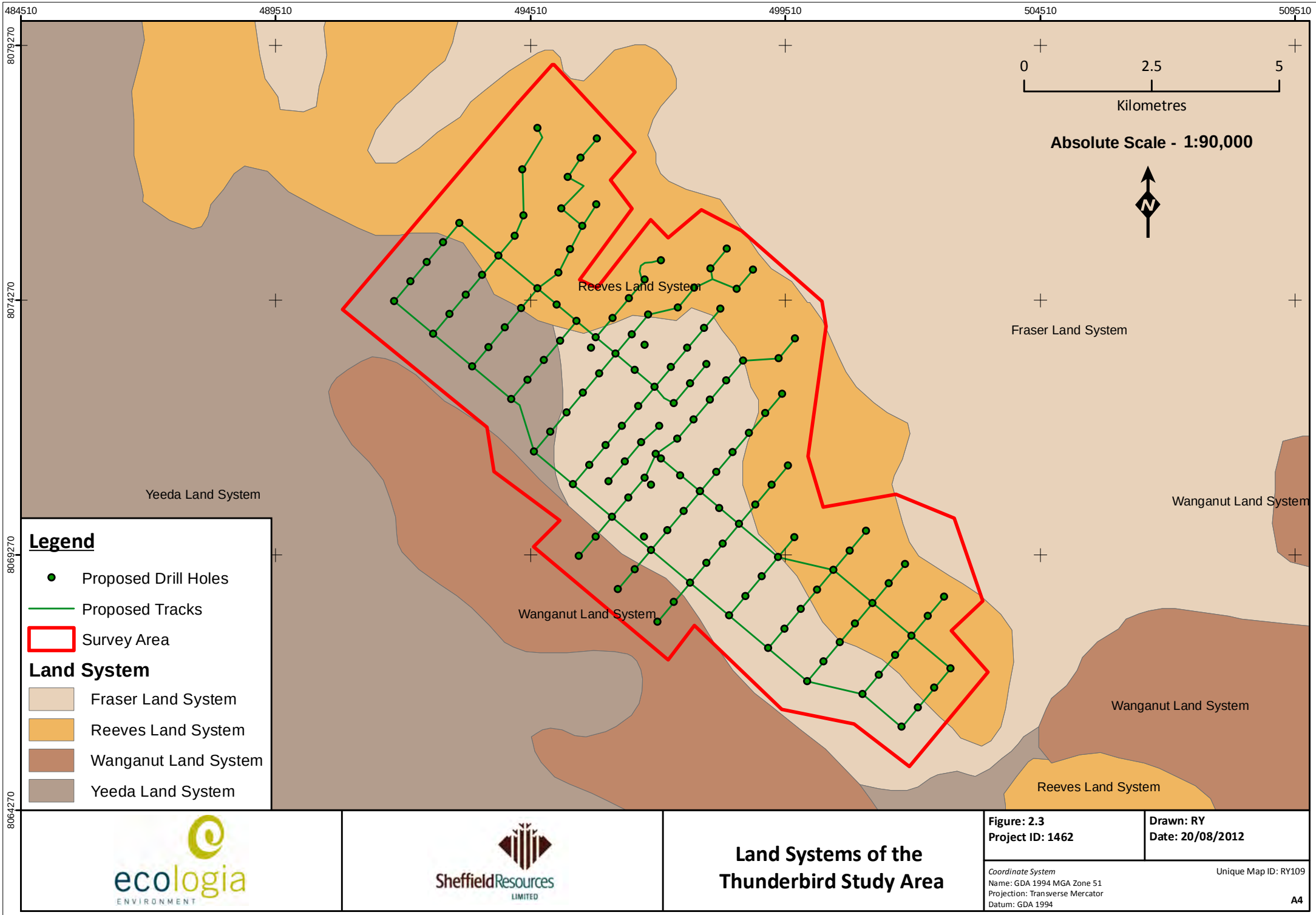
2.4.3.1 Yeeda Land System

TheYeeda land system is made up of sandplains and occasional dunes with shrubby spinifex grasslands or pindan woodlands. Geologically, it is comprised of quaternary Aeolian sands. It is generally not prone to degradation or erosion.

2.5 BIOGEOGRAPHY

The Interim Biogeographic Regionalisation for Australia (IBRA) classifies the Australian continent into regions (bioregions) of similar geology, landform, vegetation, fauna and climate characteristics (DSEWPC 2009). According to IBRA (Version 6.1), the Study Area lies within the Dampierland Bioregion. The Dampierland Bioregion is further subdivided into two subregions, these being the Fitzroy Trough (DL1) and Pindanland (DL2) subregions. The Study Area lies entirely within the Pindanland subregion of the Dampierland Bioregion (Figure 2.4).

The Pindanland subregion (Figure 2.4) covers approximately 59% of the Dampierland bioregion. This subregion consists of sandplains of a fine-textured sand-sheet with subdued dunes and includes the paleodelta of the Fitzroy River. The vegetation is described primarily as pindan (Graham 2002). The dominant land uses are grazing, unallocated crown land and crown reserves and native pastures.



ecologia ENVIRONMENT

Sheffield Resources LIMITED

Land Systems of the Thunderbird Study Area

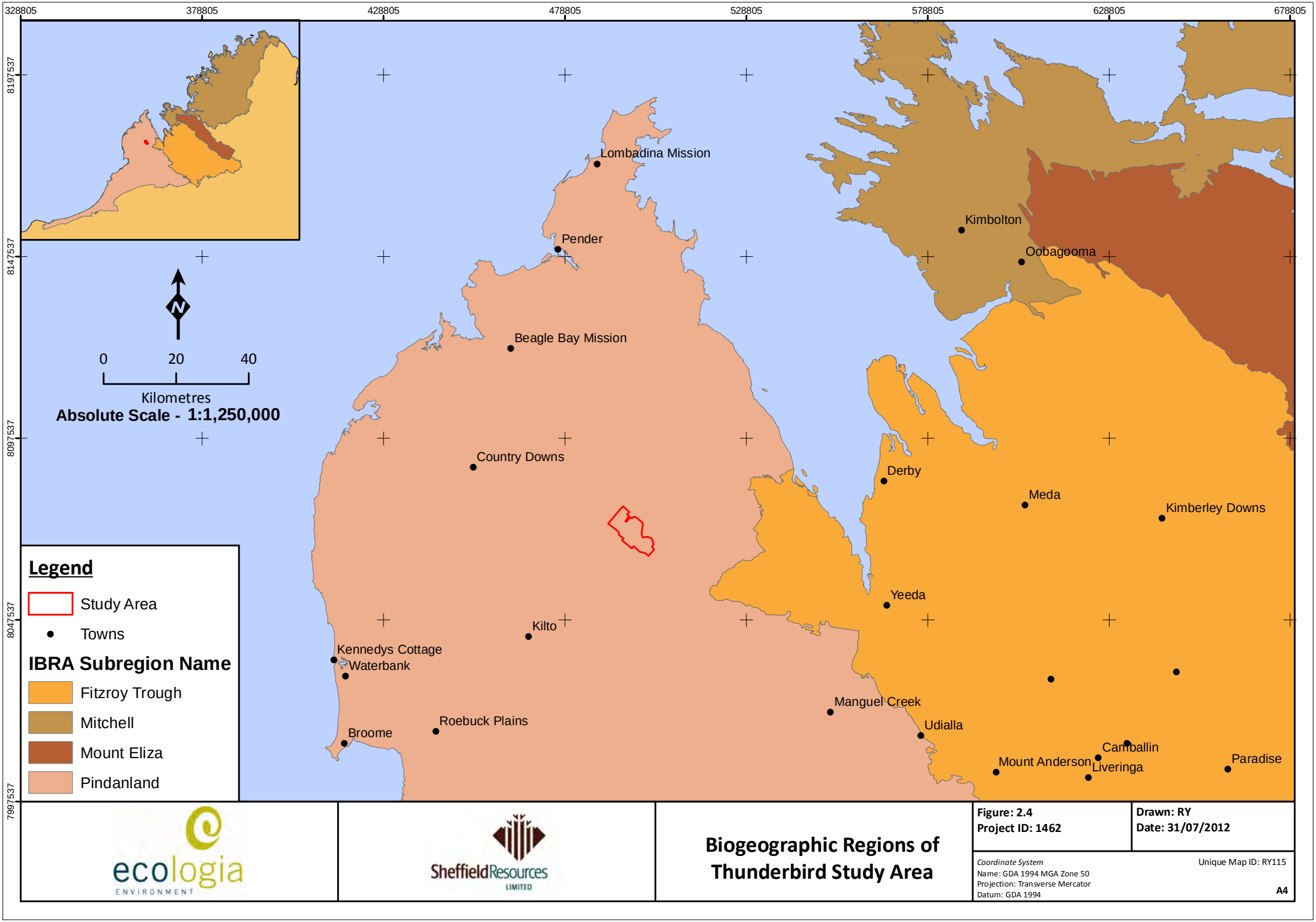
Figure: 2.3
Project ID: 1462

Drawn: RY
Date: 20/08/2012

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: RY109

A4


328805
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8047537
7997537
Lombadina Mission
Pender
Beagle Bay Mission
Country Downs
Kimbolton
Oobagooma
Derby
Meda
Kimberley Downs
Yeeda
Kilto
Kennedys Cottage
Waterbank
Broome
Roebuck Plains
Manguel Creek
Udialla
Camballin
Mount Anderson
Liveringa
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Kilometres
Absolute Scale - 1:1,250,000
Legend
Study Area
Towns
IBRA Subregion Name
Fitzroy Trough
Mitchell
Mount Eliza
Pindanland
ecologia
ENVIRONMENT
SheffieldResources
LIMITED
Biogeographic Regions of Thunderbird Study Area
Figure: 2.4
Project ID: 1462
Drawn: RY
Date: 31/07/2012
Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: RY115
A4

3 SURVEY METHODS

The survey methods of this survey were designed to be consistent with the recommendations of:

- Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004a); and,
- EPA's Guidance Statement No. 56 (EPA 2004b), Position Statement No. 3 (EPA 2002) and *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010).

A single phase Level 1 Survey was undertaken which combined the following methodological approaches:

- Desktop Assessment: to gather background information on the footprint or target area (i.e. search of literature, data and map-based information); and,
- Level 1 Survey: to enhance the level of knowledge of the flora and vegetation at the local scale and its local context or significance (if the broader scale is well known), and to ground truth the predicted fauna habitat types present in the Study Area and confirm the likelihood of occurrence for species of conservation significance.

3.1 LITERATURE REVIEW AND DATABASE SEARCHES

A search of government databases was undertaken to determine flora, vertebrate fauna, and vegetation communities of conservation significance previously recorded in the vicinity of the Study Area. A search with a 20 - 50 km buffer surrounding the Thunderbird Study Area was conducted on eight databases (Table 3.1).

Table 3.1 – Flora, Fauna and Ecological Community Database Searches.

Database	Search Details	Type of Search
Department of Environment and Conservation (DEC) Threatened Fauna Database	Records within 20 km of tenement E0402083	Fauna
DEC NatureMap	Records within 40 km of tenement E0402083	Flora and Fauna
Birds Australia Birdata	Records within 50 km of tenement E0402083	Fauna
Department of Sustainability, Environment, Water, Population and Community (DSEWPaC) protected matters database	Records within 50 km of tenement E0402083	Flora and Fauna
DEC Threatened (Declared Rare) Flora Database	Records within 50 km of tenement E0402083	Flora
DEC Western Australian Herbarium Specimen Database	Records within 50 km of tenement E0402083	Flora
DEC Declared Rare and Priority Flora List (Atkins)	Records within 50 km of tenement E0402083	Flora
DEC Threatened Ecological Community and Priority Ecological Community Databases	Records within 50 km of tenement E0402083	Ecologial Communities

In addition, ten publications reporting the vertebrate fauna conducted on the Dampier Peninsula were consulted (Table 3.2).

Table 3.2 – Previous Biological Survey Reports near the Study Area.

Survey Location and Author(s)	Distance to Study Area (km)	Comments
Beagle Bay Fauna Assessment (*ecologia* 2004)	44	1-phase Level 2 Survey
James Price Point Terrestrial Fauna Assessment (ecologia 2011)	83	1-phase Level 2 Survey
Perpendicular Head-North Head, Packer Island, Gourdon Bay and Coulomb-Quondong Vertebrate Fauna Assessment (ENV 2008)	72	1-phase Level 2 Survey
James Price Point Terrestrial Fauna Survey (Biota 2009)	83	1-phase Level 2 Survey
James Price Point Browse LNG Precinct Targeted Terrestrial Fauna Survey (Biota 2010)	83	1-phase Level 2 Survey
Supplementary Terrestrial Fauna and Habitat Assessment (AECOM 2010)	83	1-phase Level 1 Survey
Browse LNG Precinct Access Road: Targeted Fauna Survey – Greater Bilby (AECOM 2011)	86	Targeted Bilby survey
Monitoring Yellow Sea Migrants in Australia (MYSMA) (Rogers *et al.* 2009)	0 - 375	Targeted shorebird survey
Assessment of Birds Utilising Habitat within the Vine Thickets and Woodlands of James Price Point (Bamford 2011)	83	Targeted bird survey
Browse Project Greater Bilby Survey of the James Price Point Area - Summary Report (ENV 2011)	83	Targeted Bilby survey

3.2 CONSERVATION SIGNIFICANT SPECIES

After the results of the literature review, database searches and survey results were compiled, flora, and vertebrate fauna species that are listed under current legislative frameworks were identified. Recorded conservation significant fauna and flora taxa of the area were categorised into their conservation status under:

- *Environment Protection and Biodiversity Conservation Act 1999* (National)

Flora and fauna species are protected at a national level under the Commonwealth EPBC Act. The EPBC Act contains a list of species that are considered either 'Critically Endangered', 'Endangered', 'Vulnerable', 'Conservation Dependent', 'Extinct' or 'Extinct in the Wild' (Appendix A).

- *Wildlife Conservation Act 1950* (State)

Flora and fauna taxa protected under the *Western Australian Wildlife Conservation Notice* of the WC Act are known as Threatened taxa. This notice lists flora and fauna taxa that are extant and considered likely to become extinct or rare, defined as "taxa which have been adequately searched for and deemed to be either rare, in danger of extinction, or otherwise in need of special protection in the wild". These taxa are legally protected and their removal or impact to their surroundings cannot be conducted without Ministerial approval, obtained specifically on each occasion for each population (refer to Appendix A for category definitions).

- DEC Priority Flora and Fauna Lists (State)

The DEC maintains a list of Priority Flora and Fauna taxa, which are considered poorly known, uncommon or under threat but for which there is insufficient justification, based on known distribution and population sizes, for inclusion in the Threatened schedule. A Priority taxon is assigned to one of five priority categories (Atkins 2008) as defined in Appendix A.

The likelihood of a conservation significant species being present within the Study Area was determined by examining the following:

- potential fauna and flora habitats, and their condition, known to exist within the Study Area;
- distance of previously recorded locations from the Study Area;
- frequency of occurrence of records in the region; and,
- time elapsed since recorded within, or surrounding, the Study Area.

For each conservation significant species potentially occurring in the Study Area, the examined factors were collated and assigned to their corresponding category (Table 3.3).

Table 3.3 – Likelihood of Occurrence Categories.

HIGH/RECORDED	Species recorded within, or in proximity to, the Study Area within 50 years; suitable habitat occurs.
MEDIUM	Species recorded outside Study Area, but within 100 km; limited suitable habitat occurs.
LOW	Species rarely, or not, recorded within 100 km of the Study Area, and/or suitable habitat does not occur.

If a conservation significant species is located within the Study Area, the impact of disturbance to these individuals was assessed at a regional scale. All of these species are significant as they have been assigned a conservation status by the DEC, and any disturbance to populations located within the Study Area should be avoided where possible. The regional impact to each species was categorised into three levels (Table 3.4).

Table 3.4 – Regional Impact to the Conservation Significant Species.

HIGH	Disturbance to individuals will have a major regional impact as this is the only, or one of few, records within the region.
MEDIUM	There are some additional records for this species outside the Study Area within the region and the nature and scale of disturbance to these individuals would determine impact to the species at a regional scale.
LOW	The species has many records within the region and disturbance to individuals is unlikely to be regionally significant.

3.3 SURVEY TIMING

ecologia personnel assessed the Thunderbird Study Area between the 21st June and 26th June 2012.

The rainfall on the Dampier Peninsula in the six months preceeding the survey were higher than average, with Broome and Derby receiving 62.3 and 238.8 mm more than their long term average rainfall respectively. However, consistent with annual rainfall patterns, there was relatively little rainfall in the three months preceeding the survey (Table 3.5).

Table 3.5 – Rainfall received at Derby and Broome preceeding the survey.

Location		Jan	Feb	March	April	May	June	6 Month Total
Broome	2012	192.2	152.0	243.8	3.4	0.2	0	591.6
	Mean	178.5	179.1	100.8	26.7	26.4	17.8	529.3
Derby	2012	380.8	122.6	316.6	0	0	0	820
	Mean	196.3	199.8	132.6	26.5	18.1	7.9	581.2

3.4 QUADRAT SELECTION

3.4.1 Flora and Vegetation Quadrat Selection

Land system maps, aerial images, Shepherd vegetation maps, and maps provided by Sheffield with proposed drill lines and holes were reviewed and interpreted to assist in quadrat selection. Several well-established access tracks enabled most parts of the Study Area to be surveyed.

Seventeen flora quadrats were surveyed during the Level 1 assessment. The locations of these quadrats are depicted in Figure 3.1, listed in Table 3.6 and detailed in Appendix B.

Table 3.6 – Location of Flora Quadrats.

Quadrat	Location	
	Easting	Northing
TB Q 01	8074300	491807
TB Q 03	8074375	493242
TB Q 04	8074125	494332
TB Q 05	8073582	494080
TB Q 06	8073234	493955
TB Q 09	8068053	500545
TB Q 10	8067413	499677
TB Q 11	8067396	500022
TB Q 12	8067699	502523
TB Q 13	8075978	496085
TB Q 15	8075987	495950
TB Q 16	8074676	497409
TB Q 17	8068357	497314
TB Q 18	8071422	495997
TB Q 19	8071234	497776
TB Q 20	8071874	499829
TB Q 21	8073619	500192

Datum: MGA Zone 51 (GDA 94)

3.4.2 Fauna Site Selection

Previous survey information, aerial photographs, vegetation and land system maps of the Study Area were studied prior to the survey to determine the potential habitat types of the Study Area. Several sites were selected based on the potential habitats expected to occur in the Study Area. The habitats of the Study Area were confirmed and then mapped using information from on-site reconnaissance. Locations of fauna assessment sites are provided in Table 3.7, Figure 3.2 and described in Appendix E.

Table 3.7 – Location of Fauna Survey Sites.

Site	Location	
	Easting	Northing
TB OS 01	491805	8074295
TB OS 03	493234	8074381
TB OS 04	494327	8074118
TB OS 05	494448	8072731
TB OS 06	501991	8067685
TB OS 09	499829	8068232
TB OS 10	499681	8067419
TB OS 11	502522	8067699
TB OS 12	496082	8076026
TB OS 13	497451	8074696
TB OS 15	497289	8068337
TB OS 16	495995	8071421

Datum: MGA Zone 51 (GDA 94)

Figure 3.1 – Location of Flora Sites within the Study Area.

Figure 3.2 – Location of Fauna Sites within the Study Area.

3.5 SAMPLING METHODS

3.5.1 Flora sampling methods

The survey involved a combination of quadrat-based sampling and some additional opportunistic sampling from field traverses. Quadrats were utilised to determine the floristic composition within vegetation units, and the resultant species by quadrat matrix was used to conduct multivariate analysis. Both methods contributed to the delineation of small-scale vegetation communities and the floristic species inventory of the Study Area.

3.5.1.1 Floristic Quadrats

Seventeen quadrats were established over the Study Area with each quadrat equivalent to a polygon of 2,500 m^2.

The following information was recorded at each Quadrat:

1. **Location details, including GPS coordinates**: Quadrats were aligned along a north-south bearing with each corner of the quadrat recorded using a Garmin GPSmap 76Cx GDA84;
2. **Photograph of vegetation structure**: A photograph of the vegetation structure was taken from the north-west corner of the quadrat, with additional photographs taken throughout the area if needed to supplement the complexity of the quadrat;
3. **Topography, surface soil composition and colour, and surface lithology**: Information on habitats, slope, drainage lines, surface layers, soil colour, soil texture, rock type, rock size and rock abundance were recorded at each quadrat location;
4. **Structural information describing the vegetation community:** Vegetation type, life-form strata and percentage cover for each stratum were recorded using the NVIS vegetation classifications, as described in Appendix B;
5. **Height ranges and foliage canopy cover for each species recorded within the Quadrat**: Height ranges and foliage canopy cover for each species were recorded using the NVIS vegetation classifications, as described in Appendix B;
6. **Vegetation condition and the nature of disturbance:** Vegetation condition within the Study Area was assessed at each quadrat using the rankings indicated in Appendix B. Criteria considered when determining these levels were the presence of weeds, animal and vehicle tracks, litter, grazing, dust and any other ground disturbances, based on the criteria proposed by Trudgen (1988); and,
7. **The estimated time since the last fire at each quadrat.**

3.5.1.2 Opportunistic Collections

While walking between quadrats, opportunistic collections of introduced taxa and native taxa not recorded within the quadrats were made where possible to ensure a more comprehensive species inventory. The location and local percentage cover was recorded for each collection. The locations of introduced flora and notes on the boundaries of the vegetation communities were recorded to facilitate the mapping of the vegetation communities.

3.5.2 Fauna Sampling Methods

The survey was undertaken using the opportunistic sampling methods of bird surveying, hand searching for reptiles and mammals, spotlighting and recording bat calls with an Anabat system. Each of these methods is described below.

3.5.2.1 Bird Surveying

Records were made of bird species observed during the site and habitat assessments at each survey site. Opportunistic observations of birds made while travelling within the Study Area were also recorded.

3.5.2.2 Opportunistic Sightings

All vertebrate fauna species observed outside the survey sites, while searching and travelling within the Study Area were recorded. Tracks, diggings, scats, burrows and nests were recorded where possible.

3.6 ANIMAL ETHICS

Surveying was conducted as per *ecologia*'s Animal Ethics Code of Practice, which conforms to Section 5 of the *Australian code of practice for the care and use of animals for scientific purposes* (NHMRC 2004).

3.7 VEGETATION MAPPING

Vegetation mapping is the hierarchical delineation of vegetation into groups or associations. The distinctive characteristics that these groups or communities share include species dominance, stratum structure and species composition. The quadrats were analysed for similarity and grouped via a dendrogram (Appendix C). Vegetation communities identified were used to interpret aerial photography that was mapped through a series of GIS polygons.

The vegetation of the Study Area has been mapped at a scale of 1:15,000 on the basis of multivariate cluster analysis, field observation and aerial photography.

3.8 TAXONOMY AND NOMENCLATURE

3.8.1 Flora

Voucher specimens were collected from all quadrats, opportunistic collections and targeted searches, and assigned a unique code for later identification or verification. Specimens were pressed daily and subsequently dried. Identification and verification of specimens was completed by Dr Andrew Craigie and Dr Udani Sirisena with reference to specimens lodged at the Western Australian Herbarium (WAHERB). Botanical nomenclature follows the conventions currently adopted by the WAHERB (2010).

3.8.2 Fauna

Nomenclature for mammals, reptiles and amphibians follows *Western Australian Museum Checklist of the Vertebrates of Western Australia*, and for birds follows Christidis and Boles (2008). References used for fauna identification are listed in Table 3.8.

Table 3.8 – References used for Fauna Identification.

Fauna Group	Reference
Mammals	Menkhorst and Knight (2011), Van Dyck and Strahan (2008)
Bats	Churchill (1998), Menkhorst and Knight (2011)
Birds	Simpson and Day (2004)
Reptiles	Cogger (2000), Wilson and Swan (2010)
Geckos	Storr et al. (1990), Wilson and Swan (2010)
Skinks	Storr et al. (1999), Wilson and Swan (2010)
Dragons	Storr et al. (1983), Wilson and Swan (2010)
Varanids	Storr et al. (1983), Wilson and Swan (2010)
Legless Lizards	Storr et al. (1990), Wilson and Swan (2010)
Snakes	Storr et al. (2002), Wilson and Swan (2010)
Amphibians	Menkhorst and Knight (2011), Van Dyck and Strahan (2008)

3.9 SURVEY ADEQUACY AND ANALYSIS

3.9.1 Species Richness

The number of species present (species richness) is the simplest representation of species diversity (Fowler and Cohen 1990), and is a basic indicator of diversity used for this survey.

3.9.2 Randomised Species Accumulation Curves

There are three general methods of estimating species richness from sample data: extrapolating species accumulation curves (SACs), fitting parametric models of relative abundance, and using non-parametric estimators (Bunge and Fitzpatrick 1993; Colwell and Coddington 1994; Gaston 1996). In this report, the level of survey adequacy was estimated using SACs as computed by Mao Tao. In addition, a Michaelis-Menten enzyme kinetic curve was calculated. To eliminate features caused by random or periodic temporal variation, the sample order was randomised 1000 times. The estimator applied to the dataset was performed using EstimateS (version 8, Colwell 2009).

3.9.3 Vegetation Community Analysis

A quadrat by species matrix was created and formed the basis of the cluster analysis. Annual and weekly perennial species, species recorded once (unless dominant in the vegetation) and opportunistic collections beyond the boundaries of quadrats were excluded. Cluster analysis was performed using an association matrix of the Bray-Curtis coefficient. The similarity between quadrats and the similarity between the occurrences of species was analysed using the multivariate statistical programme SYSTAT™. These methods provide an objective means to classify vegetation communities based on groups with similar species composition. A dendrogram was produced to statistically delineate the floristic communities present. The dendrogram and quadrat by species matrix are provided electronically in Appendix C.

3.10 SURVEY TEAM

The vegetation and flora assessment described in this document was planned, coordinated and executed by Dr Renee Tuckett, and Dr Udani Sirisena. The vertebrate fauna assessment described

in this document was planned, coordinated and executed by Nigel Jackett and Damien Cancilla. Their qualifications are provided in Table 3.9, and licence details in Table 3.10.

Table 3.9 – Project Staff and Qualifications.

Staff Member	Position	Qualifications	Experience
Dr Renee Tuckett	Team Leader, Senior Botanist	Ph.D.	4 years
Dr Udani Sirisena	Taxonomist	Ph.D.	5 years
Damien Cancilla	Senior Zoologist	BSc (Hon)	7 years
Nigel Jackett	Level 2 Zoologist	BSc (Hon)	11 years

Table 3.10 – Relevent DEC Licence Details.

Name	Permit Type	Permit Number	Valid Until
Renee Tuckett	Flora Licence	SL009432	30/04/13
Nigel Jackett	Fauna Licence	SF008707	21/07/12

Mr Bob Bullen (Principal, Bat Call WA) identified the bat species present based on their acoustic calls recorded on Anabat devices. Mr Bullen has 16 years experience working directly with bats and has published a number of peer-reviewed journal articles on bat ecology and several other bat-related articles (see, for example, Bullen and McKenzie 2001, 2002, 2005).

3.11 SURVEY LIMITATIONS AND CONSTRAINTS

The survey limitations and constraints were analysed following the field trips. The surveys were reviewed for the following aspects:

- Scope (what faunal groups were sampled, and were some sampling methods not able to be employed because of constraints such as weather conditions);
- Sources of information (previously available information as distinct from new data);
- Competency/experience of the consultant carrying out the survey;
- The proportion of the task achieved and further work which might be needed;
- Proportion of fauna identified, recorded and/or collected;
- Proportion of flora collected and identified;
- Mapping reliability;
- Timing/weather/season/cycle;
- Intensity (in retrospect, was the intensity adequate);
- Completeness (e.g. was relevant area fully surveyed);
- Resources (e.g. degree of expertise available in animal identification to taxon level);
- Remoteness and/or access problems;
- Availability of contextual (e.g. biogeographic) information on the region; and,
- Efficacy of sampling methods (i.e. any groups not sampled by survey methods).

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4 RESULTS

4.1 SURVEY LIMITATIONS

Limitations of the current survey are summarised Table 4.1 below. Given the few limitations encountered, it can be confirmed that an adequate level of survey has been undertaken to meet the specific objectives of the study.

Table 4.1 – Flora Survey Limitations and Constraints

Aspect	Relevant (yes/no)	Comment
Sources of information and availability of contextual information (i.e. pre-existing background versus new material)	No	Information regarding vegetation at a regional scale is limited to the mapping of Beard (1975) at a scale of 1:1,000,000, and subsequently digitised and reinterpreted by Shepherd *et al.* (2001). More recently described, land systems (Van Vreeswyk *et al.* 2004) provide a good source of regional information on vegetation communities and condition, based on land systems, again at a relatively broad scale of 1:250,000.
The scope (i.e. what life forms were sampled)	No	Vascular flora of the Study Area was sampled.
Proportion of flora collected and identified (based on sampling, timing and intensity)	No	A total of 617 specimens were collected during the survey of the Study Area, from which 155 taxa were identified to species, subspecies or variety. Three taxa were limited to identification to genus level due to insufficient reproductive material. A SAC analysis indicated 60-67 % of the total vascular species likely to be present were recorded. The sampling timing was not optimal, however was sufficient to obtain baseline data to satisfy the requirements of the survey.
Completeness and further work which might be needed (e.g. was the relevant area fully surveyed)	No	The Study Area was surveyed at a density of one quadrat per 447 ha. To survey the vegetation at a level sufficient for environemtal approvals a higher density of quadrats would be required, although much of the area was covered and six vegetation units were described from the current survey. A large proportion of the Study Area in the north was recently burnt and would also require a greater survey effort.
Mapping reliability	No	Colour aerial imagery was used to select quadrats and to map the vegetation of the Study Area. Uncommon vegetation communities, which were not recognised in the pre-survey inspection of the aerial imagery, but were encountered during the survey, were opportunistically sampled.
Timing/weather/season/cycle	No	Rainfall recorded at Broome and Derby in the six months preceding they survey (June 2012) was 591.6 and 820 mm, 62.3 mm and 238.8 mm greater than the long-term mean for the same six months respectively. However, almost no rainfall was received in the between April-June and some species were not flowering. It is likely that there are annuals occurring within the Study Area that were not present during the current survey.
Disturbances (e.g. fire, flood, accidental human intervention)	Yes	A large area in the northern portion of the Study Area was burnt in 2012. This area had not regenerated and most species had not regenerated. Hence this area was not surveyed.
Intensity (in retrospect, was the intensity adequate?)	No	The objective of the survey was to obtain baseline data and satisfy the conditions of the Traditional Owners. To meet this requirement the intensity was sufficient. However, for statuatory environmental approvals a higher survey effort would be required.
Resources	No	Resources were adequate for the botanical survey; 6 person days were invested in the field survey.
Access problems	No	Tracks available in the Study Area were limited and thus the full Study Area could not be accessed through walking. However, since the survey was conducted, new tracks have been established and should be available for

Aspect	Relevant (yes/no)	Comment
		future surveys.
Experience levels (e.g. degree of expertise in plant identification to taxon level)	No	One botanist conducting the survey had sufficient experience in conducting botanical surveys in the Kimberley. Plant specimens were collected from each quadrat surveyed for verification. The taxonomist responsible is broadly experienced in identifying the flora of Western Australia and cryptic specimens were referred to the WAHERB. The project was overseen and reviewed by the Principal Botanist with 21 years of experience in EIA. Qualifications of the project staff are detailed in Section 3.11.1.

Table 4.2 – Fauna Survey Limitations and Constraints

Aspect	Relevant (yes/no)	Comment
Competency/experience of the consultant carrying out the survey.	No	All staff were experienced in identifying fauna and fauna habitats.
Scope (what groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions).	No	All groups were surveyed using methods sufficient for Level 1 Surveys.
Proportion fauna identified, recorded and/ or collected.	No	All fauna observed were identified in the field.
Sources of information (previously available information as distinct from new data).	No	A number of previous Level 2 Surveys had been conducted within 100 km of the Study Area, as well as records available from public databases.
The proportion of the task achieved and further work which might be needed.	No	No additional work is required.
Timing/weather/season/cycle.	No	Weather and activity of fauna species is negligible for the current Level 1 Survey.
Disturbances which affected results of the survey (e.g. fire, flood, accidental human intervention).	No	No disturbances occurred.
Intensity (in retrospect was the intensity adequate).	No	The survey was developed following the guidelines for terrestrial surveys (EPA and DEC 2010).
Completeness (e.g. was relevant area fully surveyed).	No	Survey is complete.
Resources (e.g. degree of expertise available in animal identification to taxon level).	No	There were no resource constraints.
Remoteness and/or access problems.	No	Areas to be disturbed by the development were mainly accessible by tracks and on foot.
Availability of contextual (e.g. biogeographic) information on the region).	No	Sufficient contextual information was available for the Kimberley region and the Study Area.
Efficiency of sampling methods (i.e. any groups not sampled by survey methods).	No	The survey methods employed were effective to assess habitats within the Study Area.

4.2 VEGETATION RESULTS

4.2.1 Threatened Ecological Communities

No EPBC-listed TECs occur within the Study Area. No state-listed TECs occur within in the Study Area.

4.2.2 Priority Ecological Communities

No PECs occur within the Study Area.

4.2.3 Vegetation Condition of the Study Area

The vegetation condition of quadrats at Thunderbird ranged from poor to excellent, with the temporary pool being the most highly degraded with severe impacts from cattle. The remainder of the quadrats were classifiifed as either Good, Very Good, or Excellent with low impacts from weeds and cattle (tracks, grazing, faeces). Three introduced species were recorded within the Study Area; *Cynodon dactylon* (couch grass), *Stylosanthes hamata* and *Stylosanthes scabra*. The locations are listed in Table 4.10 and mapped in Figure 4.7. The characteristics and broad distribution of these species are summarised in Table 4.9.

4.2.3.1 Fire History of the Study Area

A large proportion of the Study Area had been burnt within a few months prior to the survey. These areas were not sampled as most species had not germinated or resprouted. This area was estimated to cover approximately 25% of the Study Area. Of the areas that had not been burnt in 2012, 24% had been burnt in the past 1-2 years, 41% in the past 2-5 years and 35% had no evidence or had not been burnt in the past 5 years.

4.2.4 Vegetation Communities of the Study Area

Six vegetation units were described for the Study Area. Each group is described, and notes on the habitat, land system, vegetation condition species richness are provided along with, a representative panoramic photograph of the vegetation type. The vegetation communities are mapped in Figures 4.15, 4.16 and 4.17.

4.2.4.1 Vegetation of Hills and Ridges

CdAdCpGt: ***Corymbia dendromerinx* woodland over *Acacia drepanocarpa* subsp. *latifolia* open shrubland over *Cymbopogon procerus*, *Eriachne obtusa* and *Sorghum plumosum* tussock grassland with *Glycine tomentella* creepers.**

Vegetation *Unit* Area: 213.73 ha

Habitat: Hill tops/ Ridge top

Land System: Reeves

Vegetation Condition: Very Good

Quadrats Surveyed: 5

Species Richness: 37

Associated Species:

Atalaya variifolia, Bonamia linearis, Calytrix extipulata, Cenchrus elymoides, Crotalaria medicaginea var. *neglecta, Cyperus microcephalus, Dicliptera armata, Eriachne* sp. *Dampier Peninsula, Eucalyptus tectifica, Ficus platypoda, Flueggea virosa* subsp. *melanthesoides, Gomphrena canescens* subsp. *canescens, Tinospora smilacina, Triumfetta breviaculeata* and *vigna lanceolata* var. *filiformis.*

Photograph

Figure 4.1 – Representative Photograph of Vegetation Unit CdAdCpGt.

4.2.4.2 Vegetation of Pindan Plains

CgApTcAh: ***Corymbia greeniana* and *Erythophleum chlorostachys* open woodland over *Acacia platycarpa* and *A. tumida* var *tumida* open shrubland, over *Triodia caelestialis* hummock grassland and *Aristida holathera* var *holathera*, *Crysopogon* sp., *Eriachne obtusa* and *Sorghum plumosum* tussock grassland.**

Vegetation *Unit* Area: 1610.09 ha

Habitat: Flat sandy plain

Land System: Reeves and Fraser

Vegetation Condition: Excellent to Good

Quadrats Surveyed: 3, 12, 13, 16

Species Richness: 31.5 ± 2.1

Associated Species:

Bauhinia cunninghamii, Brachychiton diversifolius subsp. *diversifolius, Dodonaea hispidula* var. *arida, Eucalyptus tectifica, Grevillea refracta* subsp. *refracta, Gomphrena canescens* subsp. *canescens Microstachys chamelea and Pterocaulon sphacelatum.*

Photograph

Figure 4.2 – Representative Photograph of Vegetation Unit CgApTcAh.

CzAtSpTc: ***Corymbia greeniana* and *C. zygophylla* open woodland over *Acacia tumida* var. *tumida* shrubland over *Sorghum plumosum* tussock grassland and *Triodia caelestialis* sparse hummock grassland.**

Vegetation *Unit* Area: 4033.45 ha

Habitat: Flat sandy plain

Land System: Reeves and Yeeda

Vegetation Condition: Excellent to Very Good

Quadrats Surveyed: 6, 11, 17, 21

Species Richness: 26.0 ± 2.9

Associated Species:

Acacia platycarpa, Brachychiton diversifolius subsp. *diversifolius, Buchnera linearis, Dodonaea hispidula* var. *arida, Dolichandrone heterophylla, Eriachne melicacea Erythrophleum chlorostachys, Terminalia canescens* and *Wrightia saligna.*

Photograph

Figure 4.3 – Representative Photograph of Vegetation Unit CzAtSpTc.

GpSpTc: ***Corymbia dendromerinx* and *C. greeniana* open woodland over *Grevillea pyramidalis* subsp. *pyramidalis* and *G. refracta* subsp *refracta* shrubland over *Sorghum plumosum* tussock grassland and *Triodia caelestialis* hummock grassland**

Vegetation *Unit* Area: 986.10 ha

Habitat: Plains, Gullies and Mid-slopes

Land System: Reeves and Yeeda

Vegetation Condition: Excellent to Very Good

Quadrats Surveyed: 4, 9, 10, 19

Species Richness: 35.5 ± 2.9

Associated Species:

Buchnera asperata, Corchorus sidoides subsp. *vermicularis, Dolichandrone heterophylla, Eriachne ciliata, Fimbristylis simulans, Glycine tomentella, Gomphrena canescens* subsp. *canescens, Hybanthus aurantiacus, Microstachys chamelea, Oldenlandia mitrasacmoides* subsp. *mitrasacmoides, Polycarpaea corymbosa, Pterocaulon sphacelatum, Ptilotus corymbosus, Terminalia canescens* and *Wrightia saligna.*

Photograph

Figure 4.4 – Representative Photograph of Vegetation Unit GpSpTc.

4.2.4.3 Vegetation of Clay-based Lowlands

MnMvAcEoTc: ***Corymbia greeniana*** **and** ***Melaleuca nervosa*** **or** ***M. viridiflora*** **open woodland, over** ***Acacia colei*** **var.** ***colei*** **tall shrubland, over** ***Eriachne obtusa*** **tussock grassland and** ***Triodia caelestialis*** **hummock grassland.**

Vegetation *Unit* Area: 750.05 ha

Habitat: Flat sandy-clay plains

Land System: Fraser and Waganut

Vegetation Condition: Excellent to Good

Quadrats Surveyed: 15, 20

Species Richness: 28 ± 3

Associated Species:

Buchnera asperata, Carissa lanceolata, Crotalaria crispata, Desmodium filiforme, Drosera derbyensis, Drosera indica, Ectrosia schultzii, Gomphrena canescens subsp. *canescens, Heliotropium cunninghamii, Oldenlandia mitrasacmoides* subsp. *mitrasacmoides, Paspalidium rarum, Pterocaulon serrulatum* var. *velutinum Spermacoce occidentalis, Stackhousia intermedia, Stemodia lathraia* and *Xyris complanata.*

Photograph

Figure 4.5 – Representative Photograph of Vegetation Unit MnMvAcEoTc.

EtMvSi: ***Eucalyptus tectifica*** **and** ***Melaleuca viridiflora*** **open woodland over** ***Sacciolepis indica*****,** ***Sorghum plumosum*****,** ***Fuirena ciliaris*** **tussock grassland.**

Vegetation *Unit* Area: 9.39 ha

Habitat: Flat sandy-clay plains

Land System: Fraser

Vegetation Condition: Poor

Quadrats Surveyed: 1

Species Richness: 33

Associated Species:

Blumea integrifolia, Byblis filifolia, Chamaecrista mimosoides, Cyperus ? *conicus, Digitaria bicornis, Drosera indica, Eleocharis geniculata, Fimbristylis dichotoma, Lipocarpha microcephala, Ludwigia perennis, Melochia corchorifolia, Mimulus uvedaliae* var. *lutea, Oldenlandia galioides, Phyllanthus virgatus, Rotala occultiflora, Sida hackettiana, Stackhousia intermedia, Stylosanthes hamata, Stylosanthes scabra* and *Thysanotus chinensis.*

Photograph

Figure 4.6 – Representative Photograph of Vegetation Unit EtMvSi.

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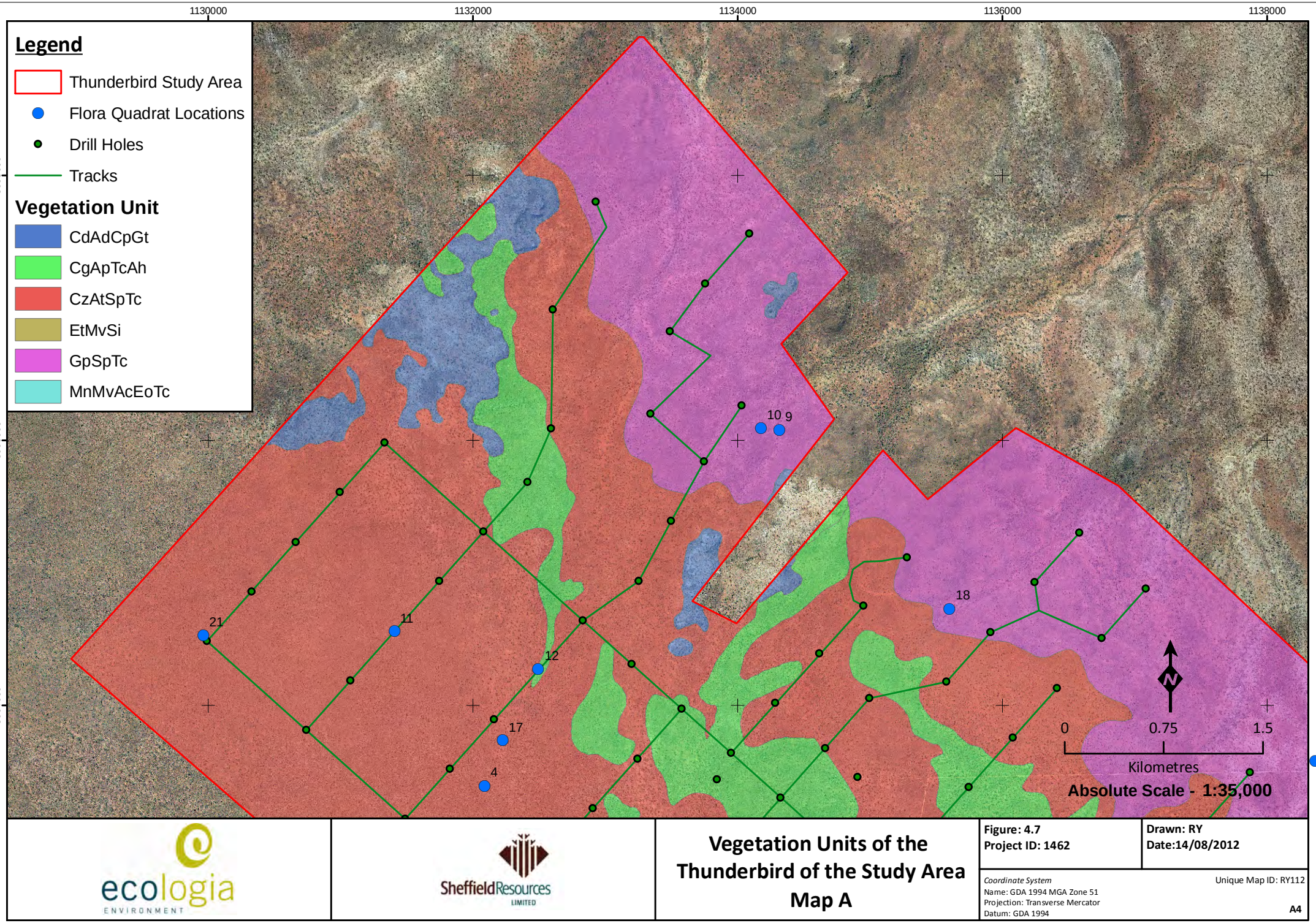

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Vegetation Units of the Thunderbird of the Study Area Map A

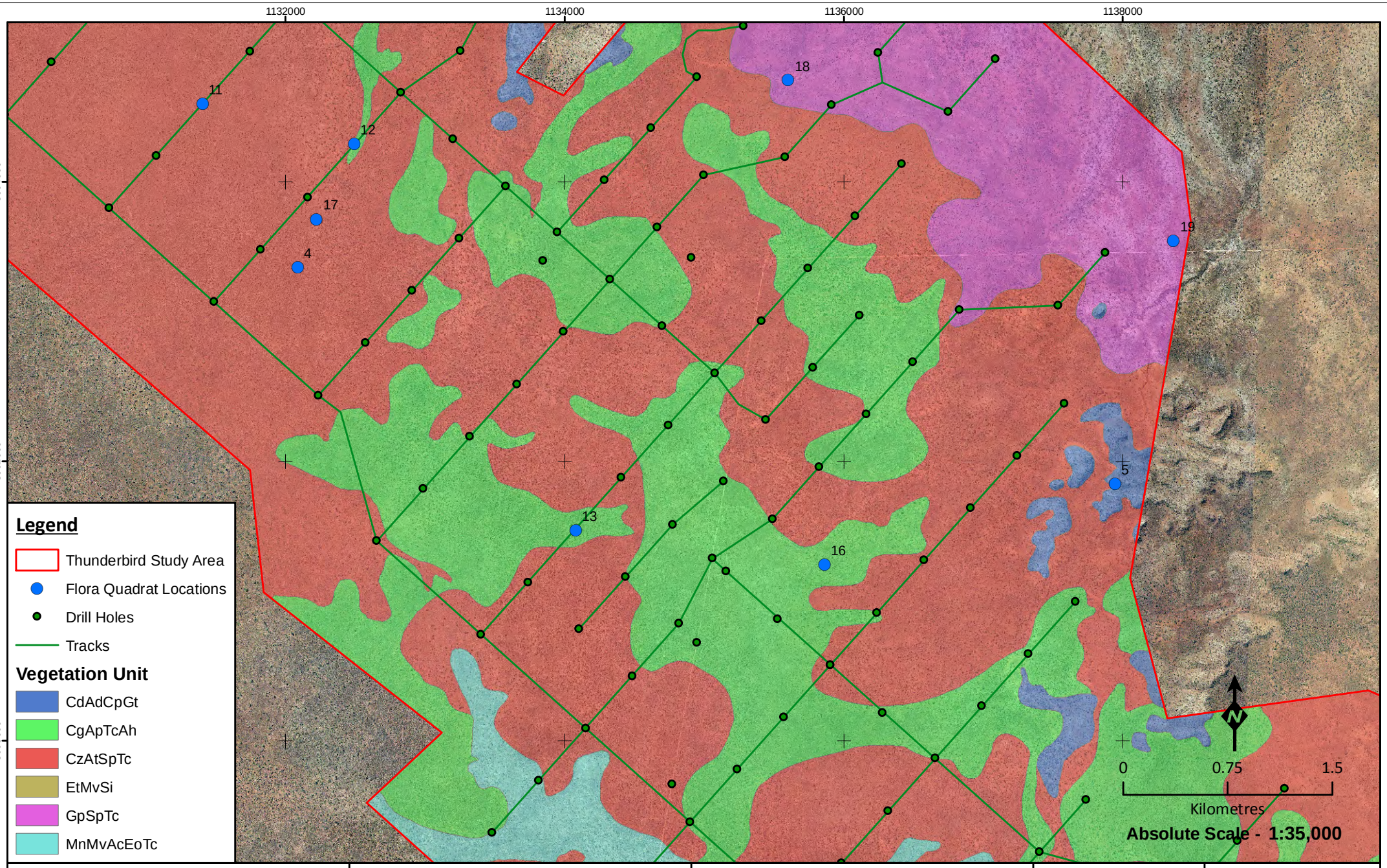
Figure: 4.7
Project ID: 1462

Drawn: RY
Date:14/08/2012

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: RY112

A4



ecologia ENVIRONMENT

Sheffield Resources LIMITED

Vegetation Units of the Thunderbird of the Study Area Map B

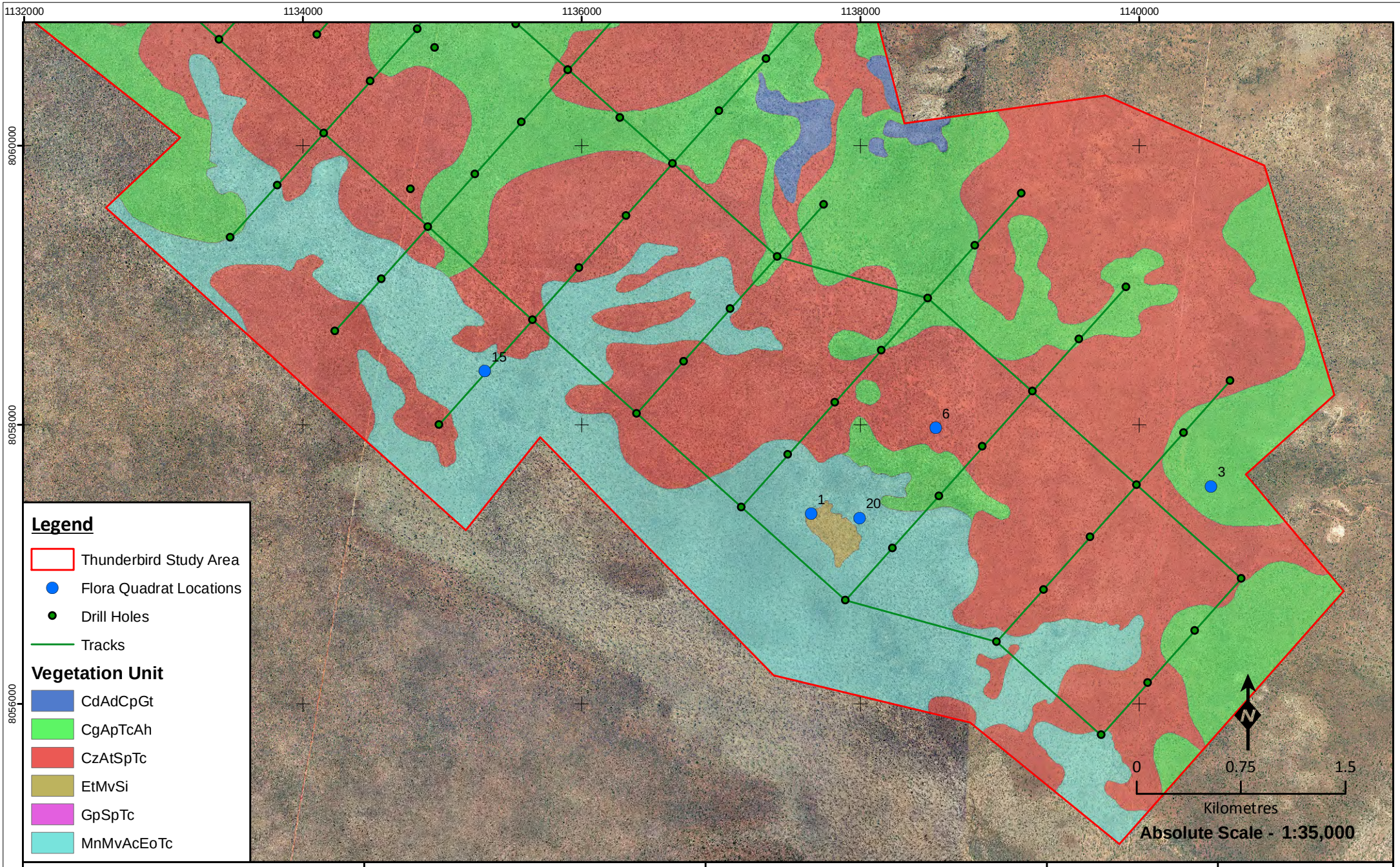
Figure: 4.8
Project ID: 1462

Drawn: RY
Date:14/08/2012

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: RT113

A4



ecologia ENVIRONMENT

Sheffield Resources LIMITED

Vegetation Units of the Thunderbird of the Study Area Map C

Figure: 4.9
Project ID: 1462

Drawn: RY
Date:14/08/2012

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: RT114

A4

4.3 FLORA RESULTS

A total of 155 flora taxa were recorded and fully identified, including subspecies, varieties and hybrids, as detailed in Appendix D. The composition of the flora is summarised in Table 4.3.

Table 4.3 – Taxonomic Composition of the Flora of the Study Area.

Number of Quadrats Surveyed	Number of Taxa Recorded	Number of Families	Number of Genera	Number of Families Represented by a Single Taxon	Number of Genera Represented by a Single Taxon
17	155	43	108	20	77

The families and genera represented by the greatest number of taxa and the most frequently recorded species in the Study Area are listed in Table 4.4.

Table 4.4 – Most Frequently Recorded Families, Genera and Taxa in the Study Area.

Most Common Families	Most Common Genera	Most Frequently Recorded Taxa
Fabaceae (28 taxa) Poaceae (25 taxa) Malvaceae (11 taxa) Cyperaceae (9 taxa) Myrtaceae (8 taxa)	*Acacia* (7 taxa) *Eriachne* (5 taxa) *Aristida* (4 taxa) *Tephrosia* (4 taxa)	*Triodia caelestialis* (18 taxa, P3) *Brachychiton diversifolius* subsp. *diversifolius* (16 taxa) *Sorghum plumosum* (16 taxa) *Corymbia greeniana* (15 taxa) *Gomphrena canescens* subsp. *canescens* (14 taxa) *Terminalia canescens* (14 taxa)

The highest species richness values in the Study Area were recorded in quadrats 5 and 9. Lower species richness values were recorded in quadrats 11, 6 and 21. The areas of highest and lowest vegetation units were from a range vegetation types, however on average the rocky hills (CdAdCpGt) were highest and vegetation unit CzAtSpTc of the Pindan plains was lowest in species richness.

4.3.1 Sampling Adequacy and Species Accumulation Curve Analysis for the Study Area

Using species Accumulation curve (SAC) analysis (Colwell 2009) and extrapolation of the curve to the asymptote using Michaelis-Menten modelling, the incidence-based coverage estimator of species richness (ICE Mean, Chao 2 Mean) was determined between 245 and 249 (Figure 4.10). A total of 155 taxa were recorded on the survey, estimating that between 60 and 67 % of the flora species potentially present within the Study Area were recorded. Given the level of survey required to meet the objectives of the current survey, the density of quadrats was fairly low and did not occur at the directly following the wet season (March-April) when then presence of annuals is highest in the Kimberley.

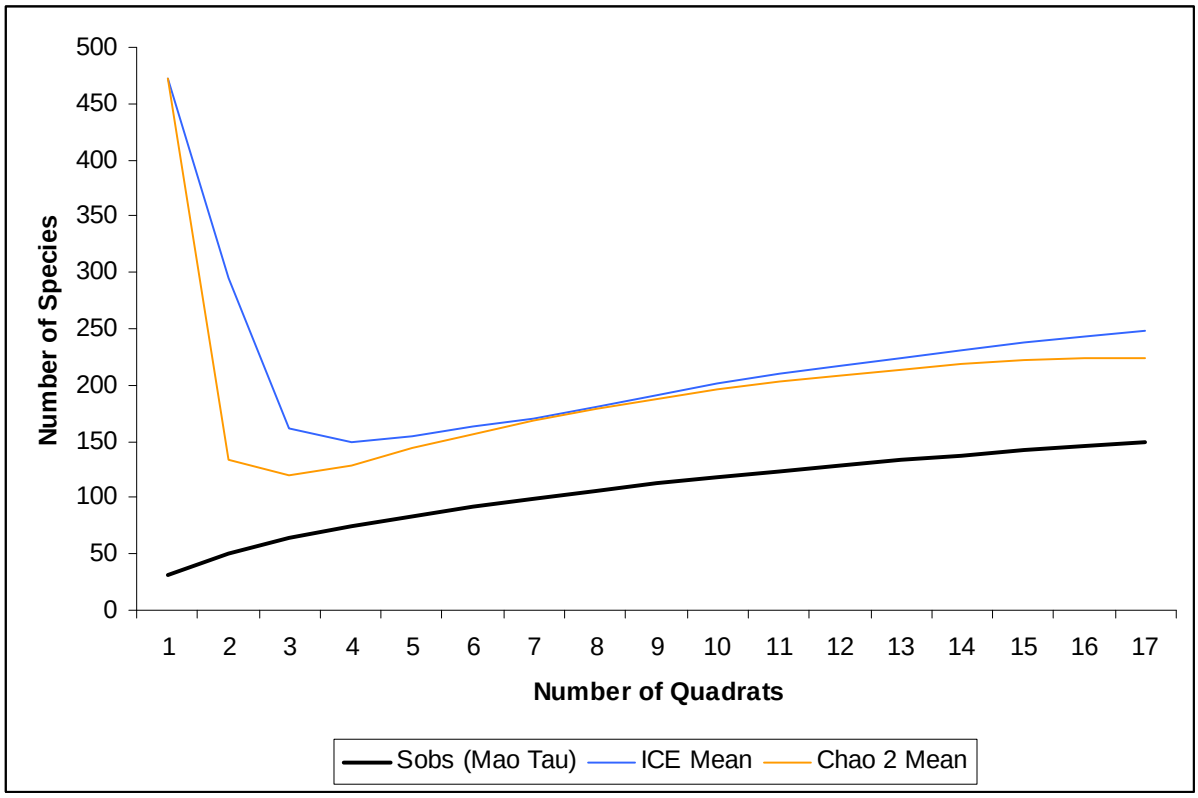


Figure 4.10 – Average Randomised SAC for the Study Area.

4.3.2 Flora of Conservation Significance

4.3.2.1 Environment Protection and Biodiversity Conservation Act 1999

No EPBC Act listed species were recorded in the Study Area.

4.3.2.2 Wildlife Conservation Act 1950

No Threatened taxa were recorded in the Study Area.

4.3.2.3 Priority Flora with Potential to Occur in the Study Area

Currently, 75 Priority Flora taxa are listed as occurring in Dampierland (WAHERB, August 2012). A database search of the DEC's Threatened (Declared Rare) Flora Database and the DEC's WAHERB Specimen Database indicated that 40 Priority Flora have previously been recorded within 50 km of the Study Area (Table 4.5). Twenty of these Priority Flora taxa are assessed to have a medium or high likelihood of occurrence within the Study Area.

Table 4.5 – Assessment of Potential of Priority Flora to Occur in the Study Area.

Taxon	DEC Conservation Code	Preferred Habitat	Distribution	Likelihood of Occurrence	Regional Impacts
Aizoaceae					
Tetragonia coronata	P3	Occurs on calcrete outcrops, red loamy soil, in the shade of larger shrubs.	Overlander Roadhouse, Hamelin Pool, Broome, Carey Downs Stn.	Medium	High
Amaranthaceae					
Gomphrena pusilla	P3	Occurs on coastal sand dunes, with either calcrete sands or fine shell grit	Dampier Peninsula, Pt Hedland	Low	Medium
Apocynaceae					
Parsonsia kimberleyensis	P1	Occurs on vine thicketts	Dampier Peninsula	Low	High
Araceae					
Colocasia esculenta var. *aquatilis*	P3	Occurs in wet grasslands which have perminant water	Theda Station Homestead, Doongan Station, Lady Forrest Ranges, Mt Hart Station Homested, Dampier Peninsula	Low	Medium
Asteraceae					
Pterocaulon intermedium (formally – *Pterocaulon* sp. A. Kimberley Flora (B.J. Carter 599))	P3	No information	Broome, Anna Plains, Anjo Peninsula, South Headland, Dampier Peninsula	High	Medium
Thespidium basiflorum	P1	Occurs in sandy soil creek beds	Dampier Peninsula	Medium	Medium
Byblidaceae					
Byblis guehoi	P1	Occurs in sand and silt-loam soils that are waterlogged in the wet season but dry soonafter.	Dampier Peninsula	Medium	High
Celastraceae					
Stackhousia clementii	P3	Occurs close to water on fine sand in limestone or calcrete areas.	Dampier Peninsula, Wiluna, Burrup Peninsula, Gnaraloo Homestead	Low	Medium

Taxon	DEC Conservation Code	Preferred Habitat	Distribution	Likelihood of Occurrence	Regional Impacts
Convolvulaceae					
Ipomoea gracilis	P1	Occurs on clay or irrigated sand, close to rivers.	Kununurra, Ord River.	Low	Medium
Ipomoea sp. A Kimberley Flora (L.J. Penn 84)	P1	Occurs in shallow soils on sandstone	Dampier Peninsula	Medium	High
Jacquemontia sp. Broome (A.A. Mitchell 3028)	P1	Occurs in woodlands on Pindan plain	Dampier Peninsula	Low	Medium
Cyperaceae					
Cyperus haspan subsp. *haspan*	P1	Occurs in peat bank on the edge of spring	Dampier Peninsula	Low	High
Fuirena incrassata	P3	Occurs in sand and claypans, generally close to water	Googhenama Creek, Broome	Medium	Low
Schoenus punctatus	P3	Occurs close to water, in both sand and clay	Nurrup Peninsula, Broome, Mt Barnett Stn	Low	Medium
Euphorbiaceae					
Croton aridus	P3	Occurs on sand plains in Pindan soil.	Edgar Range, Broome, Shay Gap	Medium	Medium
Fabaceae					
Acacia sp. Broome (B.R. Maslin 4918)	P3	Occurs on coastal cliffs and low lying areas	Broome, Camballin, Wallan Downs Stn.	High	Low
Acacia sp. Riddell Beach (T. Willing 71)	P3	Occurs on cliffs and gullys, and close to roads. In sand, loam and rocky soil.	Broome, Dampier Peninsula	Low	Medium
Aphyllodium glossocarpum	P3	Occurs in sand verging onto cleared areas and open grassland fringes	Dampier Peninsula	High	Medium
Aphyllodium parvifolium	P1	Occurs in san and clay, can be close to water.	Broome, McLarty Hills	Low	Medium
Glycine pindanica	P1	Occurs in disturbed open areas, in Pindan sand. Can be close to drainage areas.	Broome, Beagle Bay	Medium	High

Taxon	DEC Conservation Code	Preferred Habitat	Distribution	Likelihood of Occurrence	Regional Impacts
Tephrosia andrewii	P1	In dry sand Pindan soils, on hill sides and road verges.	Port Hedland-Broome	Low	High
Goodeniaceae					
Goodenia sepalosa var. *glandulosa*	P3	Occurs in Pindan sand or loam	Derby, Lake Argyle, Robinson River, Fitzroy Crossing, Yeeda	Medium	Low
Haemodoraceae					
Haemodorum gracile	P4	Occurs in sand, and sandy clay in open woodlands and creek banks	Cahmpagny Is., Yampi Peninsula, Dampier Peninsula, Edkins Range, Kimbolton Stn.,Prince Regnet River N.R., Derby	High	Low
Lentibulariaceae					
Utricularia stellaris	P1	Occurs in swampy areas, commonly submerged in water.	Wyndham, Dampier Peninsula, Mitchell Plateau	Medium	High
Loranthaceae					
Decaisnina signata subsp. *cardiophylla*	P1	Occurs in damp swamp areas and Banksia dentata	Napier Broome Bay, Theda Stn., Doongan Stn,	Low	High
Dendrophthoe odontocalyx	P3	Occurs in swamp areas and woodlands.	Koolan Is., Dampier Peninsula, Prince Regent N.R.,	Medium	Medium
Malvaceae					
Hibiscus kenneallyi	P3	Occurs in rocky outcrops	Prince Regent N.R., Middle Osborn Is., Roe River, Vansittart Bay, Bouganville Peninsula Calder River, Napier Broome Bay	Low	High
Keraudrenia exastia	T	Occurs on dunes and slight slopes in clay, and Pindan sand	Broome	Low	High
Keraudrenia katatona	P3	Occurs in dune areas on Pindan sand	Broome, Edgar Range, Wallal Downs, Canning Stock Route	Low	Medium
Menyanthaceae					
Nymphoides beaglensis	P2	In shallow freshwater. Edges of permanent waterholes or in seasonally inundated claypans & depressions.	Dampier Peninsular, Beagle Bay, Lake Campion, Yabbagoody Clay Pan	High	Low

Taxon	DEC Conservation Code	Preferred Habitat	Distribution	Likelihood of Occurrence	Regional Impacts
Myrtaceae					
Corymbia paractia	P1	Skeletal soils. In transition zone between coastal beach dunes & red pindan soils.	Broome, Cable Beach, Cape Boileau	Low	High
Lophostemon grandiflorus subsp. *grandiflorus*	P3	Occurs in damp habitats	Dampier Peninsula, Edgar Range	Medium	Low
Pandanaceae					
Pandanus spiralis var. *flammeus*	T	White clay. Springs.	Dampier Downs Station	Low	High
Pittosporaceae					
Pittosporum moluccanum	P4	White sand. Sand dunes	Dampier Peninsula, N of Broome, Berthier Is., Maret Is., N.T., SE Asia	Low	Medium
Poaceae					
Eriachne sp. Dampier Peninsula (K.F. Kenneally 5946)	P3	Plain. Red-brown sandy loam. Pindan Sands	Scattered on Dampierland an in the Fitzroyu Trough	High	Low
Phragmites karka	P3	Edges of pools and creeks	Scattered throughout the Kimberley and Pilbara	Low	Low
Triodia acutispicula	P3	Sandy soils. River levees, pindan plains, rocky hillslopes & outcrops.	Scattered throughtout Western Kimberley	High	Low
Sapindaceae					
Cupaniopsis anacardioides	P3	Vine thickets	Dampier Peninsula, Mitchell Plateau, Middle Osborn Is., Bouganville Peninsula, NT, QLD	Low	High
Solanaceae					
Nicotiana heterantha	P1	Black clay. Seasonally wet flats.	Broome, Dampier Peninsula, Roy Hill, Mandora, Anna Plains	Medium	Medium

Taxon	DEC Conservation Code	Preferred Habitat	Distribution	Likelihood of Occurrence	Regional Impacts
Stylidiaceae					
Stylidium costulatum	P3	Sandy or clayey soils. Creeks or seasonally wet areas.	Dampier Peninsula, Beverley Springs Stn, Mt Barnett Stn, Coulomb Point	Medium	Medium

4.3.2.4 Priority Flora Recorded in the Study Area

Three Priority Flora were recorded in the Study Area in this survey: *Pterocaulon intermedium* (P3); *Eriachne* sp. Dampier Peninsula (K.F. Kennealy 5946) (P3); and *Triodia caelestialis* (P3). Their locations and an illustrative picture are presented in Table 4.9. *Triodia caelestialis* was not identified as a Priority Flora with potential to occur within the Study Area from the DEC searches. However, this species has only recently been described (2008) and its distribution has not yet been fully established.

4.3.2.5 Range Extensions Recorded in the Study Area

Ten records from the current survey represent range extensions of more than 100 km from the nearest previously known record (Table 4.7), based on collection lodged at the WA Herbarium (Western Australian Herbarium 1998-2012). In some instances range extensions can represent poorly collected taxa particularly given the relative paucity of records from the eastern portion of Dampierland. Specimens from these taxa will be lodged with the WA Herbarium.

Table 4.6 – Priority Flora Recorded in the Study Area.

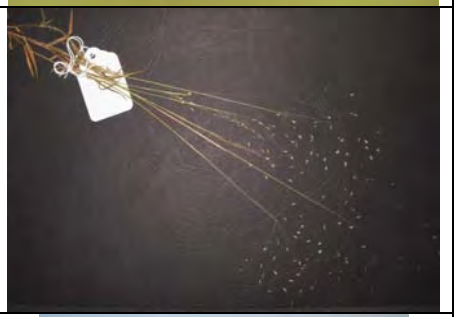
Family	Taxon	Status	Quadrat	Easting	Northing	Picture
Asteraceae	*Pterocaulon intermedium*	P3	13	495997	8071422	
Poaceae	*Eriachne* sp. Dampier Peninsula (K.F. Kennealy 5946)	P3	5 15 18	499829 497314 497409	8071874 8068357 8074676	
Poaceae	*Triodia caelestialis*	P3	3 4 6 9 10 11 12 13 15 16 17 18 19 20A 20B	502523 493955 500545 496085 495950 493242 494332 495997 497314 497776 494080 497409 500192 491807 500022	8067699 8073234 8068053 8075978 8075987 8074375 8074125 8071422 8068357 8071234 8073582 8074676 8073619 8074300 8067396	

Table 4.7 – Taxa with Range Extensions Greater than 100 km.

Species	Approximate distance and Direction of Extension	Bioregions in which Species Known to Occur	Number of Records (Florabase)	Number of records by *ecologia*
Heliotropium dichotomum	135 km W of eastern population	DL NK OVP VP	13	2
Fimbristylis simulans	118 km NW of known Northern Province records	CK, DL,NK,OVP, PIL, TAN	30	4
Acacia drepanocarpa subsp. *latifolia*	128 km NW of southeastern record	CK, DL, GSD, OVP, PIL	19	1
Tephrosia forrestiana	417 km W of known population	CK, OVP, VB	9	2
Rotala occultiflora	200km WSW of known population	CK, CR, DL, NK, OVP, VB	27	1
Stemodia lythrifolia	653 km SW of known records	CK, DL, NK, OVP, VB	46	4
Cenchrus elymoides	120 km SW of known population	CK, NK, VB	59	5
Triodia caelestialis	197 km W of known population	CK, DL, NK	3	15
Triodia intermedia	152 km W of eastern population and 220 km NE of southwerstern record	CK, DL, GAS, GSD, OVP, PIL	26	2
Polygala linariifolia	116 km NW of Northern Province population	CK, DL, NK, OVP, PIL, TAN, VB	43	2
Trichodesma zeylanicum var. *zeylanicum*	Bridging extension 192 km W of eastern population and 523 km NE of Pilbara population	CAR, CK, DL, GAS, GD, GVD, LSD, NK, OVP, PIL, YAL	28	2

Bioregion codes:
Northern: Central Kimberley (CK), Dampierland (DL), Northern Kimberley (NK), Ord-Victoria Plains (OVP) and Victoria Bonaparte (VB).
Eremaean: Carnarvon (CAR), Central Ranges (CR), Coolgardie (COO), Gascoyne (GAS), Gibson Desert (GD), Great Sandy Desert (GSD), Great Victoria Desert (GVD), Hampton (HAM), Little Sandy Desert (LSD), Murchison (MUR), Nullarbor (NUL) Pilbara (PIL), Tanami (TAN) and Yalgoo (YAL).
South-west: Avon Wheatbelt (AW), Esperance Plains (ESP), Geraldton Sandplains (GS), Jarrah Forest (JF), Mallee (MAL), Swan Coastal Plain (SWA), Warren (WAR).

4.3.3 Introduced Flora

4.3.3.1 Weeds of National Significance

At a national level there are 32 weed species listed as Weeds of National Significance (WONS). *The Commonwealth National Weeds Strategy: A Strategic Approach to Weed Problems of National Significance* describes broad goals and objectives to manage these species. Of these species, seven are currently recorded within the Kimberley (Athel Pine - *Tamarix aphylla*; Bellyachne bush – *Jatropha gossypiifolia*; Gamba Grass – *Andropogon gayanus*; Mesquite – *Prosopis* spp; Parkinsonia – *Parkinsonia aculeata;* Rubber Vine – *Cryptostegia grandiflora* and Salvinia – *Salvinia molesta*).

No WONS were recorded in the Study Area during *ecologia*'s 2011 survey.

4.3.3.2 Declared Plants

Weeds that are, or have the potential to become, pests to agriculture can be declared formally under the *Agriculture and Related Resources Protection Act 1976* as declared plants.

No Declared Plants were recorded by *ecologia* in the Study Area.

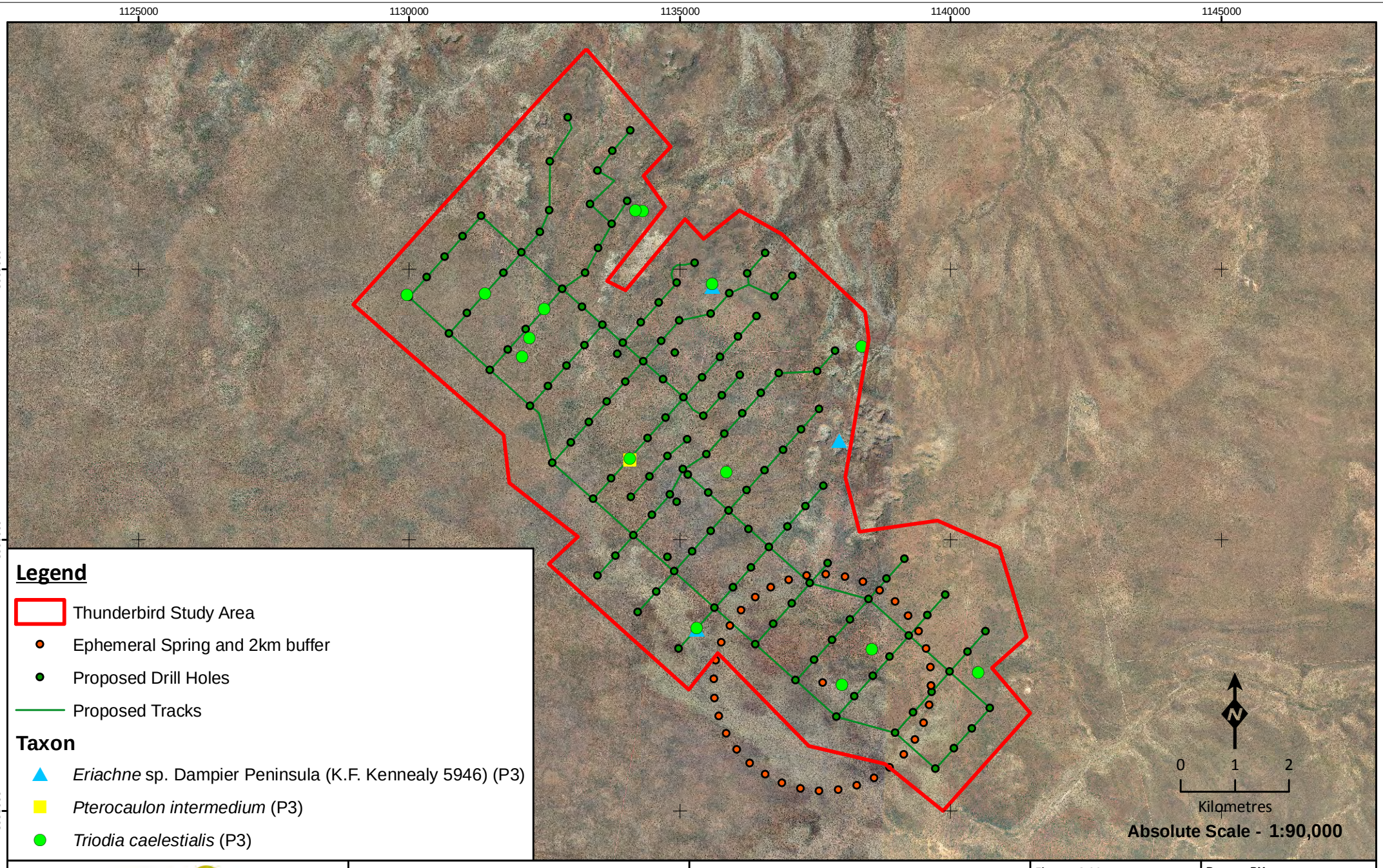
4.3.3.3 Environmental Weeds

A third and much more extensive categorisation of weeds has been developed by DEC, formerly the Department of Conservation and Land Management (CALM) in an Environmental Weed Strategy for Western Australia (CALM 1999). There are currently 270 recognised environmental weeds in the Kimberley.

Three introduced species were recorded within the Study Area; *Cynodon dactylon* (couch grass), *Stylosanthes hamata* and *Stylosanthes scabra*. The locations are listed in. Table 4.8. The attributes and characteristics of these species are summarised in Table 4.9 and Table 4.10.

Table 4.8 – Introduced Species Recorded in the Study Area and their Location.

Family	Species	Quadrat	Easting	Northing
Poaceae	**Cynodon dactylon*	3	502523	8067699
Fabaceae	**Stylosanthes hamata*	1	499677	8067413
Fabaceae	**Stylosanthes scabra*	1	499677	8067413
		19	500192	8073619



ecologia ENVIRONMENT

Sheffield Resources LIMITED

Priority Flora within the Study Area

Figure: 4.11
Project ID: 1462

Drawn: RY
Date: 04/07/2012

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: RT108

A4

Table 4.9 – Attributes of Introduced Flora in the Study Area.

Family	Taxa	DEC Attribute Rankings Within Kimberley							
		Present in Dampierland	Current Distribution	Abundance	Ecological Impact	Invasiveness	Feasibility of Control	General Trend	Status
Fabaceae	*Stylosanthes hamata*	Yes	Extensive	Common	Moderate	Rapid	Low	Increasing	Established
	Stylosanthes scabra	Yes	Extensive	Common	Moderate	Rapid	Low	Increasing	Established
Poaceae	*Cynodon dactylon*	Yes	-	-	-	-	-	-	-

Table 4.10 – Characteristics of Introduced Flora Recorded in the Study Area

Taxa	Description	Picture
Cynodon dactylon Poaceae (Couch grass)	*Cynodon dactylon* is a rhizomatous or stoliniferous prostrate perennial, 5 to 30 cm high (WAHERB 2012). It invades wetlands and river edges and has been found in virtually all parts of Western Australia (Hussey *et al.* 2007). Native to the Kimberley and the tropics worldwide (Hussey *et al.* 2007).	 WAHERB (2011)
Stylosanthes hamata Fabaceae (Verano Stylo)	*S. hamata* is an erect or decumbent herb or shrub up to 70 cm high with yellow flowers (WAHERB 2012). It can be found in seepage areas, creek banks, pool edges, lawn and disturbed vegetation (WAHERB 2012). Native to Central and South America (Hussey *et al.* 2007).	 WAHERB (2012)
Stylosanthes scabra Fabaceae (Stylo)	*S. scabra* is an erect shrub ranging from 0.3 to 2 metres in height with yellow flowers (WAHERB 2012). It can be observed in levees adjacent to major rivers, flood prove areas, well-watered cultivated grounds and road verges (WAHERB 2012). Native to the Caribbean and South America (Hussey *et al.* 2007).	 www.hear.org (2012)

4.4 FAUNA RESULTS

4.4.1 Fauna Assemblages

The assessment of the potential fauna assemblage of the Study Area which incorporates database searches and records of previous surveys from within 100 km of the Study Area, has identified a total of 358 terrestrial vertebrate fauna species with potential to occur in the Study Area (Appendix F). This includes 33 native and six introduced mammal species, 232 bird species, 78 reptile species and nine amphibian species. A comparison of the number of species recorded during previous surveys is presented in Table 4.11. During the Level 1 Survey a total of eight mammals (five native, three introduced), 59 birds, seven reptiles and one amphibian were recorded within the Study Area (Table 4.12).

Table 4.11 – Comparison of Results of Previous Fauna Surveys.

Survey	Mammals Native (introduced)	Birds	Reptiles	Amphibians
ecologia (2004)	6 (1)	65	28	4
ecologia (2011)	11	82	33	2
AECOM (2010)	5 (3)	103	17	0
Biota (2009)	10 (2)	68	39	4
Biota (2010)	3 (1)	n/a	27	1
ENV (2008)	27 (6)	177	56	8
Rogers *et al.* (2009)	n/a	80	n/a	n/a
NatureMap	4	67	7	1
DEC Threatened and Priority Fauna Search	2	4	0	0
DSEWPaC Protected Matters Search	3	11	1	0
Birdata	n/a	219	n/a	n/a
This survey	5 (3)	59	7	1
Total	**33 (6)**	**232**	**78**	**9**

4.4.2 Conservation Significant Fauna Potentially Occurring in Study Area

Results from the desktop assessment and Level 1 Survey information indicate that 69 species of conservation significance may potentially occur in the Study Area, these species are summarised in Table 4.14. Of these, one mammal and five birds have a medium to high likelihood of occurring in the Study Area and are discussed in greater detail in Section 5.3. Previous regional records of conservation significant species are mapped in Figure 4.12 and Figure 4.13.

During the current survey, three conservation significant species were recorded: Rainbow Bee-eater (EPBC Migratory, WC Act Schedule 3), Australian Bustard (DEC Priority 4) and Bush-stone Curlew (DEC Priority 4).

Table 4.12 – Vertebrate Fauna Species Recorded During Current Survey Within Study Area.

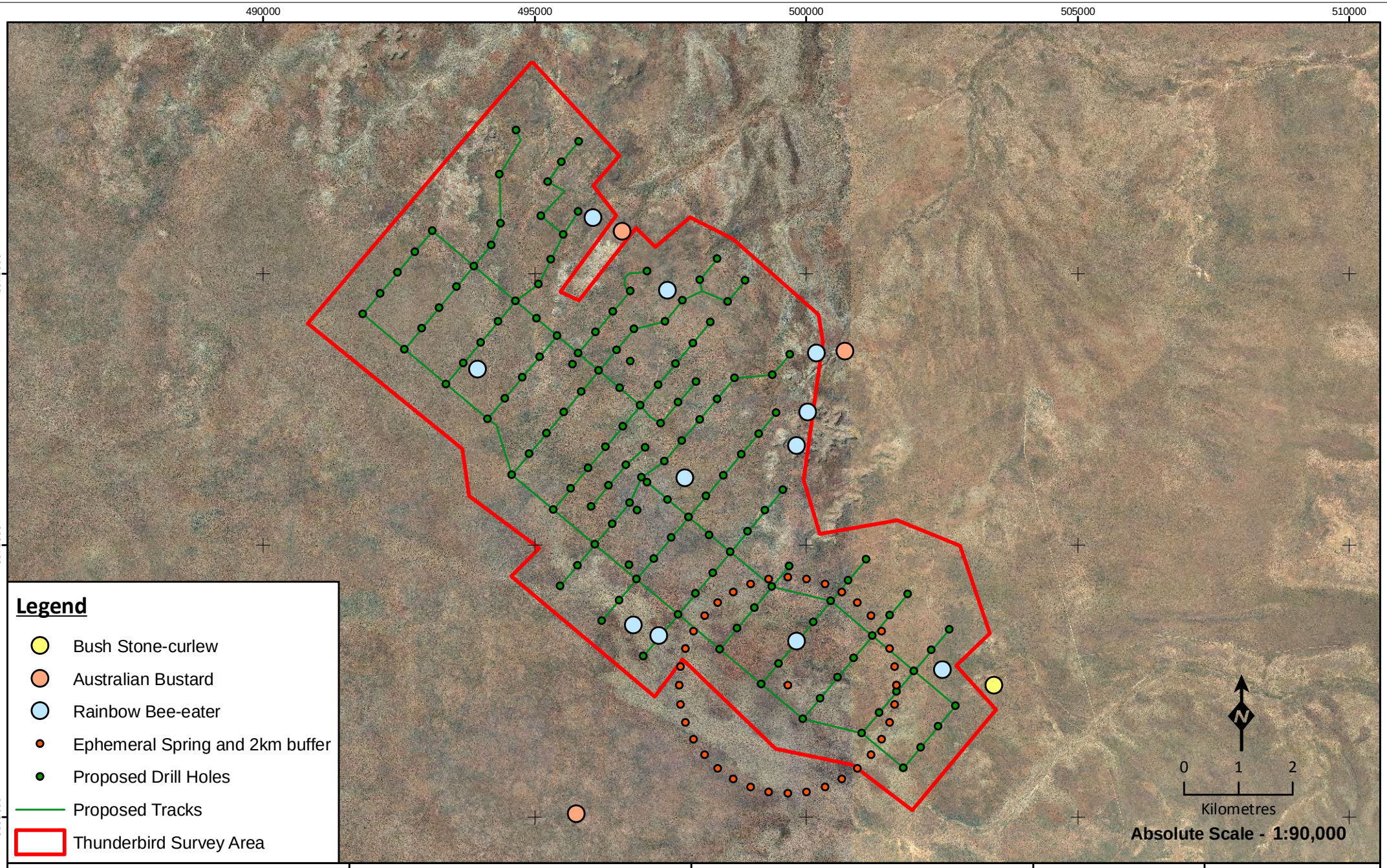
Family and Species Name	Common Name	Conservation Code
MAMMALS		
MACROPODIDAE		
Macropus robustus	Euro	
VESPERTILIONIDAE		
Chalinolobus gouldii	Gould's Wattled Bat	
Chalinolobus nigrogriseus	Hoary Wattled Bat	
Scotorepens greyii	Little Broad-nosed Bat	
MOLOSSIDAE		
Chaerophon jobensis	Northern Freetail Bat	
INTRODUCED MAMMALS		
Canis lupus	Dog/Dingo	
Felis catus	Cat	
Bos taurus	Cow	
BIRDS		
ANATIDAE		
†*Anas gracilis*	Grey Teal	
†*Anas superciliosa*	Pacific Black Duck	
COLUMBIDAE		
Ocyphaps lophotes	Crested Pigeon	
Geopelia cuneata	Diamond Dove	
Geopelia striata	Peaceful Dove	
PHALACROCORACIDAE		
†*Microcarbo melanoleucos*	Little Pied Cormorant	
ARDEIDAE		
†*Ardea pacifica*	White-necked Heron	
†*Egretta novaehollandiae*	White-faced Heron	
THRESKIORNITHIDAE		
†*Threskiornis spinicollis*	Straw-necked Ibis	
ACCIPITRIDAE		
Hamirostra melanosternon	Black-breasted Buzzard	
Haliastur sphenurus	Whistling Kite	
†*Milvus migrans*	Black Kite	
Accipiter fasciatus	Brown Goshawk	
Aquila audax	Wedge-tailed Eagle	
FALCONIDAE		
Falco cenchroides	Nankeen Kestrel	
Falco berigora	Brown Falcon	
GRUIDAE		
†*Grus rubicunda*	Brolga	
OTIDIDAE		
Ardeotis australis	Australian Bustard	DEC Priority 4
BURHINIDAE		

Family and Species Name	Common Name	Conservation Code
Burhinus grallarius	Bush Stone-curlew	DEC Priority 4
CHARADRIIDAE		
†*Elseyornis melanops*	Black-fronted Dotterel	
†*Vanellus miles*	Masked Lapwing	
TURNICIDAE		
Turnix velox	Little Button-quail	
CACATUIDAE		
Calyptorhynchus banksii	Red-tailed Black-Cockatoo	
Eolophus roseicapillus	Galah	
Cacatua sanguinea	Little Corella	
Nymphicus hollandicus	Cockatiel	
PSITTACIDAE		
Trichoglossus haematodus rubritorquis	Red-collared Lorikeet	
Psitteuteles versicolor	Varied Lorikeet	
Aprosmictus erythropterus	Red-winged Parrot	
Melopsittacus undulatus	Budgerigar	
CUCULIDAE		
Centropus phasianinus	Pheasant Coucal	
Chalcites basalis	Horsfield's Bronze-Cuckoo	
Cacomantis pallidus	Pallid Cuckoo	
STRIGIDAE		
Ninox novaeseelandiae	Southern Boobook	
HALCYONIDAE		
†*Dacelo leachii*	Blue-winged Kookaburra	
MEROPIDAE		
Merops ornatus	Rainbow Bee-eater	EPBC Act Migratory, WC Act Schedule 3
CLIMACTERIDAE		
Climacteris melanura	Black-tailed Treecreeper	
PTILONORHYNCHIDAE		
Ptilonorhynchus nuchalis	Great Bowerbird	
MALURIDAE		
Malurus melanocephalus	Red-backed Fairy-wren	
ACANTHIZIDAE		
Smicrornis brevirostris	Weebill	
Gerygone albogularis	White-throated Gerygone	
PARDALOTIDAE		
Pardalotus rubricatus	Red-browed Pardalote	
Pardalotus striatus	Striated Pardalote	
MELIPHAGIDAE		
Lichenostomus virescens	Singing Honeyeater	
Lichenostomus flavescens	Yellow-tinted Honeyeater	
Sugomel niger	Black Honeyeater	

Family and Species Name	Common Name	Conservation Code
Lichmera indistincta	Brown Honeyeater	
Melithreptus gularis	Black-chinned Honeyeater	
Philemon citreogularis	Little Friarbird	
POMATOSTOMIDAE		
Pomatostomus temporalis	Grey-crowned Babbler	
NEOSITTIDAE		
Daphoenositta chrysoptera	Varied Sittella	
CAMPEPHAGIDAE		
Coracina novaehollandiae	Black-faced Cuckoo-shrike	
Lalage sueurii	White-winged Triller	
PACHYCEPHALIDAE		
Pachycephala rufiventris	Rufous Whistler	
Colluricincla harmonica	Grey Shrike-thrush	
ORIOLIDAE		
Oriolus sagittatus	Olive-backed Oriole	
ARTAMIDAE		
Artamus personatus	Masked Woodswallow	
Artamus cinereus	Black-faced Woodswallow	
Artamus minor	Little Woodswallow	
Cracticus nigrogularis	Pied Butcherbird	
RHIPIDURIDAE		
Rhipidura albiscapa	Grey Fantail	
Rhipidura leucophrys	Willie Wagtail	
CORVIDAE		
Corvus orru	Torresian Crow	
MONARCHIDAE		
†*Myiagra inquieta*	Restless Flycatcher	
Grallina cyanoleuca	Magpie-lark	
PETROICIDAE		
Microeca fascinans	Jacky Winter	
MEGALURIDAE		
Cincloramphus mathewsi	Rufous Songlark	
HIRUNDINIDAE		
Petrochelidon ariel	Fairy Martin	
Petrochelidon nigricans	Tree Martin	
NECTARINIIDAE		
Dicaeum hirundinaceum	Mistletoebird	
ESTRILDIDAE		
Taeniopygia guttata	Zebra Finch	
REPTILES		
AGAMIDAE		
Pogona minor	Dwarf Bearded Dragon	
GEKKONIDAE		

Family and Species Name	Common Name	Conservation Code
Gehyra pilbara		
SCINCIDAE		
Carlia munda		
Cryptoblepharus ruber		
Ctenotus inornatus		
Lerista apoda		
Morethia sp. (*storri* or *ruficauda*)		
AMPHIBIANS		
HYLIDAE		
Litoria rothii	Northern Laughing Tree Frog	

† Species recorded just outside Study Area at Mt. Jowlaenga homestead/billabong



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Locations of Conservation Significant Fauna Recorded During the Survey

Figure: 4.1H
Project ID: 1462

Drawn: NJ
Date: 06/07/2012

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ009

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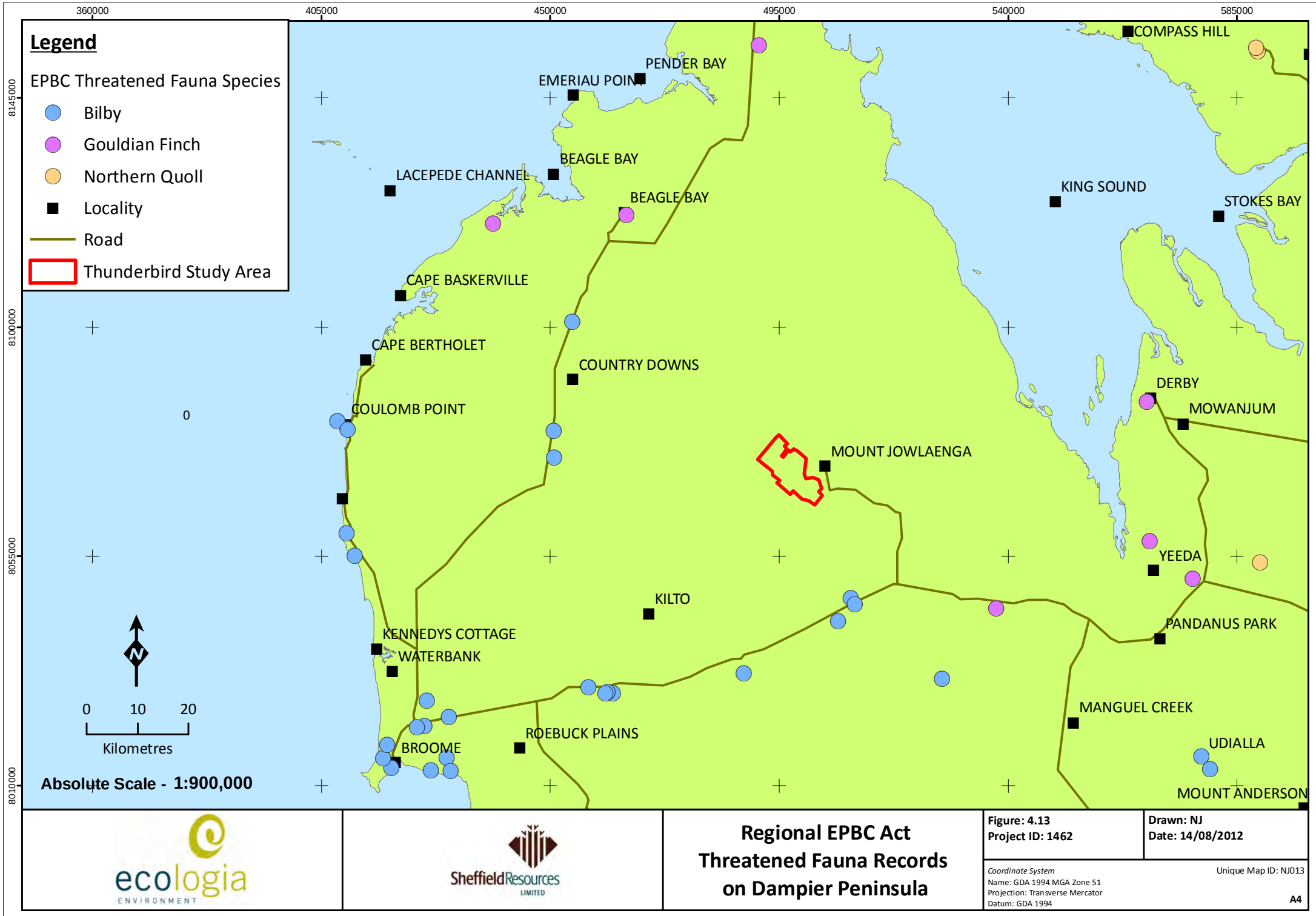

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Regional EPBC Act Threatened Fauna Records on Dampier Peninsula

Figure: 4.13
Project ID: 1462

Drawn: NJ
Date: 14/08/2012

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ013

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4.5 FAUNA HABITATS

The habitat assessment revealed three main fauna habitat types within the Study Area:

- Rocky Hills;
- Pindan Plains;
- Savannah Woodlands;

The habitats of the Study Area are described below, mapped in Figure 4.18, with area calculations of habitats within the Study Area displayed in Table 4.13

Table 4.13 – Fauna Habitat area Calculations of the Study Area.

Habitat	Area in Study Area (ha)	% of Study Area
Rocky Hills	1199.83	15.78
Pindan Plains	1610.09	21.18
Savannah Woodlands	4792.88	63.04

4.5.1 Rocky Hills

Rocky Hills within the Study Area are associated with the Reeves Land System, and are characterised by sparse *Corymbia dendromerinx* over moderately dense *Acacia drepanocarpa* subsp. *latifolia* over a ground vegetation layer of dense *Triodia caelestialis* hummock grassland and *Sorghum plumosum* tussock grassland on rocky hilltops, slopes, gullies and outcrops.

Reptile species expected to favour this habitat include the skinks *Ctenotus pantherinus*, *Ctenotus inornatus* and *Carlia munda*, the goannas *Varanus brevicauda* (Short-tailed Pygmy Monitor) and *Varanus tristis* (Black-headed Monitor), the dragon *Pogona minor* (Dwarf Bearded Dragon), the geckos *Diplodactylus conspicillatus* (Fat-tailed Gecko) and *Lucasium stenodactylum*, the snakes *Aspidites melanocephalus* (Black-headed Python), *Suta punctata* (Little Spotted Snake) and *Pseudechis australis* (Mulga Snake).

Bird diversity within the Study Area is lowest in this habitat, due to the dry, open nature of the vegetation. However, this habitat provides foraging opportunities for raptors, and during flowering periods, many honeyeaters species will be present. The Little Woodswallow is likely to nest locally on the faces of large rock outcrops. Of conservation signifance, the Australian Bustard and Rainbow Bee-eater are likely to occur in this habitat, with potential for the latter to nest along drainage lines.

Crevices and small caves in large rock outcrops may provide roosting opportunities for several bat species, including the Northern Freetail Bat. The Common Rock-rat is expected to occur in large outcrops, and major crevices and overhangs will provide shelter for the Euro.

During the Level 1 Survey, the burrowing skink *Lerista apoda* was recorded under a sandstone rock within the Rocky Hills habitat. This species was previously only known from sandy coastal habitats on the Dampier Peninsula, and may represent an inland range extension of approximately 85 km.

Figure 4.14 – The Burrowing Skink *Lerista apoda* Recorded During the Level 1 Survey in Rocky Hills.

Figure 4.15 – Representative Photo of Rocky Hills Habitat Type.

4.5.2 Pindan plains

Pindan Plains within the Study Area are associated with the Yeeda and Fraser Land Systems, and are characterised by scattered *Corymbia greeniana* over a moderately dense to dense shrub layer consisting primarily of *Acacia tumida* var *tumida*, *Acacia platycarpa* and *Grevillea refracta* on weak orange to red sandy soils. The ground vegetation layer consists of a mix of grasses including *Triodia caelestialis*, *Aristida holathera* var *holathera*, *Crysopogon* sp., *Eriachne obtusa* and *Sorghum plumosum*.

Reptile species expected to favour this habitat include the skinks *Eremiascincus isolepis*, *Ctenotus pantherinus*, *Ctenotus inornatus* and *Carlia munda*, the dragons *Diporiphora pindan* and *Pogona minor* (Dwarf Bearded Dragon), the monitor *Varanus gouldii* (Sand Goanna), the geckos *Strophurus ciliaris* and *Lucasium stenodactylum*, and the snakes *Aspidites melanocephalus* (Black-headed Python), *Brachyurophis roperi* and *Pseudechis australis* (Mulga Snake).

A diverse range of bird species are expected to occur within this habitat, including the Red-backed Fairy-wren, Long-tailed Finch, Little Friarbird, Red-winged Parrot, Budgerigar and Zebra Finch. Of conservation signifance, the Australian Bustard, Rainbow Bee-eater and Bush Stone-curlew are likely to be common within this habitat.

Due to the weak soil substrate, a number of small burrowing mammals are likely to occur. The Bilby (EPBC Act Vulnerable), Western Chestnut Mouse and Lesser Hairy-footed Dunnart may occur in this habitat. The Euro and Northern Nailtail Wallaby are both likely to occur throughout the Study Area in this habitat.

Figure 4.16 – Representative Photo of Pindan Plains Habitat Type.

4.5.3 Savannah woodlands

Savannah woodlands within the Study Area are associated with the Wanganut Land System, and are characterised by scattered *Corymbia greeniana* over a ground vegetation layer of *Eriachne obtusa* tussock grassland and *Triodia caelestialis* hummock grassland on firm clay soils, often with the presence of large termite mounds.

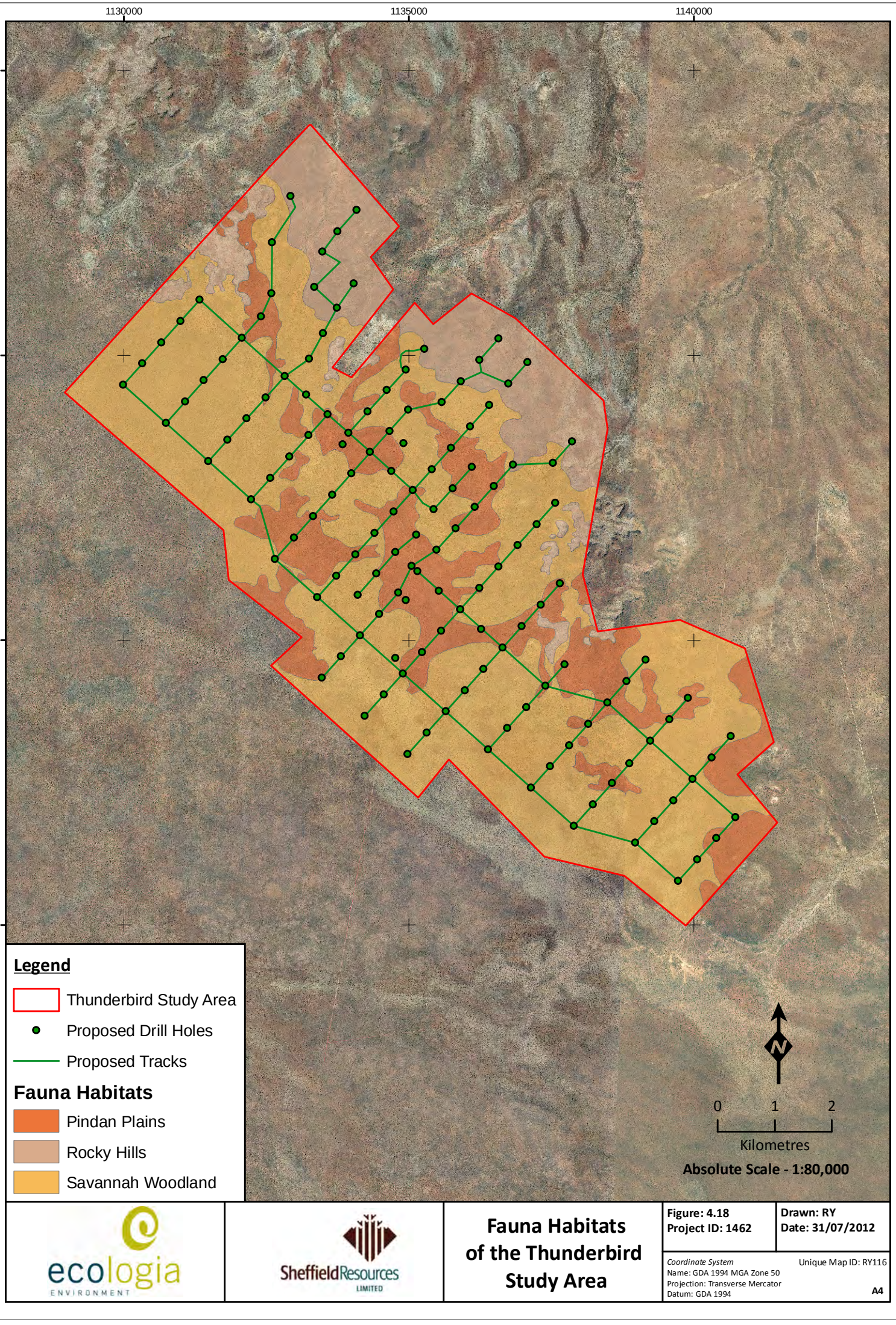
Reptile species expected to favour this habitat include the skinks *Cryptoblepharus ruber*, *Ctenotus inornatus* and *Carlia munda*, the dragons *Chlamydosaurus kingii* (Frilled Lizard) and *Pogona minor* (Dwarf Bearded Dragon), the monitor *Varanus gouldii* (Sand Goanna), the geckos *Diplodactylus conspicillatus* and *Lucasium stenodactylum*, and the snakes *Aspidites melanocephalus* (Black-headed Python), *Demansia angusticeps* and *Pseudechis australis* (Mulga Snake).

A diverse range of bird species are expected to occur within this habitat, including the Red-tailed Black-cockatoo, Red-winged Parrot, Varied Lorikeet, Rufous Songlark, Double-barred Finch, Australian Owlet-nightjar and Southern Boobook. Several species of raptor may nest and forage in

this habitat. Of conservation signifance, the Australian Bustard, Rainbow Bee-eater, and Gouldian Finch (EPBC Act Endangered) may occur in this habitat.

Mammal species expected to occur within this habitat include grassland generalists such as the Delicate Mouse, Euro, Northern Nailtail Wallaby and Dingo. Several bat species that roost in tree hollows are likely to occur, including Gould's and Hoary Wattled Bats, Little Broad-nosed Bats and Northern Freetail Bats.

Figure 4.17 – Representative Photo of Savannah woodlands Habitat Type.



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Fauna Habitats of the Thunderbird Study Area

Figure: 4.18	**Drawn: RY**
Project ID: 1462	**Date: 31/07/2012**

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: RY116

A4

Table 4.14 – Conservation Significant Fauna Occurring or Potentially Occurring in the Study Area.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DEC			
Mammals						
Northern Quoll *Dasyurus hallucatus*	EN	S1	EN	Rocky areas, also eucalypt forest and woodland.	Not previously recorded on the Dampier Peninsula, but has been recorded in similar habitat to that present, 90 km east of the Study Area in 2001 (NatureMap)	**LOW** Some suitable habitat in rocky hills, but not previously recorded on Dampier Peninsula.
Bilby *Macrotis lagotis*	VU	S1	VU	Variety of habitats on soft soil, including spinifex grassland, acacia shrubland, open woodland, and cracking clays.	Numerous records within 100 km of Study Area (NatureMap), including eight records within 20 km of tenement E0402083 (DEC Rare Fauna Search), the most recent record being from 1996.	**MEDIUM** Extensive suitable habitat occurs within the Study Area. However, threats including soil degradation due to livestock combined with high fire frequency may inhibit the Bilby's occurrence.
Crest-tailed Mulgara *Dasycercus cristicauda*	VU	S1	VU	Sandy areas predominately on the top of sand dunes at the base of large Canegrass clumps or Nitre Bush hummocks.	Not previously recorded within 100 km of the Study Area (NatureMap)	**LOW** No suitable habitat. Not previously recorded within 100 km of the Study Area.
Golden Horseshoe Bat *Rhinonicteris aurantius*	VU	S1	VU	Roost in caves with high humidity (95%) and temperature (32 °C). Forage along waterbodies with fringing vegetation.	No previously recorded within 100 km of Study Area (NatureMap).	**LOW** No potential roost caves. Not previously recorded on Dampier Penisula.
Northern Leaf-nosed Bat *Hipposideros stenotis*			P2	Sandstone caves.	Recorded at Derby, 65 km east of Study Area (NatureMap)	**LOW** No potential roost caves. Not previously recorded on Dampier Penisula.
Yellow-lipped Cave Bat *Vespadelus douglasorum*			P2	Tropical woodlands of West Kimberley	Recorded near Beagle Bay, approximately 45 km north of Study Area (NatureMap).	**LOW** No potential roost caves. Rarely recorded on Dampier Peninsula.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DEC			
Ghost Bat *Macroderma gigas*			P4	Caves, rockpiles and abandoned mines.	Not previously recorded on Dampier Peninsula (NatureMap)	**LOW** No potential roost caves. Not previously recorded on Dampier Penisula.
Birds						
Gouldian Finch *Erythrura gouldiae*	EN	S1	EN	Tropical savannas; breed in rocky hills with hollow-bearing eucalypts near water.	Regularly recorded near Cape Leveque, 100 km north of Study Area (NatureMap).	**MEDIUM** Suitable habitat occurs within the Study Area. However, known from very few locations on Dampier Peninsula.
Fork-tailed Swift *Apus pacificus*	M	S3		Almost entirely aerial, particularly associated with storm fronts.	Recorded 80 km west of the Study Area at James Price Point (*ecologia* internal database). Numerous records throughout Dampier Peninsula (NatureMap).	HIGH A relatively common summer migrant in the northwest of Australia that will occasionally forage in the aerial space above the Study Area.
Eastern Great Egret *Ardea modesta*	M	S3		Floodwaters, rivers, shallows of wetlands, intertidal mud-flats.	Numerous records throughout the Dampier Peninsula (NatureMap).	**LOW** Very little suitable habitat, but may occur during the wet season in flooded depressions.
Glossy Ibis *Plegadis falcinellus*	M	S3		Shallows and adjacent flats of freshwater lakes and swamps; river pool; flooded samphire; sewage ponds. Nest in freshwater/brackish wetlands with tall, dense stands of emergent vegetation and low trees or bushes.	Recorded throughout the southern Dampier Peninsula, including a record 20 km east of the Study Area (NatureMap).	**LOW** Very little suitable habitat, but may occur during the wet season in flooded depressions.
Cattle Egret *Ardea ibis*	M	S3		Grassy habitats and wetlands, particularly damp pastures.	Recorded approximately 37 km south-west, and 65 km east (Derby) of Study Area (NatureMap).	**LOW** Very little suitable habitat, but may occur during the wet season in open flooded depressions.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DEC			
White-bellied Sea-Eagle *Haliaeetus leucogaster*	M	S3		Coastal and near coastal water bodies.	Numerous records approximately 37 km south-west, and 68 km south-east of Study Area (NatureMap).	**LOW** Very little suitable habitat, but may occur during the wet season in open flooded depressions.
*shorebirds	M	S3		Open plains, coastal and freshwater lakes, swamps, rivers, mudflats, flooded grasslands	Most shorebirds listed are regularly recorded in the coastal regions of the Dampier Penisula, with infrequent records from inland swamps, lakes and rivers (NatureMap).	**LOW** Little suitable habitat within the Study Area for shorebird species.
Rainbow Bee-eater *Merops ornatus*	M	S3		Open country, most vegetation types, dunes, banks.	Numerous records throughout the Dampier Penisula (NatureMap).	**RECORDED** This species was recorded throughout the Study Area during the Level 1 Survey. Some nesting habitat present along drainage lines.
Barn Swallow *Hirundo rustica*	M	S3		Open country, agricultural land, especially near water.	Recorded approximately 37 km south-west, and 65 km east (Derby) of Study Area (Birdata)	**LOW** Little suitable habitat within the Study Area.
Eastern Osprey *Pandion cristatus*	M			Mangroves, rivers, estuaries, inland seas, coastal islands.	Recorded approximately 37 km south-west, and 68 km south-east of Study Area (Birdata).	**LOW** Little suitable habitat within the Study Area.
Peregrine Falcon *Falco peregrinus*		S4		Coastal cliffs, riverine gorges and wooded watercourses.	Recorded approximately 37 km south-westof Study Area (NatureMap).	**LOW** Little suitable habitat within the Study Area.
Grey Falcon *Falco hypoleucos*			P4	Lightly wooded coastal and riverine plains.	Two records approximately 37 km south-west, and 68 km south-east of Study Area (NatureMap).	**LOW** Little suitable habitat within the Study Area.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DEC			
Australian Bustard *Ardeotis australis*			P4	Open grasslands, chenopod flats and low heathland.	Numerous records in southern Dampier Peninsula, including the nearest record of 35 km east of Study Area (NatureMap).	**RECORDED** This species was recorded on three occasions during the survey. Extensive suitable habitat occurs throughout.
Masked Owl (*Tyto novaehollandiae*)			P4	Forest, woodland, caves, mature trees with hollows.	Not recorded within 100 km of Study Area (NatureMap)	**LOW** Little suitable habitat within the Study Area. Not known from Dampier Peninsula.
Bush Stone-curlew *Burhinus grallarius*			P4	Lightly wooded country next to daytime shelter of thickets or long grass.	Several records approximately 37 km south-west, and 68 km south-east of Study Area (NatureMap).	**RECORDED** This species was recorded on one occasion during the survey. Extensive suitable habitat occurs throughout.
Star Finch (western) *Neochmia ruficauda subclarescens*			P4	Vegetation around watercourses, particularly thick reed beds.	Recorded approximately 35 km east, and 82 km south-east of Study Area (NatureMap).	**LOW** Little suitable habitat within the Study Area.
Reptiles						
Salt-water Crocodile *Crocodylus porosus*		S4	Other	Tidal rivers, coastal floodplains and channels, billabongs and swamps up to 150 km inland.	Not recorded away from coast on Dampier Peninsula, with scare records in the region (NatureMap)	**LOW** No suitable habitat within the Study Area.
Lerista separanda			P2	Sandy areas.	Several records along the north-west coast of the Dampier Peninsula, all greater than 85 km from Study Area (NatureMap).	**LOW** Little suitable habitat within the Study Area.
Simoselaps minimus			P2	Coastal dunes or sandy areas between dunes and adjacent acacia shrublands.	Five records within 100 km of Study Area, all coastal between Broome and Beagle Bay (NatureMap)	**LOW** No suitable habitat within the Study Area.

* Refer to Appendix F for complete list of migratory-listed shorebird species of the families Charadriidae, Rostratulidae, Scolopacidae, Glareolidae, and Laridae.
Note: Description of conservation significant codes provided in Appendix A.

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5 DISCUSSION

5.1 VEGETATION COMMUNITIES CONSERVATION ASSESSMENT

The significance of the vegetation of the Study Area has been assessed at four spatial scales; national, state, regional and local.

5.1.1 Vegetation of National and State significance

Currently, there are no nationally listed TECs listed under the EPBC Act, nor state listed TECs or PECs listed under the WC Act that occurs within the Study Area.

5.1.2 Vegetation of Regional Significance

Regional significance addresses the representation of species and habitats at a biogeographic regional level. Species or habitat types that are endemic to the Dampierland bioregion and with limited or unknown distributions are considered regionally significant.

Regional conservation significance of the vegetation communities of the Study Area has been assessed based upon two sources of information; land systems (Van Vreeswyk *et al.* 2004) and the digitised dataset of native vegetation (Shepherd *et al.* 2001) which reinterpreted Beard's (1975) vegetation mapping. These are the only broad-scale mapping projects that have been conducted in the vicinity of the Study Area from which the regional extent of each vegetation unit mapped at this scale can be quantified.

Based on the regional distribution (as discussed in Sections 5.1.2.1 and 5.1.2.2 below), it is considered that the vegetation communities recorded in the Study Area are fairly widespread throughout the Kimberley bioregion and have low-medium conservation significance.

5.1.2.1 Land System Analysis

At a regional level, four land systems occur within the Thunderbird Study Area. The Study Area contains a very small proportion of these systems within Dampierland and development of the Thunderbird project is unlikely to affect Fraser, Waganut or Yeeda lands systems at a regional scale.

The Reeves Landsystem (sand plain with scattered hills and minor plateaux, reddish sandy soils, pindan) runs as a band along the north-eastern boundary of the Study Area. The total area of this landsystem that occurs within the Dampier Peninsula is 44,794 ha, of which 7.5% occurs within the Thunderbird Study Area.

5.1.2.2 Analysis of Shepherd *et al.* Dataset

The Study Area is comprised of Shrublands, pindan; *Acacia tumida* shrubland with grey box and cabbage gum medium woodland over ribbon grass and curly spinifex (750); Hummock grasslands, shrub steppe; *Acacia eriopoda* over soft spinifex (751) and Shrublands, pindan; *Acacia eriopoda* & *A. tumida* shrubland with scattered low *Eucalyptus confertifolia* over curly spinifex (762). While vegetation unit 750 is covers vast areas in Dampierland, almost 10 % of vegetation units 751 and 762 occur within the Study Area.

5.1.3 Vegetation of Local Significance

5.1.3.1 Assessment of the riparian vegetation

The creeklines of the Thunderbird Study Area have been identified by the Traditional Owners as areas that have environmental cultural significance and a 2 km buffer surrounding each creekline has been suggested. The multi-variate analysis of the quadrats and derived vegetation communities from the current survey did not distinguish these creeklines as vegetation units separate from the surrounding vegetation. *Eucalyptus camaldulensis* and *E. victrix* are two key phreatophytic species sometimes found along drainage lines that are dependent on ground water; these were not present on the drainage lines surveyed within the current survey.

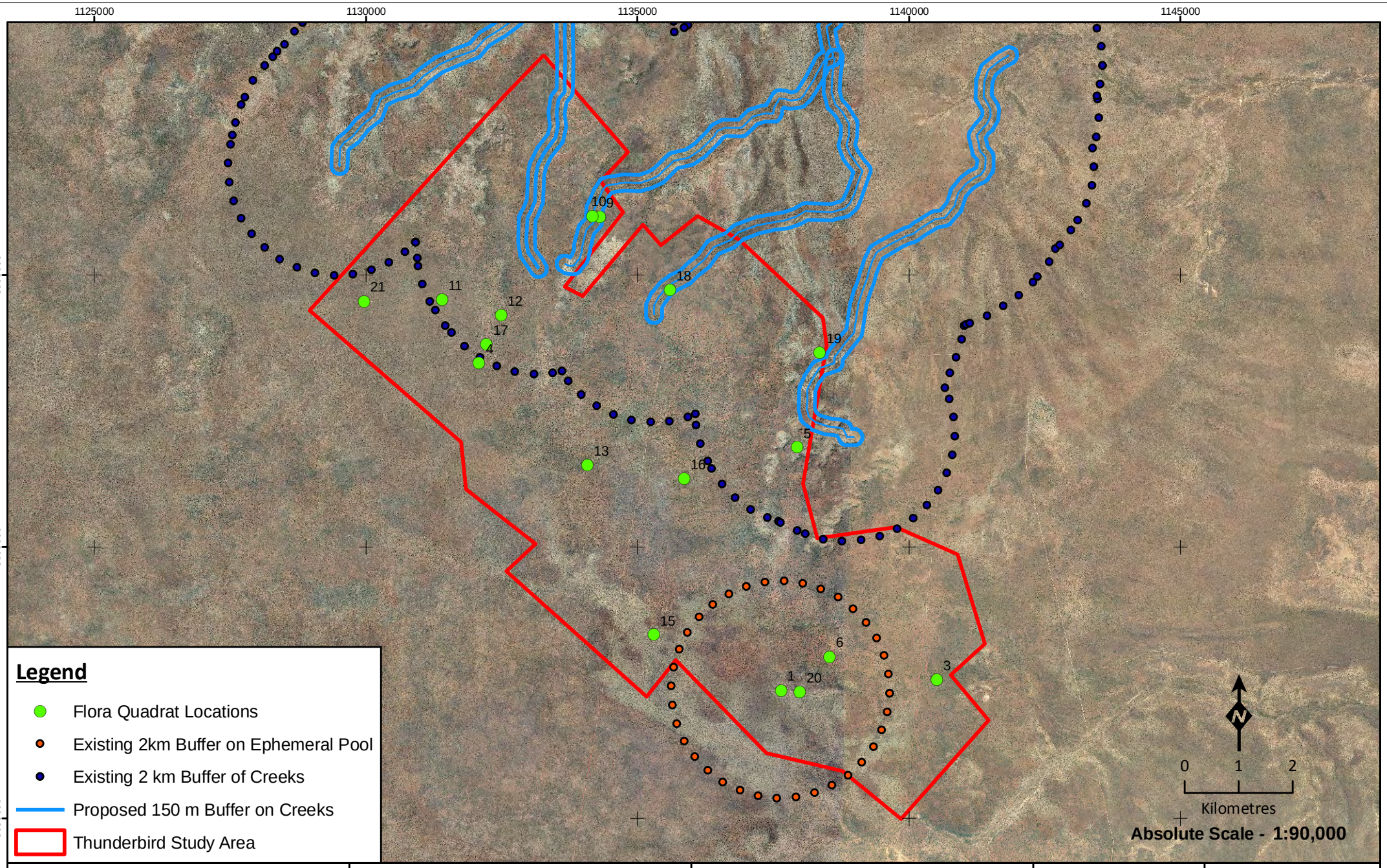
The current drilling program is non-intensive, with the drilling holes separated from each other by ca. 500-1000 m, and as the soils of the Thunderbird Study Area are sand-based soils it is anticipated that the drill holes will collapse following drilling and not affect the drainage or alter the water table. To avoid the extracted sediments from being washed into surrounding drainage lines, samples should either be replaced or collected with no extracted soil left on the surface. To avoid disturbance to the drainage lines in the current drilling program it is recommended that buffer zones of 150 m from the drainage lines would be sufficient to avoid disturbance to the creekline vegetation composition, structure and function.

5.1.3.2 Assessment of the ephemeral pool

The vegetation of the ephemeral pool was dominated by low *Melaleuca viridiflora*, over dense tussock grassland (*Sacciolepis indica*, *Sorghum plumosum*, *Fruiena ciliaris*) and herbs (*Byblis* filifolia. and *Drosera* indica) (EtMvSi). *Melaleuca*'s are known phreatophytic species that rely on the groundwater at least some of the year for survival. This temporary pool vegetation unit appears to be localised with a gradation to the vegetation unit MnMvAcEoTc, Sparse *Corymbia greeniana* over *Melaleuca nervosa* or *M. viridiflora* over *Acacia colei* var. *colei* over *Eriachne obtusa* tussock grassland and *Triodia caelestialis* hummock grassland over a distance of approximately 250 m. The current drilling program maintains a buffer zone of 2 km from the temporary pool and should be adequate to ensure that there is no adverse impact to this vegetation unit.

5.1.3.3 Assessment of the Phreatophytic vegetation units

As discussed in Section 5.1.3.2, *Melaleuca*'s are known to be phreatophytic (groundwater dependent) species. The impact to the *Melaleuca* vegetation communities (EtMvSi and MnMvAcEoTc) from the current drilling program should be minimal given that the drilling program is of low intensity and the soils appear to be mostly sandy and thought to collapse rapidly following drilling. The impact to these vegetation units from an altered water table if the Thunderbird project is developed could be assessed through a seperate hydrological survey.



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Buffer Zones on Significant Locations within the Study Area

Figure:5.1
Project ID: 1462

Drawn: RY
Date: 04/07/2012

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: RT106

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5.2 FLORA CONSERVATION ASSESSMENT

The conservation significance of the flora of the Study Area has been assessed at four spatial scales; national, state, regional and local.

5.2.1 Flora of National and State Conservation Significance

National significance refers to those features of the environment which are recognised under legislation as being of importance to the Australian community; in particular, species listed under the EPBC Act are regarded as nationally significant.

State significance refers to those features of the environment that are recognised under State legislation as being of importance to the Western Australian community, in particular, species listed as DRF under the WC Act are of state significance.

No flora of national or state significance was recorded in the Study Area.

5.2.2 Flora of Regional and Local Conservation Significance

Regional significance addresses the representation of habitats at a biogeographic regional level. Priority Flora taxa that are endemic to the Kimberley bioregion, and whose distributions are limited or unknown, are considered regionally significant.

Flora are of local significance when their presence is confined to a specialised habitat type that is not common in the local area and whose disturbance or removal may lead to local extinction.

Three Priority taxa were recorded by *ecologia* within the Study Area.

Table 5.1 summarises the known distribution and abundance of these taxa from all sources, including DEC records. As a dominant species in most of the vegetation groups, *Triodia caelestialis* was recorded throughout the Study Area in high percentage covers. Previously, this species was only known from three records in the central and western Kimberely and on the very eastern edge of Dampierland. *Triodia caelestialis* has been recently described (2008) and is thought to occur widely in the Thunderbird area. A regional survey for this species would assist in determining its extent in the eastern Dampier Peninsula.

Eriachne sp. Dampier Peninsula is restricted to the Dampierland bioregion based on current records. One taxon, *Pterocaulon intermedium,* has been recorded within the King Leopold Conservation Park

Table 5.1 – Regional Distribution of Priority Flora Recorded during the Current Survey

Species	Status	Number of locations recorded in this study	Number of other records regionally (AVH)	Bioregions in which Recorded	Records within Con. Estate	Recorded abundance elsewhere
Pterocaulon intermedium	P3	1	12	PIL, DL, NK, CK	1	n/a
Eriachne sp. Dampier Peninsula (K.F. Kennealy 5946)	P3	3	8	DL	0	Scattered on Pindan plains
Triodia caelestialis	P3	15	3	CK, DL, NK	0	n/a

Bioregion codes:
Northern: Central Kimberley (CK), Dampierland (DL), Northern Kimberley (NK), Ord-Victoria Plains (OVP) and Victoria Bonaparte (VB).
Eremaean: Carnarvon (CAR), Central Ranges (CR), Coolgardie (COO), Gascoyne (GAS), Gibson Desert (GD), Great Sandy Desert (GSD), Great Victoria Desert (GVD), Hampton (HAM), Little Sandy Desert (LSD), Murchison (MUR), Nullarbor (NUL) Pilbara (PIL), Tanami (TAN) and Yalgoo (YAL).
South-west: Avon Wheatbelt (AW), Esperance Plains (ESP), Geraldton Sandplains (GS), Jarrah Forest (JF), Mallee (MAL), Swan Coastal Plain (SWA), Warren (WAR).

As detailed in Table 4.7, the collections for 11 taxa are range extensions of more than 100 km from any collection previously lodged with the Western Australian Herbarium: *Heliotropium dichotomum*, *Fimbristylis simulans*, *Acacia drepanocarpa* subsp. *latifolia*, *Tephrosia forrestiana*, *Rotala occultiflora*, *Stemodia lythrifolia*, *Cenchrus elymoides*, *Triodia caelestialis*, *Triodia intermedia*, *Polygala linariifolia* and *Trichodesma zeylanicum* var. *zeylanicum*.

5.3 CONSERVATION SIGNIFICANT FAUNA WITH A MEDIUM OR HIGH LIKELIHOOD

5.3.1 Mammals

5.3.1.1 Bilby (*Macrotis lagotis*)

Conservation Status: EPBC Act Vulnerable, WC Act Schedule 1 (Vulnerable).

Distribution and Habitat: Once common over 70% of mainland Australia's arid and semiarid regions, Bilbies are currently patchily distributed through the Tanami, Great Sandy and Gibson Deserts (Maxwell *et al.* 1996). Isolated populations also occur in south-west Queensland and to the north-east of Alice Springs. Bilbies occur in a variety of habitats, including spinifex grassland, acacia shrubland, open woodland and cracking clays (Maxwell *et al.* 1996; Johnson 2008). The species underwent a sudden and widespread collapse in population size in the early 1900s, and the distribution may still be contracting and fragmenting. Reasons for the decline include predation by feral predators on both young and adult bilbies, competition from rabbits and livestock, reduced food as a result of changed fire regimes, and drought (Maxwell *et al.* 1996; O'Malley 2006a; Johnson 2008).

Ecology: The Bilby is a nocturnal marsupial with soft, silky fur (Pavey 2006). It uses its strong forelimbs and claws to construct an extensive tunnel system of up to 3 m long and 1.8 m deep in which it shelters during the day. Its long tongue is an adaptation to its specialised diet of seeds, insects, bulbs, fruit and fungi (Johnson 2008).

Likelihood of Occurrence: MEDIUM – There is a medium likelihood of the Bilby occuring based on the number of existing records within 20 km of the Study Area, as well as the presence of extensive shrubland with soft soils suitable for burrowing. However, due to high fire frequencies, in combination with soil trampling from cattle, the Bilby may now be very rare or extirpated from the local area, as indicated by a lack of records since 1996 (DEC Rare Fauna Database).

5.3.2 Birds

5.3.2.1 Gouldian Finch (*Erythrura gouldiae*)

Conservation Status: EPBC Act Endangered, WC Act Schedule 1 (Endangered)

Distribution and Habitat: The Gouldian Finch was formally distributed throughout the tropical savannas of northern Australia. It is now restricted to isolated areas mostly within the Northern Territory and the Kimberley region of Western Australia (Woinarski and Palmer 2006). Known breeding habitat is characterised by rocky hills with hollow-bearing, smooth-barked gums that are close to small waterholes or springs that persist through the dry season (O'Malley 2006b).

Ecology: Gouldian finches forage on the ground, feeding on seeding grasses, particularly native *Sorghum* spp. (Pizzey and Knight 2003). Due to the restricted diet of Gouldian Finches, they are particularly vulnerable to seed shortages (O'Malley 2006b). The decline in populations of the Gouldian Finch is representative of the general decline of granivorous birds occurring as a result of current land management practices. Ongoing key threats to the Gouldian Finch are vegetation change through inappropriate fire regimes, and grazing impacts of stock and feral herbivores (O'Malley 2006b).

Likelihood of Occurrence: MEDIUM – The Gouldian Finch is regularly recorded at Cape Leveque on the Dampier Peninsula, approximately 100 km north of the Study Area. However, suitable habitat exists throughout the Study Area, and as this species is additionally found to the east of the Study Area, inland from Derby, it may infrequently occur.

5.3.2.2 Fork-tailed Swift *(Apus pacificus)*

Conservation Status: EPBC Act Migratory, WC Act Schedule 3

Distribution and Habitat: The Fork-tailed Swift is a small insectivorous species with a white throat and rump and a deeply forked tail (Morcombe 2000). It is distributed from central Siberia and throughout Asia, breeding in north-east and mid-east Asia, and wintering in Australia and south New Guinea. It is a relatively common trans-equatorial migrant from October to April throughout mainland Australia (Simpson and Day 2004). In Western Australia the species begins to arrive in the Kimberley in late September, the Pilbara in November and in the South-west by mid-December (Johnstone and Storr 1998). In Western Australia, the Fork-tailed Swift is considered uncommon to moderately common near the north-west, west and south-east coasts, common in the Kimberley and rare or scarce elsewhere (Johnstone and Storr 1998).

Ecology: Fork-tailed swifts are nomadic in response to broad-scale weather pattern changes. They are attracted to thunderstorms where they can be seen in flocks, occasionally up to 2,000 birds. They rarely land, living almost exclusively in the air and feeding entirely on aerial insects, especially nuptial swarms of beetles, ants, termites and native bees (Simpson and Day 2004).

Likelihood of Occurrence: HIGH – Fork-tailed Swifts have been recorded throughout the Dampier Penisula during the austral summer months. It is very likely this species will utilise the aerial space

above the Study Area for foraging, particularly in response to changing weather, from October to April.

5.3.2.3 Rainbow Bee-eater (*Merops ornatus*)

Conservation Status: EPBC Act Migratory, WC Act Schedule 3

Distribution and Habitat: The Rainbow Bee-eater is scarce to common throughout much of Western Australia, except for the arid interior, preferring lightly wooded, preferably sandy, country near water (Johnstone and Storr 1998).

Ecology: In Western Australia the Rainbow Bee-eater can occur as a resident, breeding visitor, post-nuptial nomad, passage migrant or winter visitor. It nests in burrows usually dug at a slight angle on flat ground, sandy banks or cuttings, and often at the margins of roads or tracks (Simpson and Day 2004). Eggs are laid at the end of the metre long tunnel from August to January (Boland 2004). Bee-eaters are most susceptible to predation.

Likelihood of Occurrence: RECORDED – This species was recorded throughout the Study Area during the Level 1 Survey. Nesting was not recorded, although some drainage lines within the rocky hills may provide nesting opportunities for this widespread species.

Figure 5.2 – Rainbow Bee-eater (EPBC Migratory, WC Schedule 3) Recorded During the Survey.

5.3.2.4 Australian Bustard (*Ardeotis australis*)

Conservation Status: DEC Priority 4

Distribution and Habitat: The Australian Bustard is a large ground-dwelling bird that occurs Australia-wide and utilises a number of open habitats, including open or lightly wooded grasslands, chenopod flats, plains and heathlands (Johnstone and Storr 1998).

It is a nomadic species, ranging over very large areas and its abundance varies locally and seasonally from scarce to common, largely dependent on rainfall and food availability.

Ecology: The bustard has an omnivorous diet, feeding on grasses, seeds, fruit, insects and small vertebrates. Although the population size is still substantial, there has been a large historical decline in abundance, particularly south of the tropics, but also across northern Australia (Garnett and Crowley 2000). This is a result of hunting, degradation of its grassland habitat by sheep and rabbits and predation by foxes and cats (Frith 1976; Garnett and Crowley 2000). Bustards readily desert nests in response to disturbance by humans, sheep or cattle (Garnett and Crowley 2000).

Likelihood of Occurrence: **RECORDED** – This species was recorded on three occasions during the Level 1 Survey, in each of the three fauna habitats present. The Australian Bustard is expected to be a regularly occuring, widespread species within the Study Area.

Figure 5.3 – Australian Bustard (DEC Priority 4) Recorded During the Level 1 Survey.

5.3.2.5 Bush Stone-curlew (*Burhinus grallarius*)

Conservation Status: DEC Priority 4

Distribution and Habitat: The Bush Stone-curlew occurs across much of Australia, except the arid interior and central south coast, preferring lightly wooded country near thickets or long grass that act

as daytime shelter (Johnstone and Storr 1998). Historically, this species was widely distributed throughout much of WA, but it is now considered rare, with an estimated Australian population of 15,000 individuals (Garnett and Crowley 2000).

Ecology: The species is insectivorous, preying primarily upon beetles, although they will also eat seeds and shoots, frogs, lizards and snakes (Marchant and Higgins 1993; NSW National Parks and Wildlife Service 1999). They are usually seen in pairs, although may occasionally flock together during the breeding season (August to January) and are generally nocturnal, especially on moonlight nights (NSW National Parks and Wildlife Service 1999). Since Bush Stone-curlews are a ground dwelling and non-migratory species they are quite susceptible to local disturbances by humans and to predation by cats and foxes (Frith 1976; Johnstone and Storr 1998). Additional threats are altered fire regimes, degradation of habitat due to overgrazing by domestic stock as well as poisoning by eating pollard baits laid to control rabbits (NSW National Parks and Wildlife Service 1999). They are most common where land disturbance is minimal and generally become rare or extinct around human settlements (Johnstone and Storr 1998).

Likelihood of Occurrence: RECORDED – A Bush Stone-curlew was heard calling from the quarry camp after dusk, below the hill near the densly vegetated drainage line. It is likely this species occurs in similar habitat throughout the Study Area.

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6 FURTHER INVESTIGATIONS

This study has identified that forty flora species and six vertebrate fauna species of conservation significance could potentially occur within the Study Area. Further investigations required to assess the impacts to these species are recommended in order to support future Environmental Impact Assessment of a development proposal at Thunderbird. The information provided by these investigations will support future State and Commonwealth Environmental Impact Assessment processes.

6.1 STATE ASSESSMENT PROCESS

Mining activities require approval under the Mining Act 1978, by way of assessment of a Mining proposal by the Department of Mines and Petroleum (DMP). Approval is granted following DMP environmental assessment and; the issue of a Clearing Permit by the DEC, or the granting of Ministerial approval under Part IV of the Environmental Protection Act 1986.

The Western Australian *Environmental Protection Act 1986* provides that where a proposal is likely to have a significant effect on the environment, the proposal may be referred to the EPA for a decision on whether or not it requires formal assessment. The EPA then makes a decision on the level of assessment for the proposal, whether it be Public Environmental Review (PER) or Assessment on Proponent Information (API).

Projects are subject to API levels of assessment when sufficient information has been provided in the referral documentation enabling the EPA to make judgment on the acceptability of the project without further scrutiny. The API levels are further broken down into category A for projects that are more straightforward and category B for those that have unmanageable impacts.

A PER level of assessment is applied to complex projects, particularly those that arouse high levels of public interest. For projects that are subject to Public Environmental Review, the proponent is required to conduct a full environmental assessment of the project with form, content and timing stipulated by the EPA. The PER document is then released for a public environmental review period of between four and twelve weeks, also determined by the EPA depending on the significance of the proposal and the level of public interest. The whole PER process can take between 18 and 24 months to complete, if not longer. To conclude the process the Minister for the Environment determines whether, and in what manner, the proposal may be implemented, and legally binds the proponent to a set of ministerial conditions.

6.2 COMMONWEALTH ASSESSMENT PROCESS

Where a project or development is likely to have significant impact to matters of national environmental significance protected by the *Environmental Protection and Biodiversity Conservation Act 1999*, it must be referred to the Department of Sustainability, Environment, Water, Population and the Community (DSEWPaC) for assessment. The first stage of an EPBC assessment is the referral stage, which involves the submission of all known information on the proposed action to the department who review the information and release it for a ten day public comment period. The second stage is the assessment and decision stage where the department decides on the level of assessment for the proposed action, and once the relevant documentation is provided, the minister makes a final decision on whether or not to approve, approve with conditions or disapprove of the proposed action.

6.3 SHEFFIELD RESOURCES THUNDERBIRD DAMPIER PENINSULA PROJECT

Based on our knowledge of the current scale of the project, size of the proposed impact footprint and level of expected environmental impact, *ecologia* anticipates that the Thunderbird Project will potentially be assessed at the Mining Proposal level by the DMP. This level of assessment warrants the following level of biological surveys to allow adequate assessment.

It is recommended that Sheffield undertake:

- A single phase Level 2 Vertebrate Fauna Assessment which incorporates targeted conservation significant fauna surveys;
- A Level 2 Vegetation and Flora Assessment;
- A baseline Short-Range Endemic Fauna Assessment, and
- A baseline Subterranean Fauna Assessment for Troglofauna and Stygofauna.

If the level of assessment is increased due to unforeseen circumstances, additional phases of surveys can be implemented to compliment the above surveys, and raise the level of biological assessment to a level that would be acceptable for higher EPA level assessments.

There is also the potential need for referral under the EPBC Act, as several EPBC listed species may potentially occur in the Study Area. Species such as the Bilby and Gouldian Finch require specific targeted surveys that are conducted at specific times of the year. Results from the above surveys will clarify the need for these targeted surveys and *ecologia* will provide separate advice and proposals if EPBC listed species are recorded inside the Study Area.

7 REFERENCES

AECOM. 2010. Supplementary Terrestrial Fauna and Habitat Assessment: James Price Point, WA. Unpublished report for the Department of State Development.

Prepared by AECOM for Main Roads Western Australia. 2011. Browse LNG Precinct Access Road: Targeted Fauna Survey – Greater Bilby

Atkins, K. J. 2008. Declared Rare and Priority Flora List for Western Australia. Department of Environment and Conservation.

Bamford Consulting Ecologists 2011. Assessment of Birds Utilising Habitat within the Vine Thickets and Woodlands of James Price Point, WA. Field Report, May 2011. Unpublished Report Prepared for Woodside Energy Limited.

Beard, J. S. 1975. The vegetation of the Pilbara region. Explanatory notes to map sheet 5 of vegetation survey of Western Australia: Pilbara. University of Western Australia Press, Nedlands.

Beard, J. S. 1979. *Kimberley. The vegetation of the Kimberley area*. Vegetation Survey of Western Australia 1:1,000,000 series, explanatory notes and map. University of Western Australia Press, Nedlands, WA.

Biota Environmental Sciences. 2009. James Price Point Terrestrial Fauna Survey: Wet Season. Unpublished report for the Department of State Development.

Biota Environmental Sciences. 2010. James Price Point Browse LNG Precinct Targeted Terrestrial Fauna Survey. Unpublished report for ERM on behalf of Woodside.

Boland, C. R. J. 2004. Breeding biology of Rainbow Bee-eaters (Merops ornatus): a migratory, colonial, cooperative bird. The Auk. 121:811-823.

BoM. 2011. Climate Data Online, Bureau of Meteorology. Accessed http://www.bom.gov.au/climate/data/.

Bullen, R. D. and McKenzie, N. L. 2001. Bat airframe design: Flight performance, stability and control in relation to foraging ecology. Australian Journal of Zoology. 49:235-261.

Bullen, R. D. and McKenzie, N. L. 2002. Scaling bat wingbeat frequency and amplitude. The Journal of Experimental Biology. 205:2615-2626.

Bullen, R. D. and McKenzie, N. L. 2005. Seasonal range variation of *Tadarida australis* (Chiroptera: Molossidae) in Western Australia: the impact of enthalpy. Australian Journal of Zoology. 53:145-156.

Bunge, J. and Fitzpatrick, M. 1993. Estimating the number of species: A review. Journal of the American Statistical Association. 88:364-373.

CALM. 1999. Environmental weed strategy for Western Australia. Department of Conservation and Land Management, Government of Western Australia.

Christidis, L. and Boles, W. E. 2008. Systematics and Taxonomy of Australian Birds. CSIRO Publishing, Collingwood.

Churchill, S. 1998. Australian Bats. Reed New Holland, Sydney.

Cogger, H. G. 2000. Reptiles and Amphibians of Australia. Reed New Holland, Sydney.

Colwell, R. K. 2009. EstimateS: Statistical estimation of species richness and shared species from samples. Version 8.

Colwell, R. K. and Coddington, J. A. 1994. Estimating terrestrial biodiversity through extrapolation. Philosophical Transactions of the Royal Society (Series B). 345:101-118.

Department of Sustainability, Environment, Water, Population and Communities. 2009. Interim Biogeographic Regionalisation for Australia (IBRA), Version 6.1

ecologia Environment. 2004. Beagle Bay Big Tree Country Tropical Timber Plantation Project. Fauna Assessment Survey. Unpublished report for Tropical Timber Plantations Pty Limited.

ecologia. 2011. James Price Point: Light Industrial Area, Workers' Accommodation Camp and Southern Pipeline Terrestrial Vertebrate Fauna Assessment. Unpublished Report for Woodside Energy Limited.

ENV Australia. 2008. Perpendicular Head-North Head, Packer Island, Gourdon Bay and Coulomb-Quondong Vertebrate Fauna Assessment. Unpublished report for the Department of Industry and Resources.

2011. Browse Project Greater Bilby Survey of the James Price Point Area: Summary Report.

Environmental Protection Authority. 2002. Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection.

Environmental Protection Authority. 2004a. Guidance Statement No. 51: Terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia.

Environmental Protection Authority. 2004b. Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia.

EPA and DEC. 2010. Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment.

Fowler, J. and Cohen, L. 1990. Practical Statistics for Field Biology, Wiley, Chichester, UK.

Frith, A. J. 1976. Reader's Digest Complete Birds of Australia. Reader's Digest, Sydney.

Garnett, S. T. and Crowley, G. M. 2000. The Action Plan for Australian Birds. Environment Australia, Canberra.

Gaston, K. J. 1996. Species richness: measure and measurement. In: Biodiversity, a biology of number and difference. Blackwell Science, Cambridge.

Graham, G. 2002. Dampierland 2 (DL2 – Pindanland subregion). Department of Conservation and Land Management, Perth, Western Australia.

Johnson, K. A. 2008. Bilby, *Macrotis lagotis*. pp. 191-193 *in* van Dyck, S., and Strahan, R., eds. The Mammals of Australia. Reed New Holland, Sydney.

Johnstone, R. E. and Storr, G. M. 1998. Handbook of Western Australian Birds, Volume I - Non-Passerines (Emu to Dollarbird). Western Australian Museum, Perth.

Kenneally, K. F., Edinger, D. C., and Willing, T. 1996. Broome and Beyond: Plants and People of the Dampier Peninsula, Kimberley, Western Australia. Department of Conservation and Land Management, Western Australia.

Marchant, S. and Higgins, P. J. 1993. Handbook of Australian, New Zealand and Antarctic Birds. Oxford University Press, Melbourne.

Maxwell, S., Burbidge, A. A., and Morris, K. D., eds. 1996. The 1996 Action Plan for Australian Marsupials and Monotremes. Wildlife Australia, Canberra.

Menkhorst, P. and Knight, F. 2011. *A Field Guide to the Mammals of Australia*. Oxford University Press, Melbourne.

Morcombe, M. 2000. Field Guide to Australian Birds. Steve Parish Publishing Pty Ltd, Archerfield, Australia.

National Health and Medical Research Council. 2004. Australian code of practice for the care and use of animals for scientific purposes.

NSW National Parks and Wildlife Service. 1999. Bush Stone-curlew *Burhinus grallarius* (Latham, 1801). NSW National Parks and Wildlife Service, Hurstville, NSW www.npws.nsw.gov.au,.

O'Malley, C. 2006a. Australian Threatened Species, Greater Bilby, *Macrotis lagotis*.

O'Malley, C. 2006b. National Recovery Plan for the Gouldian Finch (*Erythrura gouldiae)*. WWF-Australia, Sydney and Parks and Wildlife NT, Department of Natural Resources, Environment and the Arts, NT Government.

Pavey, C. 2006. Threatened Species of the Northern Territory: Greater Bilby *Macrotis lagotis in* Department of Natural Resources Environment and the Arts, ed. Parks and Wildlife Commission - Northern Territory Government.

Pizzey, G. and Knight, F. 2003. A Field Guide to the Birds of Australia. Harper Collins Publishers, Sydney.

Rogers, D., Hassell, C., Oldland, J., Clemens, R., Boyle, A., and Rogers, K. 2009. Monitoring Yellow Sea Migrants in Australia (MYSMA): North-western Australian shorebird surveys and workshops.

Shepherd, D. P., Beeston, G. R., and Hopkins, A. J. M. 2001. Native vegetation in Western Australia: Extent, type and status. Technical Report 249. Department of Agriculture, South Perth.

Shepherd, D. P., Beeston, G. R., and Hopkins, A. J. M. 2002. Native Vegetation in Western Australia. Technical Report 249. Department of Agriculture, Western Australia, South Perth.

Simpson, K. and Day, N. 2004. Field Guide to the Birds of Australia. Penguin Group, Camberwell.

Storr, G. M., Smith, L. A., and Johnstone, R. E. 1983. Lizards of Western Australia II: Dragons and Monitors. Western Australian Museum, Perth.

Storr, G. M., Smith, L. A., and Johnstone, R. E. 1990. Lizards of Western Australia III: Geckos and Pygopods. Western Australian Museum, Perth.

Storr, G. M., Smith, L. A., and Johnstone, R. E. 1999. Lizards of Western Australia I: Skinks. Western Australian Museum, Perth.

Storr, G. M., Smith, L. A., and Johnstone, R. E. 2002. Snakes of Western Australia. Western Australian Museum, Perth.

van Dyck, S. and Strahan, R. 2008. *The Mammals of Australia*. Reed New Holland, Sydney.

Van Vreeswyk, A. M. E., Payne, A. L., Leighton, K. A., and Hennig, P. 2004. An inventory and condition survey of the Pilbara region, Western Australia. Department of Agriculture Technical Bulletin. 92.

WAHERB. 2010. FloraBase - The Western Australian Flora. Department of Environment and Conservation.

Western Australian Herbarium. 1998-2012. FloraBase - The Western Australian Flora. Accessed December 2011. http://florabase.dec.wa.gov.au/.

Wilson, S. and Swan, G. 2010. *A Complete Guide to Reptiles of Australia*. New Holland Publishers, Sydney.

Woinarski, J. C. Z. and Palmer, C. 2006. Threatened Species of the Northern Territory: Gouldian Finch *Erythrura gouldiae*. Parks and Wildlife Commission - Northern Territory Government.

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APPENDIX A EXPLANATION OF CONSERVATION CODES

Appendix A1 – Definitions of relevant categories under the *Environment Protection and Biodiversity Conservation Act*.

Category	Definition
Endangered (EN)	The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction.
Vulnerable (VU)	Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate.
Migratory (M)	Species are defined as migratory if they are listed in an international agreement approved by the Commonwealth Environment Minister, including: • the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animal) for which Australia is a range state; • the agreement between the Government of Australian and the Government of the Peoples Republic of China for the Protection of Migratory Birds and their environment (CAMBA); or • the agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (JAMBA).

Appendix A2 – Definition of Schedules under the *Wildlife Conservation Act 1950*.

Schedule	Definition
Schedule 1 (S1)	Fauna which are rare of likely to become extinct, are declared to be fauna that is in need of special protection.
Schedule 2 (S2)	Fauna which are presumed to be extinct, are declared to be fauna that is in need of species protection.
Schedule 3 (S3)	Birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction, are declared to be fauna that is in need of species protection.
Schedule 4 (S4)	Declared to be fauna that is in need of species protection, otherwise than for the reasons mentioned above.

Appendix A3 – Definition of Department of Environment and Conservation Priority Codes.

Threatened	**Definition**
Critically Endangered (CR)	Considered to be facing an extremely high risk of extinction in the wild.
Endangered (EN)	Considered to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	Considered to be facing a high risk of extinction in the wild.
Priority	**Definition**
Priority 1 (P1)	*Taxa with few, poorly known populations on threatened lands.* Taxa which are known from few specimens or sight records from one or a few localities, on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 2 (P2)	*Taxa with few, poorly known populations on conservation lands.* Taxa which are known from few specimens or sight records from one or a few localities, on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 3 (P3)	*Taxa with several, poorly known populations, some on conservation lands.* Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 4 (P4)	*Taxa in need of monitoring.* Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could if present circumstances change. These taxa are usually represented on conservation lands.
Priority 5 (P5)	*Taxa in need of monitoring.* Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Table A4 – Definition of codes for Threatened Ecological Communities

Code	Definition
PD: Presumed Totally Destroyed	An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant
CR: Critically Endangered	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future.
EN: Endangered	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future.
VU: Vulnerable	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future.

Table A5 – Definition of codes for Priority Ecological Communities

Code	Definition
P1: Priority One	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or Pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
P2: Priority Two	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
P3: Priority Three	(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (iii) Communities made up of large, and/or widespread occurrences that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
P4: Priority Four	Ecological communities that are adequately known, Rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring. (a) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands. (b) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Ecological communities that have been removed from the list of threatened communities during the past five years. P5: Priority Five Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.
P5: Priority Five	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

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APPENDIX B FLORA QUADRAT DESCRIPTIONS

Quadrat 1

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	499677
Northing	8067413
Habitat and Waterway	Floodplain (Depression)
Slope	Gentle
Surface Layer	Loose
Soil Colour	White, Grey
Soil Texture	Sandy-Clay, Clay
Rock Type	No Rocks
Rock Size and Abundance	No Rocks - None
Vegetation Condition	Poor (moderate grazing, weeds)
Disturbance Type	Animal Tracks; Faeces
Time since Fire	> 5 years
Leaf Litter Distribution and Cover	Dispersed; 2**%**

Stratum	Taxa
Trees (<10 m)	*Eucalyptus tectifica; Melaleuca viridiflora*
Shrubs (>2 m)	*Acacia colei var. colei*
Shrubs (1-2 m)	*Bauhinia cunninghamii; Sida hackettiana*
Shrubs (<1 m)	*Stylosanthes hamata*
Herbs	*Asteraceae sp.; Blumea integrifolia; Buchnera asperata; Byblis filifolia; Chamaecrista mimosoides; Drosera indica; Eleocharis geniculata; Ludwigia perennis; Melochia corchorifolia; Mimulus uvedaliae var. lutea; Oldenlandia galioides; Phyllanthus virgatus; Rotala occultiflora; Stackhousia intermedia; Stemodia lathraia; Stylosanthes scabra; Thysanotus chinensis*
Sedges	*Cyperus ? conicus; Fimbristylis dichotoma; Lipocarpha microcephala*
Tussock Grasses	*Chrysopogon sp.; Digitaria bicornis; Eragrostis cumingii; Eriachne obtusa; Fuirena ciliaris; Sacciolepis indica; Sorghum plumosum*

Quadrat 3

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	502522
Northing	8067698
Habitat and Waterway	Plain
Slope	Negligible
Surface Layer	Loose
Soil Colour	Orange
Soil Texture	Sandy-Clay
Rock Type	No Rocks
Rock Size and Abundance	No Rocks - None
Vegetation Condition	Excellent (no obvious disturbance)
Disturbance Type	No Disturbance
Time since Fire	2-5 years
Leaf Litter Distribution and Cover	Dispersed; 75**%**

Stratum	Taxa
Trees (<10 m)	*Corymbia greeniana; Erythrophleum chlorostachys; Eucalyptus tectifica*
Shrubs (>2 m)	*Acacia platycarpa; Acacia tumida var. tumida; Bauhinia cunninghamii; Grevillea pyramidalis subsp. pyramidalis*
Shrubs (1-2 m)	*Acacia hippuroides; Brachychiton diversifolius subsp. diversifolius; Dodonaea hispidula var. arida; Ehretia saligna var. saligna; Grevillea refracta subsp. refracta*
Climbers	*Galactia tenuiflora*
Herbs	*Buchnera asperata; Byblis filifolia; Corchorus sidoides subsp. vermicularis; Crotalaria crispata; Galactia tenuiflora; Gomphrena canescens subsp. canescens; Microstachys chamelea; Pterocaulon sphacelatum*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Aristida holathera var. holathera; Chrysopogon sp.; Cynodon dactylon; Eriachne obtusa; Sorghum plumosum*

Quadrat 4

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	493955
Northing	8073233
Habitat and Waterway	Plain
Slope	Negligible
Surface Layer	Loose, Crust
Soil Colour	Orange, Brown
Soil Texture	Sandy-Clay
Rock Type	Limestone
Rock Size and Abundance	Boulders - Few (<10%)
Vegetation Condition	Very Good (slight disturbance)
Disturbance Type	Animal Tracks; Grazing; Faeces
Time since Fire	> 5 years
Leaf Litter Distribution and Cover	Dispersed; 15**%**

Stratum	Taxa
Trees (<10 m)	*Indetermined; Terminalia sp.*
Shrubs (>2 m)	*Acacia monticola; Brachychiton diversifolius subsp. diversifolius; Grevillea pyramidalis subsp. pyramidalis; Grevillea refracta subsp. refracta; Santalum lanceolatum; Terminalia canescens*
Shrubs (1-2 m)	*Dodonaea hispidula var. arida*
Shrubs (<1 m)	*Acacia hippuroides; Sida spinosa; Tephrosia remotiflora; Triumfetta plumigera; Ventilago viminalis*
Climbers	*Dicliptera armata*
Herbs	*Buchnera asperata; Glycine tomentella; Gomphrena canescens subsp. canescens; Gomphrena flaccida; Heliotropium dichotomum; Hybanthus aurantiacus; Microstachys chamelea; Oldenlandia mitrasacmoides subsp. mitrasacmoides; Polycarpaea corymbosa; Polycarpaea longiflora; Pterocaulon sphacelatum; Ptilotus corymbosus; Waltheria indica; Zornia prostrata var. prostrata*
Sedges	*Fimbristylis simulans*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Chrysopogon sp.; Eriachne ciliata; E. melicacea; Setaria apiculata; Sorghum plumosum*

Quadrat 5

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	499829
Northing	8071874
Habitat and Waterway	Hillslope - Ridgetop
Slope	Moderate, Steep
Surface Layer	Rocky/Stony
Soil Colour	Orange, Brown
Soil Texture	Sandy-Clay
Rock Type	Sandstone
Rock Size and Abundance	Stones, Boulders, Surface Plates - Continuous (>70%)
Vegetation Condition	Very Good (slight disturbance)
Disturbance Type	Animal Tracks
Time since Fire	2-5 years
Leaf Litter Distribution and Cover	Dispersed; 30**%**

Stratum	Taxa
Trees (<10 m)	*Corymbia dendromerinx; Eucalyptus tectifica; Ficus platypoda*
Shrubs (>2 m)	*Acacia platycarpa; Dolichandrone heterophylla; Grevillea refracta subsp. refracta; Indetermined; Terminalia canescens*
Shrubs (1-2 m)	*Acacia drepanocarpa subsp. latifolia; Atalaya hemiglauca; Atalaya variifolia; Calytrix exstipulata; Dodonaea hispidula var. arida; Dolichandrone heterophylla; Ehretia saligna var. saligna; Flueggea virosa subsp. melanthesoides; Indetermined; Premna acuminata*
Shrubs (<1 m)	*Corymbia dendromerinx; Grevillea pyramidalis subsp. pyramidalis; Premna acuminata; Solanum cunninghamii; Triumfetta breviaculeata*
Climbers	*Dicliptera armata; Glycine tomentella; Tinospora smilacina; Vigna lanceolata var. filiformis*
Herbs	*Bonamia linearis; Buchnera linearis; Crotalaria medicaginea var. neglecta; Gomphrena canescens subsp. canescens; Microstachys chamelea; Pterocaulon sphacelatum; Tephrosia remotiflora; Waltheria indica*
Sedges	*Cyperus microcephalus*
Tussock Grasses	*Cenchrus elymoides; Chrysopogon sp.; Cymbopogon procerus; Eriachne obtusa; Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946); Sorghum plumosum*

Quadrat 6

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	500544
Northing	8068052
Habitat and Waterway	Plain
Slope	Negligible
Surface Layer	Loose
Soil Colour	Orange, Brown, White
Soil Texture	Sandy-Clay
Rock Type	No Rocks
Rock Size and Abundance	No Rocks - None
Vegetation Condition	Excellent (no obvious disturbance)
Disturbance Type	No Disturbance
Time since Fire	2-5 years
Leaf Litter Distribution and Cover	Dispersed; 80**%**

Stratum	Taxa
Trees (<10 m)	*Corymbia dendromerinx; Corymbia greeniana; Corymbia zygophylla*
Shrubs (>2 m)	*Acacia colei var. colei; Acacia tumida var. tumida; Brachychiton diversifolius subsp. diversifolius; Grevillea pyramidalis subsp. pyramidalis; Grevillea refracta subsp. refracta; Persoonia falcata; Terminalia canescens*
Shrubs (1-2 m)	*Calytrix exstipulata; Dodonaea hispidula var. arida*
Shrubs (<1 m)	*Erythrophleum chlorostachys; Wrightia saligna*
Climbers	*Marsdenia viridiflora subsp. tropica*
Herbs	*Buchnera linearis; Chamaecrista symonii; Corchorus sidoides subsp. vermicularis; Microstachys chamelea; Pterocaulon sphacelatum; Spermacoce occidentalis*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Aristida holathera var. latifolia; Eriachne obtusa; Sorghum plumosum*

Quadrat 9

Botanist	Renee Tuckett
Quadrat Size	25 x 100 m
Easting	496084
Northing	8075977
Habitat and Waterway	Gully (Minor Creek (<5m))
Slope	Gentle
Surface Layer	Loose, Rocky/Stony
Soil Colour	Orange, Brown, White
Soil Texture	Sandy-Clay
Rock Type	Ironstone, Quartz
Rock Size and Abundance	Gravel/Pebble, Stones, Boulders - Many (30-70%)
Vegetation Condition	Very Good (slight disturbance)
Disturbance Type	Animal Tracks; Faeces
Time since Fire	> 5 years
Leaf Litter Distribution and Cover	Dispersed; 5**%**

Stratum	Taxa
Trees (<10 m)	*Corymbia greeniana*
Shrubs (>2 m)	*Dolichandrone heterophylla; Grevillea pyramidalis subsp. pyramidalis; Terminalia canescens*
Shrubs (1-2 m)	*Acacia tumida var. tumida; Corymbia dendromerinx*
Shrubs (<1 m)	*Bauhinia cunninghamii; Dodonaea hispidula var. arida; Grevillea refracta subsp. refracta; Senna oligoclada; Triumfetta sp.; Wrightia saligna*
Climbers	*Dicliptera armata; Xenostegia tridentata*
Herbs	*Buchnera asperata; Corchorus sidoides subsp. vermicularis; Euphorbia ?myrtoides; Glycine tomentella; Gomphrena canescens subsp. canescens; Gomphrena flaccida; Indigofera haplophylla; Microstachys chamelea; Oldenlandia mitrasacmoides subsp. mitrasacmoides; Polycarpaea corymbosa; Pterocaulon sphacelatum; Ptilotus corymbosus; Stemodia lythrifolia; Tephrosia remotiflora; Waltheria indica*
Sedges	*Bulbostylis barbata; Fimbristylis simulans*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Eragrostis cumingii; Eriachne ciliata; Eriachne obtusa; Eriachne sulcata; Heteropogon contortus; Sorghum plumosum; Sporobolus australasicus*

Quadrat 10

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	495950
Northing	8075986
Habitat and Waterway	Hillslope - Midslope
Slope	Gentle
Surface Layer	Rocky/Stony
Soil Colour	Orange, Brown
Soil Texture	Sandy-Clay
Rock Type	Ironstone
Rock Size and Abundance	Gravel/Pebble, Stones, Boulders - Continuous (>70%)
Vegetation Condition	Excellent (no obvious disturbance)
Disturbance Type	No Disturbance
Time since Fire	2-5 years
Leaf Litter Distribution and Cover	Dispersed; 2%

Stratum	Taxa
Trees (<10 m)	*Corymbia dendromerinx; Corymbia greeniana*
Shrubs (>2 m)	*Acacia tumida var. tumida; Dolichandrone heterophylla; Grevillea pyramidalis subsp. pyramidalis; Terminalia canescens*
Shrubs (1-2 m)	*Ficus aculeata var. indecora; Wrightia saligna*
Shrubs (<1 m)	*Corchorus sidoides subsp. vermicularis; Grevillea refracta subsp. refracta; Hybanthus aurantiacus; Indigofera haplophylla; Solanum cunninghamii; Tephrosia simplicifolia; Terminalia canescens*
Herbs	*Asteraceae sp.; Buchnera linearis; Euphorbia myrtoides; Gomphrena canescens subsp. canescens; Hibiscus geranioides; Indigofera haplophylla; Indigofera linifolia; Oldenlandia mitrasacmoides subsp. mitrasacmoides; Polycarpaea corymbosa; Polygala linariifolia; Pterocaulon sphacelatum; Ptilotus corymbosus; Spermacoce occidentalis; Stemodia lythrifolia*
Sedges	*Bulbostylis barbata; Fimbristylis simulans*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Eriachne ciliata; Sorghum plumosum*

Quadrat 11

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	493242
Northing	8074375
Habitat and Waterway	Plain
Slope	Negligible
Surface Layer	Loose
Soil Colour	Orange
Soil Texture	Sand Sandy-Clay
Rock Type	No Rocks
Rock Size and Abundance	No Rocks - None
Vegetation Condition	Excellent (no obvious disturbance)
Disturbance Type	No Disturbance
Time since Fire	1-2 years
Leaf Litter Distribution and Cover	Dispersed; 25**%**

Stratum	Taxa
Trees (<10 m)	*Corymbia greeniana; Corymbia zygophylla; Erythrophleum chlorostachys*
Shrubs (>2 m)	*Brachychiton diversifolius subsp. diversifolius; Grevillea refracta subsp. refracta*
Shrubs (1-2 m)	*Acacia tumida var. tumida*
Shrubs (<1 m)	*Acacia platycarpa; Brachychiton diversifolius subsp. diversifolius; Dodonaea hispidula var. arida; Dolichandrone heterophylla; Terminalia canescens; Wrightia saligna*
Climbers	*Galactia tenuiflora*
Herbs	*Buchnera linearis; Chamaecrista symonii; Crotalaria brevis; Glycine tomentella; Gomphrena canescens subsp. canescens; Indetermined; Polycarpaea corymbosa; Pterocaulon sphacelatum*
Sedges	*Cyperaceae sp.*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Aristida holathera var. holathera; Chrysopogon sp.; Eriachne melicacea; Sorghum plumosum*

Quadrat 12

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	494331
Northing	8074124
Habitat and Waterway	Plain
Slope	Negligible
Surface Layer	Loose
Soil Colour	Orange
Soil Texture	Sand Sandy-Clay
Rock Type	No Rocks
Rock Size and Abundance	No Rocks - None
Vegetation Condition	Excellent (no obvious disturbance)
Disturbance Type	No Disturbance
Time since Fire	No Evidence
Leaf Litter Distribution and Cover	Dispersed; 25**%**

Stratum	Taxa
Trees (<10 m)	*Corymbia greeniana; Erythrophleum chlorostachys; Hakea arborescens*
Shrubs (>2 m)	*Acacia platycarpa; Acacia tumida var. tumida; Bauhinia cunninghamii; Dolichandrone heterophylla; Ehretia saligna var. saligna; Grevillea refracta subsp. refracta; Terminalia canescens; Ventilago viminalis*
Shrubs (1-2 m)	*Brachychiton diversifolius subsp. diversifolius; Dodonaea hispidula var. arida; Grevillea pyramidalis subsp. pyramidalis*
Shrubs (<1 m)	*Brachychiton diversifolius subsp. diversifolius; Corchorus sidoides subsp. vermicularis; Premna acuminata*
Herbs	*Buchnera asperata; Calandrinia strophiolata; Chamaecrista symonii; Crotalaria brevis; Gomphrena canescens subsp. canescens; Hybanthus aurantiacus; Jasminum molle; Melhania oblongifolia; Microstachys chamelea; Polygala tepperi; Pterocaulon sphacelatum; Spermacoce occidentalis; Velleia panduriformis; Waltheria indica*
Sedges	*Scleria brownii*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Aristida holathera var. latifolia; Eriachne ciliata; Eriachne obtusa; Sorghum plumosum*

Quadrat 13

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	495996
Northing	8071422
Habitat and Waterway	Plain
Slope	Negligible
Surface Layer	Loose
Soil Colour	Orange, Brown, White
Soil Texture	Sandy-Clay
Rock Type	No Rocks
Rock Size and Abundance	No Rocks - None
Vegetation Condition	Good (low grazing, few weeds)
Disturbance Type	Animal Tracks; Faeces
Time since Fire	2-5 years
Leaf Litter Distribution and Cover	Dispersed; 15**%**

Stratum	Taxa
Trees (<10 m)	*Corymbia greeniana; Eucalyptus tectifica; Indetermined*
Shrubs (>2 m)	*Acacia platycarpa; Acacia tumida var. tumida; Atalaya hemiglauca; Bauhinia cunninghamii; Brachychiton diversifolius subsp. diversifolius; Grevillea refracta subsp. refracta; Terminalia canescens*
Shrubs (1-2 m)	*Acacia tumida var. tumida; Brachychiton diversifolius subsp. diversifolius; Dodonaea hispidula var. arida; Erythrophleum chlorostachys; Gardenia pyriformis subsp. keartlandii; Wrightia saligna*
Shrubs (<1 m)	*Microstachys chamelea; Premna acuminata; Sida spinosa*
Climbers	*Galactia tenuiflora*
Herbs	*Bonamia linearis; Calandrinia strophiolata; Chamaecrista symonii; Corchorus sidoides subsp. vermicularis; Gomphrena canescens subsp. canescens; Microstachys chamelea; Pterocaulon intermedium; Pterocaulon sphacelatum; Spermacoce occidentalis; Waltheria indica*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Aristida holathera var. latifolia; Chrysopogon sp.; Eragrostis ?eriopoda; Eriachne melicacea; Sorghum plumosum*

Quadrat 15

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	497313
Northing	8068356
Habitat and Waterway	Plain
Slope	Negligible
Surface Layer	Loose
Soil Colour	Yellow, White
Soil Texture	Sandy-Clay, Loam, Clay
Rock Type	No Rocks
Rock Size and Abundance	No Rocks - None
Vegetation Condition	Good (low grazing, few weeds)
Disturbance Type	Animal Tracks; Faeces
Time since Fire	2-5 years
Leaf Litter Distribution and Cover	Dispersed; 5**%**

Stratum	Taxa
Trees (<10 m)	*Corymbia greeniana; Melaleuca nervosa*
Shrubs (>2 m)	*Bauhinia cunninghamii; Ehretia saligna var. saligna; Hakea arborescens*
Shrubs (1-2 m)	*Acacia colei var. colei*
Shrubs (<1 m)	*Carissa lanceolata; Dolichandrone heterophylla*
Climbers	*Glycine tomentella*
Herbs	*?Ptilotus sp; Buchnera asperata; Crotalaria crispata; Drosera derbyensis; Gomphrena canescens subsp. canescens; Heliotropium cunninghamii; Oldenlandia mitrasacmoides subsp. mitrasacmoides; Pterocaulon serrulatum var. velutinum; Spermacoce occidentalis; Stemodia lathraia; Stemodia lythrifolia*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*?Eragrostis sp.; Aristida holathera var. holathera; Eriachne obtusa; Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)*

Quadrat 16

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	497776
Northing	8071234
Habitat and Waterway	Plain
Slope	Negligible
Surface Layer	Loose
Soil Colour	Orange, Brown, White
Soil Texture	Sandy-Clay
Rock Type	No Rocks
Rock Size and Abundance	No Rocks - None
Vegetation Condition	Very Good (slight disturbance)
Disturbance Type	Animal Tracks
Time since Fire	> 5 years
Leaf Litter Distribution and Cover	Dispersed; 25**%**

Stratum	Taxa
Trees (<10 m)	*Brachychiton diversifolius subsp. diversifolius; Corymbia greeniana; Corymbia zygophylla; Eucalyptus tectifica; Melaleuca nervosa*
Shrubs (>2 m)	*Acacia platycarpa; Brachychiton diversifolius subsp. diversifolius; Grevillea pyramidalis subsp. pyramidalis; Grevillea refracta subsp. refracta*
Shrubs (1-2 m)	*Bauhinia cunninghamii; Brachychiton diversifolius subsp. diversifolius; Dolichandrone heterophylla; Ehretia saligna var. saligna; Erythrophleum chlorostachys*
Shrubs (<1 m)	*Dodonaea hispidula var. arida; Solanum cunninghamii*
Climbers	*Glycine tomentella*
Herbs	*Buchnera asperata; Buchnera linearis; Chamaecrista symonii; Crotalaria crispata; Glycine tomentella; Gomphrena canescens subsp. canescens; Indetermined; Microstachys chamelea; Pterocaulon sphacelatum; Spermacoce occidentalis; Trichodesma zeylanicum var. zeylanicum*
Sedges	*Cyperaceae sp.; Scleria brownii*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Aristida holathera var. latifolia; Chrysopogon sp.; Eragrostis ?eriopoda; Eriachne obtusa; Sorghum plumosum*

Quadrat 17

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	494080
Northing	8073582
Habitat and Waterway	Plain
Slope	Negligible
Surface Layer	Loose
Soil Colour	Orange
Soil Texture	Sand, Sandy-Clay
Rock Type	No Rocks
Rock Size and Abundance	No Rocks - None
Vegetation Condition	Very Good (slight disturbance)
Disturbance Type	Animal Tracks
Time since Fire	2-5 years
Leaf Litter Distribution and Cover	Dispersed; 30**%**

Stratum	Taxa
Trees (<10 m)	*Corymbia greeniana; Corymbia zygophylla; Erythrophleum chlorostachys; Gardenia pyriformis subsp. keartlandii*
Shrubs (>2 m)	*Acacia platycarpa; Bauhinia cunninghamii; Brachychiton diversifolius subsp. diversifolius; Codonocarpus cotinifolius; Dodonaea hispidula var. arida; Hakea arborescens; Terminalia canescens*
Shrubs (1-2 m)	*Acacia tumida var. tumida; Grevillea refracta subsp. refracta*
Shrubs (<1 m)	*Corchorus sidoides subsp. vermicularis; Dolichandrone heterophylla; Heliotropium cunninghamii; Solanum cunninghamii; Wrightia saligna*
Herbs	*Buchnera linearis; Byblis rorida; Crotalaria crispata; Evolvulus alsinoides var. decumbens; Gomphrena canescens subsp. canescens; Microstachys chamelea; Polycarpaea corymbosa; Pterocaulon sphacelatum; Spermacoce occidentalis; Trianthema pilosa*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Aristida holathera var. holathera; Aristida inaequiglumis; Eriachne melicacea; Eriachne obtusa; Sorghum plumosum*

Quadrat 18

Botanist	Renee Tuckett
Quadrat Size	10 x 250 m
Easting	497408
Northing	8074676
Habitat and Waterway	Gully (Minor Creek (<5m))
Slope	Gentle
Surface Layer	Loose
Soil Colour	Brown
Soil Texture	Sandy-Clay
Rock Type	Ironstone
Rock Size and Abundance	Gravel/Pebble, Stones, Boulders, Surface Plates - Common (10-30%)
Vegetation Condition	Good (low grazing, few weeds)
Disturbance Type	Animal Tracks; Grazing; Faeces
Time since Fire	1-2 years
Leaf Litter Distribution and Cover	Dispersed; 5**%**

Stratum	Taxa
Trees (<10 m)	*Corymbia dendromerinx; Corymbia greeniana; Eucalyptus tectifica; Hakea arborescens; Melaleuca viridiflora*
Shrubs (>2 m)	*Acacia monticola; Acacia tumida var. tumida; Cyperus conicus; Grevillea pyramidalis subsp. pyramidalis*
Shrubs (1-2 m)	*Bauhinia cunninghamii; Ehretia saligna var. saligna; Tephrosia forrestiana; Triumfetta breviaculeata*
Climbers	*Dicliptera armata*
Herbs	*Bacopa floribunda; Blumea integrifolia; Desmodium filiforme; Euphorbia sp.; Gomphrena canescens subsp. canescens; Hybanthus aurantiacus; Indigofera linifolia; Microstachys chamelea; Oldenlandia mitrasacmoides subsp. mitrasacmoides; Pterocaulon serrulatum var. velutinum; Stemodia lathraia; Stemodia lythrifolia; Waltheria indica*
Sedges	*Fimbristylis dichotoma; Fimbristylis simulans*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Aristida hygrometrica; Cymbopogon procerus; Eragrostis cumingii; Eriachne obtusa; Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946); Heteropogon contortus; Sorghum plumosum*

Quadrat 19

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	500192
Northing	8073618
Habitat and Waterway	Plain
Slope	Negligible
Surface Layer	Loose, Rocky/Stony
Soil Colour	White
Soil Texture	Sandy-Clay
Rock Type	Ironstone
Rock Size and Abundance	Gravel/Pebble - Many (30-70%)
Vegetation Condition	Very Good (slight disturbance)
Disturbance Type	Animal Tracks
Time since Fire	1-2 years
Leaf Litter Distribution and Cover	Dispersed; 2%

Stratum	Taxa
Trees (<10 m)	*Bauhinia cunninghamii; Corymbia dendromerinx; Corymbia greeniana*
Shrubs (>2 m)	*Dolichandrone heterophylla; Ehretia saligna var. saligna; Grevillea pyramidalis subsp. pyramidalis*
Shrubs (1-2 m)	*Acacia stipuligera; Bridelia tomentosa*
Shrubs (<1 m)	*Acacia hippuroides; Acacia stipuligera; Atalaya hemiglauca; Corchorus sidoides subsp. vermicularis; Ehretia saligna var. saligna; Grevillea refracta subsp. refracta; Solanum cunninghamii*
Climbers	*Glycine tomentella*
Herbs	*Buchnera asperata; Buchnera linearis; Evolvulus alsinoides; Goodenia scaevolina; Goodenia sepalosa var. sepalosa; Heliotropium dichotomum; Hybanthus aurantiacus; Microstachys chamelea; Oldenlandia mitrasacmoides subsp. mitrasacmoides; Polycarpaea corymbosa; Spermacoce occidentalis; Stylosanthes scabra; Tephrosia leptoclada; Trachymene microcephala; Wrightia saligna; Zornia prostrata*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Aristida hygrometrica; Chrysopogon sp.; Eriachne ciliata; Sorghum plumosum; Yakirra australiensis var. intermedia*

Quadrat 20

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	491807
Northing	8074299
Habitat and Waterway	Plain
Slope	Negligible
Surface Layer	Loose
Soil Colour	Orange
Soil Texture	Sand, Sandy-Clay
Rock Type	No Rocks
Rock Size and Abundance	No Rocks - None
Vegetation Condition	Very Good (slight disturbance)
Disturbance Type	Animal Tracks; Faeces
Time since Fire	1-2 years
Leaf Litter Distribution and Cover	Dispersed; 10**%**

Stratum	Taxa
Trees (<10 m)	*Corymbia greeniana; Corymbia zygophylla; Erythrophleum chlorostachys*
Shrubs (>2 m)	*Brachychiton diversifolius subsp. diversifolius; Hakea arborescens; Terminalia canescens*
Shrubs (1-2 m)	*Acacia tumida var. tumida; Brachychiton diversifolius subsp. diversifolius; Wrightia saligna*
Shrubs (<1 m)	*Acacia platycarpa; Dolichandrone heterophylla; Premna acuminata*
Climbers	*Galactia tenuiflora*
Herbs	*Buchnera asperata; Gomphrena canescens subsp. canescens; Microstachys chamelea; Oldenlandia mitrasacmoides subsp. mitrasacmoides; Solanum cunninghamii*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Aristida holathera var. latifolia; Eriachne melicacea; Eriachne obtusa; Sorghum plumosum*

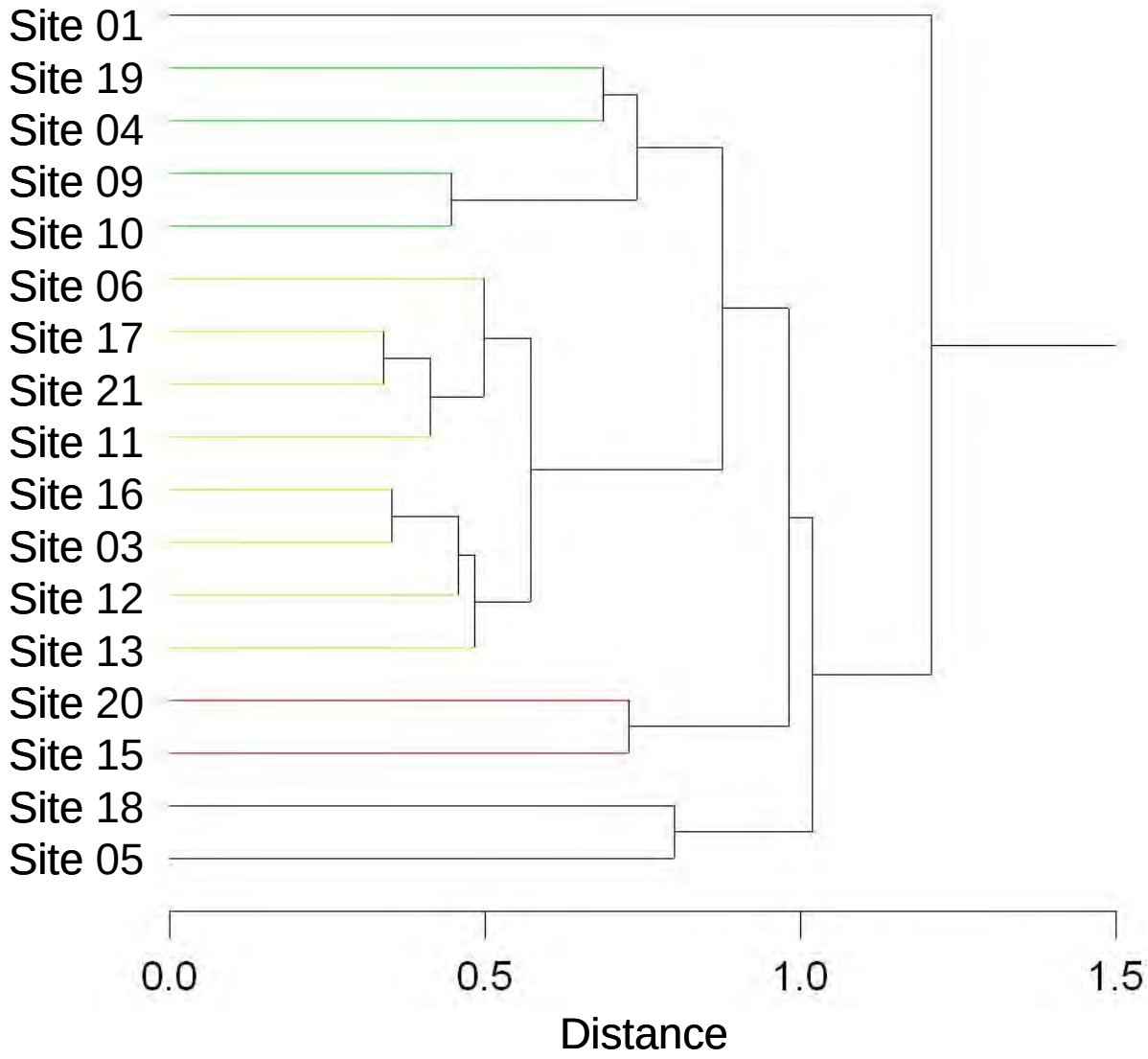
Quadrat 21

Botanist	Renee Tuckett
Quadrat Size	50 x 50 m
Easting	500022
Northing	8067395
Habitat and Waterway	Plain
Slope	Negligible
Surface Layer	Loose
Soil Colour	Orange, Yellow, White
Soil Texture	Sandy-Clay, Clay
Rock Type	No Rocks
Rock Size and Abundance	No Rocks - None
Vegetation Condition	Excellent (no obvious disturbance)
Disturbance Type	No Disturbance
Time since Fire	> 5 years
Leaf Litter Distribution and Cover	Dispersed; 5**%**

Stratum	Taxa
Trees (<10 m)	*Melaleuca viridiflora*
Shrubs (>2 m)	*Acacia colei var. colei; Terminalia canescens*
Shrubs (1-2 m)	*Brachychiton diversifolius subsp. diversifolius*
Shrubs (<1 m)	*Grevillea pyramidalis subsp. pyramidalis; Tephrosia remotiflora; Wrightia saligna*
Climbers	*Zornia prostrata*
Herbs	*Buchnera asperata; Byblis filifolia; Chamaecrista symonii; Crotalaria brevis; Crotalaria crispata; Desmodium filiforme; Drosera derbyensis; Drosera indica; Gomphrena canescens subsp. canescens; Melaleuca nervosa; Oldenlandia mitrasacmoides subsp. mitrasacmoides; Spermacoce occidentalis; Stackhousia intermedia; Stemodia lathraia; Waltheria indica; Xyris complanata*
Hummock Grasses	*Triodia caelestialis*
Tussock Grasses	*Chrysopogon sp.; Ectrosia schultzii; Eriachne melicacea; Eriachne obtusa; Paspalidium rarum; Sorghum plumosum*

APPENDIX C DENDROGRAM AND SPECIES X QUADRAT MATRIX

Dendrogram of Cluster Analysis



APPENDIX D VASCULAR FLORA WITHIN THUNDERBIRD STUDY AREA

Family	Taxon	Observation
Acanthaceae	*Dicliptera armata*	
Aizoaceae	*Trianthema pilosa*	
Amaranthaceae	*?Ptilotus sp*	
	Gomphrena canescens subsp. canescens	
	Gomphrena flaccida	
	Ptilotus corymbosus	
Apocynaceae	*Carissa lanceolata*	
	Marsdenia viridiflora subsp. tropica	
	Wrightia saligna	
Araliaceae	*Trachymene microcephala*	
Asparagaceae	*Thysanotus chinensis*	
Asteraceae	*Asteraceae sp.*	
	Blumea integrifolia	
	Pterocaulon intermedium	P3
	Pterocaulon serrulatum var. velutinum	
	Pterocaulon sphacelatum	
Bignoniaceae	*Dolichandrone heterophylla*	
Boraginaceae	*Ehretia saligna var. saligna*	
	Heliotropium cunninghamii	
	Heliotropium dichotomum	
	Trichodesma zeylanicum var. zeylanicum	
Byblidaceae	*Byblis filifolia*	
	Byblis rorida	
Caryophyllaceae	*Polycarpaea corymbosa*	
	Polycarpaea holtzei	
	Polycarpaea longiflora	
Celastraceae	*Stackhousia intermedia*	
Combretaceae	*Terminalia canescens*	
	Terminalia sp.	
Convolvulaceae	*Bonamia linearis*	

Family	Taxon	Observation
Convolvulaceae	*Evolvulus alsinoides*	
	Evolvulus alsinoides var. decumbens	
	Polymeria ambigua	
	Xenostegia tridentata	
Cyperaceae	*Bulbostylis barbata*	
	Cyperaceae sp.	
	Cyperus ? conicus	
	Cyperus conicus	
	Cyperus microcephalus	
	Eleocharis geniculata	
	Fimbristylis dichotoma	
	Fimbristylis simulans	
	Fuirena ciliaris	
	Lipocarpha microcephala	
	Scleria brownii	
Droseraceae	*Drosera derbyensis*	
	Drosera indica	
Euphorbiaceae	*Euphorbia ?myrtoides*	
	Euphorbia myrtoides	
	Euphorbia sp.	
	Microstachys chamelea	
Fabaceae	*Acacia colei var. colei*	
	Acacia drepanocarpa subsp. latifolia	
	Acacia hippuroides	
	Acacia monticola	
	Acacia platycarpa	
	Acacia stipuligera	
	Acacia tumida var. tumida	
	Bauhinia cunninghamii	
	Chamaecrista mimosoides	
	Chamaecrista symonii	

Family	Taxon	Observation
Fabaceae	*Crotalaria brevis*	
	Crotalaria crispata	
	Crotalaria medicaginea var. neglecta	
	Desmodium filiforme	
	Erythrophleum chlorostachys	
	Galactia tenuiflora	
	Glycine tomentella	
	Indigofera haplophylla	
	Indigofera linifolia	
	Senna oligoclada	
	Stylosanthes hamata	Invasive
	Stylosanthes scabra	Invasive
	Tephrosia forrestiana	
	Tephrosia leptoclada	
	Tephrosia remotiflora	
	Tephrosia simplicifolia	
	Vigna lanceolata var. filiformis	
	Zornia prostrata var. prostrata	
Goodeniaceae	*Goodenia scaevolina*	
	Goodenia sepalosa var. sepalosa	
	Velleia panduriformis	
Gyrostemonaceae	*Codonocarpus cotinifolius*	
Lamiaceae	*Premna acuminata*	
Lythraceae	*Rotala occultiflora*	
Malvaceae	*Brachychiton diversifolius subsp. diversifolius*	
	Corchorus sidoides subsp. vermicularis	
	Gossypium australe	
	Hibiscus geranioides	
	Melhania oblongifolia	
	Melochia corchorifolia	
	Sida hackettiana	

Family	Taxon	Observation
Malvaceae	*Sida spinosa*	
	Triumfetta breviaculeata	
	Triumfetta plumigera	
	Triumfetta sp.	
	Waltheria indica	
Menispermaceae	*Tinospora smilacina*	
Moraceae	*Ficus aculeata var. indecora*	
	Ficus platypoda	
Myrtaceae	*Calytrix exstipulata*	
	Corymbia dendromerinx	
	Corymbia greeniana	
	Corymbia zygophylla	
	Eucalyptus tectifica	
	Lophostemon grandiflorus	
	Melaleuca nervosa	
	Melaleuca viridiflora	
Oleaceae	*Jasminum molle*	
Onagraceae	*Ludwigia perennis*	
Orobanchaceae	*Buchnera asperata*	
	Buchnera linearis	
Phrymaceae	*Mimulus uvedaliae var. lutea*	
Phyllanthaceae	*Bridelia tomentosa*	
	Flueggea virosa subsp. melanthesoides	
	Phyllanthus virgatus	
Plantaginaceae	*Bacopa floribunda*	
	Stemodia lathraia	
	Stemodia lythrifolia	
Poaceae	*?Eragrostis sp.*	
	Aristida holathera var. holathera	
	Aristida holathera var. latifolia	
	Aristida hygrometrica	

Family	Taxon	Observation
Poaceae	*Aristida inaequiglumis*	
	Cenchrus elymoides	
	Chrysopogon sp.	
	Cymbopogon bombycinus	
	Cymbopogon procerus	
	Cynodon dactylon	Invasive
	Digitaria bicornis	
	Ectrosia schultzii	
	Eragrostis ?eriopoda	
	Eragrostis cumingii	
	Eriachne ciliata	
	Eriachne melicacea	
	Eriachne obtusa	
	Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)	P3
	Eriachne sulcata	
	Heteropogon contortus	
	Paspalidium rarum	
	Sacciolepis indica	
	Setaria apiculata	
	Sorghum plumosum	
	Sporobolus australasicus	
	Triodia caelestialis	P3
	Triodia intermedia	
	Yakirra australiensis var. intermedia	
Polygalaceae	*Polygala linariifolia*	
	Polygala tepperi	
Portulacaceae	*Calandrinia strophiolata*	
Proteaceae	*Grevillea pyramidalis subsp. pyramidalis*	
Proteaceae	*Grevillea refracta subsp. refracta*	
	Hakea arborescens	
	Persoonia falcata	

Family	Taxon	Observation
Rhamnaceae	*Ventilago viminalis*	
Rubiaceae	*Gardenia pyriformis subsp. keartlandii*	
	Oldenlandia galioides	
	Oldenlandia mitrasacmoides subsp. mitrasacmoides	
Rubiaceae	*Spermacoce occidentalis*	
Santalaceae	*Santalum lanceolatum*	
Sapindaceae	*Atalaya hemiglauca*	
	Atalaya variifolia	
	Dodonaea hispidula var. arida	
Solanaceae	*Solanum cunninghamii*	
Violaceae	*Hybanthus aurantiacus*	
Xyridaceae	*Xyris complanata*	

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APPENDIX E FAUNA SITE DESCRIPTIONS

Vegetation and Fauna Habitat Description	Site Photo
Site TB OS 1 Moderately dense *Corymbia greeniana* and *C. greeniana* woodland over moderately dense *Acacia platycarpa* and *A. tumida* shrubland over dense *Triodia caelestialis*, *Aristida holathera* and *Sorghum plumosum* tussock grassland. Soil substrate consists of weak orange sand-loam. **Habitat type:** Pindan plains	
Site TB OS 2 Moderately dense *Corymbia zygophylla* woodland over moderately dense *Acacia platycarpa* and *A. tumida* shrubland over dense *Triodia caelestialis* hummock grassland and *Sorghum plumosum* tussock grassland. Soil substrate consists of weak orange sand-loam. **Habitat type:** Pindan plains	

Site TB OS 3 Moderately dense *Corymbia greeniana* over dense *Bauhinia cunninghamii* and *Hakea* sp. shrubland over *Triodia caelestialis* hummock grassland and *Sorghum plumosum* tussock grassland. Soil substrate consists of weak orange sand-loam. **Habitat type:** Pindan plains	
Site TB OS 4 Open *Corymbia greeniana* woodland over moderately dense *Acacia tumida*, *Bauhinia cunninghamii* and *Dodonaea hispidula* shrubland over dense *Triodia caelestialis* hummock grassland and *Aristida holathera* and *Sorghum plumosum* tussock grassland. Soil substrate consists of firm reddish-brown sand-clay. **Habitat type:** Pindan plains	

Site TB OS 5 Very open *Corymbia greeniana* and *Terminalia canescens* over moderately dense *Grevillea refracta* shrubland over *Aristida holathera* tussock grassland. Soil substrate consists of firm reddish-brown sand-loam with scattered loose sandstone rocks. **Habitat type:** Pindan plains	
Site TB OS 6 Moderately dense *Corymbia zygophylla* and *C. greeniana* woodland over *Grevillea refracta*, *Dodonaea hispidula* and *Acacia tumida* shrubland over *Eriachne* sp. tussock grassland. Soil substrate consists of weak brown sand-loam with plentiful leaflitter and moderate woodlitter. **Habitat type:** Pindan plains	

Site TB OS 7 Low-lying depression within open *Corymbia greeniana* and *Melaleuca* sp. woodland over open *Acacia colei* shrubland over *Enneapogon* sp. tussock grassland. Soil substrate consists of firm grey loam-clay with numerous termite mounds. **Habitat type:** Savannah woodlands	
Site TB OS 8 Open *Corymbia greeniana* woodland over *Acacia* spp. and *Grevillea refracta* over *Aristida holathera* and *Sorghum plumosum* tussock grassland. Soil substrate consists of firm reddish-brown sand-loam. **Habitat type:** Pindan plains	

Site TB OS 9 Open *Corymbia* spp. woodland over *Grevillea refracta*, *Hakea* sp. and *Acacia tumida* over *Triodia caelestialis* hummock grassland and *Sorghum plumosum* tussock grassland in a dry creekline. Soil substrate consists of firm brown sand-loam with continuous ferruginised sandstone stones. **Habitat type:** Rocky hills	
Site TB OS 10 Moderately open *Corymbia* spp. and *Melaleuca* sp. woodland over *Acacia* spp., *Hakea* sp. and *Grevillea refracta* shrubland over *Triodia caelestialis* hummock grassland and *Sorghum plumosum* tussock grassland in a dry creekline. Soil substrate consists of firm brown loam with continuous sandstone stones. Site was burnt in April 2012. **Habitat type:** Rocky hills	

Site TB OS 11 Open *Corymbia greeniana*, *Melaleuca* sp. and *Bauhinia cunninghamii* woodland over *Acacia colei*, *Hakea* sp. and *Gardenia pyriformis* over *Triodia caelestialis* hummock grassland. Soil substrate consists of firm grey sand-loam. **Habitat type:** Savannah woodlands	
Site TB OS 12 Moderately open *Corymbia greeniana* woodland over moderately dense *Acacia tumida* and *Grevillea refracta* shrubland over *Triodia caelestialis* hummock grassland and *Sorghum plumosum* tussock grassland plain. Soil substrate consists of weak orange sand-loam. **Habitat type:** Pindan plains	

Site TB OS 13 Open *Corymbia greeniana* woodland over moderately dense *Acacia tumida*, *A. platycarpa*, *Bauhinia cunninghamii* and *Dodonaea hispidula* shrubland over *Eriachne* sp. and *Chrysopogon* sp. tussock grassland plain. Soil substrate consists of weak brown sand-loam. **Habitat type:** Pindan plains	
Site TB OS 14 Large sandstone rock outcrop. Scattered *Corymbia* sp. woodland over moderately dense *Grevillea refracta*, *Hakea* sp., *Acacia tumida* and *Calytrix extipulata* shrubland over dense *Triodia caelestialis* hummock grassland and sparse *Sorghum plumosum* tussock grassland. Soil substrate consists of strong orange sand-clay with continuous loose rocks and sandstone boulders. **Habitat type:** Rocky hills	

Site TB OS 15 Scattered *Corymbia* sp. woodland over moderately dense *Hakea* sp., *Acacia* sp. and *Calytrix extipulata* shrubland over dense *Triodia caelestialis* hummock grassland on rocky hillslope. Soil substrate consists of firm brown sand-loam with continuous loose sandstone stones. **Habitat type:** Rocky hills	
Site TB OS 16 Open *Corymbia greeniana* and *Bauhinia cunninghamii* woodland over moderately dense *Hakea* sp. shrubland over dense *Triodia caelestialis* hummock grassland on plain. Soil substrate consists of firm brown sand-clay wit h many laterite pebbles. **Habitat type:** Savannah woodlands	

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APPENDIX F REGIONAL FAUNA RECORDS

Appendix F1: Mammals

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (AECOM 2011)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search
		EPBC Act	WC Act	DEC											
TACHYGLOSSIDAE															
Tachyglossus aculeatus	Echidna						S				✓				
DASYURIDAE															
Dasyurus hallucatus	Northern Quoll	EN	S1	EN											✓
Dasycercus cristicauda	Crest-tailed Mulgara	VU	S1	VU											✓
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart					✓									
PERAMELIDAE															
Isoodon auratus	Golden Bandicoot	VU	S1	VU										✓	
THYLACOMYIDAE															
Macrotis lagotis	Bilby	VU	S1	VU		S	S	S			S	S	✓	✓	
PHALANGERIDAE															
Trichosurus vulpecula arnhemensis	Northern Brushtail Possum				✓						✓				
POTOROIDAE															
Bettongia lesueur	Burrowing Bettong	VU	S1	VU									✓		
MACROPODIDAE															
Macropus agilis	Agile Wallaby					S	✓		✓	✓	✓				
Macropus robustus	Euro										✓		✓		
Macropus rufus	Red Kangaroo										✓				
EMBALLONURIDAE															
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat					✓			✓		✓				
Taphozous georgianus	Common Sheathtail Bat										✓				
MOLOSSIDAE															
Chaerophon jobensis	Northern Freetail Bat					✓			✓		✓				
Mormopterus beccarii	Beccari's Freetail Bat										✓				

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (AECOM 2011)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search
		EPBC Act	WC Act	DEC											
Mormopterus loriae	Little Northern Freetail Bat P1			P1							✓				
Tadarida australis	White-striped Freetail Bat										✓				
VESPERTILIONIDAE															
Chalinolobus gouldii	Gould's Wattled Bat					✓			✓		✓				
Chalinolobus nigrogriseus	Hoary Wattled Bat				✓	✓			✓		✓				
Miniopterus schreibersii orianae	Common Bentwing Bat										✓				
Nyctophilus arnhemensis	Arnhem Land Long-eared Bat								✓		✓				
Nyctophilus geoffroyi	Lesser Long-eared Bat					✓					✓				
Pipistrellus westralis	Northern Pipistrell										✓				
Scotorepens greyii	Little Broad-nosed Bat				✓	✓			✓		✓				
Scotorepens sanborni	Northern broad-nosed Bat								✓		✓				
Vespadelus caurinus	Western Cave Bat										✓				
Vespadelus douglasorum	Yellow-lipped Cave Bat			P2	✓										
Vespadelus finlaysoni	Finlayson's Cave Bat										✓				
MURIDAE															
Leggadina lakedownensis	Lakeland Downs Mouse			P4							✓				
Pseudomys delicatulus	Delicate Mouse				✓	✓	S		✓	✓	✓				
Pseudomys nanus	Western Chestnut Mouse				✓						✓		✓		
Rattus tunneyi	Pale Field Rat										✓	✓			
CANIDAE															
Canis lupus	Dog/Dingo					✓	✓		✓	✓	✓				
INTRODUCED MAMMALS															
Mus musculus	House Mouse								✓		✓				
Rattus rattus	Black Rat						✓				✓				
Vulpes vulpes	Red Fox										✓				
Felis catus	Cat				✓		✓		✓	✓	✓				

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (AECOM 2011)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search
		EPBC Act	WC Act	DEC											
Equus asinus	Donkey				✓						✓				
Bos taurus	Cow						✓				✓				

S – Secondary signs found

Appendix F2: Birds

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata
		EPBC Act	WC Act	DEC											
PHASIANIDAE															
Coturnix ypsilophora	Brown Quail					✓	✓	✓	✓	✓		✓			✓
ANSERANATIDAE															
Anseranas semipalmata	Magpie Goose											✓			✓
ANATIDAE															
Dendrocygna eytoni	Plumed Whistling-duck									✓	✓	✓			✓
Dendrocygna arcuata	Wandering Whistling-duck									✓	✓				✓
Chenonetta jubata	Australian Wood Duck										✓				✓
Malacorhynchus membranaceus	Pink-eared Duck										✓				✓
Nettapus pulchellus	Green Pygmy-Goose										✓				✓
Anas gracilis	Grey Teal									✓	✓	✓			✓
Anas superciliosa	Pacific Black Duck									✓	✓				✓
Aythya australis	Hardhead									✓	✓	✓			✓
PODICIPEDIDAE															
Tachybaptus novaehollandiae	Australasian Grebe									✓	✓	✓			✓
Poliocephalus poliocephalus	Hoary-headed Grebe										✓				✓
COLUMBIDAE															
Phaps histrionica	Flock Bronzewing			P4		✓				✓					✓
Ocyphaps lophotes	Crested Pigeon				✓		✓	✓	✓	✓		✓			✓
Geopelia cuneata	Diamond Dove				✓	✓		✓	✓	✓		✓			✓
Geopelia striata	Peaceful Dove				✓	✓	✓	✓	✓	✓		✓			✓
Geopelia humeralis	Bar-shouldered Dove				✓	✓	✓	✓	✓	✓					✓
PODARGIDAE															
Podargus strigoides	Tawny Frogmouth				✓	✓	✓	✓	✓	✓		✓			✓

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata
		EPBC Act	WC Act	DEC											
EUROSTOPODIDAE															
Eurostopodus argus	Spotted Nightjar						✓			✓					✓
AEGOTHELIDAE															
Aegotheles cristatus	Australian Owlet-nightjar				✓	✓	✓		✓	✓		✓			✓
APODIDAE															
Apus pacificus	Fork-tailed Swift	M	S3		✓	✓	✓		✓					✓	✓
FREGATIDAE															
Fregata ariel	Lesser Frigatebird	M	S3			✓	✓	✓		✓	✓			✓	✓
SULIDAE															
Sula leucogaster	Brown Booby	M	S3			✓				✓	✓				✓
ANHINGIDAE															
Anhinga novaehollandiae	Australasian Darter									✓	✓				✓
PHALACROCORACIDAE															
Microcarbo melanoleucos	Little Pied Cormorant									✓	✓				✓
Phalacrocorax carbo	Great Cormorant														✓
Phalacrocorax sulcirostris	Little Black Cormorant									✓	✓				✓
Phalacrocorax varius	Pied Cormorant						✓			✓	✓				✓
PELECANIDAE															
Pelecanus conspicillatus	Australian Pelican					✓	✓			✓	✓	✓			✓
CICONIIDAE															
Ephippiorhynchus asiaticus	Black-necked Stork									✓	✓				✓
ARDEIDAE															
Ardea pacifica	White-necked Heron									✓	✓	✓			✓
Ardea modesta	Eastern Great Egret	M	S3							✓	✓			✓	✓
Egretta picata	Pied Heron									✓					✓
Egretta novaehollandiae	White-faced Heron						✓			✓	✓				✓

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata
		EPBC Act	WC Act	DEC											
Ardea ibis	Cattle Egret	M	S3							✓				✓	✓
Butorides striatus	Striated Heron									✓	✓				✓
Egretta garzetta	Little Egret									✓	✓				✓
Egretta sacra	Eastern Reef Egret	M	S3							✓	✓				✓
Nycticorax caledonicus	Nankeen Night Heron							✓							✓
THRESKIORNITHIDAE															
Plegadis falcinellus	Glossy Ibis	M	S3							✓	✓	✓			✓
Threskiornis molucca	Australian White Ibis									✓	✓	✓			✓
Threskiornis spinicollis	Straw-necked Ibis						✓			✓	✓	✓			✓
Platalea regia	Royal Spoonbill										✓				✓
ACCIPITRIDAE															
Pandion cristatus	Eastern Osprey						✓	✓		✓					✓
Elanus axillaris	Black-shouldered Kite						✓			✓					✓
Lophoictinia isura	Square-tailed Kite					✓		✓		✓					✓
Hamirostra melanosternon	Black-breasted Buzzard											✓			✓
Haliaeetus leucogaster	White-bellied Sea-Eagle	M	S3			✓	✓	✓	✓	✓				✓	✓
Haliastur sphenurus	Whistling Kite						✓			✓		✓			✓
Haliastur indus	Brahminy Kite					✓	✓		✓	✓					✓
Milvus migrans	Black Kite				✓	✓	✓			✓		✓			✓
Accipiter fasciatus	Brown Goshawk				✓	✓	✓	✓	✓	✓		✓			✓
Accipiter cirrhocephalus	Collared Sparrowhawk				✓					✓					✓
Circus assimilis	Spotted Harrier									✓					✓
Circus approximans	Swamp Harrier									✓					✓
Aquila audax	Wedge-tailed Eagle											✓			✓
Hieraaetus morphnoides	Little Eagle					✓				✓					✓
FALCONIDAE															

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata
		EPBC Act	WC Act	DEC											
Falco cenchroides	Nankeen Kestrel				✓	✓	✓	✓		✓		✓			✓
Falco berigora	Brown Falcon				✓	✓	✓	✓	✓	✓		✓			✓
Falco longipennis	Australian Hobby						✓								✓
Falco hypoleucos	Grey Falcon			P4											✓
Falco peregrinus	Peregrine Falcon		S4				✓	✓		✓			✓		✓
GRUIDAE															
Grus rubicunda	Brolga									✓	✓	✓			✓
RALLIDAE															
Porphyrio porphyrio	Purple Swamphen									✓					✓
Rallina fasciata	Red-legged Crake									✓					
Gallirallus philippensis	Buff-banded Rail									✓					✓
Fulica atra	Eurasian Coot										✓				✓
OTIDIDAE															
Ardeotis australis	Australian Bustard			P4	✓	✓				✓			✓		✓
BURHINIDAE															
Burhinus grallarius	Bush Stone-curlew			P4	✓			✓		✓			✓		✓
Esacus magnirostris	Beach Stone-curlew						✓			✓					✓
HAEMATOPODIDAE															
Haematopus longirostris	Australian Pied Oystercatcher					✓	✓	✓		✓	✓				✓
Haematopus fuliginosus	Sooty Oystercatcher					✓	✓			✓	✓				✓
RECURVIROSTRIDAE															
Himantopus himantopus	Black-winged Stilt									✓	✓	✓			✓
Recurvirostra novaehollandiae	Red-necked Avocet										✓				✓
CHARADRIIDAE															
Pluvialis fulva	Pacific Golden Plover		S3							✓	✓				✓
Pluvialis squatarola	Grey Plover		S3							✓	✓				✓

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata
		EPBC Act	WC Act	DEC											
Charadrius leschenaultii	Greater Sand Plover		S3				✓			✓	✓				✓
Charadrius mongolus	Lesser Sand Plover		S3				✓				✓				✓
Charadrius ruficapillus	Red-capped Plover					✓				✓	✓				✓
Charadrius veredus	Oriental Plover		S3								✓			✓	✓
Elseyornis melanops	Black-fronted Dotterel						✓			✓	✓				✓
Erythrogonys cinctus	Red-kneed Dotterel									✓	✓				✓
Vanellus miles	Masked Lapwing						✓			✓	✓	✓			✓
JACANIDAE															
Irediparra gallinacea	Comb-crested Jacana									✓					✓
ROSTRATULIDAE															
Rostratula australis	Australian Painted Snipe	VU	S1	VU										✓	✓
SCOLOPACIDAE															
Gallinago megala	Swinhoe's Snipe	M	S3								✓				✓
Limosa limosa	Black-tailed Godwit	M	S3								✓				✓
Limosa lapponica	Bar-tailed Godwit	M	S3				✓			✓	✓				✓
Numenius minutus	Little Curlew	M	S3								✓				✓
Numenius phaeopus	Whimbrel	M	S3				✓			✓	✓				✓
Numenius madagascariensis	Eastern Curlew	M	S3	P4			✓			✓	✓				✓
Numenius arquata	Eurasian Curlew	M	S3								✓		✓		
Xenus cinereus	Terek Sandpiper	M	S3								✓				✓
Actitis hypoleucos	Common Sandpiper	M	S3					✓		✓	✓				✓
Tringa brevipes	Grey-tailed Tattler	M	S3				✓			✓	✓				✓
Tringa glareola	Wood Sandpiper	M	S3				✓				✓				✓
Tringa nebularia	Common Greenshank	M	S3				✓			✓	✓				✓
Tringa stagnatilis	Marsh Sandpiper	M	S3								✓				✓
Arenaria interpres	Ruddy Turnstone	M	S3				✓			✓	✓				✓

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata
		EPBC Act	WC Act	DEC											
Limnodromus semipalmatus	Asian Dowitcher	M	S3								✓				✓
Calidris tenuirostris	Great Knot	M	S3							✓	✓				✓
Calidris canutus	Red Knot	M	S3								✓				✓
Calidris alba	Sanderling	M	S3				✓			✓	✓				✓
Calidris ruficollis	Red-necked Stint	M	S3				✓			✓	✓				✓
Calidris subminuta	Long-toed Stint	M	S3								✓				✓
Calidris melanotos	Pectoral Sandpiper	M	S3								✓				✓
Calidris acuminata	Sharp-tailed Sandpiper	M	S3				✓				✓				✓
Calidris ferruginea	Curlew Sandpiper	M	S3								✓				✓
Limicola falcinellus	Broad-billed Sandpiper	M	S3								✓				✓
Philomachus pugnax	Ruff	M	S3								✓				✓
TURNICIDAE															
Turnix maculosus	Red-backed Button-quail								✓	✓					✓
Turnix castanotus	Chestnut-backed Button-quail			P4			✓								
Turnix pyrrhothorax	Red-chested Button-quail					✓	✓								✓
Turnix velox	Little Button-quail				✓	✓				✓					✓
GLAREOLIDAE															
Glareola maldivarum	Oriental Pratincole	M	S3								✓			✓	✓
Stiltia isabella	Australian Pratincole									✓	✓	✓			✓
STERCORARIIDAE															
Stercorarius parasiticus	Arctic Jaeger	M	S3												✓
LARIDAE															
Sternula albifrons	Little Tern	M	S3				✓			✓	✓				✓
Sternula nereis	Fairy Tern									✓					✓
Gelochelidon nilotica	Gull-billed Tern						✓			✓	✓				✓

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		EPBC Act	WC Act	DEC											
Hydroprogne caspia	Caspian Tern	M	S3								✓				✓
Chlidonias hybrida	Whiskered Tern									✓	✓				✓
Chlidonia leucopterus	White-winged Black Tern	M	S3							✓	✓				✓
Sterna dougallii	Roseate Tern	M	S3							✓	✓				✓
Sterna sumatrana	Black-naped Tern	M	S3							✓					
Sterna hirundo	Common Tern	M	S3			✓	✓				✓				✓
Thalasseus bengalensis	Lesser Crested Tern	M	S3			✓	✓			✓	✓				✓
Thalasseus bergii	Crested Tern					✓	✓			✓	✓				✓
Chroicocephalus novaehollandiae	Silver Gull						✓			✓	✓				✓
CACATUIDAE (PSITTACIDAE)															
Calyptorhynchus banksii	Red-tailed Black-Cockatoo				✓	✓	✓			✓					✓
Eolophus roseicapillus	Galah				✓					✓					✓
Cacatua sanguinea	Little Corella						✓			✓		✓			✓
Nymphicus hollandicus	Cockatiel					✓									✓
PSITTACIDAE															
Trichoglossus haematodus	Rainbow Lorikeet				✓	✓		✓	✓						✓
Trichoglossus haematodus rubritorquis	Red-collared Lorikeet						✓			✓		✓			
Psitteuteles versicolor	Varied Lorikeet				✓	✓		✓		✓					✓
Aprosmictus erythropterus	Red-winged Parrot				✓	✓	✓	✓	✓	✓					✓
Melopsittacus undulatus	Budgerigar									✓					✓
CUCULIDAE															
(Centropodidae) *Centropus phasianinus*	Pheasant Coucal				✓	✓	✓	✓	✓	✓					✓
Scythrops novaehollandiae	Channel-billed Cuckoo						✓								✓
Chalcites basalis	Horsfield's Bronze-Cuckoo				✓	✓	✓	✓		✓					✓
Chalcites osculans	Black-eared Cuckoo						✓	✓							✓

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		EPBC Act	WC Act	DEC											
Chalcites minutillus	Little Bronze-Cuckoo				✓	✓				✓					✓
Cacomantis pallidus	Pallid Cuckoo				✓	✓	✓			✓					✓
Cacomantis variolosus	Brush Cuckoo				✓		✓	✓		✓					✓
Cuculus optatus	Oriental Cuckoo						✓								✓
STRIGIDAE															
Ninox connivens	Barking Owl									✓					✓
Ninox novaeseelandiae	Southern Boobook				✓	✓				✓					✓
TYTONIDAE															
Tyto longimembris	Eastern Grass Owl									✓					✓
Tyto novaehollandiae	Masked Owl			P4										✓	
HALCYONIDAE															
Dacelo leachii	Blue-winged Kookaburra				✓	✓	✓	✓		✓					✓
Todiramphus pyrrhopygius	Red-backed Kingfisher						✓	✓		✓					✓
Todiramphus sanctus	Sacred Kingfisher				✓	✓	✓	✓	✓	✓					✓
Todiramphus chloris	Collared Kingfisher									✓					✓
MEROPIDAE															
Merops ornatus	Rainbow Bee-eater	M	S3		✓	✓	✓	✓	✓	✓				✓	✓
CORACIIDAE															
Eurystomus orientalis	Dollarbird					✓	✓	✓							✓
CLIMACTERIDAE															
Climacteris melanura	Black-tailed Treecreeper				✓					✓		✓			✓
PTILINORHYNCHIDAE															
Ptilonorhynchus nuchalis	Great Bowerbird				✓	✓	✓	✓	✓	✓					✓
MALURIDAE															
Malurus lamberti	Variegated Fairy-wren					✓	✓	✓	✓	✓					✓
Malurus melanocephalus	Red-backed Fairy-wren				✓	✓	✓	✓		✓		✓			

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata
		EPBC Act	WC Act	DEC											
ACANTHIZIDAE															
Smicrornis brevirostris	Weebill				✓	✓		✓		✓		✓			✓
Gerygone levigaster	Mangrove Gerygone						✓			✓					✓
Gerygone fusca	Western Gerygone									✓					✓
Gerygone tenebrosa	Dusky Gerygone									✓					✓
Gerygone albogularis	White-throated Gerygone				✓	✓	✓	✓	✓	✓					✓
PARDALOTIDAE															
Pardalotus rubricatus	Red-browed Pardalote						✓	✓		✓		✓			✓
Pardalotus striatus	Striated Pardalote				✓	✓		✓	✓	✓		✓			✓
MELIPHAGIDAE															
Certhionyx variegatus	Pied Honeyeater									✓					
Lichenostomus virescens	Singing Honeyeater				✓	✓	✓	✓	✓	✓		✓			✓
Lichenostomus unicolor	White-gaped Honeyeater					✓	✓	✓	✓	✓					✓
Lichenostomus plumulus	Grey-fronted Honeyeater							✓							
Lichenostomus flavescens	Yellow-tinted Honeyeater				✓	✓		✓		✓		✓			✓
Lichenostomus penicillatus	White-plumed Honeyeater						✓	✓							
Manorina flavigula	Yellow-throated Miner									✓					✓
Conopophila rufogularis	Rufous-throated Honeyeater				✓	✓	✓	✓		✓		✓			✓
Epthianura tricolor	Crimson Chat									✓					
Sugomel niger	Black Honeyeater														✓
Myzomela erythrocephala	Red-headed Honeyeater						✓			✓					✓
Cissomela pectoralis	Banded Honeyeater				✓	✓						✓			✓
Lichmera indistincta	Brown Honeyeater				✓	✓	✓	✓	✓	✓		✓			✓
Melithreptus gularis	Black-chinned Honeyeater				✓	✓	✓	✓	✓	✓					✓
Melithreptus albogularis	White-throated Honeyeater				✓	✓	✓			✓		✓			✓
Philemon argenticeps	Silver-crowned Friarbird						✓			✓					

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata
		EPBC Act	WC Act	DEC											
Philemon citreogularis	Little Friarbird				✓	✓	✓	✓	✓	✓		✓			✓
POMATOSTOMIDAE															
Pomatostomus temporalis	Grey-crowned Babbler				✓	✓	✓	✓	✓	✓		✓			✓
NEOSITTIDAE															
Daphoenositta chrysoptera	Varied Sittella				✓	✓	✓	✓		✓		✓			✓
CAMPEPHAGIDAE															
Coracina novaehollandiae	Black-faced Cuckoo-shrike				✓	✓	✓	✓	✓	✓		✓			✓
Lalage sueurii	White-winged Triller				✓	✓	✓		✓	✓					✓
PACHYCEPHALIDAE															
Pachycephala melanura	Mangrove Golden Whistler									✓					✓
Pachycephala rufiventris	Rufous Whistler				✓	✓	✓	✓	✓	✓					✓
Pachycephala lanioides	White-breasted Whistler									✓					✓
Colluricincla harmonica	Grey Shrike-thrush				✓	✓	✓	✓	✓	✓					✓
Oreoica gutturalis	Crested Bellbird									✓					
ORIOLIDAE															
Oriolus sagittatus	Olive-backed Oriole				✓	✓	✓			✓					✓
ARTAMIDAE															
Artamus leucorhynchus	White-breasted Woodswallow						✓	✓	✓	✓					✓
Artamus personatus	Masked Woodswallow				✓	✓			✓	✓					✓
Artamus superciliosus	White-browed Woodswallow					✓				✓					✓
Artamus cinereus	Black-faced Woodswallow				✓	✓	✓	✓	✓	✓					✓
Artamus minor	Little Woodswallow				✓	✓	✓	✓	✓	✓					✓
Cracticus torquatus	Grey Butcherbird							✓							✓
Cracticus nigrogularis	Pied Butcherbird				✓	✓	✓	✓	✓	✓		✓			✓
RHIPIDURIDAE (DICRURIDAE)															

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata
		EPBC Act	WC Act	DEC											
Rhipidura albiscapa	Grey Fantail									✓					✓
Rhipidura phasiana	Mangrove Grey Fantail									✓					✓
Rhipidura rufiventris	Northern Fantail					✓	✓	✓	✓	✓					✓
Rhipidura leucophrys	Willie Wagtail				✓	✓	✓	✓		✓		✓			✓
CORVIDAE															
Corvus bennetti	Little Crow				✓					✓					✓
Corvus orru	Torresian Crow				✓	✓	✓	✓	✓	✓		✓			✓
MONARCHIDAE (DICRURIDAE)															
Myiagra ruficollis	Broad-billed Flycatcher									✓					✓
Myiagra rubecula	Leaden Flycatcher				✓	✓	✓	✓							✓
Myiagra inquieta	Restless Flycatcher				✓	✓	✓	✓	✓	✓		✓			✓
Grallina cyanoleuca	Magpie-lark				✓		✓			✓		✓			✓
PETROICIDAE															
Microeca fascinans	Jacky Winter				✓	✓	✓	✓		✓		✓			✓
Microeca flavigaster	Lemon-bellied Flycatcher									✓					✓
Melanodryas cucullata	Hooded Robin				✓					✓					✓
ALAUDIDAE															
Mirafra javanica	Horsfield's Bushlark									✓					✓
CISTICOLIDAE (SYLVIIDAE)															
Cisticola exilis	Golden-headed Cisticola							✓							✓
ACROCEPHALIDAE (SYLVIIDAE)															
Acrocephalus australis	Australian Reed-Warbler									✓					✓
MEGALURIDAE (SYLVIIDAE)															
Megalurus timoriensis	Tawny Grassbird									✓					✓
Cincloramphus mathewsi	Rufous Songlark					✓			✓	✓					✓
Cincloramphus cruralis	Brown Songlark					✓				✓					✓

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata
		EPBC Act	WC Act	DEC											
TIMALIIDAE (ZOSTEROPIDAE)															
Zosterops luteus	Yellow White-eye						✓		✓	✓					✓
HIRUNDINIDAE															
Hirundo rustica	Barn Swallow	M	S3									✓			✓
Petrochelidon ariel	Fairy Martin					✓				✓					✓
Petrochelidon nigricans	Tree Martin				✓	✓		✓	✓	✓					✓
NECTARINIIDAE (DICAEIDAE)															
Dicaeum hirundinaceum	Mistletoebird				✓	✓	✓		✓	✓					✓
ESTRILDIDAE															
Taeniopygia guttata	Zebra Finch							✓	✓	✓		✓			✓
Taeniopygia bichenovii	Double-barred Finch					✓		✓		✓		✓			✓
Poephila acuticauda	Long-tailed Finch				✓	✓	✓	✓		✓		✓			✓
Emblema pictum	Painted Finch														✓
Erythrura gouldiae	Gouldian Finch	EN	S1	EN			✓	✓	✓	✓				✓	✓
Lonchura castaneothorax	Chestnut-breasted Mannikin														✓
MOTACILLIDAE															
Motacilla flava	Yellow Wagtail									✓	✓				✓

* Introduced species

Appendix F3: Reptiles

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search
		EPBC Act	WC Act	DEC									
CROCODYLIDAE													
Crocodylus porosus	Salt-water Crocodile		S4							✓			✓
DIPLODACTYLIDAE													
Diplodactylus conspicillatus	Fat-tailed Gecko					✓	✓	✓	✓	✓			
Lucasium stenodactylum	Sand-plain Gecko				✓	✓		✓	✓	✓			
Oedura rhombifer							✓			✓			
Rhynchoedura ornata	Beaked Gecko				✓								
Strophurus ciliaris					✓	✓	✓	✓	✓	✓			
Strophurus jeanae										✓			
Strophurus taeniatus										✓			
GEKKONIDAE													
Gehyra australis						✓							
Gehyra nana										✓			
Gehyra pilbara					✓	✓		✓		✓			
Gehyra punctata								✓		✓			
Gehyra variegata							✓			✓			
Heteronotia binoei	Bynoe's Gecko				✓	✓		✓	✓	✓			
**Hemidactylus frenatus*	Asian House Gecko									✓			
PYGOPODIDAE													
Delma borea										✓			
Delma tincta								✓		✓			
Lialis burtonis						✓	✓	✓	✓	✓			
Pygopus nigriceps					✓								
Pygopus steelescotti	Northern Hooded Scaly-foot							✓					

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search
		EPBC Act	WC Act	DEC									
SCINCIDAE													
Carlia munda					✓	✓				✓			
Carlia rufilatus						✓		✓	✓	✓			
Carlia triacantha					✓								
Cryptoblepharus carnabyi					✓								
Cryptoblepharus metallicus										✓			
Cryptoblepharus ruber	Tawny Snake-eyed Skink					✓		✓	✓	✓			
Ctenotus colletti										✓			
Ctenotus helenae										✓			
Ctenotus inornatus					✓	✓	✓	✓	✓	✓	✓		
Ctenotus pantherinus						✓							
Ctenotus serventyi					✓	✓		✓					
Eremiascincus isolepis					✓	✓	✓	✓	✓	✓			
Eremiascincus richardsonii	Banded Skink									✓			
Lerista apoda						✓		✓	✓				
Lerista bipes						✓		✓	✓	✓			
Lerista greeri										✓			
Lerista griffini					✓	✓		✓	✓				
Lerista labialis										✓			
Lerista separanda				P2				✓		✓			
Menetia greyii									✓				
Morethia ruficauda										✓			
Morethia storri					✓	✓		✓					
Proablepharus tenuis								✓					
Tiliqua multifasciata	Central Blue-tongue							✓		✓			
Tiliqua scincoides	Common Blue-tongue				✓	✓	✓	✓	✓	✓			

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search
		EPBC Act	WC Act	DEC									
AGAMIDAE													
Amphibolurus gilberti	Gilbert's Dragon					✓	✓	✓	✓	✓			
Chelosania brunnea	Chameleon Dragon									✓			
Chlamydosaurus kingii	Frilled Lizard				✓	✓	✓	✓	✓	✓	✓		
Ctenophorus caudicinctus	Ring-tailed Rock Dragon									✓			
Ctenophorus isolepis	Military Dragon									✓	✓		
Ctenophorus nuchalis	Central Netted Dragon									✓			
Dipophora magna					✓						✓		
Dipophora pindan					✓	✓	✓	✓	✓	✓			
Diporiphora sp.					✓								
Pogona minor	Dwarf Bearded Dragon				✓	✓	✓	✓	✓	✓			
VARANIDAE													
Varanus acanthurus	Spiny-tailed Monitor						✓			✓			
Varanus brevicauda	Short-tailed Pygmy Monitor					✓		✓					
Varanus gouldii	Gould's Monitor				✓	✓	✓	✓		✓			
Varanus panoptes	Yellow-spotted Monitor						✓	✓					
Varanus scalaris	Spotted Tree Monitor				✓								
Varanus tristis	Black-headed Monitor					✓	✓	✓	✓	✓			
TYPHLOPIDAE													
Ramphotyphlops diversus					✓	✓		✓	✓	✓			
BOIDAE													
Antaresia stimsoni	Stimson's Python				✓		✓	✓		✓			
Aspidites melanocephalus	Black-headed Python				✓	✓			✓	✓	✓		
Liasis olivaceus	Olive Python									✓			
COLUBRIDAE													
Dendrelaphis punctulata	Common Tree Snake								✓	✓			

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (AECOM 2010)	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search
		EPBC Act	WC Act	DEC									
ELAPIDAE													
Brachyurophis roperi	Northern Shovel-nosed Snake				✓	✓		✓	✓				
Demansia angusticeps						✓		✓	✓				
Demansia olivacea	Olive Whipsnake									✓			
Demansia psammophis	Yellow-faced Whipsnake									✓			
Ephalophis greyae	Mangrove Sea Snake												✓
Furina ornata	Moon Snake				✓	✓		✓	✓	✓			
Pseudechis australis	Mulga Snake					✓		✓	✓	✓	✓		
Pseudonaja mengdeni	Western Brown Snake				✓	✓							
Pseudonaja nuchalis	Northern Brown Snake							✓		✓			
Simoselaps anomalus	Desert Banded Snake									✓			
Simoselaps minimus	Dampierland Burrowing Snake			P2				✓		✓			
Suta punctata	Spotted Snake							✓	✓	✓	✓		

* Introduced species

Appendix F4: Amphibians

Family and Species	Common name	Conservation Status			Beagle Bay (*ecologia* 2004)	James Price Point (*ecologia* 2011)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search
		EPBC Act	WC Act	DEC								
HYLIDAE												
Cyclorana australis	Giant Frog				✓		✓		✓			
Cyclorana longipes	Long-footed Frog						✓					
Litoria caerulea	Green Tree Frog				✓	✓	✓		✓			
Litoria coplandi	Copland's Rock Frog								✓			
Litoria nasuta	Rocket Frog								✓			
Litoria rothii	Northern Laughing Tree Frog								✓			
Litoria rubella	Little Red Tree Frog				✓				✓			
LIMNODYNASTIDAE												
Platyplectrum ornatum	Ornate Burrowing Frog					✓	✓	✓	✓			
MYOBATRACHIDAE												
Uperoleia talpa	Mole Toadlet				✓				✓	✓		

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APPENDIX G RARE FLORA REPORT FORMS

Department of Environment and Conservation
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Threatened and Priority Flora Report Form

Version 1.0 January 2010

Please complete as much of the form as possible, with emphasis on those sections bordered in black.

TAXON: Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946) **TPFL Pop. No:**

OBSERVATION DATE: 25/06/2012 **CONSERVATION STATUS:** P3 New population ☐

OBSERVER/S: Renee Young **PHONE:** 93221944

ROLE: Senior Botanist **ORGANISATION:** ecologia Environment

DESCRIPTION OF LOCATION (Provide at least nearest town/named locality, and the distance and direction to that place):

70km West of Derby on the Dampier Peninsula

Reserve No:

DEC DISTRICT: **LGA:** Land manager present: ☐

DATUM:
GDA94 / MGA94 ☒
AGD84 / AMG84 ☐
WGS84 ☐
Unknown ☐

COORDINATES: (If UTM coords provided, Zone is also required)
DecDegrees ☐ DegMinSec ☐ UTMs ☒
Lat / Northing: 8071874
Long / Easting: 0499829
ZONE: 50

METHOD USED:
GPS ☒ Differential GPS ☐ Map ☐
No. satellites: +3 Map used:
Boundary polygon captured: ☐ Map scale:

LAND TENURE:
Nature reserve ☐ Timber reserve ☐ Private property ☐ Rail reserve ☐ Shire road reserve ☐
National park ☐ State forest ☐ Pastoral lease ☐ MRWA road reserve ☐ Other Crown reserve ☐
Conservation park ☐ Water reserve ☐ UCL ☐ SLK/Pole _____ to _____ Specify other:

AREA ASSESSMENT: Edge survey ☐ Partial survey ☐ Full survey ☒ Area observed (m²): 2500

EFFORT: Time spent surveying (minutes): 60 No. of minutes spent / 100 m²:

POP'N COUNT ACCURACY: Actual ☐ Extrapolation ☐ Estimate ☒ Count method: (Refer to field manual for list)

WHAT COUNTED: Plants ☒ Clumps ☐ Clonal stems ☐

TOTAL POP'N STRUCTURE:	**Mature:**	**Juveniles:**	**Seedlings:**	**Totals:**
Alive				60
Dead				

Area of pop (m²):

Note: Pls record count as numbers (not percentages) for database.

QUADRATS PRESENT: No. Size Data attached ☐ Total area of quadrats (m²):

Summary Quad. Totals: Alive				60

REPRODUCTIVE STATE: Clonal ☐ Vegetative ☐ Flowerbud ☐ Flower ☐
Immature fruit ☐ Fruit ☐ Dehisced fruit ☐ Percentage in flower: %

CONDITION OF PLANTS: Healthy ☒ Moderate ☐ Poor ☐ Senescent ☐

COMMENT:

THREATS - type, agent and supporting information: Eg clearing, too frequent fire, weed, disease. Refer to field manual for list of threats & agents. **Specify agent** where relevant. Rate current and potential threat impact: N=Nil, L=Low, M=Medium, H=High, E=Extreme Estimate time to potential impact: S=Short (<12mths), M=Medium (<5yrs), L=Long (5yrs+)	**Current impact (N-E)**	**Potential Impact (L-E)**	**Potential Threat Onset (S-L)**
• Mining	N	E	L
• Grazing	L	M	M
• Invasive species	L	L	M

Please return completed form to DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: Please forward to **Administrative Officer, Flora,** Species and Communities Branch.

Record entered by: **Sheet No.:** **Record Entered in Database** ❑

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Version 1.0 January 2010

HABITAT INFORMATION:

LANDFORM:
Crest ☐
Hill ☐
Ridge ☒
Outcrop ☐
Slope ☐
Flat ☐
Open depression ☐
Drainage line ☐
Closed depression ☐
Wetland ☐

ROCK TYPE:
Granite ☐
Dolerite ☐
Laterite ☐
Ironstone ☐
Limestone ☐
Quartz ☐
Specify other: Sanstone

LOOSE ROCK: (on soil surface; eg gravel, quartz fields)
0-10% ☐
10-30% ☐
30-50% ☐
50-100% ☐

SOIL TYPE:
Sand ☐
Sandy loam ☐
Loam ☐
Clay loam ☐
Light clay ☐
Peat ☐
Specify other: Sandy-clay

SOIL COLOUR:
Red ☐
Brown ☒
Yellow ☐
White ☐
Grey ☐
Black ☐
Specify other: Orange

DRAINAGE:
Well drained ☐
Seasonally inundated ☐
Permanently inundated ☐
Tidal ☐

Specific **Landform** Element: _____
(Refer to field manual for additional values)

CONDITION OF SOIL: Dry ☒ Moist ☐ Waterlogged ☐ Inundated ☐

VEGETATION CLASSIFICATION*:
Eg: 1. Banksia woodland (B. attenuata, B. ilicifolia); 2. Open shrubland (Hibbertia sp., Acacia spp.) ; 3. Isolated clumps of sedges (Mesomelaena tetragona)

1. _____
2. _____
3. _____
4. _____

ASSOCIATED SPECIES: _____

Other (non-dominant) spp _____

* Please record up to four of the most representative vegetation layers (with up to three dominant species in each layer). Structural Formations should follow 2009 *Australian Soil and Land Survey Field Handbook* guidelines – refer to field manual for further information and structural formation table.

CONDITION OF HABITAT: Pristine ☐ Excellent ☐ Very good ☒ Good ☐ Degraded ☐ Completely degraded ☐

COMMENT: Animal tracks

FIRE HISTORY: **Last Fire:** Season/Month: _____ Year: 4yrs **Fire Intensity:** High ☐ Medium ☐ Low ☐ No signs of fire ☐

FENCING: Not required ☐ Present ☐ Replace / repair ☐ Required ☐ Length req'd: _____

ROADSIDE MARKERS: Not required ☐ Present ☐ Replace / reposition ☐ Required ☐ Quantity req'd: _____

OTHER COMMENTS: (Please include recommended management actions and/or implemented actions - include date. Also include details of additional data available, and how to locate it.)

SPECIMEN: Collectors No: 1462RY05-06 WA Herb. ☐ Regional Herb. ☐ District Herb. ☐ Other: _____

ATTACHED: Map ☐ Mudmap ☐ Photo ☐ GIS data ☐ Field notes ☐ Other: _____

COPY SENT TO: Regional Office ☐ District Office ☐ Other:

Submitter of Record: Heather Broad Role: Botanist Signed: H.Broad Date: 09/08/2012

Please return completed form to DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: Please forward to **Administrative Officer, Flora,** Species and Communities Branch.

Record entered by: _____ **Sheet No.:** _____ **Record Entered in Database** ☐

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Version 1.0 January 2010

Please complete as much of the form as possible, with emphasis on those sections bordered in black.

TAXON: Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946) **TPFL Pop. No:**

OBSERVATION DATE: 23/06/2012 **CONSERVATION STATUS:** P3 New population ☐

OBSERVER/S: Renee Young **PHONE:** 93221944

ROLE: Senior Botanist **ORGANISATION:** ecologia Environment

DESCRIPTION OF LOCATION (Provide at least nearest town/named locality, and the distance and direction to that place):

70km West of Derby on the Dampier Peninsula

Reserve No:

DEC DISTRICT: **LGA:** Land manager present: ☐

DATUM:
GDA94 / MGA94 ☒
AGD84 / AMG84 ☐
WGS84 ☐
Unknown ☐

COORDINATES: (If UTM coords provided, **Zone** is also required)
DecDegrees ☐ DegMinSec ☐ UTMs ☒

Lat / Northing: 8068356

Long / Easting: 0497313

ZONE: 50

METHOD USED:
GPS ☒ Differential GPS ☐ Map ☐

No. satellites: +3 Map used:

Boundary polygon captured: ☐ Map scale:

LAND TENURE:

Nature reserve ☐	Timber reserve ☐	Private property ☐	Rail reserve ☐	Shire road reserve ☐
National park ☐	State forest ☐	Pastoral lease ☐	MRWA road reserve ☐	Other Crown reserve ☐
Conservation park ☐	Water reserve ☐	UCL ☐	SLK/Pole _____ to _____	Specify other:

AREA ASSESSMENT: Edge survey ☐ Partial survey ☐ Full survey ☒ Area observed (m²): 2500

EFFORT: Time spent surveying (minutes): 30 No. of minutes spent / 100 m²:

POP'N COUNT ACCURACY: Actual ☐ Extrapolation ☐ Estimate ☒ Count method:
(Refer to field manual for list)

WHAT COUNTED: Plants ☐ Clumps ☐ Clonal stems ☐

TOTAL POP'N STRUCTURE:

	Mature:	Juveniles:	Seedlings:	Totals:
Alive				30
Dead				

Area of pop (m²):

Note: PIs record count as numbers (not percentages) for database.

QUADRATS PRESENT: No. _____ Size _____ Data attached ☐ Total area of quadrats (m²):

Summary Quad. Totals: Alive				30

REPRODUCTIVE STATE: Clonal ☐ Vegetative ☐ Flowerbud ☐ Flower ☐
Immature fruit ☐ Fruit ☐ Dehisced fruit ☐ Percentage in flower: _____ %

CONDITION OF PLANTS: Healthy ☒ Moderate ☐ Poor ☐ Senescent ☐

COMMENT:

THREATS - type, agent and supporting information: Eg clearing, too frequent fire, weed, disease. Refer to field manual for list of threats & agents. **Specify agent** where relevant. Rate current and potential threat impact: N=Nil, L=Low, M=Medium, H=High, E=Extreme Estimate time to potential impact: S=Short (<12mths), M=Medium (<5yrs), L=Long (5yrs+)	**Current impact (N-E)**	**Potential Impact (L-E)**	**Potential Threat Onset (S-L)**
• Mining	N	E	L
• Grazing	L	M	M
• Invasive species	L	L	M

Please return completed form to DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: Please forward to **Administrative Officer, Flora,** Species and Communities Branch.

Record entered by: _____ **Sheet No.:** _____ **Record Entered in Database** ☐

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Version 1.0 January 2010

HABITAT INFORMATION:

LANDFORM:
Crest ☐
Hill ☐
Ridge ☐
Outcrop ☐
Slope ☐
Flat ☒
Open depression ☐
Drainage line ☐
Closed depression ☐
Wetland ☐

ROCK TYPE:
Granite ☐
Dolerite ☐
Laterite ☐
Ironstone ☐
Limestone ☐
Quartz ☐
Specify other: No rocks

LOOSE ROCK: (on soil surface; eg gravel, quartz fields)
0-10% ☐
10-30% ☐
30-50% ☐
50-100% ☐

SOIL TYPE:
Sand ☐
Sandy loam ☐
Loam ☐
Clay loam ☐
Light clay ☐
Peat ☐
Specify other: Sandy-clay

SOIL COLOUR:
Red ☐
Brown ☐
Yellow ☒
White ☒
Grey ☐
Black ☐
Specify other: _____

DRAINAGE:
Well drained ☐
Seasonally inundated ☐
Permanently inundated ☐
Tidal ☐

Specific **Landform** Element: _____
(Refer to field manual for additional values)

CONDITION OF SOIL: Dry ☒ Moist ☐ Waterlogged ☐ Inundated ☐

VEGETATION CLASSIFICATION*:
Eg: 1. Banksia woodland (B. attenuata, B. ilicifolia); 2. Open shrubland (Hibbertia sp., Acacia spp.) ; 3. Isolated clumps of sedges (Mesomelaena tetragona)

1. _____
2. _____
3. _____
4. _____

ASSOCIATED SPECIES: _____

Other (non-dominant) spp _____

* Please record up to four of the most representative vegetation layers (with up to three dominant species in each layer). Structural Formations should follow 2009 *Australian Soil and Land Survey Field Handbook* guidelines – refer to field manual for further information and structural formation table.

CONDITION OF HABITAT: Pristine ☐ Excellent ☐ Very good ☐ Good ☐ Degraded ☐ Completely degraded ☐

COMMENT: Animal tracks

FIRE HISTORY: **Last Fire:** Season/Month: _____ Year: 4yrs **Fire Intensity:** High ☐ Medium ☐ Low ☐ No signs of fire ☐

FENCING: Not required ☐ Present ☐ Replace / repair ☐ Required ☐ Length req'd: _____

ROADSIDE MARKERS: Not required ☐ Present ☐ Replace / reposition ☐ Required ☐ Quantity req'd: _____

OTHER COMMENTS: (Please include recommended management actions and/or implemented actions - include date. Also include details of additional data available, and how to locate it.) _____

SPECIMEN: Collectors No: 1462RY15-19 WA Herb. ☐ Regional Herb. ☐ District Herb. ☐ Other: _____

ATTACHED: Map ☐ Mudmap ☐ Photo ☐ GIS data ☐ Field notes ☐ Other: _____

COPY SENT TO: Regional Office ☐ District Office ☐ Other:

Submitter of Record: Heather Broad Role: Botanist Signed: HBroad Date: 09/08/2012

Please return completed form to DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: Please forward to **Administrative Officer, Flora,** Species and Communities Branch.

Record entered by: _____ **Sheet No.:** _____ **Record Entered in Database** ☐

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Version 1.0 January 2010

Please complete as much of the form as possible, with emphasis on those sections bordered in black.

TAXON: Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946) **TPFL Pop. No:**

OBSERVATION DATE: 23/06/2012 **CONSERVATION STATUS:** P3 New population ☐

OBSERVER/S: Renee Young **PHONE:** 93221944

ROLE: Senior Botanist **ORGANISATION:** ecologia Environment

DESCRIPTION OF LOCATION (Provide at least nearest town/named locality, and the distance and direction to that place):

70km West of Derby on the Dampier Peninsula

Reserve No:

DEC DISTRICT: **LGA:** Land manager present: ☐

DATUM:
GDA94 / MGA94 ☒
AGD84 / AMG84 ☐
WGS84 ☐
Unknown ☐

COORDINATES: (If UTM coords provided, **Zone** is also required)
DecDegrees ☐ DegMinSec ☐ UTMs ☒

Lat / Northing: 8074676

Long / Easting: 0497408

ZONE: 50

METHOD USED:
GPS ☒ Differential GPS ☐ Map ☐

No. satellites: +3 Map used:

Boundary polygon captured: ☐ Map scale:

LAND TENURE:

Nature reserve ☐	Timber reserve ☐	Private property ☐	Rail reserve ☐	Shire road reserve ☐
National park ☐	State forest ☐	Pastoral lease ☐	MRWA road reserve ☐	Other Crown reserve ☐
Conservation park ☐	Water reserve ☐	UCL ☐	SLK/Pole _____ to _____	Specify other:

AREA ASSESSMENT: Edge survey ☐ Partial survey ☐ Full survey ☒ Area observed (m²): 2500

EFFORT: Time spent surveying (minutes): 60 No. of minutes spent / 100 m²:

POP'N COUNT ACCURACY: Actual ☐ Extrapolation ☐ Estimate ☒ Count method: (Refer to field manual for list)

WHAT COUNTED: Plants ☒ Clumps ☐ Clonal stems ☐

TOTAL POP'N STRUCTURE:

	Mature:	Juveniles:	Seedlings:	Totals:
Alive				30
Dead				

Area of pop (m²):

Note: Pls record count as numbers (not percentages) for database.

QUADRATS PRESENT: No. _____ Size _____ Data attached ☐ Total area of quadrats (m²):

Summary Quad. Totals: Alive				30

REPRODUCTIVE STATE: Clonal ☐ Vegetative ☐ Flowerbud ☐ Flower ☐
Immature fruit ☐ Fruit ☐ Dehisced fruit ☐ Percentage in flower: %

CONDITION OF PLANTS: Healthy ☒ Moderate ☐ Poor ☐ Senescent ☐

COMMENT:

THREATS - type, agent and supporting information: Eg clearing, too frequent fire, weed, disease. Refer to field manual for list of threats & agents. **Specify agent** where relevant. Rate current and potential threat impact: N=Nil, L=Low, M=Medium, H=High, E=Extreme Estimate time to potential impact: S=Short (<12mths), M=Medium (<5yrs), L=Long (5yrs+)	**Current impact (N-E)**	**Potential Impact (L-E)**	**Potential Threat Onset (S-L)**
• Mining	N	E	L
• Grazing	M	M	M
• Invasive species	L	L	M

Please return completed form to DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: Please forward to **Administrative Officer, Flora,** Species and Communities Branch.

Record entered by: **Sheet No.:** **Record Entered in Database** ☐

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Version 1.0 January 2010

HABITAT INFORMATION:

LANDFORM:
Crest ☐
Hill ☐
Ridge ☐
Outcrop ☐
Slope ☒
Flat ☐
Open depression ☐
Drainage line ☒
Closed depression ☐
Wetland ☐

ROCK TYPE:
Granite ☐
Dolerite ☐
Laterite ☐
Ironstone ☒
Limestone ☐
Quartz ☐
Specify other: _____

LOOSE ROCK: (on soil surface; eg gravel, quartz fields)
0-10% ☐
10-30% ☐
30-50% ☐
50-100% ☐

SOIL TYPE:
Sand ☐
Sandy loam ☐
Loam ☐
Clay loam ☐
Light clay ☐
Peat ☐
Specify other: Sandy-clay

SOIL COLOUR:
Red ☐
Brown ☒
Yellow ☐
White ☐
Grey ☐
Black ☐
Specify other: _____

DRAINAGE:
Well drained ☐
Seasonally inundated ☐
Permanently inundated ☐
Tidal ☐

Specific **Landform** Element: _____
(Refer to field manual for additional values)

CONDITION OF SOIL: Dry ☒ Moist ☐ Waterlogged ☐ Inundated ☐

VEGETATION CLASSIFICATION*:
Eg: 1. Banksia woodland (B. attenuata, B. ilicifolia); 2. Open shrubland (Hibbertia sp., Acacia spp.); 3. Isolated clumps of sedges (Mesomelaena tetragona)

1. _____
2. _____
3. _____
4. _____

ASSOCIATED SPECIES: _____

Other (non-dominant) spp _____

* Please record up to four of the most representative vegetation layers (with up to three dominant species in each layer). Structural Formations should follow 2009 *Australian Soil and Land Survey Field Handbook* guidelines – refer to field manual for further information and structural formation table.

CONDITION OF HABITAT: Pristine ☐ Excellent ☐ Very good ☐ Good ☒ Degraded ☐ Completely degraded ☐

COMMENT: Animal tracks, grazing

FIRE HISTORY: **Last Fire:** Season/Month: _____ Year: 2yrs **Fire Intensity:** High ☐ Medium ☐ Low ☐ No signs of fire ☐

FENCING: Not required ☐ Present ☐ Replace / repair ☐ Required ☐ Length req'd: _____

ROADSIDE MARKERS: Not required ☐ Present ☐ Replace / reposition ☐ Required ☐ Quantity req'd: _____

OTHER COMMENTS: (Please include recommended management actions and/or implemented actions - include date. Also include details of additional data available, and how to locate it.)

SPECIMEN: Collectors No: 1462RY18-19 WA Herb. ☐ Regional Herb. ☐ District Herb. ☐ Other: _____

ATTACHED: Map ☐ Mudmap ☐ Photo ☐ GIS data ☐ Field notes ☐ Other: _____

COPY SENT TO: Regional Office ☐ District Office ☐ Other:

Submitter of Record: Heather Broad Role: Botanist Signed: HBroad Date: 09/08/2012

Please return completed form to DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: Please forward to **Administrative Officer, Flora,** Species and Communities Branch.

Record entered by: _____ **Sheet No.:** _____ **Record Entered in Database** ☐

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Version 1.0 January 2010

Please complete as much of the form as possible, with emphasis on those sections bordered in black.

TAXON: Pterocaulon intermedium **TPFL Pop. No:**

OBSERVATION DATE: 25/06/2012 **CONSERVATION STATUS:** P3 New population ☐

OBSERVER/S: Renee Young **PHONE:** 93221944

ROLE: Senior Botanist **ORGANISATION:** ecologia Environment

DESCRIPTION OF LOCATION (Provide at least nearest town/named locality, and the distance and direction to that place):

70km West of Derby on the Dampier Peninsula

Reserve No:

DEC DISTRICT: **LGA:** Land manager present: ☐

DATUM:
GDA94 / MGA94 ☒
AGD84 / AMG84 ☐
WGS84 ☐
Unknown ☐

COORDINATES: (If UTM coords provided, **Zone** is also required)
DecDegrees ☐ DegMinSec ☐ UTMs ☒
Lat / Northing: 8071422
Long / Easting: 0495996
ZONE: 50

METHOD USED:
GPS ☐ Differential GPS ☐ Map ☐
No. satellites: +3 Map used:
Boundary polygon captured: ☐ Map scale:

LAND TENURE:
Nature reserve ☐ Timber reserve ☐ Private property ☐ Rail reserve ☐ Shire road reserve ☐
National park ☐ State forest ☐ Pastoral lease ☐ MRWA road reserve ☐ Other Crown reserve ☐
Conservation park ☐ Water reserve ☐ UCL ☐ SLK/Pole _____ to _____ Specify other:

AREA ASSESSMENT: Edge survey ☐ Partial survey ☐ Full survey ☒ Area observed (m²): 2500

EFFORT: Time spent surveying (minutes): 60 No. of minutes spent / 100 m²:

POP'N COUNT ACCURACY: Actual ☐ Extrapolation ☐ Estimate ☒ Count method:
(Refer to field manual for list)

WHAT COUNTED: Plants ☒ Clumps ☐ Clonal stems ☐

TOTAL POP'N STRUCTURE:	**Mature:**	**Juveniles:**	**Seedlings:**	**Totals:**
Alive				5
Dead				

Area of pop (m²):

Note: Pls record count as numbers (not percentages) for database.

QUADRATS PRESENT: No. _____ Size _____ Data attached ☐ Total area of quadrats (m²):

Summary Quad. Totals: Alive				5

REPRODUCTIVE STATE: Clonal ☐ Vegetative ☐ Flowerbud ☐ Flower ☐
Immature fruit ☐ Fruit ☐ Dehisced fruit ☐ Percentage in flower: _____ %

CONDITION OF PLANTS: Healthy ☒ Moderate ☐ Poor ☐ Senescent ☐

COMMENT:

THREATS - type, agent and supporting information: Eg clearing, too frequent fire, weed, disease. Refer to field manual for list of threats & agents. **Specify agent** where relevant. Rate current and potential threat impact: N=Nil, L=Low, M=Medium, H=High, E=Extreme Estimate time to potential impact: S=Short (<12mths), M=Medium (<5yrs), L=Long (5yrs+)	**Current impact (N-E)**	**Potential Impact (L-E)**	**Potential Threat Onset (S-L)**
• Mining	N	E	L
• Grazing	L	M	M
• Invasive species	L	L	M

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RECORDS: Please forward to **Administrative Officer, Flora,** Species and Communities Branch.

Record entered by: _____ **Sheet No.:** _____ **Record Entered in Database** ❑

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Threatened and Priority Flora Report Form

Version 1.0 January 2010

HABITAT INFORMATION:

LANDFORM:
Crest ☐
Hill ☐
Ridge ☐
Outcrop ☐
Slope ☐
Flat ☒
Open depression ☐
Drainage line ☐
Closed depression ☐
Wetland ☐

ROCK TYPE:
Granite ☐
Dolerite ☐
Laterite ☐
Ironstone ☐
Limestone ☐
Quartz ☐
Specify other: No rocks

LOOSE ROCK: (on soil surface; eg gravel, quartz fields)
0-10% ☐
10-30% ☐
30-50% ☐
50-100% ☐

SOIL TYPE:
Sand ☐
Sandy loam ☐
Loam ☐
Clay loam ☐
Light clay ☐
Peat ☐
Specify other: Sandy-clay

SOIL COLOUR:
Red ☐
Brown ☒
Yellow ☐
White ☐
Grey ☐
Black ☐
Specify other: Orange

DRAINAGE:
Well drained ☐
Seasonally inundated ☐
Permanently inundated ☐
Tidal ☐

Specific **Landform** Element: _____
(Refer to field manual for additional values)

CONDITION OF SOIL: Dry ☒ Moist ☐ Waterlogged ☐ Inundated ☐

VEGETATION CLASSIFICATION*:
Eg: 1. Banksia woodland (B. attenuata, B. ilicifolia); 2. Open shrubland (Hibbertia sp., Acacia spp.); 3. Isolated clumps of sedges (Mesomelaena tetragona)

1. _____
2. _____
3. _____
4. _____

ASSOCIATED SPECIES: _____

Other (non-dominant) spp _____

* Please record up to four of the most representative vegetation layers (with up to three dominant species in each layer). Structural Formations should follow 2009 *Australian Soil and Land Survey Field Handbook* guidelines – refer to field manual for further information and structural formation table.

CONDITION OF HABITAT: Pristine ☐ Excellent ☐ Very good ☐ Good ☒ Degraded ☐ Completely degraded ☐

COMMENT: Animal tracks

FIRE HISTORY: **Last Fire:** Season/Month: _____ Year: 4yrs **Fire Intensity:** High ☐ Medium ☐ Low ☐ No signs of fire ☐

FENCING: Not required ☐ Present ☐ Replace / repair ☐ Required ☐ Length req'd: _____

ROADSIDE MARKERS: Not required ☐ Present ☐ Replace / reposition ☐ Required ☐ Quantity req'd: _____

OTHER COMMENTS: (Please include recommended management actions and/or implemented actions - include date. Also include details of additional data available, and how to locate it.)

Small range extension - 70 km E of known record (note: few GPS locations)

SPECIMEN: Collectors No: 1462RY13-28 WA Herb. ☐ Regional Herb. ☐ District Herb. ☐ Other: _____

ATTACHED: Map ☐ Mudmap ☐ Photo ☐ GIS data ☐ Field notes ☐ Other: _____

COPY SENT TO: Regional Office ☐ District Office ☐ Other:

Submitter of Record: Heather Broad Role: Botanist Signed: HBroad Date: 09/08/2012

Please return completed form to DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: Please forward to **Administrative Officer, Flora,** Species and Communities Branch.

Record entered by: _____ **Sheet No.:** _____ **Record Entered in Database** ☐

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Version 1.0 January 2010

Please complete as much of the form as possible, with emphasis on those sections bordered in black.

TAXON: Triodia caelestialis **TPFL Pop. No:**

OBSERVATION DATE: 22-25/06/2012 **CONSERVATION STATUS:** P3 New population ☐

OBSERVER/S: Renee Young **PHONE:** 93221944

ROLE: Senior Botanist **ORGANISATION:** ecologia Environment

DESCRIPTION OF LOCATION (Provide at least nearest town/named locality, and the distance and direction to that place):

70km West of Derby on the Dampier Peninsula

Reserve No:

DEC DISTRICT: **LGA:** Land manager present: ☐

DATUM: GDA94 / MGA94 ☒ AGD84 / AMG84 ☐ WGS84 ☐ Unknown ☐

COORDINATES: (If UTM coords provided, Zone is also required) DecDegrees ☐ DegMinSec ☐ UTMs ☒

Lat / Northing: See attached sheet

Long / Easting: See attached sheet

ZONE: 50

METHOD USED: GPS ☐ Differential GPS ☐ Map ☐

No. satellites: +3 Map used:

Boundary polygon captured: ☐ Map scale:

LAND TENURE:

Nature reserve ☐ Timber reserve ☐ Private property ☐ Rail reserve ☐ Shire road reserve ☐

National park ☐ State forest ☐ Pastoral lease ☐ MRWA road reserve ☐ Other Crown reserve ☐

Conservation park ☐ Water reserve ☐ UCL ☐ SLK/Pole _____ to _____ Specify other:

AREA ASSESSMENT: Edge survey ☐ Partial survey ☐ Full survey ☒ Area observed (m²): 2500

EFFORT: Time spent surveying (minutes): 60 No. of minutes spent / 100 m²:

POP'N COUNT ACCURACY: Actual ☐ Extrapolation ☐ Estimate ☒ Count method: (Refer to field manual for list)

WHAT COUNTED: Plants ☒ Clumps ☐ Clonal stems ☐

TOTAL POP'N STRUCTURE:	**Mature:**	**Juveniles:**	**Seedlings:**	**Totals:**
Alive				1100
Dead				

Area of pop (m²):

Note: Pls record count as numbers (not percentages) for database.

QUADRATS PRESENT: No. _____ Size _____ Data attached ☐ Total area of quadrats (m²):

Summary Quad. Totals: Alive				1100

REPRODUCTIVE STATE: Clonal ☐ Vegetative ☐ Flowerbud ☐ Flower ☐

Immature fruit ☐ Fruit ☐ Dehisced fruit ☐ Percentage in flower: _____ %

CONDITION OF PLANTS: Healthy ☒ Moderate ☐ Poor ☐ Senescent ☐

COMMENT:

THREATS - type, agent and supporting information: Eg clearing, too frequent fire, weed, disease. Refer to field manual for list of threats & agents. **Specify agent** where relevant. Rate current and potential threat impact: N=Nil, L=Low, M=Medium, H=High, E=Extreme Estimate time to potential impact: S=Short (<12mths), M=Medium (<5yrs), L=Long (5yrs+)	**Current impact (N-E)**	**Potential Impact (L-E)**	**Potential Threat Onset (S-L)**
• Mining	N	E	L
• Grazing	_____	M	M
• Invasive species	L	L	M

Please return completed form to DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

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HABITAT INFORMATION:

LANDFORM:
Crest ☐
Hill ☐
Ridge ☐
Outcrop ☐
Slope ☐
Flat ☐
Open depression ☐
Drainage line ☐
Closed depression ☐
Wetland ☐

ROCK TYPE:
Granite ☐
Dolerite ☐
Laterite ☐
Ironstone ☐
Limestone ☐
Quartz ☐
Specify other: _____

LOOSE ROCK:
(on soil surface; eg gravel, quartz fields)
0-10% ☐
10-30% ☐
30-50% ☐
50-100% ☐

SOIL TYPE:
Sand ☐
Sandy loam ☐
Loam ☐
Clay loam ☐
Light clay ☐
Peat ☐
Specify other: _____

SOIL COLOUR:
Red ☐
Brown ☐
Yellow ☐
White ☐
Grey ☐
Black ☐
Specify other: _____

DRAINAGE:
Well drained ☐
Seasonally inundated ☐
Permanently inundated ☐
Tidal ☐

Specific **Landform** Element: _____
(Refer to field manual for additional values)

CONDITION OF SOIL: Dry ☒ Moist ☐ Waterlogged ☐ Inundated ☐

VEGETATION CLASSIFICATION*:
Eg: 1. Banksia woodland (B. attenuata, B. ilicifolia); 2. Open shrubland (Hibbertia sp., Acacia spp.) ; 3. Isolated clumps of sedges (Mesomelaena tetragona)

1. _____
2. _____
3. _____
4. _____

ASSOCIATED SPECIES: _____

Other (non-dominant) spp _____

* Please record up to four of the most representative vegetation layers (with up to three dominant species in each layer). Structural Formations should follow 2009 *Australian Soil and Land Survey Field Handbook* guidelines – refer to field manual for further information and structural formation table.

CONDITION OF HABITAT: Pristine ☐ Excellent ☐ Very good ☐ Good ☐ Degraded ☐ Completely degraded ☐

COMMENT: _____

FIRE HISTORY: **Last Fire:** Season/Month: _____ Year: _____ **Fire Intensity:** High ☐ Medium ☐ Low ☐ No signs of fire ☐

FENCING: Not required ☐ Present ☐ Replace / repair ☐ Required ☐ Length req'd: _____

ROADSIDE MARKERS: Not required ☐ Present ☐ Replace / reposition ☐ Required ☐ Quantity req'd: _____

OTHER COMMENTS: (Please include recommended management actions and/or implemented actions - include date. Also include details of additional data available, and how to locate it.)

Range extension - 152 km W of eastern population and 220 km NE of southwerstern record

SPECIMEN: Collectors No: See attached sheet WA Herb. ☐ Regional Herb. ☐ District Herb. ☐ Other: _____

ATTACHED: Map ☐ Mudmap ☐ Photo ☐ GIS data ☐ Field notes ☐ Other: locations

COPY SENT TO: Regional Office ☐ District Office ☐ Other:

Submitter of Record: Heather Broad Role: Botanist Signed: HBroad Date: 09/08/2012

Please return completed form to DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: Please forward to **Administrative Officer, Flora,** Species and Communities Branch.

Record entered by: _____ **Sheet No.:** _____ **Record Entered in Database** ☐

Triodia caelestialis Locations

Location	Number of Plants	Northing	Easting	Landform	Rock type	Soil type
03-21	40	8067698	502522	Flat	No rocks	Sandy-clay
04-06	100	8067686	501984	Flat	Limestone	Sandy-clay
06-09	40	8068230	499830	Flat	No rocks	Sandy-clay
09-11	100	8075977	496084	Slope, drainage	Ironstone,	Sandy-clay
10-01	150	8075986	495950	Slope	Ironstone	Sandy-clay
11-10	20	8074375	493242	Flat	No rocks	Sandy-clay
12-02	40	8074124	494331	Flat	No rocks	Sandy-clay
13-01	100	8071422	495996	Flat	No rocks	Sandy-clay
15-02	150	8068356	497313	Flat	No rocks	Sandy-clay, Loam
15-28	20	8068356	497313	Flat	No rocks	Sandy-clay, Loam
16-01	40	8071234	497776	Flat	No rocks	Sandy-clay
16-29	20	8071234	497776	Flat	No rocks	Sandy-clay
17-16	40	8072735	494449	Flat	No rocks	Sandy-clay, sand
18-13	40	8074676	497408	Slope, drainage	Ironstone	Sandy-clay
19-01	100	8073618	500192	Flat	Ironstone	Sandy-clay
20A-10	40	8074299	491807	Flat	No rocks	Sand, sandy-clay
20A-22	20	8074299	491807	Flat	No rocks	Sand, sandy-clay
20B-07	40	8067457	500071	Flat	No rocks	Sandy-clay, clay

APPENDIX 3: TERRESTRIAL AND SUBTERRANEAN FAUNA ASSESSMENT, ECOLOGIA, 2014

MARCH 2014

Providing sustainable environmental strategies,
management and monitoring solutions
to industry and government.

ecologia
ENVIRONMENT

SHEFFIELD RESOURCES LTD
THUNDERBIRD PROJECT
TERRESTRIAL AND SUBTERRANAEAN FAUNA ASSESSMENT

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TABLE OF CONTENTS

EXECUTIVE SUMMARY VIII

1 INTRODUCTION 1
1.1 PROJECT OVERVIEW 1
1.2 LEGISLATION AND POLICY 3
1.3 SURVEY OBJECTIVES 5
1.4 BACKGROUND SUMMARY OF FAUNA GROUPS 5

2 ENVIRONMENT 9
2.1 CLIMATE 9
2.2 BIOGEOGRAPHY 10
2.3 LAND SYSTEMS 12
2.4 VEGETATION 14
2.5 GEOLOGY, SOILS AND HYDROGEOLOGY 16
2.6 PREVIOUS SURVEYS AND LAND USE 18

3 METHODS 23
3.1 DETERMINATION OF SURVEY SAMPLING DESIGN AND INTENSITY 23
3.2 SURVEY TIMING 23
3.3 SAMPLING METHODS 24
3.4 SITE SELECTION 32
3.5 SURVEY EFFORT 39
3.6 POTENTIAL CONSERVATION SIGNIFICANT VERTEBRATE FAUNA 43
3.7 DETERMINING SRE STATUS 43
3.8 FAUNA HABITAT MAPPING 45
3.9 DATA ANALYSIS 46
3.10 TAXONOMY AND NOMENCLATURE 47
3.11 ANIMAL ETHICS 47
3.12 SURVEY TEAM AND LICENCES 48

4 RESULTS 49
4.1 FAUNA HABITATS 49
4.2 FAUNA HABITAT ANALYSIS 53
4.3 FAUNA ASSEMBLAGES 56
4.4 POTENTIAL CONSERVATION SIGNIFICANT VERTEBRATE FAUNA 61
4.5 CONSERVATION SIGNIFICANT VERTEBRATE FAUNA RECORDED 69

4.6 SURVEY ADEQUACY 83

5 DISCUSSION 86

5.1 HABITATS AND ASSOCIATED FAUNA 86

5.2 HABITAT ANALYSIS 87

5.3 FAUNA ASSEMBLAGES 87

5.4 CONSERVATION SIGNIFICANT VERTEBRATE FAUNA 90

5.5 SRE INVERTEBRATE FAUNA 96

5.6 STYGOFAUNA 101

5.7 TROGLOFAUNA 101

5.8 SURVEY ADEQUACY 102

5.9 SURVEY LIMITATIONS 103

6 CONCLUSIONS 104

7 REFERENCES 105

TABLES

Table 2.1 – Annual climate data for Broome Airport and Derby Aero weather stations (BoM 2013)...10
Table 2.2 – Land systems of the study area 12
Table 2.3 – Vegetation associations of the study area....14
Table 2.4 – Databases searched to determine the potential vertebrate fauna assemblage....18
Table 2.5 – Previous biological survey reports within the region of the study area....19
Table 2.6 – Summary of previous vertebrate fauna biological surveys and database results....21
Table 3.1 – Factors likely to influence survey design (EPA 2004) 23
Table 3.2 – Summary of survey timing and duration 24
Table 3.3 – Vertebrate fauna sites 32
Table 3.4 – SRE fauna sites....33
Table 3.5 – Stygofauna sample sites 34
Table 3.6 – Troglofauna sites 35
Table 3.7 – Terrestrial vertebrate fauna survey effort....40
Table 3.8 – SRE fauna survey effort 41
Table 3.9 – Stygofauna survey effort 41
Table 3.10 – Troglofauna survey effort 42
Table 3.11 – Likelihood of occurrence categories....43
Table 3.12 – Western Australian Museum SRE categories (2013)....44
Table 3.13 – Phoenix's SRE categories (2013)....45
Table 3.14 – Habitat condition assessment 46
Table 3.15 – References used for identification....47
Table 3.16 – Field survey personnel....48
Table 3.17 – Taxonomic specialists 48
Table 4.1 – Summary of fauna habitats 49
Table 4.2 – Survey effort per habitat type 50
Table 4.3 – One-way ANOSIM test results for fauna habitat comparisons 54
Table 4.4 – Stygofauna sampling results....60
Table 4.5 – Summary of groundwater physio-chemistry....60
Table 4.6 – Troglofauna sampling results....61
Table 4.7 – Assessment of likelihood of occurrence of potential conservation significant fauna....62
Table 4.8 – Coastal and wetland conservation significant bird species....66
Table 4.9 – Conservation significant fauna recorded....69
Table 4.10 – Mean estimates of total species richness of systematically sampled fauna....83
Table 5.1 – Summary of survey limitations....103

FIGURES

Figure 1.1 – Location of the study area 2
Figure 2.1 – Climate data for Broome Airport and Derby Aero Weather Stations (BoM 2013) 9
Figure 2.2 – Biogeographic regions of the study area 11
Figure 2.3 – Land systems of the study area 13
Figure 2.4 – Vegetation associations of the study area 15
Figure 2.5 – Soils of the study area 17
Figure 2.6 – Previous biological survey locations 20
Figure 3.1 – Diagram of the systematic sampling trap arrangement 25
Figure 3.2 – Image of single *ecologia* trap point 25
Figure 3.3 – A motion camera monitoring a Greater Bilby burrow 27
Figure 3.4 – A motion camera monitoring a Rainbow Bee-eater nesting burrow 27
Figure 3.5 – Example of the leaf litter reducer 28
Figure 3.6 – Custom built troglofauna trap 30
Figure 3.7 – Tullgren funnels 31
Figure 3.8 – Vertebrate fauna sites 36
Figure 3.9 – Short Range Endemic invertebrate fauna sites 37
Figure 3.10 – Stygofauna and troglofauna sample sites 38
Figure 4.1 – Fauna habitats of the study area 51
Figure 4.2 – Example of the pindan shrubland habitat 52
Figure 4.3 – Example of undulating rocky hills in the sandstone range habitat 52
Figure 4.4 – Example of a rock outcrop in the sandstone range habitat 53
Figure 4.5 – Example of the savannah woodland habitat. 53
Figure 4.6 – Terrestrial vertebrates MDS plot 55
Figure 4.7 – Avifauna MDS plot 55
Figure 4.8 – SRE invertebrates MDS plot 56
Figure 4.9 – *Lerista apoda* recorded 58
Figure 4.10 – Previous NatureMap *Lerista apoda* records 58
Figure 4.11 – *Ctenotus colletti* recorded 59
Figure 4.12 – Regional conservation significant mammal and reptile records 67
Figure 4.13 – Regional conservation significant bird records 68
Figure 4.14 – Greater Bilby recorded at active burrow via motion camera 73
Figure 4.15 – Active Greater Bilby burrow where an individual was recorded 73
Figure 4.16 – Greater Bilby scat 74
Figure 4.17 – Fresh digging signs from Greater Bilby 74

Figure 4.18 – Wood Sandpiper recorded at Mount Jowlaenga homestead 75
Figure 4.19 – Rainbow Bee-eater recorded at nesting burrow via motion camera.....75
Figure 4.20 – Australian Bustard recorded 76
Figure 4.21 – Bush Stone-curlew recorded 76
Figure 4.22 – Conservation significant fauna recorded 77
Figure 4.23 – Locations of Greater Bilby evidence recorded during the survey 78
Figure 4.24 – Locations of potential SRE mygalomorph spiders recorded during the survey 79
Figure 4.25 – Locations of potential SRE scorpions and pseudoscorpions recorded during the survey80
Figure 4.26 – Locations of isopods, opilions and land snails recorded during the survey 81
Figure 4.27 – Locations of troglofauna recorded during the survey.....82
Figure 4.28 – Species accumulation curve for terrestrial vertebrates 84
Figure 4.29 – Species accumulation curve for birds.....84
Figure 4.30 – Species accumulation curve for SRE invertebrates 85
Figure 5.1 – Greater Bilby scats recorded 91
Figure 5.2 – Greater Bilby diggings in *Acacia tumida* root stock 92
Figure 5.3 – Representative image of *Lychas* 'JPP'.....98
Figure 5.4 – Representative image of the harvestmen *Dampetrus* sp.....99
Figure 5.5 – Representative image of the confirmed SRE *Rhagada bulgana* 101

APPENDICES

Appendix A Explanation of conservation codes.....112
Appendix B Daily weather data during the survey.....115
Appendix C Results of literature review and database searches.....117
Appendix D Survey site descriptions 147
Appendix E Voucher specimens lodged with WA Museum.....155
Appendix F Fauna recorded during the survey.....157
Appendix G Stygofauna drill hole Groundwater Physio-chemical results.....174

ACRONYMS

BoM	Bureau of Meteorology
CAMBA	China-Australia Migratory Bird Agreement
DEC	Department of Environment and Conservation (now DPaW or DER)
DPaW	Department of Parks and Wildlife (formerly DEC)
DoE	Department of the Environment (formerly DSEWPaC)
DoW	Department of Water
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (now DoE)
EIA	Environmental Impact Assessment
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
JAMBA	Japan-Australian Migratory Bird Agreement
SAC	Species Accumulation Curve
WC Act	*Wildlife Conservation Act 1950*

EXECUTIVE SUMMARY

Sheffield Resources Limited is a rapidly emerging mineral sands company with significant additional nickel, talc and iron assets, all located within the state of Western Australia. Sheffield are currently validating extensive historical work and undertaking biological surveys at an early stage to aid their project pathway. Sheffield commissioned *ecologia* Environment to undertake a two-phase, Level 2 terrestrial (vertebrate and SRE invertebrate) and subterranean fauna assessment of its Thunderbird Project, located 70 kilometres west of Derby on the Dampier Peninsula. Sheffield seeks to gain an understanding of the fauna of the Thunderbird study area, and identify the environmental values present.

The potential vertebrate fauna assemblage identified during the literature review comprised 39 mammal species, 234 bird species, 81 reptile species and 12 amphibian species. Of these potential species, seven mammal, 15 bird (excluding wetland and coastal dependent species) and two reptile species are listed as conservation significant. Thirty invertebrate species from SRE groups previously recorded on the Dampier Penisula were also identified during the literature review, but no subterranean fauna have yet to be recorded.

The two-phase survey was undertaken using a variety of techniques, both systematic and opportunistic, in accordance with relevant guidelines. In summary, the fauna survey effort consisted of the following:

Vertebrate fauna:

- seven trapping grids were open for 14 nights over two seasons;
- approximately 29 hours were spent surveying for birds;
- 20 hours and 20 minutes were spent on opportunistic diurnal searching;
- 35 hours and 15 minutes were spent on opportunistic nocturnal searching;
- 385 hours and 15 minutes of camera trapping data was analysed; and,
- 180 hours of acoustic (SM2Bat) recordings were analysed to determine bat assemblage and distribution.

SRE Invertebrate Fauna:

- six SRE dry pitfall trapping grids were open for six nights;
- seven vertebrate fauna trapping grids, with pitfalls that doubled as invertebrate traps, were open for 14 nights over two seasons; and,
- three leaf litter samples were taken from each of the SRE dry pitfall grids, totalling 18 samples.

Stygofauna:

- a total of 90 net hauls from 15 drill holes were sampled for stygofauna.

Troglofauna

- a total of 12 traps and 12 scraping hauls at six drill holes were sampled for troglofauna.

A total of three broad-scale terrestrial habitat types have been determined to exist within the study area; pindan shrubland, savannah woodland and sandstone range. None of the habitats recorded are regarded as rare or unique to the study area. Statistical analysis of the systematic survey data

did not indicate a significant difference between the three habitat types in terms of their respective vertebrate or SRE invertebrate fauna assemblages.

A total of 16 native mammals, two introduced mammals, 107 bird species (27 only recorded at the Mount Jowlaenga homestead), 43 reptile species and eight amphibians were recorded during the survey.

Nine species of conservation significant vertebrate fauna (two mammal and seven bird species) were recorded during the survey, with an additional four species assessed as having a medium or high likelihood of occurrence. Three of the recorded species are wetland dependent species, and only recorded at the Mount Jowlaenga homestead, adjacent to (outside) the study area. The six species recorded within the study area included the Greater Bilby (EPBC Act Vulnerable), Short-tailed Mouse (DPaW Priority 4), Fork-tailed Swift (EPBC Act Migratory), Rainbow Bee-eater (EPBC Act Migratory), Australian Bustard (DPaW Priority 4) and Bush Stone-curlew (DPaW Priority 4).

A total of 28 invertebrate taxa from six orders were submitted for identification and SRE status assessment. The results from the identifications showed one taxon is a confirmed SRE (the land snail *Rhagada bulgana*). This taxon has previously been recorded on the Dampier Peninsula. Additionally, 20 taxa are considered potential SREs (seven mygalomorph spiders, one pseudoscorpion, seven scorpions, one harvestmen, three slaters and one land snail). Due to the lack of regional surveys on the Dampier Peninsula, it is not possible to assess the true SRE status of these taxa from the available data. However, as the vegetation communities and landforms present within study area do not appear to be unique, it is unlikely that any of these taxa are geographically confined to the boundary of the proposed impact area.

Two specimens of troglofauna were collected during the troglofauna survey including one specimen of the centipede *Cryptops '*sp. indet.', and a specimen of rove beetle from the family Staphylinidae (Staphylinidae 'sp. indet.'). Both taxa are considered to be potential SREs; however, the continuous sandstone strata are expected to extend well beyond the study area.

Ten specimens of Naididae worms were collected during the stygofauna survey, and are classified as opportunistically stygal. The absence of obligate stygofauna suggests there is a low likelihood of a diverse and abundant stygofauna community within the study area.

Systematically obtained data was analysed to determine the survey adequacy through SACs. Extrapolation of the Michaelis-Menten (MM) curve suggests that 93.8% of trappable terrestrial vertebrate fauna (reptiles and mammals), 97.2% of birds and 77.2% of SRE invertebrate fauna were recorded. These results indicate that the majority of species were recorded for all fauna groups. However, increased sampling is likely to record additional species, particularly within the SRE invertebrate group.

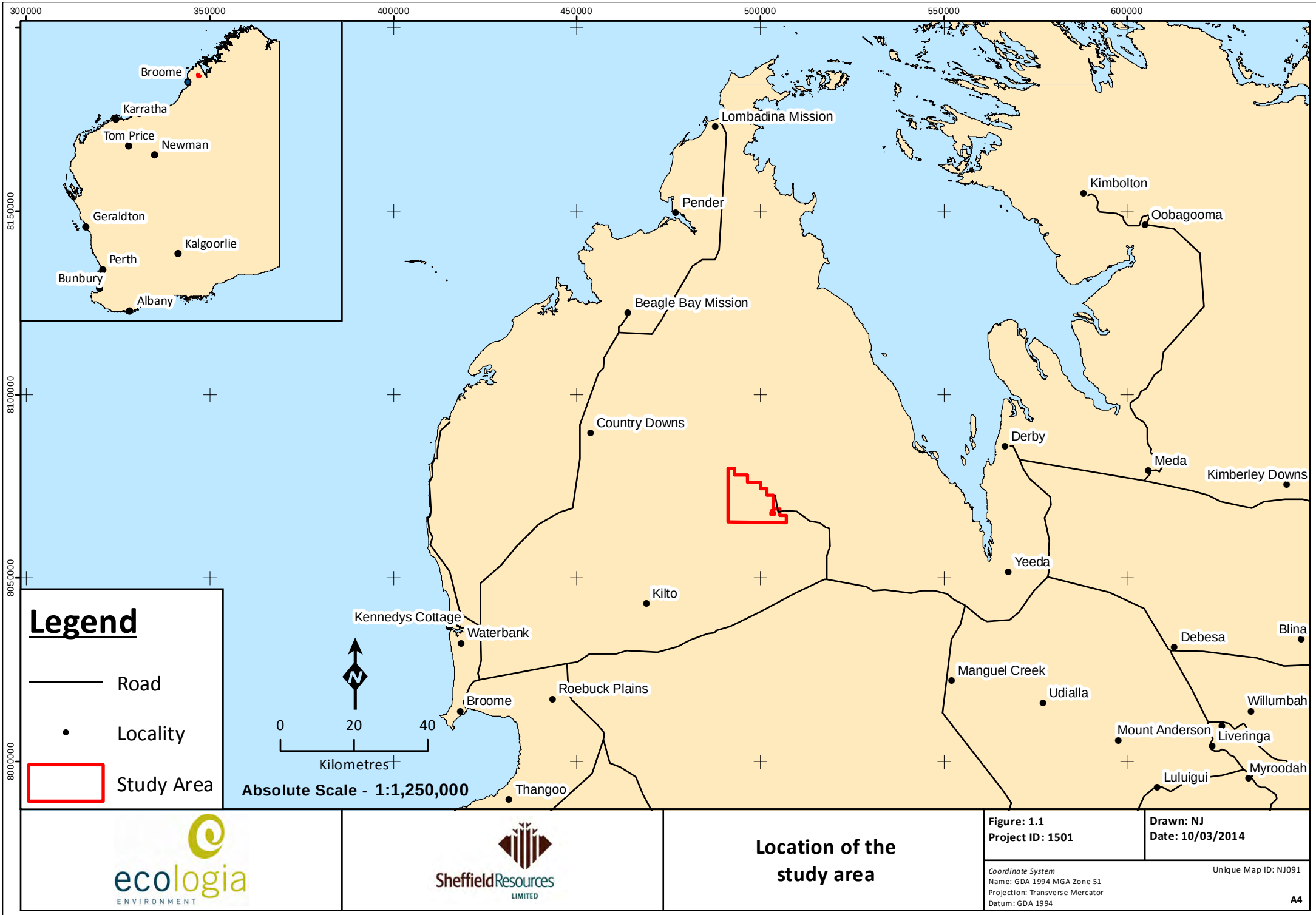
No significant limitations were experienced during the surveys. Given the lack of limitations and the fact that the majority of fauna were recorded, the surveys can be considered adequate and have met their objectives.

1 INTRODUCTION

1.1 PROJECT OVERVIEW

Sheffield Resources Limited (Sheffield) is a rapidly emerging mineral sands company with significant additional nickel, talc and iron assets, all located within the state of Western Australia. Sheffield are currently validating extensive historical work and undertaking biological surveys at an early stage to aid their project pathway.

Sheffield commissioned *ecologia* Environment (*ecologia*) to undertake a two-phase, Level 2 terrestrial (vertebrate and short range endemic (SRE) invertebrate) and subterranean fauna survey of its Thunderbird Project, located 70 kilometres west of Derby on the Dampier Peninsula (Figure 1.1). Sheffield seeks to gain an understanding of the fauna that occurs in the Thunderbird area (study area), and identify the environmental values present.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Bunbury
Albany
Lombadina Mission
Pender
Kimbolton
Oobagooma
Beagle Bay Mission
Country Downs
Derby
Meda
Kimberley Downs
Yeeda
Kilto
Kennedys Cottage
Waterbank
Debesa
Blina
Manguel Creek
Roebuck Plains
Udialla
Broome
Willumbah
Mount Anderson
Liveringa
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Locality
Study Area
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Location of the study area
Figure: 1.1
Project ID: 1501
Drawn: NJ
Date: 10/03/2014
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: NJ091
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1.2 LEGISLATION AND POLICY

The *Environmental Protection Act 1986* (EP Act) is "an Act to provide for an Environmental Protection Authority, for the prevention, control and abatement of environmental pollution, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing." Section 4a of this Act outlines five principles that are required to ensure that the objectives of the Act are addressed. Three of these principles are relevant to native fauna and flora:

- *The Precautionary Principle*

  Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

- *The Principle of Intergenerational Equity*

  The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

- *The Principle of the Conservation of Biological Diversity and Ecological Integrity*

  Conservation of biological diversity and ecological integrity should be a fundamental consideration.

In addition to these principles, projects undertaken as part of the Environmental Impact Assessment (EIA) process are required to address guidelines produced by the Environmental Protection Authority (EPA). In this case, principles outlined in following guidelines:

- Guidance for the Assessment of Environmental Factors, Statement No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004);
- *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010)*;*
- Guidance for the Assessment of Environmental Factors, Statement No. 20: *Sampling of Short range endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009);
- Environmental Assessment Guideline No. 12: *Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia* (EPA 2013);
- Guidance for the Assessment of Environmental Factors, Statement No. 54a (Technical Appendix to Guidance Statement 54 - superseded by Environmental Assessment Guideline No. 12): *Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (EPA 2007); and,
- EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002b).

In relation to terrestrial SRE fauna, EPA Guidance Statement No. 56 states that:

> *"Comprehensive systematic reviews of different faunal groups often reveal the presence of short range endemic species (Harvey 2002). Among the terrestrial fauna there are numerous regions that possess short range endemics. Mountainous terrains and freshwater habitats often harbour short range endemics, but the widespread aridification and forest contraction that have occurred since the Miocene has resulted in the fragmentation of populations and the evolution of many new species. Particular attention should be given to these types of species in environmental impact assessment because habitat loss and degradation will further decrease their prospects for long-term survival."*

The State is committed to the principles and objectives for the protection of biodiversity as outlined in *The National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth Government 1996).

Native flora and fauna formally recognised as rare, threatened with extinction, or as having high conservation value are protected at a Commonwealth level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and at a state level under the *Wildlife Conservation Act 1950* (WC Act).

The EPBC Act also takes into consideration four international agreements related to migratory species which include the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), the Japan-Australian Migratory Bird Agreement, the China-Australia Migratory Bird Agreement and the Republic of Korea-Australian Migratory Bird Agreement.

The EPBC Act provides for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance, to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources, and to promote the conservation of biodiversity. The EPBC Act includes provisions to protect native species (and in particular to prevent the extinction and promote the recovery of threatened species) and to ensure the conservation of migratory species. In addition to the principles outlined in Section 4a of the EPBC Act, Section 3a includes a principle of ecologically sustainable development dictating that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. Schedule 1 of the EPBC Act contains a list of species that are considered Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable and Conservation Dependent. Definitions of categories relevant to fauna occurring or potentially occurring in the project area are provided in Appendix A.

The Western Australian WC Act provides for the conservation and protection of wildlife in Western Australia. Under Section 14 of this Act, all flora and fauna within Western Australia is protected; however, the Minister may, via a notice published in the *Government Gazette*, declare a list of fauna identified as rare, likely to become extinct, or otherwise in need of special protection (Appendix A). These species are considered Threatened Fauna. The current listing was gazetted on 17 September 2013.

In addition, the Department of Parks and Wildlife (DPaW), maintains a ranked list of specially protected fauna, which includes Threatened Fauna and Priority Fauna. These rankings dictate which species should receive the highest priority for conservation management. Threatened fauna that are listed as Schedule 1 under the WC Act are further ranked by the DPaW according to their level of threat using IUCN Red List categories and criteria. Schedule 1 species can be ranked as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU).

Priority Fauna are placed into five categories. The first three Priority Fauna categories are species that have not yet been adequately surveyed to be listed under Schedule 1 or 2, and are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna. Species that are adequately known and are rare but not threatened, meet IUCN criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Species meeting criteria for the IUCN category of Conservation Dependent are placed in Priority 5. The three Threatened Fauna codes and five Priority codes are also summarised in Appendix A.

Some better known SRE species are listed as threatened or endangered under State or Commonwealth legislation in the WC Act and/or EPBC Act, but the majority are not. Often the lack of knowledge about these species precludes their consideration for listing as threatened or

endangered. Listing under legislation should therefore not be the only conservation consideration in environmental impact assessment.

1.3 SURVEY OBJECTIVES

Sheffield commissioned *ecologia* to undertake a comprehensive survey of the terrestrial and subterranean fauna of the Thunderbird study area to facilitate the EIA of the project. Faunal groups assessed include vertebrate fauna, terrestrial epigean SRE invertebrate fauna, troglofauna and stygofauna.

The aim of this study was to document and describe the fauna of the study area and provide sufficient information to enable an assessment of the impact of the project on fauna populations.

This report satisfies the requirements of relevant EPA Guidance documents by providing:

- a review of background information (including literature and database searches);
- an inventory of fauna species occurring in the study area, incorporating recent published and unpublished records;
- a discussion related to the species of biological and conservation significance recorded or likely to occur within the project area and the surrounding region;
- a description of fauna habitats occurring in the study area;
- a description of the characteristics of the invertebrate and vertebrate fauna assemblage;
- an appraisal of the current knowledge base for the area, including a review of previous surveys conducted in the area that are relevant to the current study; and,
- a review of regional and biogeographical significance, including the conservation status of species recorded in the study area.

1.4 BACKGROUND SUMMARY OF FAUNA GROUPS

1.4.1 Terrestrial fauna

1.4.1.1 Terrestrial vertebrate fauna

Australia's terrestrial vertebrate fauna assemblages include reptiles (917 species), birds (828 species), amphibians (227 species) and mammals (386 species), the latter of which is dominated by marsupials, bats, and rodents (Chapman 2009). The majority (80%) of Australia's terrestrial vertebrate fauna are endemic to Australia, with many species restricted to small areas or regions. Endemism refers to the restriction of species to a particular area, whether it is at a continental, national or local level (Allen *et al.* 2002). The cause of the high level of endemism in Australia is attributed to its long period of geographic isolation after the dividing of Gondwana.

Australia's vertebrate fauna, in particular mammal and bird species, have experienced a high rate of decline and extinction over the last two hundred years (Johnson 2006) with approximately 30 species of mammals and birds becoming extinct. A further 57 species of mammals, birds, reptiles, frogs and fish are considered endangered and likely to become extinct in the near future (Johnson 2006).

Changes in fire regime and the introduction of feral animals, such as the European Red Fox and the Cat, have also resulted in a decrease and the extinction of several species (Short and Smith 1994). A number of ground-dwelling birds, such as the Night Parrot and the Ground Parrot, and small to medium sized mammals (Lesser Greater Bilby and Greater Stick-nest Rat) have reduced drastically in numbers or even become extinct. With the onset of progressively more impact by human activity, already rare fauna species that are generally restricted to a particular habitat or microhabitat, have

been identified and protected to preserve existing populations within their habitat (Brown and Saunders 2013).

1.4.1.2 Terrestrial invertebrate fauna (Short Range Endemics)

Invertebrate fauna are characterised by the lack of a vertebral column. The vast majority of animal species are invertebrates with over 90% of all fauna belonging to this group.

This review focuses on SREs, outlines the major paths to short range endemism, the current knowledge of short range endemism in Australia and the conservation significance of such species. It is important to note that the individual taxa and broader groups discussed are not an exhaustive list of all SREs. This is due to the fact that SREs are dominated by invertebrate species, which are historically understudied and in many cases lack formal descriptions. An extensive, reliable taxonomic evaluation of these species has begun only relatively recently and thus the availability of literature relevant to SREs is relatively scarce.

Short range endemism is influenced by numerous processes, which generally contribute to the isolation of a species. A number of factors, including the ability and opportunity to disperse, life history, physiology, habitat requirements, habitat availability, biotic and abiotic interactions, and historical conditions, influence not only the distribution of a taxon, but also the tendency for differentiation and speciation (Ponder and Colgan 2002).

Many SREs are considered to be relict taxa (remnants of species that have become extinct elsewhere) and are confined to certain habitats, and in some cases, single geographic areas (Main 1996). Relict taxa include extremely old species that can be traced back to Gondwanan periods (180-65 million years ago) and have a very restrictive biology (Harvey 2002).

With the onset of progressively dryer and more seasonal climatic conditions since this time, suitable habitats have become increasingly fragmented in Western Australia. Relict species now generally persist in habitats characterised by permanent moisture and shade, maintained by high rainfall and/or prevalence of fog (Main 1996; Main 1999). However, hundreds of species of invertebrate are considered under threat and may soon become extinct.

1.4.2 Subterranean fauna

Subterranean fauna are characterised by the following traits (from Cho 2010):

- high endemism but low local diversity relative to regional diversity;
- a relatively small number of genetic lineages resulting in species dissimilar in appearance to related groups;
- many relicts from previous climatic conditions; and,
- truncated food webs.

Traditionally, arid and semi-arid areas were considered poor potential habitat for subterranean fauna as these organisms are moisture-dependent (Harvey *et al.* 2008). However, recent descriptions of subterranean fauna in the arid and semi-arid zone of WA have indicated the presence of a diverse fauna, with an estimate of 4,140 subterranean taxa found in the western half of Australia (Biota 2008). A total of 403 species has been described to date and additional 367 are known but undescribed (EPA 2012). Based on this estimate, over 80% of the subterranean fauna likely to be present has not yet been documented (Biota 2008).

1.4.2.1 Stygofauna

Stygofauna are generally thought of as fauna that live in subterranean water, and comprise three groups that relate to the species' affinity with groundwater. Stygofauna occurring in groundwater are either accidentals (*stygoxenes*) or with varying degrees of affinity for groundwater, inhabiting it on a permanent or temporary basis (*stygophiles*), but only *stygobites* are obligate inhabitants of groundwater (Gilbert *et al.* 1994)..

The subterranean environment is devoid of light, may have restricted available space (i.e. porous or fissured rock) and has a relatively constant temperature. These species have evolved unique features such as a lack of pigmentation, elongated appendages, filiform body shape (worm like) and reduced or absent eyes. Many species are believed to be relict taxa with affinities with Tethys, Pangea and derived landmasses (Humphreys 1993; Knott 1993; Danielopol and Stanford 1994; Humphreys 1999, 2001).

Stygofauna are known to be present in the groundwater associated with a variety of geologies. These include (but are not limited to) calcrete aquifers associated with palaeochannels, hematite sandstone aquifers (e.g. Koolan Island), clay-sandstone aquifers on the Swan and Scott Coastal Plains (ecologia 1998; Humphreys 2001; *ecologia* 2006a, b; Rockwater 2006), porous aquifers (e.g. alluvium) (Mamonier *et al.* 1993), fractured-rock aquifers, springs and hyporheic habitats (Eberhard *et al.* 2005). However, distribution patterns of stygofauna are determined by hydrogeological aquifer types rather than by affiliation of aquifers to a given geological unit. Two main types of aquifer relevant for stygofauna have been defined by Hahn and Fuchs (2009):

1. Compact aquifers (aquitard), comprise materials such as clay, loess, and very fine sands, as well as compact rocks, which have reduced pore spaces and thus a low hydraulic conductivity (kf < 10 -6 m sec-1). Exchange with surface water for food and oxygen supply is reduced and living space is minimal in this type of aquifer, which is why these aquifers are either devoid of fauna or have depleted taxonomic richness and abundance.
2. Open aquifers, comprise of porous, fractured and karstic groundwater circulation systems with at least moderate hydraulic conductivity (kf > 10 -6 m sec-1). There is continuous exchange with surface water for food and oxygen supply and more abundant living space, which is why stygofauna communities are often found in this aquifer type (Hahn and Fuchs 2009). In addition, communities of porous and karstic aquifers have been found to be more similar to each other than the communities of compact and fractured aquifers (Hahn and Fuchs 2009).

Stygofauna are found in oxygenated groundwater, usually ranging from fresh to hyposaline, but they can occur in salinities up to seawater (EC = 54,000 µS/cm) (Humphreys 1999). Recent experience west of Lake Way near Wiluna has recently shown that palaeochannel aquifers with an EC of 60,000 uS/cm can harbour diverse and abundant stygal assemblages (*ecologia* 2006a).

The presence of stygofauna in Western Australia has been well documented, especially from regions such as the Pilbara and Kimberley, and less so in the Midwest and South West regions of WA (De Laurentiis *et al.* 2001; Humphreys 2001; Wilson and Keable 2002; Eberhard 2004; Karanovic 2004; Cho *et al.* 2005). Australian stygofauna is dominated by crustaceans including Amphipoda (Bradbury and Williams 1997), Isopoda (Wilson 2001), Ostracoda (Karanovic and Marmonier 2002; Martens and Rossetti 2002; Karanovic and Marmonier 2003; Karanovic 2005) and Speleogriphacea (Poore and Humphreys 1998; Poore and Humphreys 2003).

1.4.2.2 Troglofauna

Troglofauna are terrestrial subterranean animals that inhabit air chambers in underground caves or small, humid voids. They are divided into three ecological categories (Howarth 1983):

- troglobites, obligate underground species that are unable to survive outside their subterranean environment;
- troglophiles, facultative species that live and reproduce underground but that are also found in similar dark, humid microhabitat on the surface; and,
- trogloxenes, species that regularly inhabit underground caves and cavities for refuge but normally return to the surface environment to feed.

A fourth group, 'accidentals', are vagrant individuals that might have wandered into a cave system but cannot survive there (Howarth 1983).

A species is considered truly troglobitic if it displays characteristics that appear to restrict it to subterranean habitats (Howarth 1983, 1993). These include a significant reduction or a complete loss of eyes, pigmentation, wings and circadian rhythm (24-hour biological cycle), as well as development of elongated appendages, slender body form and, in some species, a lower metabolism.

True troglobites are often spatially restricted because they are incapable of dispersing on the surface. Troglobitic species have extremely limited capacity for dispersal and are typically isolated within the extent of their habitat. Such dispersal limitations result in extremely small, fragmented species ranges and high levels of endemism (EPA 2003), and are a typical characteristic of subterranean fauna worldwide (Strayer 1994).

The presence of troglofauna in Western Australia is still poorly documented. To date, troglofauna have been recorded from karst limestone systems at Cape Range, Barrow Island and in the Kimberley (Harvey 1988; Humphreys 2001; Biota 2005), pisolitic mesa formations in the Pilbara (Biota 2006) and in the cave systems of Yanchep (EPA 2005), Margaret River (Eberhard 2006) and across the Nullarbor (Moore 1995).

2 ENVIRONMENT

2.1 CLIMATE

The study area is situated in the Kimberley region of Western Australia at the south-east edge of the Dampier Peninsula. The area has a dry, hot, tropical climate with two distinct seasons: the 'wet' from around December to March, and the 'dry' for the remainder of the year. Rainfall is highly variable in the region due to the inconsistent nature of the movement and occurrence of thunderstorms and tropical systems. Tropical cyclones can occur as late as April, but are most common in January and February. Rainfall during the cooler months is usually associated with cloud bands originating from tropical waters to the north-west (BoM 2013). The average temperature over summer is over 33 °C, with warm overnight minima of around 26 °C (BoM 2013). Winter temperatures are quite mild, with average maximum and minimum temperatures in July being 26.9 °C and 12.0 °C respectively (BoM 2013).

The Bureau of Meteorology (BoM) weather stations (with full data sets) closest to the study area are Derby Aero (BoM Station 3032) and Broome Airport (BoM Station 3003). Derby Aero is located 70 km east of the study area, with Broome Airport located 95 km to the south-west. These stations were selected as a reference to provide the best indication of the local climatic conditions of the study area (Figure 2.1)

The mean annual rainfall for Broome is 607.3 mm, but is highly variable with over 75% of the annual rainfall usually falling between January and March (BoM 2013). The mean number of rainfall days (≥1 mm) per year is only 35.1. Generally, the wettest month is February, with a mean of 179.1 mm falling over an average of 9.1 rainfall days. The hottest month is April and the coldest is July, with means of 34.3 °C and 28.8 °C, respectively (Table 2.1).

The mean annual rainfall for Derby is 690.8 mm, with over 75% of the annual rainfall usually falling between January and March (BoM 2013). The mean number of rainfall days (≥1 mm) per year is 38. January and February are generally the wettest months of the year, both recording a mean of 200.3 mm over an average of 10.1 and 9.7 rain days respectively. The hottest month is November and the coldest is June, with means of 38.0°C and 30.4°C, respectively (Table 2.1).

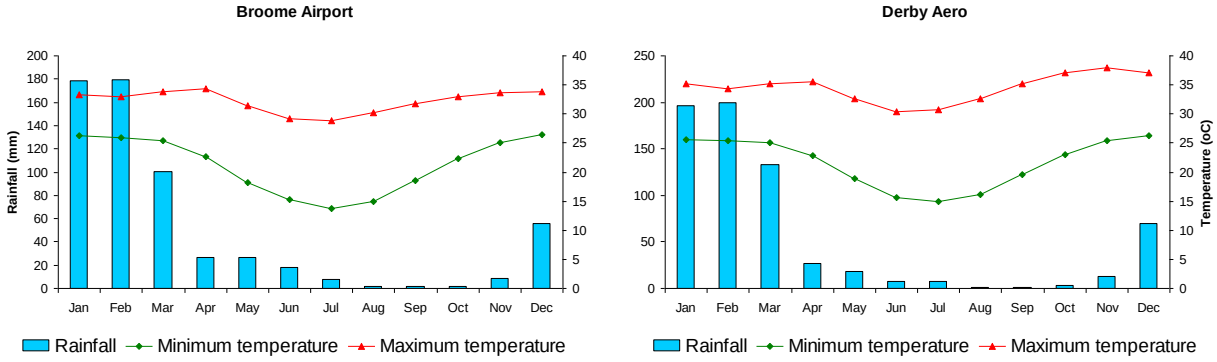


Figure 2.1 – Climate data for Broome Airport and Derby Aero Weather Stations (BoM 2013)

The weather conditions experienced during the field survey are presented in Appendix B. Both phases of the survey were conducted during hot and humid conditions with a small amount of rainfall (approx. 5 mm) at the start of the first phase.

Table 2.1 – Annual climate data for Broome Airport and Derby Aero weather stations (BoM 2013)

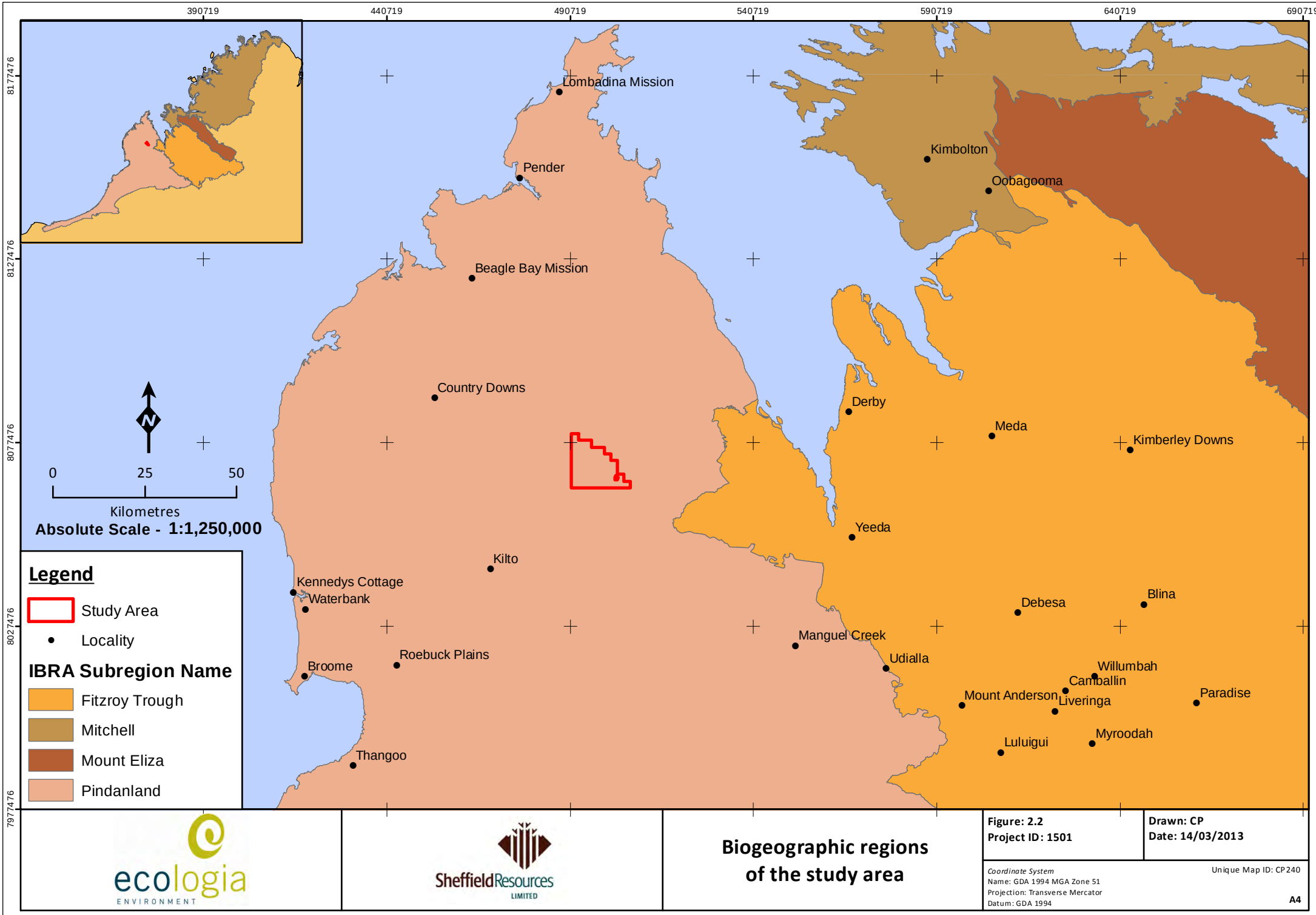
Broome Airport (003003)				**Commenced: 1939**					**Last record: 2012**				
51K 419520 8015182									**Elevation: 7 m**				
Derby Aero (003032)				**Commenced: 1951**					**Last record: 2012**				
51K 570115 8079392									**Elevation: 6 m**				
	Jan 13	**Feb 13**	**Mar 13**	**Apr 13**	**May 13**	**Jun 13**	**Jul 13**	**Aug 13**	**Sep 13**	**Oct 13**	**Nov 13**	**Dec 13**	**Annual**
Mean maximum temperature (^{o}C)													
BME	33.3	32.9	33.9	34.3	31.5	29.1	28.8	30.3	31.8	32.9	33.6	33.8	32.3
DBY	35.2	34.3	35.1	35.5	32.7	30.4	30.6	32.6	35.2	37.0	38.0	37.1	34.5
Mean minimum temperature (^{o}C)													
BME	26.3	26.0	25.4	22.6	18.2	15.2	13.7	14.9	18.5	22.3	25.1	26.5	21.2
DBY	25.6	25.4	25.0	22.7	18.8	15.6	14.7	16.0	19.6	23.0	25.4	26.3	21.5
Mean rainfall (mm)													
BME	178.5	179.1	102.8	26.4	26.0	17.5	7.2	1.7	1.4	1.4	8.9	55.6	607.3
DBY	200.3	200.3	135.8	26.1	17.8	7.7	7.6	0.8	1.1	2.6	12.8	70.1	690.8

Source: BoM (BoM 2013)

2.2 BIOGEOGRAPHY

The Interim Biogeographic Regionalisation for Australia (IBRA Version 7, Australian Government Department of Sustainability 2012) classifies the Australian continent into regions (bioregions) of similar geology, landform, vegetation, fauna and climate characteristics (DSEWPaC 2012). The study area lies within the Dampierland bioregion. The Dampierland bioregion is further divided into two subregions, these being the Fitzroy Trough (DL1) and Pindanland (DL2) subregions. The study area lies entirely within the Pindanland subregion of the Dampierland Bioregion (Figure 2.2).

The Pindanland subregion covers approximately 59% of the Dampierland bioregion (Figure 2.2). This subregion consists of sandplains of a fine-textured sand-sheet with subdued dunes and includes the paleodelta of the Fitzroy River. The vegetation is described primarily as pindan (Graham 2002). The dominant land uses are grazing, unallocated crown land, crown reserves and native pastures.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Kimberley Downs
Yeeda
Kilto
Kennedys Cottage
Waterbank
Debesa
Blina
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Figure: 2.2
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Drawn: CP
Date: 14/03/2013
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
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2.3 LAND SYSTEMS

Land systems are described using the biophysical characteristic of geology, landform, vegetation and soils. The study area falls across four of these land systems (Figure 2.3), of which details are provided in Table 2.2 below.

Table 2.2 – Land systems of the study area

Land System	Description	Total area in Dampierland (ha)	Total area within Thunderbird study area (ha)	Percentage of land system in Thunderbird study area	Percentage of land system in Dampierland impacted
Fraser	Sand plain with irregular dunes and local stony surfaces, pindan and low grassy woodlands.	73,275	4,488.17	30.16%	6.13%
Reeves	Sand plain with scattered hills and minor plateaux, reddish sandy soils, pindan.	44,794	4,647.52	31.23%	10.38%
Waganut	Low lying sandplains and dune fields with through going drainage supporting pindan *Acacia* shrublands with emergent eucalypt trees.	518,511	3,011.66	20.24%	0.58%
Yeeda	Sandplains with red and yellow sands supporting pindan *Acacia* shrublands with emergent eucalypt trees.	1,653,086	2,734.03	18.37%	0.17%

2.3.1 Fraser Land System

The Fraser land system is characterised by sandplains and dunes with pindan woodlands and spinifex/tussock grasslands. Geologically, it is comprised of quaternary Aeolian sand with minor outcrops of gentle dipping Cretaceous sandstone.

2.3.2 Reeves Land System

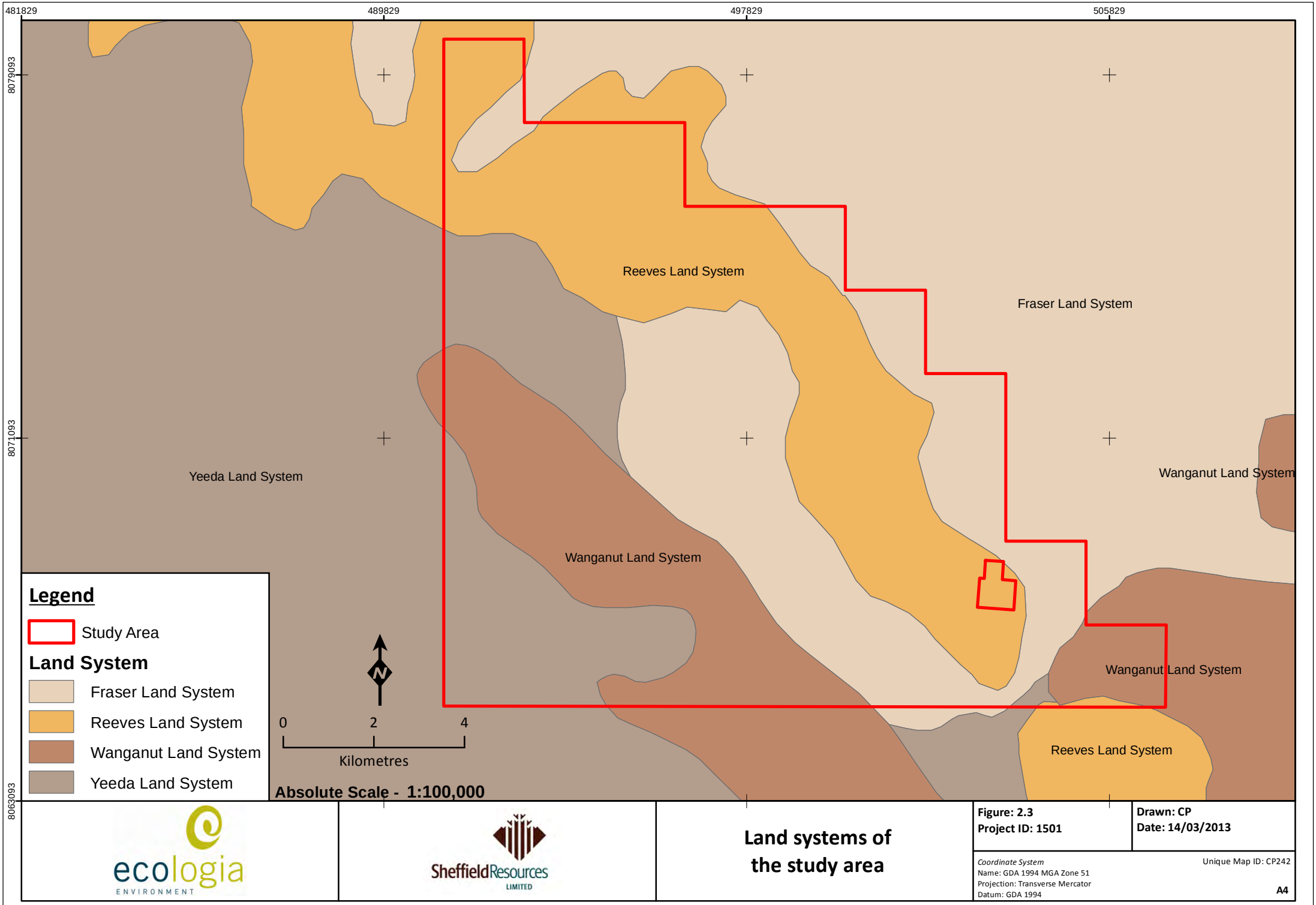
The Reeves land system is characterised by sandplains and scattered hills and minor plateaux, with pindan woodlands and spinifex/tussock grasslands. The geological formation is subhorizontal or gently dipping sandstone, sandy siltstone and silicified quartz sandstone of Cretaceous age, with Quaternary Aeolian sand. Pindan vegetation can be subject to frequent fires, which induce short term changes in botanical composition, density and structure. The sandplains have minor susceptibility to wind erosion immediately after fire but stabilise rapidly after rain.

2.3.3 Waganut Land System

The Waganut land system is characterised by low-lying sandplains and dunefields with through-going drainage, with pindan woodlands and spinifex/tussock grasslands. Its geological formation is made up of quaternary Aeolian sands. Vegetation is primarily dense wattle shrub with pindan pastures and is subject to fairly frequent fires, which induce short term changes in botanical composition, density and structure.

2.3.4 Yeeda Land System

The Yeeda land system is made up of sandplains and occasional dunes with shrubby spinifex grasslands or pindan woodlands. Geologically, it is comprised of quaternary Aeolian sands. It is generally not prone to degradation or erosion.



ecologia ENVIRONMENT

Sheffield Resources LIMITED

Land systems of the study area

Figure: 2.3
Project ID: 1501

Drawn: CP
Date: 14/03/2013

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP242

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2.4 VEGETATION

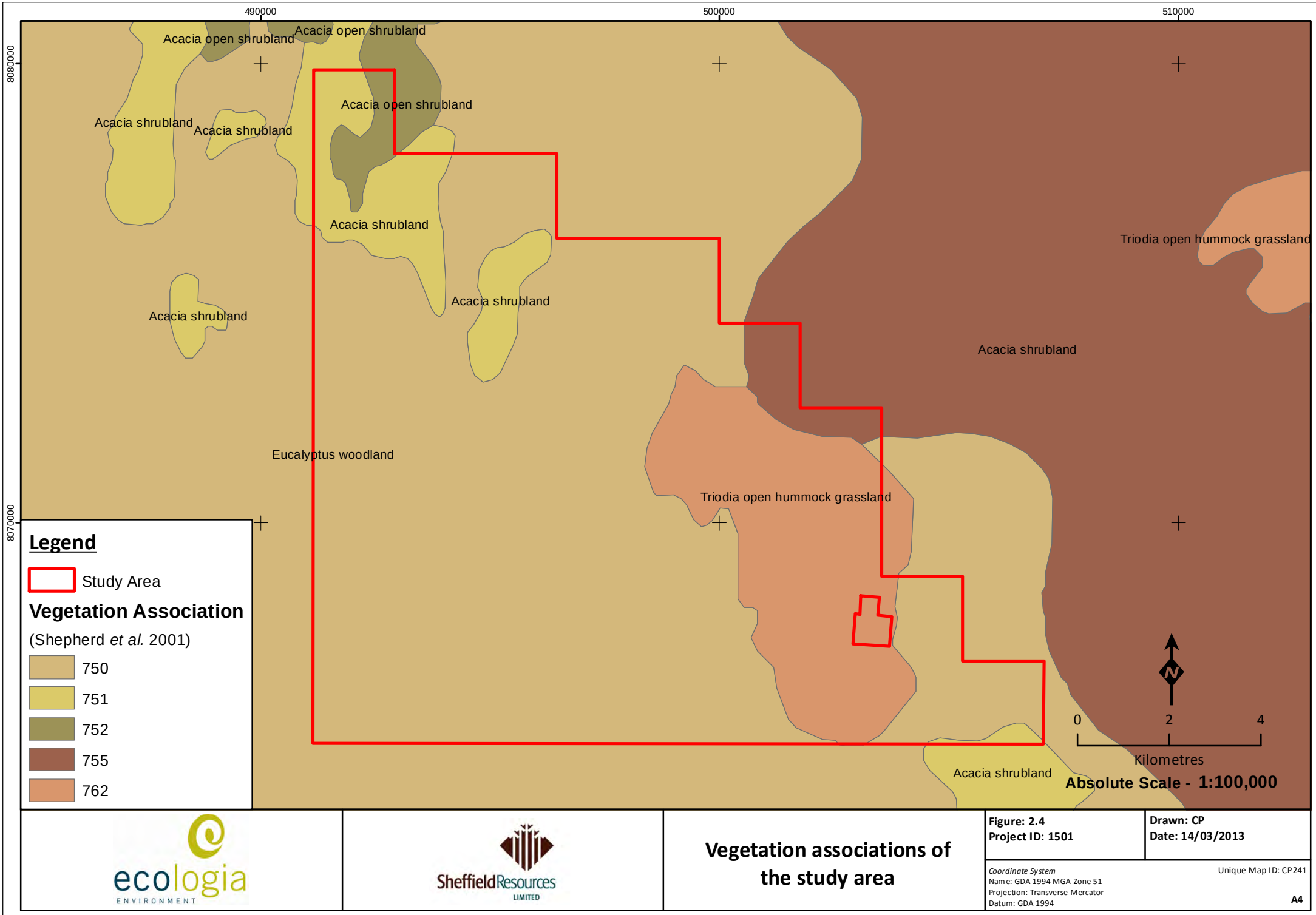
The Dampier Peninsula on which the study area is located lies within the Northern Botanical Province. The vegetation of Western Australia was originally mapped at the 1:1,000,000 scale by Beard (1979), and was subsequently reinterpreted and updated to reflect the NVIS standards (Shepherd *et al.* 2002). Five of the vegetation types identified by Shepherd *et al.* (2002) are found within the study area: Vegetation associations 750, 751, 752, 755 and 762. The majority of the study area (71.93%) consists of vegetation association 750, whereas vegetation association 752 is the least extensive, representing only 1.44% (Figure 2.4, Table 2.3).

Vegetation associations 750, 755 and 762 collectively comprise 91.04% of the study area. They are also described as having similar vegetation; typically that of pindan shrubland with *Acacia tumida* and other Acacia species, with open Eucalypt woodlands over ribbon grass and curly Spinifex (Shepherd *et al.* 2002). The other two vegetation associations (751 and 752) are also described similarly; they support hummock grasslands of Spinifex with *Acacia eriopoda* or *Acacia tumida* (Shepherd *et al.* 2002).

In a regional context, although over 70% of the study area comprises vegetation association 750, this is a common and widespread association, and represents only 0.88% of its total area within the Dampierland Bioregion (Table 2.3). Vegetation associations 751, 752 and 755 have smaller total areas, but none cover more than 7% of the study area. The smallest vegetation association is 762, so that 46.6% of its total occurs within the study area. However, this vegetation association is very similar to associations 750 and 755, so potential impacts to it should have minimal effect on local fauna habitat availability.

Table 2.3 – Vegetation associations of the study area

Vegetation Association	Description	Total area in the Dampierland Bio-region (ha)	Percentage of the total unit in the study area (%)	Total area in the Thunderbird study area (ha)	Percentage of the Thunderbird study area (%)
750	Shrublands, pindan; *Acacia tumida* shrubland with grey box & cabbage gum medium woodland over ribbon grass & curly Spinifex	1,232,039.34	0.88	10,812.22	71.93
751	Hummock grasslands, shrub steppe; *Acacia eriopoda* over soft Spinifex	16,193.97	6.97	1,128.19	7.5
752	Hummock grasslands, shrub steppe; *Acacia tumida* over *Triodia intermedia*	6,842.85	3.18	217.62	1.44
755	Shrublands, pindan; *Acacia tumida* & *A. oimpressa* shrubland with scattered low bloodwood & *Eucalyptus setosa* over ribbon & curly Spinifex	62,084.58	0.57	356.13	2.37
762	Shrublands, pindan; *Acacia eriopoda & A. tumida* shrubland with scattered low *Eucalyptus confertifolia* over curly Spinifex	5,401.68	46.6	2,516.96	16.74


490000
500000
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Acacia open shrubland
Acacia open shrubland
Acacia open shrubland
Acacia shrubland
Acacia shrubland
Acacia shrubland
Acacia shrubland
Acacia shrubland
Triodia open hummock grassland
Acacia shrubland
Eucalyptus woodland
Triodia open hummock grassland
Acacia shrubland
Legend
Study Area
Vegetation Association
(Shepherd et al. 2001)
750
751
752
755
762
N
0
2
4
Kilometres
Absolute Scale - 1:100,000
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ENVIRONMENT
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LIMITED
Vegetation associations of the study area
Figure: 2.4
Project ID: 1501
Drawn: CP
Date: 14/03/2013
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: CP241
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2.5 GEOLOGY, SOILS AND HYDROGEOLOGY

2.5.1 Geology and Soils

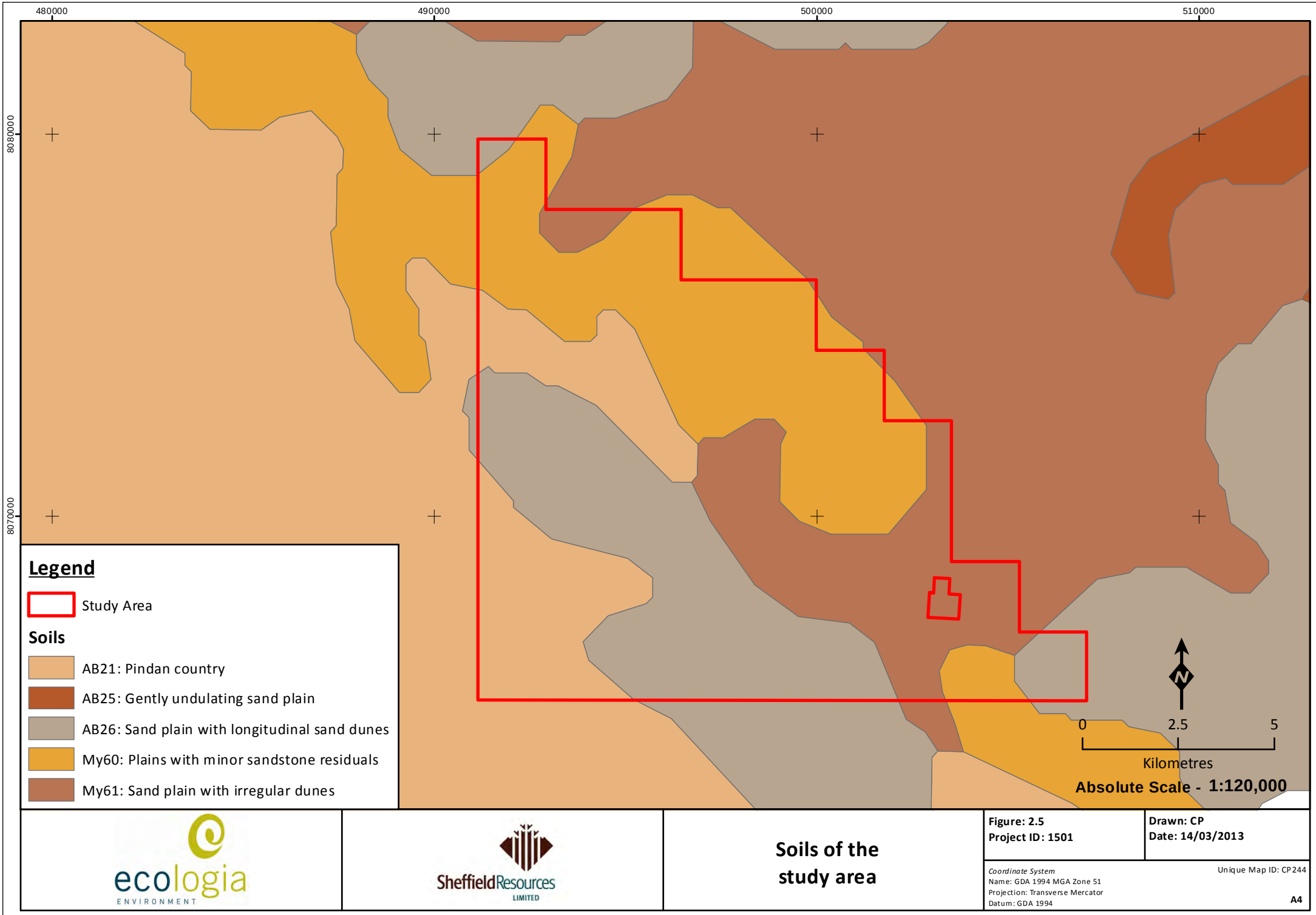
The Pindanland biogeographic subregion is situated on the north-western margin of the Canning Basin. This subregion is mainly quaternary sandplains over Jurassic and Mesozoic sandstones with pindan, as well as quaternary marine deposits on coastal plains and quaternary alluvial plains related to the Permian and Mesozoic sediments of the Fitzroy Trough (Graham 2001).

The Dampier Peninsula is underlain by Phanerozoic rocks in the north-west of the Canning Basin. The study area lies within a single geological unit (K), described as sedimentary rocks from the Cretaceous period (Hickman and Kranendonk 2008). The major soil type on the Peninsula is pindan, which developed during the Quaternary period (the past two million years) on desert dune sandstone (Figure 2.5). The pindan soils form extensive undulating plains with little or no organised surface drainage. When the pindan soils dry out, they become very hard with a dusty surface, and become soft and greasy when wet, with the potential to erode rapidly and form deep, steep-sided gullies (Kenneally *et al.* 1996). Based on the Atlas of Australian Soils (Bettenay *et al.* 1967), the dominant soil types within the study area comprise:

- AB21 - Pindan country; gently undulating sand plain with a few small rocky sandstone residuals; no external drainage: chief soils are red earthy sands with associated and hummocks of siliceous sands (18.86% of study area).
- AB26 - Sand plain with longitudinal sand dunes and some active drainage-ways: chief soils are red earthy sands associated with (Uc5.22) and (Uc5.1 l) soils on the plains, with dunes and hummocks of red sands. Some (Gn2.21) and (Dy5.32) soils occur in lower sites often with a heavy surface layer of ferruginous gravel (29.04% of study area).
- My60 - Plains with minor sandstone residuals on which there is extensive rock outcrop: main soils on the plains are neutral red earths and sandy neutral red soils (32.10% of study area).
- My61 - Sand plain with irregular dunes; active drainage systems: chief soils are neutral red earths and red earthy sands. Associated are deep red sand dunes and (Uc1.23). Some (Dy5.42) soils occur in low-lying areas. (20% of study area).

2.5.2 Hydrogeology

There are two groundwater resources present within the Dampier Peninsula; the unconfined Broome Sandstone aquifer and the extensive Wallal Sandstone aquifer, which is unconfined in the east (outside the Pindanland subregion), and confined and artesian on the Peninsula's west coast (Department of Water, 2010). The groundwater system is strongly connected to surface water expression in the form of mound springs, wetlands and small drainage lines in coastal areas, where groundwater discharge occurs from perched unconfined aquifers (DoW 2010). Drainage is poorly developed within the Dampier Peninsula with the main drainage pattern being sheet flooding, with much of the water infiltrating to groundwater (DoW 2012). There are numerous ephemeral creeks, with two main water courses: the Fraser River and Deep Creek.



ecologia ENVIRONMENT

Sheffield Resources LIMITED

Soils of the study area

Figure: 2.5
Project ID: 1501

Drawn: CP
Date: 14/03/2013

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CP244

A4

2.6 PREVIOUS SURVEYS AND LAND USE

Several databases were consulted in the preparation of potential fauna (and conservation significant fauna) lists, with search buffers around the Thunderbird study area ranging from 20–50 km (Table 2.4). In addition, 13 reports on various fauna surveys conducted on the Dampier Peninsula were consulted (Table 2.5). The locations of these surveys in relation to the study area are shown (Figure 2.6), and the results of all database searches and previous surveys are presented in Appendix C. As Figure 2.6 demonstrates, few of the previous regional surveys were near the study area, with the majority occurring along the western coastline of the peninsula. The online NatureMap database encompasses several datasets which include the WA Museum (WAM), DPaW threatened fauna database and DPaW survey return database.

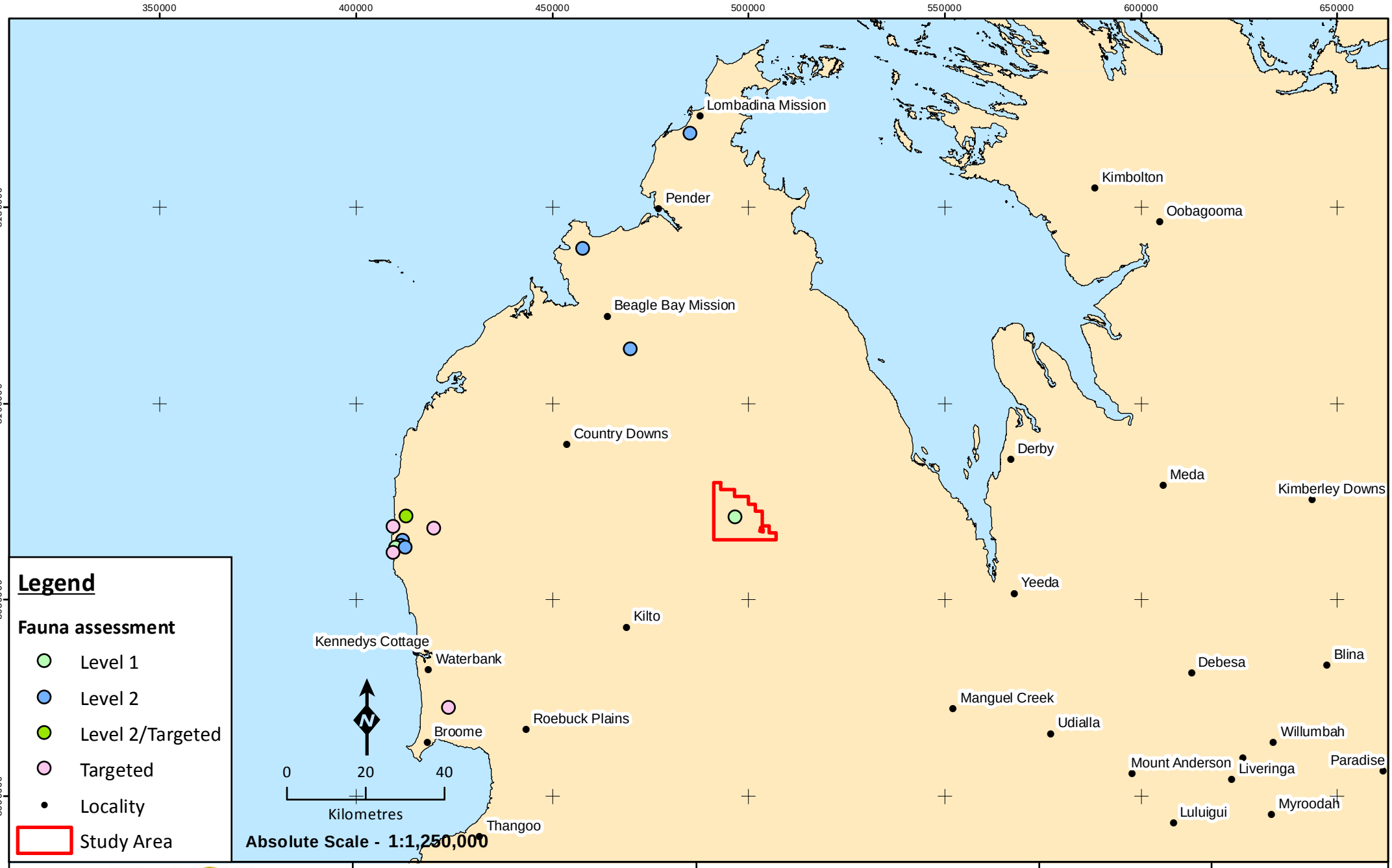
The study area is currently and historically used for pastoral purposes (Mount Jowlaenga Station), with cattle still present throughout. A small area within the study area boundary was also once used as a quarry, although this is excluded from the study area.

Table 2.4 – Databases searched to determine the potential vertebrate fauna assemblage

Group	Database	Custodian	Search details
Vertebrate fauna/ conservation significant fauna	NatureMap	DPaW	Records within 20 km of the study area. Date accessed: 24/05/12 URL:http://naturemap.dec.wa.gov.au
Vertebrate Fauna	Threatened Fauna Database	DPaW	Records within 20 km of the study area.
Vertebrate Fauna/ SRE Invertebrate fauna	Species Profile and Threats (SPRAT) Database	Department of the Environment (DoE)	Records within 50 km of the study area.
Vertebrate Fauna	Birdata	BirdLife Australia	Records within 50 km of the study area.
SRE Invertebrate fauna	WA Museum Arachnid Database	WAM	Search coordinates: 442969E, 8114590S (left top) and 518875E, 8030210S (bottom right) Zone 51, Date: 07/03/13
SRE Invertebrate fauna	WA Museum Crustacean Database	WAM	Search coordinates: 442969E, 8114590S (left top) and 518875E, 8030210S (bottom right) Zone 51, Date: 07/03/13
SRE Invertebrate fauna	WA Museum Mollusc Database	WAM	Search coordinates: 442969E, 8114590S (left top) and 518875E, 8030210S (bottom right) Zone 51, Date: 07/03/13

Table 2.5 – Previous biological survey reports within the region of the study area

Survey location and author(s)	Distance from study area	Comments
ecologia internal database	0-85	One Level 1 survey and three 1-phase Level 2 surveys
Perpendicular Head-North Head, Packer Island, Gourdon Bay and Coulomb-Quondong Vertebrate Fauna Assessment (ENV 2008)	70	1-phase Level 2 survey
James Price Point Terrestrial Fauna Survey (Biota 2009)	85	1-phase Level 2 survey
James Price Point Browse LNG Precinct Targeted Terrestrial Fauna Survey (Biota 2010)	85	1-phase Level 2 survey
Supplementary Terrestrial Fauna and Habitat Assessment (AECOM 2010)	85	1-phase Level 1 survey
Browse LNG Precinct Access Road: Targeted Fauna Survey – Greater Bilby (AECOM 2011)	85	Targeted Greater Bilby survey
Monitoring Yellow Sea Migrants in Australia (MYSMA) (Rogers *et al.* 2009)	85 – 435	Targeted shorebird survey
Assessment of Birds Utilising Habitat within the Vine Thickets and Woodlands of James Price Point (Bamford 2011)	85	Targeted bird survey
Browse Project Greater Bilby Survey of the James Price Point Area - Summary Report (ENV 2011)	85	Targeted Greater Bilby survey
Aquatic fauna and water chemistry of the mound springs and wetlands of Mandora marsh, north-western Australia (Storey *et al.* 2011)	240	Aquatic (stygofauna) survey


350000
400000
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8100000
8050000
8000000
Lombadina Mission
Pender
Kimbolton
Oobagooma
Beagle Bay Mission
Country Downs
Derby
Meda
Kimberley Downs
Yeeda
Kilto
Kennedys Cottage
Waterbank
Debesa
Blina
Manguel Creek
Roebuck Plains
Broome
Udialla
Willumbah
Mount Anderson
Liveringa
Paradise
Luluigui
Myroodah
Thangoo
Legend
Fauna assessment
Level 1
Level 2
Level 2/Targeted
Targeted
Locality
Study Area
N
0
20
40
Kilometres
Absolute Scale - 1:1,250,000
ecologia
ENVIRONMENT
SheffieldResources
LIMITED
Previous biological survey locations
Figure: 2.6
Project ID: 1501
Drawn: NJ
Date: 10/03/2014
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: NJ090
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2.6.1 Potential Fauna Assemblage

Although the majority of prior survey effort for both vertebrates and invertebrates is concentrated on the western coastline of the Dampier Peninsula, this does not necessarily diminish the relevance of many of the potential species. Additionally, the ecology of some of these species is poorly known due the low number of surveys in the region. Since the habitat across the Dampier Peninsula is relatively homogeneous, being primarily sandy pindan shrubland (Sections 2.2–2.5), this means that many of the species known mainly from coastal areas may in fact occur across the peninsula.

2.6.1.1 Terrestrial Vertebrate Fauna

The results of previous surveys in the region provided an indication of the potential vertebrate fauna on the Dampier Peninsula (Table 2.6, Appendix C). Most of these surveys were conducted on or near the western coastline of the peninsula, for example the Rogers *et al.* (2009) and Bamford (2011) surveys, therefore many of the species recorded, particularly within the bird group, are specialised coastal species and are unlikely to occur as far inland as the study area. However, the relative homogeneity of the pindan shrubland habitat across the peninsula means that it is possible for many of the previously recorded species to occur in the study area.

Table 2.6 – Summary of previous vertebrate fauna biological surveys and database results

Survey location and author(s)	Mammals	Birds	Reptiles	Amphibians
Biological survey				
ecologia internal database	18	110	42	5
Supplementary Terrestrial Fauna and Habitat Assessment (AECOM 2010)	8	103	17	0
Browse LNG Precinct Access Road: Targeted Fauna Survey – Greater Bilby (AECOM 2011)	1	0	0	0
James Price Point Terrestrial Fauna Survey (Biota 2009)	12	68	39	1
James Price Point Browse LNG Precinct Targeted Terrestrial Fauna Survey (Biota 2010)	4	0	27	1
Perpendicular Head-North Head, Packer Island, Gourdon Bay and Coulomb-Quondong Vertebrate Fauna Assessment (ENV 2008)	33	176	56	8
Browse Project Greater Bilby Survey of the James Price Point Area - Summary Report (ENV 2011)	2	0	0	0
Monitoring Yellow Sea Migrants in Australia (MYSMA) (Rogers *et al.* 2009)	0	80	0	0
Assessment of Birds Utilising Habitat within the Vine Thickets and Woodlands of James Price Point (Bamford 2011)	0	46	0	0
Databases				
DPaW Naturemap	3	54	7	1
Birdlife Australia Birdata	0	219	0	0
DPaW Threatened and Priority Fauna Search	2	3	0	0
DoE Protected Matters Search	2	11	2	0
Total	**39**	**234**	**81**	**12**

2.6.1.2 SRE Invertebrate Fauna

There is limited knowledge concerning SRE invertebrate fauna on the Dampier Peninsula, with only data from three Level 2 surveys being available from the James Price Point area, north of Broome (Biota 2009, 2010, *ecologia* internal database). Despite the minimal prior survey effort, these surveys have identified that potential SRE invertebrate fauna occur in the region. Similarly, of the three WAM invertebrate database searches, only the Mollusc database provided results (Appendix C).

The studies at James Price Point (Biota 2009, 2010), located approximately 85 km west of the study area, recorded three species of land snails (*Rhagada bulgana*, *R. reinga* and *Quistrachia leptogramma*), six mygalomorph spiders (*Missulena* sp., *Synothele* 'MYG179', *Conothele* sp. 1 and sp. 2, ?*Aganippe* sp. and *Aname* sp.), two scorpions (*Urodacus* 'rugosus' and *U*. 'sp. JP'), one pseudoscorpion (*Euryolpium* sp.), one millipede (Pachybolidae genus indet.) and one centipede (*Pilbarascutigera incola*).

A further Level 2 survey at James Price Point (*ecologia* internal database) recorded 15 invertebrates from SRE groups. These included two land snails (*R. bulgana* and *Q. leptogramma*), one harvestmen (*Dampetrus* sp.), three scorpions (*Lychas multipunctatus*, *L*. 'JPP' and *Urodacus* sp. indet.), five pseudoscorpions (*Austrohorus* sp., *Beierolpium* sp. '8/4' and sp. 'juv', *Euryolpium* sp. and *Indolpium* sp.), one slater (*Buddelundia* sp. 1) and one centipede (*Scolopendra laeta*).

2.6.1.3 Subterranean Fauna

There is very limited knowledge concerning stygofauna in the Canning Basin, and there are no published subterranean fauna surveys from the Dampier Peninsula. However, patchy survey work has revealed the occurrence of stygofauna occurring in shallow aquifers and springs (DoW 2010).

One study of the Mandora Marsh aquatic system (Storey *et al.,* 2011) lies within the La Grange South groundwater subarea of the Canning Basin, on the northern edge of the Great Sandy Desert, located approximately 140 km south-south-west of Broome and lies in the transition between the Pilbara and Kimberley regions. The survey recorded one species of subterranean fauna, a bathynellid syncarid (*Kimberleybathynella mandorana*) (Storey *et al.* 2012), collected from the Mandora wetlands, and a new bathynellid syncarid from the freshwater Coolabah Claypan (Storey et al., 2012). Further, the survey recorded subterranean copepods (*Metacyclops brooki* and *M. mortoni*) and subterranean ostracods (*Vestalenula marmonieri* and *Candona* sp.) from this aquifer (a shallow superficial aquifer).

Another stygofauna survey conducted in the Canning Basin (Subterranean Ecology 2012), found a depauperate stygofaunal community comprising one species of aphanoneouran worm (Family Aelosomatidae) collected from the Wallal Sandstone aquifer, ca. 160 km east of Port Hedland (Subterranean Ecology 2012).

3 METHODS

3.1 DETERMINATION OF SURVEY SAMPLING DESIGN AND INTENSITY

Prior to the development of field survey methods, a review was undertaken of factors likely to influence survey design and intensity (Table 3.1), as well as an initial Level 1 survey. Based on the information gathered, it was deemed necessary for a Level 2 survey to be conducted.

Table 3.1 – Factors likely to influence survey design (EPA 2004)

Factor	Relevance
Bioregion – level of existing survey/knowledge of the region and associated ability to predict accurately.	11 previous biological surveys have been conducted within 100 km of the study area (Table 2.5).
Landform special characteristics/specific fauna/specific context of the landform characteristics and their distribution and rarity in the region.	Landforms of the project area are typical of the Pindanland subregion.
Lifeforms, life cycles, types of assemblages and seasonality (e.g. migration) of species likely to be present.	The initial survey was conducted at the optimal time to survey fauna groups in the Kimberley – in April, soon after the wet season (typically December to March). This was complemented by a dry season survey in October.
Level of existing knowledge and results of previous regional sampling (e.g. species accumulation curves, species/area curves).	Although a number of surveys have previously been conducted on the Dampier peninsula, none were as far inland as this survey.
Number of different habitats or degree of similarity between habitats within a survey area.	The majority of the study area is relatively homogeneous habitat, with a few water sources adding variety.
Climatic constraints (e.g. temperature or rainfall that preclude certain sampling methods).	The timing of the surveys was optimal, capturing data both immediately after the wet season and in the dry season.
Sensitivity of the environment to the proposed activities.	The study area covers a relatively small amount of a generally ubiquitous habitat across the inner Dampier Peninsula.
Size, shape and location of the proposed activities.	The triangular study area covers 148.81 km^2, and is located slightly south-east of the centre of the Dampier Peninsula.
Scale and impact of the proposal.	The study area covers a small proportion of the Dampier Peninsula, and potential impacts can be mitigated by management plans.

3.2 SURVEY TIMING

Survey timing is summarised in Table 3.2. The first phase of the terrestrial fauna survey was conducted immediately after the wet season, between 4–15 April 2013 (Table 3.2). The second phase occurred in the dry season between 14–23 October 2013 (Table 3.2), with the timing of both determined as per the relevant guidelines (EPA 2002a, 2004, 2007; EPA and DEC 2010; EPA 2013).

A single phase of troglofauna surveying was completed, with troglofauna traps deployed during the terrestrial fauna phase 2 survey, on 19 October 2013. Traps remained in situ for 45 days and were collected on 4 December 2013.

A single phase of stygofauna surveying was completed. This occurred from 2–6 December 2013.

Table 3.2 – Summary of survey timing and duration

Survey	Dates of survey	Duration (days)	Person days
Terrestrial vertebrate and SRE fauna			
Phase 1	4–15 April 2013	12	48
Phase 2	14–23 October 2013	10	40
Total		**22**	**88**
Troglofauna			
Phase 1 - Deployment	19 October 2013	45	
Phase 1 - Collection	4 December 2013		
Total		**45**	
Stygofauna			
Phase 1	2–6 December	5	10

3.3 SAMPLING METHODS

The sampling methods adopted by *ecologia* align with the relevant guidelines (Section 1.2). The survey was undertaken using a variety of sampling techniques, both systematic and opportunistic. Systematic sampling refers to data methodically collected over a fixed time period in a discrete habitat type, using an equal or standardised sampling effort. The resulting information can be analysed statistically, facilitating comparisons between habitats. Opportunistic sampling includes data collected non-systematically from chance encounters with fauna or evidence of fauna. Sampling methods for the various fauna groups are described in detail below.

3.3.1 Terrestrial Vertebrate Fauna

3.3.1.1 Systematic Sampling

Non-volant Mammals and Herpetofauna

Trapping for non-volant mammals and herpetofauna was undertaken using a standardised trapping format comprising a combination of pit-fall traps, Elliott box traps, funnel traps and cage traps.

Each trapping site consisted of the following (Figure 3.1):

- Pit-trap and drift fence: Five PVC pipe (16 x 50 cm) and five 20 L plastic buckets (30 x 40 cm) were established at each site. A 10 m flywire drift fence (30 cm high) bisected the pits, directing fauna into the traps.
- Elliott box traps: Ten medium sized Elliott box traps (9 x 9 x 32 cm) were placed at each site, and baited with universal bait (a mixture of peanut butter, rolled oats and sardines). Each Elliott trap was placed between the pit trap setups. Elliott traps were shaded using Air Cell roof insulation.
- Funnel traps: Funnel traps (Ecosystematica Type III) were placed in association with drift fences. Twenty funnel traps were used per site, with a trap being placed at each end of the drift fence. Funnel traps were shaded using Air Cell roof insulation.
- Cage traps: Two Sheffield small animal traps (22 cm x 22 cm x 55 cm) were used per site with one trap placed at each end of the trap line. Traps were baited with universal bait.

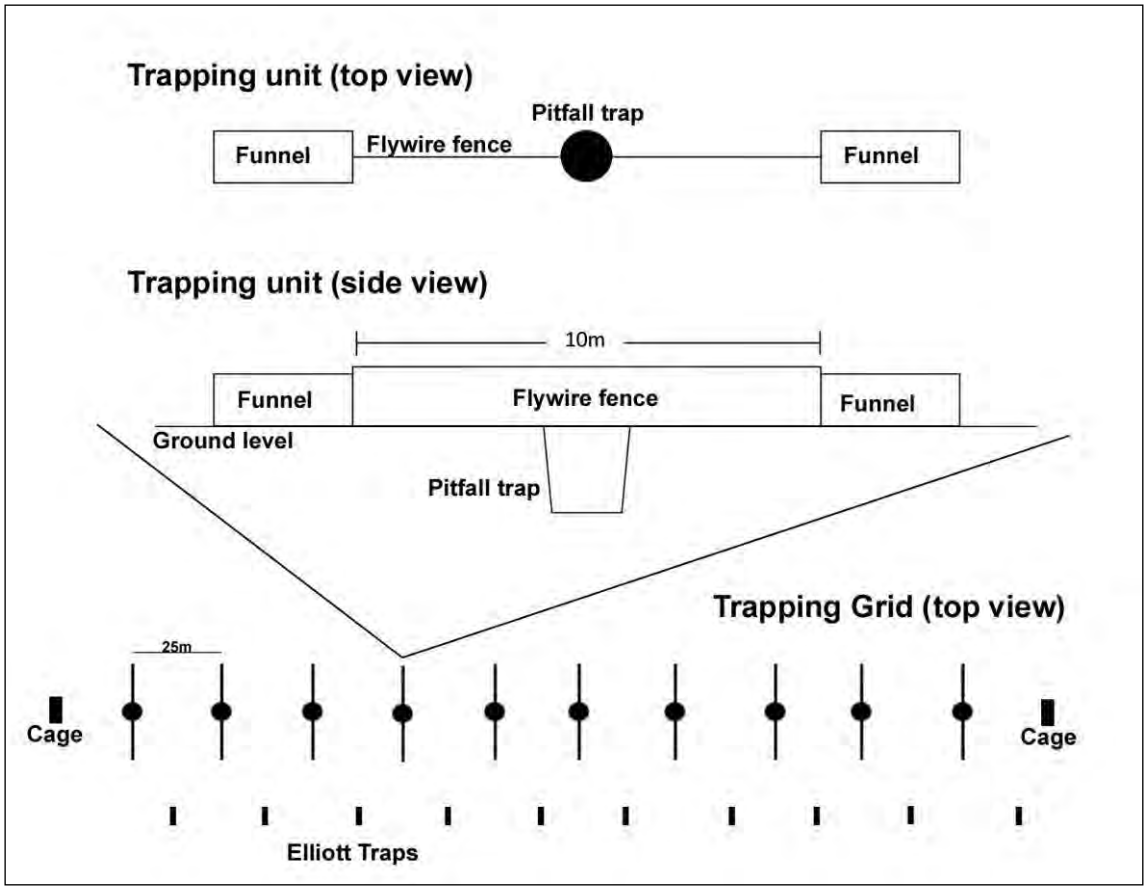


Figure 3.1 – Diagram of the systematic sampling trap arrangement

Figure 3.2 – Image of single *ecologia* trap point

Avifauna

Thirty minute set-time surveys were used to document the avifauna present at each of the fauna sites. During each set-time survey an ornithologist recorded the number of individuals of each species seen while actively searching similar habitat within 500 m of the survey site. This is aligned with survey methodology for the ongoing Birds Australia *Atlas of Australian Birds* project.

Survey effort was concentrated at survey sites within three hours of dawn, as this time is deemed to be the optimal times to record most bird species. Opportunistic surveys during the day and near dusk were also conducted, as they may yield species less frequently observed in the early morning, e.g. diurnal raptors.

Bats

Bat echolocation calls were recorded using SM2BAT 384 kHz long term passive recorder. The SM2BAT has a high sampling frequency, enabling the full spectrum of calls to be recorded without being transformed, allowing greater accuracy and sensitivity. The SM2BAT was programmed to record from dusk to dawn for each night that was surveyed.

3.3.1.2 Opportunistic Sampling

Nocturnal Searching

The study area was searched at night using a combination of road transects and opportunistic ground searches using head torches and hand held spotlights to uncover nocturnal species, including geckos, snakes, frogs and birds.

Diurnal Searching

Both trapping and opportunistic sites were searched by hand for cryptic species, which comprised searching beneath the bark of dead trees, breaking open old logs, stumps and dead free-standing trees, investigating burrows and over-turning logs and stones. Sites were selected on the basis of fauna habitat (targeting uncommon habitats or habitats poorly represented by trapping sites) and their possibility of harbouring conservation significant fauna.

Fauna were also recorded while searching, travelling and during trap establishment within the study area during the day and night. Tracks, diggings, scats, burrows and nests were recorded where possible.

Camera Trapping

Motion sensor cameras were used in areas with a high likelihood of animal activity such as burrows or crevices. The Bushnell Trophy Cam, model number 119415 was used. The camera is triggered by movement by a highly sensitive passive infra-red motion sensor and functions day and night taking either video footage or photos (Bushnell Outdoor Products 2009).

Targeted Conservation Significant Fauna Surveying

Prior to the commencement of survey activity, the preferred habitat of the conservation significant species that potentially occur in the study area was determined. These habitats were identified and targeted during survey activities using both systematic survey sites and opportunistic surveys.

On the basis of the habitats observed during surveying, specific opportunistic searches as well as motion camera trapping were also undertaken to determine the presence of potential conservation significant species (Figure 3.3, Figure 3.4).

Figure 3.3 – A motion camera monitoring a Greater Bilby burrow

Figure 3.4 – A motion camera monitoring a Rainbow Bee-eater nesting burrow

3.3.2 Short Range Endemic Invertebrate Fauna

3.3.2.1 Systematic sampling

Dry Pitfall Trapping

A total of four vertebrate fauna trap sites and six targeted SRE trap sites were established as dry pitfall sites for SRE invertebrate fauna, totalling 920 trap nights inside the potential impact area. In addition, three vertebrate fauna traps sites totalling 420 trap nights were established as dry pitfall trapping sites outside of the potential impact area (Table 3.1). These sites were checked daily and all invertebrate fauna groups potentially containing SRE species collected.

Foraging

One person hour per site was spent foraging for SREs at six sites. Opportunistic foraging involved physically searching through microhabitats for SRE's. The underside of rocks and logs were closely investigated for SRE invertebrates. Snail shells and trapdoor spiders were collected and documented where found.

Leaf Litter Collection

Three quadrats (3 m^2) of leaf litter were collected at each of the six targeted SRE trap sites during the first phase and separately placed into a leaf-litter reducer (Figure 3.5). The contents from each collection was placed into a paper bag inside a zip-lock bag and kept separate. A small amount of wet tissue paper was placed into each sample to maintain humidity. Samples were then transported back to Perth in a cool, dark container.

Figure 3.5 – Example of the leaf litter reducer

3.3.3 Stygofauna

A single survey (Level 1) of stygofauna sampling was completed in December 2013 (Section 3.2). Haul nets were used to sample the holes in accordance with the methods described in the *EPA Guidance Statement 54a* (EPA 2007). This technique involved dragging modified plankton nets through the entire water column.

Drill holes selected for stygofauna sampling consisted of cased drill holes with PVC pipes, with slits in piping throughout the length to ensure water flow through the piping. Drill hole diameter was 50 mm.

A standing water level dipper was used to determine the standing water level in each drill hole. This information assisted with information on the local aquifers for stygofauna. Water parameters such as conductivity (salinity), turbidity, temperature, dissolved oxygen and redox potential were collected *in situ* for each drill hole, using a portable water quality metre to assess habitat attributes related to water quality.

Sampling was conducted using haul nets of appropriate diameter (depending on water bore diameter), lowered slowly into bores using rope to prevent the net from free falling to the bottom of the bore. Six hauls were performed with a 50 µm mesh net at each site. All samples were washed in a 50µm sieve and preserved in a vial with 100% ethanol in case DNA assessment is required at a later date. After each drill hole was sampled, the sieve and nets were washed in Decon90® to prevent contamination between sites. All vials were labelled with the date, bore name and replicate number. Samples were stored in cool, dark conditions and returned to the *ecologia* Perth laboratory for sorting and identification.

3.3.4 Troglofauna

3.3.4.1 Trapping

A single phase of troglofauna sampling was completed (Section 3.2). Only drill holes which were sealed up to six metres and unobstructed were used for sampling. Drill holes were sampled using custom-designed traps (DEC and EPA approved, Figure 3.6) filled with leaf litter and baited with banana and sweet potato. Leaf litter was soaked over several days and sterilised by microwaving at a high setting for three minutes (to destroy any terrestrial predators present in the leaf litter that could inhibit, predate or impact on troglofauna colonising the traps once in the ground). The leaf litter was then stored in an air-tight container to further develop over eight weeks before deployment.

The water level of each drill hole was measured using a standing water level metre prior to traps being deployed. This information aids positioning of troglofauna traps above the water table. Geology mapping for each drill hole was assessed. Traps were positioned within areas of sandstone geology as these areas were recognised as having the greatest potential for supporting troglofauna communities. Sandy substrates were avoided. Traps were positioned so that the trap rested against the wall of the hole.

The drill holes were re-sealed after the insertion of traps to maintain humidity levels and to reduce contamination from surface fauna. Each site was demarcated with flagging tape and a sign ("Do not disturb – Troglofauna trapping in progress"). Site management were informed of the areas where trapping was occurring to minimise accidental disturbance and tampering.

Traps were left in the ground for 45 days to ensure troglofauna colonisation. After this period, the traps were recovered and the leaf litter from each trap was placed into plastic bags, which were immediately sealed to avoid contamination. Samples were returned to the *ecologia* Perth laboratory for fauna extraction and sorting prior to being sent to relevant taxonomic specialists for identification.

Figure 3.6 – Custom built troglofauna trap

3.3.4.2 Scraping

Troglofauna scraping involved dragging haul nets along the walls of drill holes. The net was placed down the drillhole and hauled up twice, with the contents emptied into a vial after each haul. Each vial was then filled with 100% ethanol to preserve any animals present in the sample. These were then processed in the laboratory in Perth.

3.3.5 Laboratory Sorting and Specimen Identification

3.3.5.1 Short Range Endemic Invertebrate Fauna

Tullgren funnels were used to extract any animals from the collected leaf litter samples (Figure 3.7). The principle of Tullgren funnels is that a sample of leaf litter is suspended below an incandescent lamp or heat source, so that animals inhabiting the sample are forced downwards by progressive drying and ultimately fall into a collecting vessel located below. Samples are preserved in ethanol to allow DNA extraction if required.

Figure 3.7 – Tullgren funnels

After the leaf litter samples were processed on the Tullgren funnels, each sample was examined for any other animals that were not collected during Tullgren funnel extraction. Each sample was emptied into a tray and examined using a light magnifier. Any animals found were collected and immediately preserved in ethanol.

All samples were examined under a stereo microscope and sorted into related groups. Specimens were labelled with the project name, site number and coordinates, the trap number or leaf-litter sift number, date of collection and the initials of the collectors, and were sent to the relevant taxonomic expert for further identification. Table 3.17 shows a list of taxonomic specialists consulted for identifications.

3.3.5.2 Stygofauna

Stygofauna samples were sorted at *ecologia*'s Perth laboratory under a compound microscope. Any potential stygobitic specimens collected were placed in individual vials with absolute ethanol and labelled with the date, location, coordinates and names of collectors. The specimens were identified by *ecologia* taxonomists.

3.3.5.3 Troglofauna

Once processing of the samples in the Tullgren funnels was complete, all samples were sorted under a compound microscope and sorted into related groups. These specimens were labelled with the project name, site number, date of collection, coordinates and the initials of the collectors and were sent to the relevant taxonomic expert for further identification. Table 3.17 shows a list of taxonomic specialists consulted for identifications.

3.4 SITE SELECTION

3.4.1 Terrestrial Vertebrate Fauna

Seven terrestrial fauna survey sites were selected both to achieve geographic spread over the study area and to be representative of the habitat types present, although access was slightly limited by the location of existing tracks. Information from land system and habitat maps, as well as previous on-site observations made during the Level 1 survey, was also used to aid site selection. Habitat types occurring over a larger proportion of the study area (dominant habitat types) were sampled by a larger number of trapping sites than less widespread habitat types. Habitat types poorly represented by systematic sampling sites were further surveyed using opportunistic searches, targeting potentially sensitive habitats and habitats likely to support conservation significant species. Locations of all vertebrate fauna survey sites are listed in Table 3.3 and mapped in Figure 3.8. Detailed descriptions of the systematic survey sites are listed in Appendix D.

Table 3.3 – Vertebrate fauna sites

Site type	Location		Land system	Vegetation association
	Easting	Northing		
Systematic trapping				
TB S1	499584	8073492	Reeves	750
TB S2	496173	8073359	Fraser	750
TB S3	493352	8073219	Yeeda	750
TB S4	491858	8073144	Yeeda	750
TB S5	496965	8071200	Fraser	750
TB S6	496603	8068741	Wanganut	750
TB S7	496226	8066143	Yeeda	750
Opportunistic bat recording				
Bat 1	500580	8073560	Fraser	755
Motion camera				
MCB1	495001	8073488	Yeeda	751
MCB2	495019	8073532	Fraser	751
MCD1	499751	8072256	Reeves	762
MCD2	499752	8072269	Reeves	762
MCD3	497273	8071921	Fraser	750
MCD4	496737	8069634	Fraser	750
MCE	499892	8072225	Reeves	762
MCF1	499648	8072038	Reeves	762
MCF2	499886	8072214	Reeves	762
Opportunistic search				
TB OS1	497469	8074704	Reeves	750
TB OS2	500580	8073560	Fraser	755
TB OS3	499712	8067404	Fraser	750
TB OS4	503843	8067527	Reeves	750
TB OS5	493598	8074789	Reeves	750
TB OS6	494110	8073259	Yeeda	750
TB OS7*	504152	8072770	N/A	N/A

Site type	Location		Land system	Vegetation association
	Easting	Northing		
TB OS8	494284	8072508	Yeeda	750
TB OS9	497806	8070539	Fraser	750
TB OS10	495524	8070859	Fraser	750
TB OS11	500208	8073544	Reeves	750
TB OS12	499753	8072264	Fraser	750
TB OS13	494999	8073484	Yeeda	750
TB OS14	492505	8075036	Yeeda	750
TB OS15	491842	8073155	Yeeda	750
TB OS16	496965	8071200	Fraser	750
TB OS17	498074	8073444	Fraser	750
TB OS18	496849	8066580	Wanganut	750
TB OS19	497386	8069969	Fraser	750

Datum: GDA94
Zone: 51K
*Mount Jowlaenga homestead – outside the study area

3.4.2 Short Range Endemic Invertebrate Fauna

Survey site locations were selected based on the vegetation associations, areas of potential impact and habitat types present in the study area, focusing on the habitat types that were considered likely to support SRE invertebrates (e.g. south facing rocky hillslopes, drainage lines, eucalypt woodlands and sandy shrublands). A total of six SRE dry pitfall sites (comprising five dry pitfalls each) were established and a further 16 opportunistic foraging sites were searched for potential SRE species. Leaf litter was taken from near the six dry pitfall sites, to increase the likelihood of detecting terrestrial SRE species. The locations of all SRE survey sites are provided in Table 3.4 and mapped in Figure 3.9, whilst site habitat descriptions are listed in Appendix D.

Table 3.4 – SRE fauna sites

Site type	Location		Land system	Vegetation community
	Easting	Northing		
Dry pitfall and leaf-litter sample sites				
TB SRES1	497272	8073415	Fraser	750
TB SRES2	495622	8073290	Fraser	750
TB SRES3	494110	8073259	Yeeda	750
TB SRES4	497106	8072360	Fraser	750
TB SRES5	496819	8070453	Fraser	750
TB SRES6	496635	8069217	Fraser	750
Opportunistic foraging sites				
TB SREOS1	492897	8073352	Yeeda	750
TB SREOS2	493791	8073471	Yeeda	750
TB SREOS3	500586	8073561	Fraser	755
TB SREOS4	500580	8073560	Fraser	755
TB SREOS5	499712	8067404	Fraser	750
TB SREOS6	503843	8067527	Reeves	762

Site type	Location		Land system	Vegetation community
	Easting	Northing		
TB SREOS7	496589	8068738	Wanganut	750
TB SREOS8	494284	8072508	Yeeda	750
TB SREOS9	500208	8073544	Reeves	750
TB SREOS10	495524	8070859	Fraser	750
TB SREOS11	497806	8070539	Fraser	750
TB SREOS12	499753	8072264	Reeves	762
TB SREOS13	493574	8074765	Yeeda	750
TB SREOS14	494999	8073484	Yeeda	751
TB SREOS15	492505	8075036	Yeeda	750
TB SREOS16	497478	8074704	Reeves	750

Datum: GDA94
Zone: 51K

3.4.3 Stygofauna

Sample sites (drill holes) were selected based on ground water level information, and drill holes that were suitably cased for stygofauna sampling. A total of 15 drill holes were sampled for stygofauna, these locations are shown in Table 3.5 and mapped in Figure 3.10. Twelve sites were sampled inside the proposed potential impact area, while three sites were sampled outside the proposed potential impact area.

Table 3.5 – Stygofauna sample sites

Drill hole ID		Location		Depth to water (m)
Inside proposed impact (deposit area)	Outside proposed impact (deposit area)	Easting	Northing	
-	THAC 232	497155	8068154	22
THAC 235	-	498444	8069687	30
THAC 238	-	497037	8069562	28
THAC 241	-	498198	8072514	39
THAC 243	-	497168	8072072	32
THAC 245	-	495566	8072454	38
THAC 247	-	496671	8073794	41
THAC 252	-	493367	8072972	49
-	THAC 280	501617	8069966	42
-	THAC 285	502293	8069280	44
THAC 322	-	496939	8068666	23
THAC 357	-	495882	8070540	32
THAC 390	-	497644	8070677	33
THAC 406	-	495614	8069435	30
THAC 408	-	494763	8071525	39

Datum: GDA94
Zone: 51K

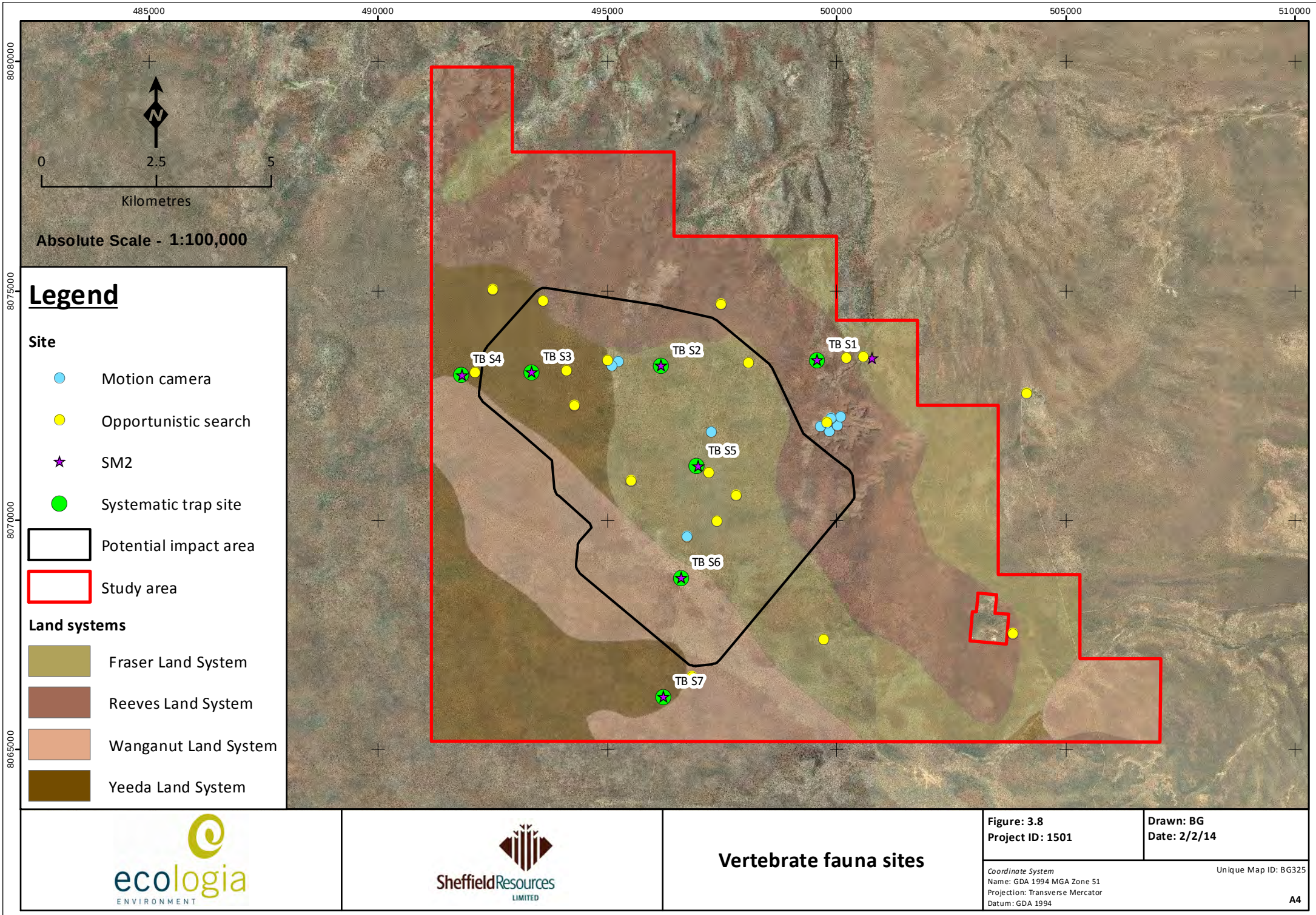
3.4.4 Troglofauna

Sample sites (drill holes) were selected based on geology, water table information, and whether they were cased. Based on the geology identified during exploratory drilling, the majority of drill holes contained only sand above the water table, and were therefore unsuitable for sampling. However, a total of six drill holes contained relatively narrow sandstone layers above the water table, and were targeted for troglofauna (Table 3.6 and Figure 3.10). Five drill holes were sampled inside the proposed potential impact area, and one drill hole was sampled outside.

Table 3.6 – Troglofauna sites

Drill hole ID	Location		Depth to water (m)	Relation to Impact Area	Number of traps	Depth of trap 1	Depth of trap 2	Depth of trap 3	Number of drill hole scraps
	Easting	Northing							
THAC 244	496364	8071105	34	Inside	1	25	-	-	2
THAC 248	495959	8073733	48	Inside	3	10	20	28.5	2
THAC 251	494452	8072706	41	Inside	2	6.5	10	-	2
THAC 266	494023	8073745	46	Inside	2	8.5	14	-	2
THAC 282	501749	8068557	36	Outside	2	10	20	-	2
THAC 407	494581	8071306	35	Inside	2	8	18	-	2

Datum: GDA94
Zone: 51K



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Vertebrate fauna sites

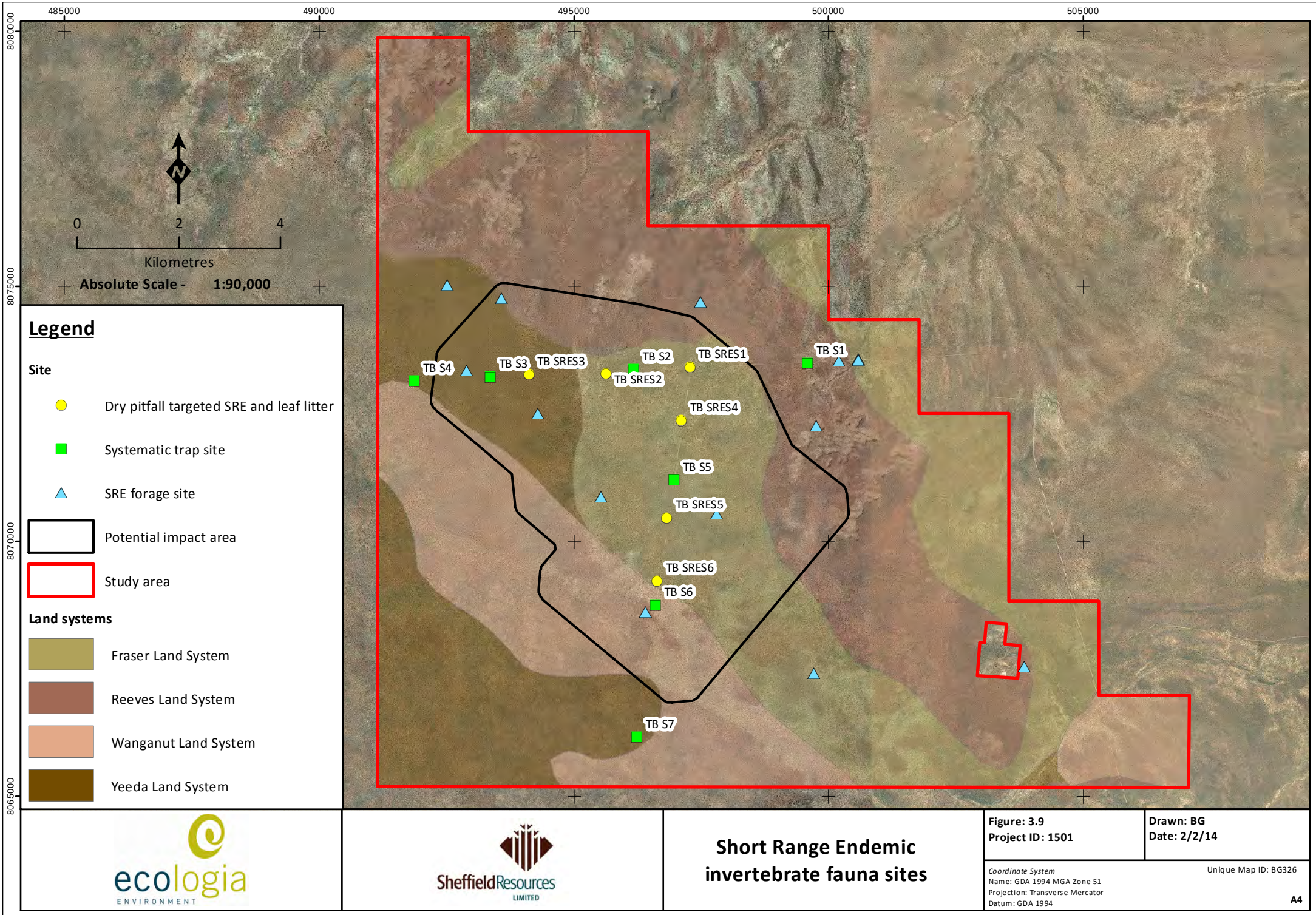
Figure: 3.8
Project ID: 1501

Drawn: BG
Date: 2/2/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: BG325

A4



ecologia ENVIRONMENT

Sheffield Resources LIMITED

Short Range Endemic invertebrate fauna sites

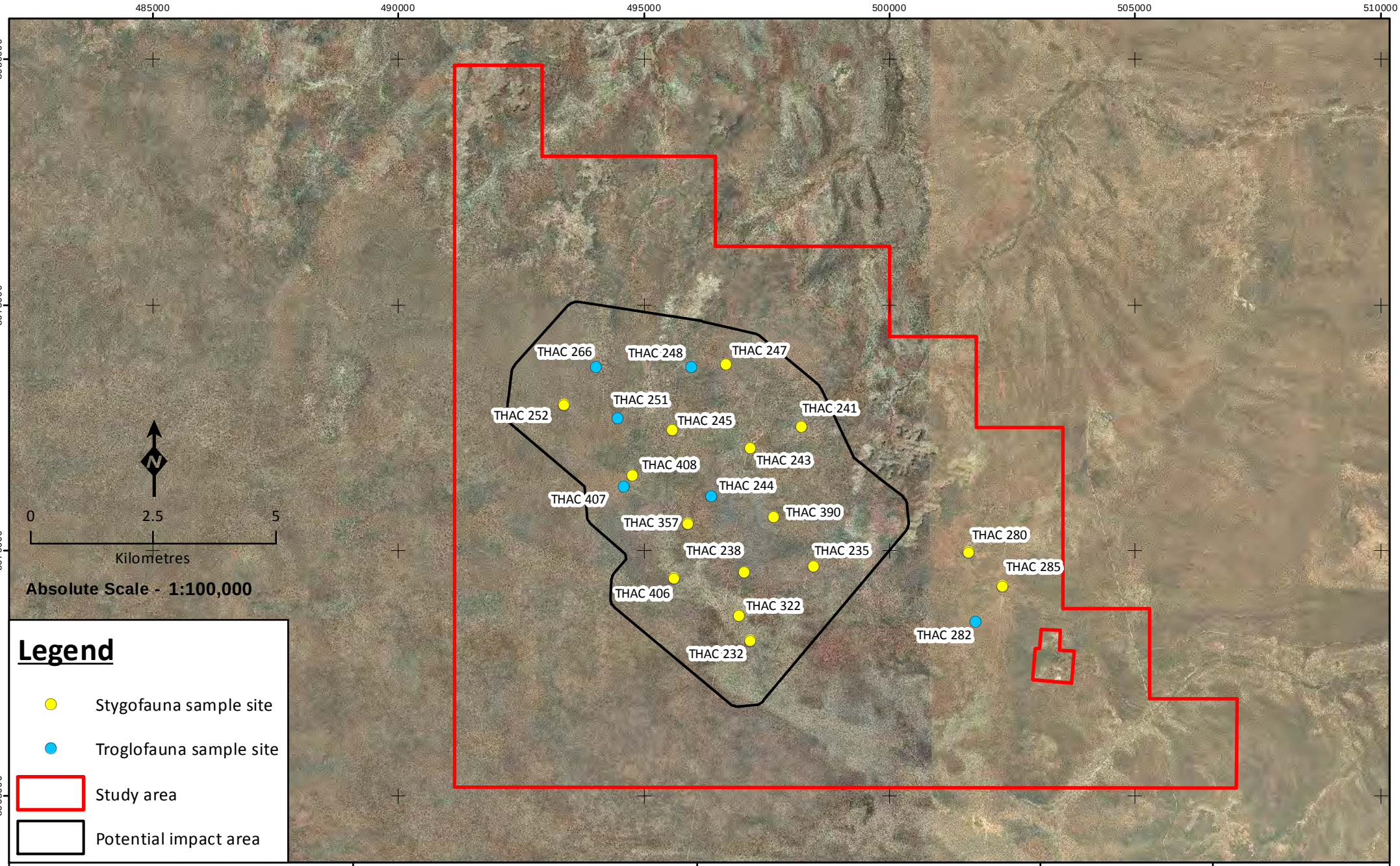
Figure: 3.9
Project ID: 1501

Drawn: BG
Date: 2/2/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: BG326

A4


485000
490000
495000
500000
505000
510000
8080000
8075000
8070000
8065000
THAC 266
THAC 248
THAC 247
THAC 252
THAC 251
THAC 241
THAC 245
THAC 243
THAC 408
THAC 244
THAC 407
THAC 390
THAC 357
THAC 280
THAC 238
THAC 235
THAC 285
THAC 406
THAC 322
THAC 282
THAC 232
N
0
2.5
5
Kilometres
Absolute Scale - 1:100,000
Legend
Stygofauna sample site
Troglofauna sample site
Study area
Potential impact area
ecologia
ENVIRONMENT
SheffieldResources
LIMITED
Stygofauna and troglofauna sample sites
Figure: 3.10
Project ID: 1501
Drawn: BG
Date: 2/2/14
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
Unique Map ID: BG327
A4

3.5 SURVEY EFFORT

Survey effort expended within the study area included the following:

Vertebrate fauna

- seven trapping grids were open for 14 trap nights;
- approximately 29 hours were spent surveying for birds;
- 20 hours and 20 minutes were spent on opportunistic diurnal searching;
- 35 hours and 15 minutes were spent on opportunistic nocturnal searching;
- 385 hours and 15 minutes of camera trapping data was analysed;
- 180 hours of recordings were analysed to determine bat assemblage and distribution; and,
- nine hours and 40 minutes were spent searching for signs of the Greater Bilby.

Total vertebrate fauna survey effort per site is presented in Table 3.7.

SRE invertebrate fauna

- six dry pitfall trapping grids were open for six nights;
- seven vertebrate fauna trapping grids were open for 14 trap nights; and,
- six leaf litter samples were taken from each of the SRE dry pitfall grids.

Total SRE invertebrate fauna survey effort per site is presented in Table 3.8.

Stygofauna

- a total of 90 net hauls from 15 drill holes were sampled for stygofauna.

Total stygofauna survey effort per site is presented in Table 3.9.

Troglofauna

- a total of 12 traps and 12 scraping hauls at six drill holes were sampled for troglofauna.

Total troglofauna survey effort per site is presented in Table 3.10.

Table 3.7 – Terrestrial vertebrate fauna survey effort

Site name	Pit traps (trap nights)	Funnels (trap nights)	Elliotts (trap nights)	Cages (trap nights)	Bird survey (min)	Diurnal opp search (min)	Nocturnal opp search (min)	Bat recording (hrs)	Camera trapping (hrs)
TB S1	140	280	140	28	240			24	
TB S2	140	280	140	28	240			24	
TB S3	140	280	140	28	240			24	
TB S4	140	280	140	28	240			24	
TB S5	140	280	140	28	240			24	
TB S6	140	280	140	28	240			24	
TB S7	140	280	140	28	240			24	
Opportunistic					54	1580	2115	12	385.25
Total	**980**	**1960**	**980**	**196**	**1734**	**1580**	**2115**	**180**	**385.25**

Table 3.8 – SRE fauna survey effort

Site name	Relation to potential impact area	Dry pit traps (trap nights)	Leaf litter Samples	Foraging
TB SRES1	Inside	60	1	60
TB SRES2	Inside	60	1	60
TB SRES3	Inside	60	1	60
TB SRES4	Inside	60	1	60
TB SRES5	Inside	60	1	60
TB SRES6	Inside	60	1	60
TB S1	Outside	140		
TB S2	Inside	140		
TB S3	Inside	140		
TB S4	Outside	140		
TB S5	Inside	140		
TB S6	Inside	140		
TB S7	Outside	140		
Opportunistic	Inside			3162
Total		**1340**	**6**	**3522**

Table 3.9 – Stygofauna survey effort

Site name	Net hauls
THAC 232	6
THAC 235	6
THAC 238	6
THAC 241	6
THAC 243	6
THAC 245	6
THAC 247	6
THAC 252	6
THAC 280	6
THAC 285	6
THAC 322	6
THAC 357	6
THAC 390	6
THAC 406	6
THAC 408	6
Total	**90**

Table 3.10 – Troglofauna survey effort

Site name	No. of Traps	Scraping hauls
THAC244	1	2
THAC248	3	2
THAC251	2	2
THAC266	2	2
THAC282	2	2
THAC407	2	2
Total	**12**	**12**

3.6 POTENTIAL CONSERVATION SIGNIFICANT VERTEBRATE FAUNA

After the results of the literature review, database searches and survey results were compiled, fauna species that are listed under current legislative frameworks were identified. Three conservation lists have been developed at national (EPBC Act) and State level (WC Act and DPaW priority list).

The likelihood of a conservation significant species being present within the project was determined by examining the following:

- fauna habitats and their condition known to exist within the study area;
- distance of previously recorded conservation significant species from the study area;
- frequency of occurrence of conservation significant species records in the region; and
- time passed since conservation significant species were recorded within, or surrounding, the study area.

Each conservation or biologically significant species potentially occurring in the study area, was assigned a likelihood of occurrence based on the below category (Table 3.11). The level of available information for each species was also taken into consideration so that species are not allocated a low likelihood of occurrence because of insufficient survey information or cryptic behaviours and ecology.

Table 3.11 – Likelihood of occurrence categories

RECORDED	Species recorded during current survey
HIGH	Species recorded within, or in proximity to, the study area within 20 years; suitable habitat occurs in the study area
MEDIUM	Species recorded within, or in proximity to, the study area more than 20 years ago. Species recorded outside study area, but within 50 km; suitable habitat occurs in the study area
LOW	Species rarely, or not recorded, within 50 km, and/or suitable habitat does not occur in the study area

3.7 DETERMINING SRE STATUS

SRE status of invertebrate fauna recorded is based on categories developed by the Western Australian Museum and modified by the consultant taxonomists in order to describe the SRE status of taxa using the current knowledge of the distribution and biology of each species. The likelihood is defined by one of the categories as listed in Table 3.12. The newly released 2013 WAM SRE categories, which have been developed to describe the SRE status of WA taxa, utilise: (a) unambiguous categories; and (b) explanations of uncertainty. This has been accomplished using a two-tier classification system. In the first tier of classification, geographic distribution and taxonomic certainty are the variables used to split taxa into “Confirmed SREs”, “Widespread (not SREs)”, and “Potential SREs”. In the second tier of classification, “Potential SREs” are categorised according to the reasons why they have been placed into this category and the presence of proxy-indicators for Confirmed SRE or Widespread status. In addition, taxonomists from Phoenix Environmental Sciences have adapted these categories and incorporated one additional category: “likely SRE”. Taxonomists from both organisations (WAM and Phoenix) undertook the identification of invertebrate fauna collected during this survey and therefore both SRE categories have been used to determine the SRE status (Table 3.12 and Table 3.13).

Table 3.12 – Western Australian Museum SRE categories (2013)

	Taxonomic Certainty	Taxonomic Uncertainty
Distribution < 10 000km^2	**Confirmed SRE** • A known distribution of <10 00km^2. • The taxonomy is well known. The group is well represented in collections and/ or via comprehensive sampling.	**Potential SRE** Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group. We have incomplete taxonomic knowledge. The group is not well represented in collections. This category is most applicable to situations where there are gaps in our knowledge of the taxon. **Sub-categories for this SRE designation are outlined below**
Distribution > 10 000km^2	**Widespread (not an SRE)** A known distribution of >10 000km^2. The taxonomy is well known. The group is well represented in collections and/ or via comprehensive sampling.	

3.7.1 SRE Sub-categories

If a taxon is determined to be a "Potential SRE", the following sub-categories will further elucidate this status.

A. Data Deficient:

- There is insufficient data available to determine SRE status.
- Factors that fall under this category include:
    - Lack of geographic information;
    - Lack of taxonomic information;
    - The group may be poorly represented in collections; and
    - The individuals sampled (e.g. juveniles) may prevent identification to species level.

B. Habitat Indicators:

- It is becoming increasingly clear that habitat data can elucidate SRE status; and
- Where habitat is known to be associated with SRE taxa and vice versa, it will be noted here.

C. Morphology Indicators:

- A suite of morphological characters are characteristic of SRE taxa; and
- Where morphological characters are known to be associated with SRE taxa and vice-versa, it will be noted here.

D. Molecular Evidence:

- If molecular work has been done on this taxon (or a close relative), it may reveal patterns congruent or incongruent with SRE status.

E. Research & Expertise:

- Previous research and/ or WAM expertise elucidates taxon SRE status; and
- This category takes into account the expert knowledge held within the WAM.

The SRE categories utilised by Phoenix include one additional category: "likely SRE". Fauna belonging to this category are included in WAM's "potential SRE" category (Table 3.12, Table 3.13).

Table 3.13 – Phoenix's SRE categories (2013)

SRE category	Criteria	Typical representative
Confirmed	Confirmed or almost certainly SRE; taxonomy of the group is well known (but not necessarily published); group well represented in collections, in particular from the region in question; high levels of endemism in documented species; inference is often possible from immature specimens.	*Antichiropus* millipedes (Paradoxosomatidae); scorpions in the genus *Aops* (Urodacidae)
Likely	Taxonomically poorly resolved group; unusual morphology for the group (i.e. some form of troglomorphism); often singleton in survey and few, if any, regional records.	Opiliones in the genus *Dampetrus*; some pseudoscorpions (*Synsphyronus*) and slaters (Philosciidae); araneomorph spiders in the genus *Karaops* (Selenopidae)
Potential	Taxonomically poorly resolved group; often common in certain microhabitats in SRE surveys (i.e. litter dwellers), but no other regional records; congeners often widespread.	Many mygalomorph spiders; some centipedes (Cryptopidae; Geophilomorpha)
Widespread/Not SRE	Taxonomically well resolved (but often not published) and demonstrated wide distribution (i.e. > 10,000 km2)	

All likely, potential and unknown SREs should be treated as confirmed SREs in accordance with the precautionary principle (Section 4a of the EP Act).

3.8 FAUNA HABITAT MAPPING

A fauna habitat type broadly describes an area of habitat that is distinguishable in its vegetation, soil characteristics and land features from its surroundings, and is likely to support a different fauna assemblage to that found in other fauna habitats. Particular attention is also paid to the likelihood that certain species are present which tend to be found only in that specific habitat. Fauna habitat types were identified, described and mapped partly using the following existing information:

- IBRA subregions;
- aerial photography;
- vegetation associations (Beard 1981; Shepherd et al. 2002);
- land systems (van Vreeswyk *et al.* 2004); and,
- on-ground observations.

During the survey, other information was also collected, including:

- landform;
- vegetation type and structure;
- soil characteristics (soil structure and substrate);
- composition of terrestrial fauna species; and,

- habitat condition (Table 3.14).

These observations did not take into account any degradation as a result of exploration or other recent mining activities (e.g. drilling, clearing).

Table 3.14 – Habitat condition assessment

Habitat Condition	Criteria
Excellent	Pristine or nearly so, no obvious sign of damage caused by modern humans or introduced fauna (cattle, feral cat, dog and rabbit). No signs of recent, extensive fires.
Very good	Some relatively slight signs of damage caused by the activities of modern humans. e.g. damage to tree trunks by repeated fires, no significant signs of introduced fauna or occasional vehicle tracks.
Good	More obvious signs of damage caused by the activities of modern humans, including some obvious impact to vegetation structure such as that caused by low levels of grazing or by selective logging. Some tracks or secondary evidence of introduced fauna. Some signs of recent fires.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of modern humans such as partial clearing or very frequent fires. Presence of introduced fauna.
Very poor	Severely impacted by grazing, introduced fauna, fire, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management.
Completely Degraded	Areas that are completely or almost completely without vegetation communities and are heavily impacted by extensive fires and/or introduced species e.g. cow paddock

3.9 DATA ANALYSIS

3.9.1 Survey Adequacy

There are three general methods of estimating species richness from sample data: extrapolating species-accumulation curves (SACs), fitting parametric models of relative abundance, and using non-parametric estimators (Bunge and Fitzpatrick 1993; Colwell and Coddington 1994; Gaston 1996). In this report, the level of survey adequacy was estimated using SACs, which graphically illustrate the accumulation of new species as more individuals are recorded. Ultimately, the asymptotic plateau is reached at the level at which no new species are present. To eliminate inconsistent values caused by random or periodic variation over time, an algorithm (Mao Tau) was applied to the sampling data using EstimateS (version 8, Colwell 2009). This algorithm effectively smooths the curve of the number of species observed by simulating an infinite number of randomisations of the sample order. In order to estimate the theoretical maximum number of species for each fauna group, a Michaelis-Menten enzyme kinetic curve was calculated and used as a stopping rule technique, as this provides the most accurate representation.

Only the results of systematic sampling are included in SAC calculations, since the algorithms assume a standard sampling effort. Therefore, species recorded through opportunistic methods are not included. Mammal, reptile and amphibian trapping data were combined for analysis as 'terrestrial vertebrates', as these groups were sampled using the same methods. Separate analyses were carried out for terrestrial vertebrates, birds, SRE invertebrates, stygofauna and troglofauna.

3.9.2 Habitat Assessment

Analysis of the fauna survey data was undertaken to determine potential differences in fauna communities and subsequently identify distinct fauna habitats.

The survey data was first subjected to a log+1 transformation, which prepares it for analyses that are not robust against outliers. To test whether the differences in species diversity between habitat types were significant, analyses of similarity (ANOSIM) (Clarke 1993) comparisons were made using the one-way ANOSIM function. ANOSIM was calculated using the Bray-Curtis Similarity Index with 999 permutations. Non-metric multidimensional scaling (MDS) was also applied to the Bray-Curtis similarity matrix. Resulting stress values below 0.2 were considered to indicate a good fit of the scaling to the matrix. The dimensions that reduced the majority of the "raw stress" were chosen for the final scaling. Analysis was undertaken using the PAST software package (Hammer *et al.* 2001).

Separate analyses were carried out for terrestrial fauna (mammal and reptile) and avifauna.

3.10 TAXONOMY AND NOMENCLATURE

3.10.1 Vertebrate Fauna

Nomenclature for mammals, reptiles and amphibians within this report is as per *Western Australian Museum Checklist of the Vertebrates of Western Australia*, birds according to Christidis and Boles (2008). References used for fauna identification are listed in Table 3.15.

Table 3.15 – References used for identification

Fauna Group	Reference
Mammals	Menkhorst and Knight (2011), Van Dyck and Strahan (2008)
Bats	Churchill (1998), Menkhorst and Knight (2011)
Birds	Simpson and Day (2004)
Reptiles	Cogger (2000), Wilson and Swan (2010)
Geckos	Storr *et al*. (1990), Wilson and Swan (2010)
Skinks	Storr *et al*. (1999), Wilson and Swan (2010)
Dragons	Storr *et al*. (1983), Wilson and Swan (2010)
Varanids	Storr *et al*. (1983), Wilson and Swan (2010)
Legless Lizards	Storr *et al*. (1990), Wilson and Swan (2010)
Snakes	Storr *et al*. (2002), Wilson and Swan (2010)
Amphibians	Tyler and Doughty (2009), Cogger (2000)

3.10.2 Invertebrate Fauna

All specimens collected during the SRE trapping, stygofauna and troglofauna sampling have been lodged with the WA Museum and identified by external specialists (Table 3.17).

3.11 ANIMAL ETHICS

Surveying was conducted as per *ecologia*'s Animal Ethics Code of Practice, which conforms to Section 5 of the *Australian code of practice for the care and use of animals for scientific purposes* (National Health and Medical Research Centre (2004).

In most cases, fauna were identified in the field and released at the point of capture. Where the taxonomy of specimens was not clearly discernable, or when species were collected that are known to exhibit significant morphological variation or are not yet fully described, vouchers specimens were lodged with the WA Museum (Appendix E). Voucher specimens were maintained according to WA Museum guidelines to ensure captured animals were subject to the least possible stress.

3.12 SURVEY TEAM AND LICENCES

Field survey team members are listed in Table 3.16 and external consultants listed in Table 3.17. The survey was conducted under DPaW Regulation 17 Licence SF009176.

Table 3.16 – Field survey personnel

Survey member	Expertise	Qualification	Experience (years)
Nigel Jackett	Ornithology	B.Sc. (Hons)	9
Bruce Greatwich	Ornithology	B.Sc.	5
Mimi d'Auvergne	Mammalogy	B.Sc. (Hons)	5
Frances Leng	Invertebrate Zoology	B.Sc. (Hons)	5
Leigh Smith	Herpetology	Cert. Vet Nursing	4
Jesse Forbes-Harper	Vertebrate Zoology	B.A., B.Sc. (Hons)	3

Table 3.17 – Taxonomic specialists

Specialist	Institution	Relevant Experience
Dr Mark Harvey	Western Australian Museum	Taxonomic specialist in arachnids and millipedes
Dr Amber Beavis	Western Australian Museum	Taxonomic specialist in pseudoscorpions
Dr Mark Castalanelli	Western Australian Museum	Taxonomic specialist in mygalomorphs
Julianne Waldock	Western Australian Museum	Taxonomic specialist in arachnids
Corey Whisson	Western Australian Museum	Taxonomic specialist in molluscs
Dr Erich Volschenk	Phoenix Environmental Sciences	Taxonomic specialist in scorpions
Dr Simon Judd	Phoenix Environmental Sciences	Taxonomic specialist in isopods
Dr Volker Framenau	Phoenix Environmental Sciences	Taxonomic specialist in spiders
Dr Karin Bankin	*ecologia* Environment	Taxonomic specialist in stygofauna
Bob Bullen	Bat Call WA	15 years – bat call identification

4 RESULTS

Three habitat types were identified within the study area based upon the information outlined in Section 3.8. The details of each habitat type are shown in Table 4.1 and mapped in Figure 4.1 below.

The study area contains the following habitat types:

- pindan shrubland;
- sandstone range; and,
- savannah woodland.

The majority of systematic survey effort was concentrated on the pindan shrubland habitat, which was the dominant habitat type (Table 4.1). Additional opportunistic effort was expended in less accessible areas, or where systematic trapping was not possible (Table 4.1, Figure 4.1).

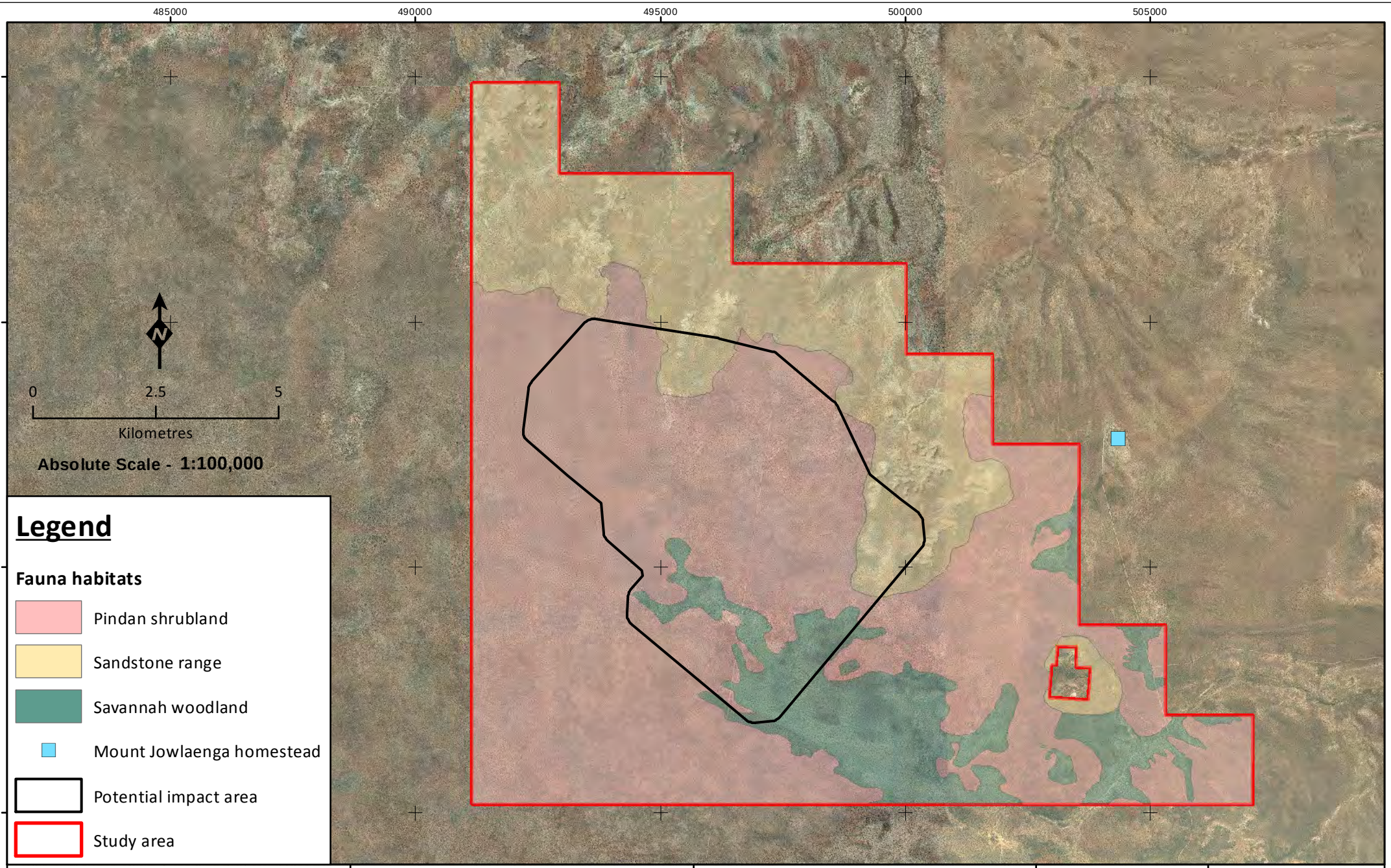
4.1 FAUNA HABITATS

Table 4.1 – Summary of fauna habitats

Fauna habitat	Area inside deposit area (ha)	Percentage of total deposit area (%)	Area inside study area (ha)	Percentage of total study area (%)
Pindan shrubland	3,125.57	78.62	9,225.24	61.95
Sandstone range	395.13	9.94	3,820.59	25.66
Savannah woodland	454.61	11.44	1,845.85	12.39
Total	**3,975.31**	-	**14,891.68**	-

Table 4.2 – Survey effort per habitat type

Fauna habitat type	Pit traps (trap nights)	Funnels (trap nights)	Elliotts (trap nights)	Cages (trap nights)	Leaf litter collection (no.)	Dry pitfall traps (trap nights)	Bird survey (min)	Diurnal opp search (min)	Nocturnal opps search (min)*	Bat recording (hrs)	Camera trapping (hrs)
Pindan shrubland	700	1,400	700	140	6	360	1,200	730		120	132.25
Sandstone range	140	280	140	28			14	420	1,380	36	253
Savannah woodland	140	280	140	28			294	70		24	



ecologia ENVIRONMENT

Sheffield Resources LIMITED

Fauna habitats of the study area

Figure: 4.1
Project ID: 1501

Drawn: NJ
Date: 30/10/13

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ

A4

4.1.1 Pindan shrubland

The pindan shrubland habitat is the most extensive type within the study area, comprising 61.95% (9,225.24 ha) of the total and covering most of the central and southern region (Figure 4.1). The geology of this habitat is flat plains, with weak orange to red sandy-loam soils. The dominant tree species is scattered *Corymbia greeniana*, over a moderately open to dense shrub layer consisting primarily of *Acacia tumida* var *tumida*, *Acacia platycarpa* and *Grevillea refracta*. The ground vegetation layer consists of a mix of grasses including *Triodia caelestialis*, *Aristida holathera* var *holathera*, *Crysopogon* sp., *Eriachne obtusa* and *Sorghum plumosum*. Leaf litter density is highly variable as a result of fire history and patchy shrub density.

Figure 4.2 – Example of the pindan shrubland habitat

4.1.2 Sandstone range

The sandstone range habitat is the second most widespread within the study area, covering 25.66% (3,820.59 ha) of the total. It is found mainly across the northern region of the study area, but also extends partly down into the east. The geology is primarily undulating hills, slopes and gullies of orange sandy soils with sandstone residuals ranging from moderately dense pebbles to dense rocks (Figure 4.3). Several rock outcrops are also present in the eastern region of the study area (Figure 4.4). The vegetation in this habitat is characterised by sparse *Corymbia dendromerinx* over moderately dense *Acacia drepanocarpa* subsp. *latifolia* over a ground vegetation layer of dense *Triodia caelestialis* hummock grassland and *Sorghum plumosum* tussock grassland.

Figure 4.3 – Example of undulating rocky hills in the sandstone range habitat

Figure 4.4 – Example of a rock outcrop in the sandstone range habitat

4.1.3 Savannah woodland

The savannah woodland habitat is the least extensive, covering only 12.39% (1845.85 ha) of the study area. It is characterised by plains in the low-lying areas to the south and east of the study area, with firm brown-white sandy clay soils. The dominant vegetation consists of scattered *Eucalyptus tectifica* and *Brachychiton diversifolius*, with open to moderately dense shrubs of mainly *Acacia platycarpa*. There is a ground vegetation layer of *Eriachne obtusa* tussock grassland and *Triodia caelestialis* hummock grassland, and termite mounds are frequently present.

Figure 4.5 – Example of the savannah woodland habitat.

4.2 FAUNA HABITAT ANALYSIS

Systematically obtained data (trapping results for terrestrial and SRE fauna, and set-time surveys for birds, excluding opportunistic data) was analysed to compare the three habitat types. A one-way ANOSIM test and MDS plot were completed separately for each group in order to determine any differences between habitat types based upon the fauna assemblages they support. The results from the one-way ANOSIM tests are shown in Table 4.3, and the MDS plots are presented in Figures 4.6 – 4.8.

When comparing trapped terrestrial fauna data against the different habitat types, the one-way ANOSIM test determined an R-value of 0.13 (R-value ranges from -1 to 1, with 1 indicating that the groups are dissimilar and -1 indicating that the groups are similar) and a p-value of 0.006 (a p-value of <0.05 indicates a significant difference). The positive R-value, close to 0 and the very low p-value from this analysis suggests some differences between habitat types, although they are not highly different, and that the data collected are sufficient to make this analysis. The MDS plot provides a visual representation of these differences, showing a large amount of overlap between the habitats in terms of terrestrial vertebrate fauna assemblages (Figure 4.6).

Statistical analysis of the avifauna data demonstrates greater differences between the assemblages recorded in each habitat type. The one-way ANOSIM test returned an R-value of 0.13, and a p-value

of 0.07, indicating no statistically significant difference between the habitats. This is also reflected in the MDS plot, which shows minimal separation of the three habitat types (Figure 4.7).

Statistical analysis of the SRE invertebrate data demonstrates greater differences between the assemblages recorded in each habitat type. The one-way ANOSIM test returned an R-value of -0.1229, and a p-value of 0.8516, indicating no statistically significant difference between the habitats. This is also reflected in the MDS plot, which shows minimal separation of the three habitat types (Figure 4.8).

Table 4.3 – One-way ANOSIM test results for fauna habitat comparisons

Fauna group	R-value	p-value
Terrestrial vertebrates	0.13	0.006
Avifauna	0.13	0.07
SRE invertebrates	-0.1229	0.8516

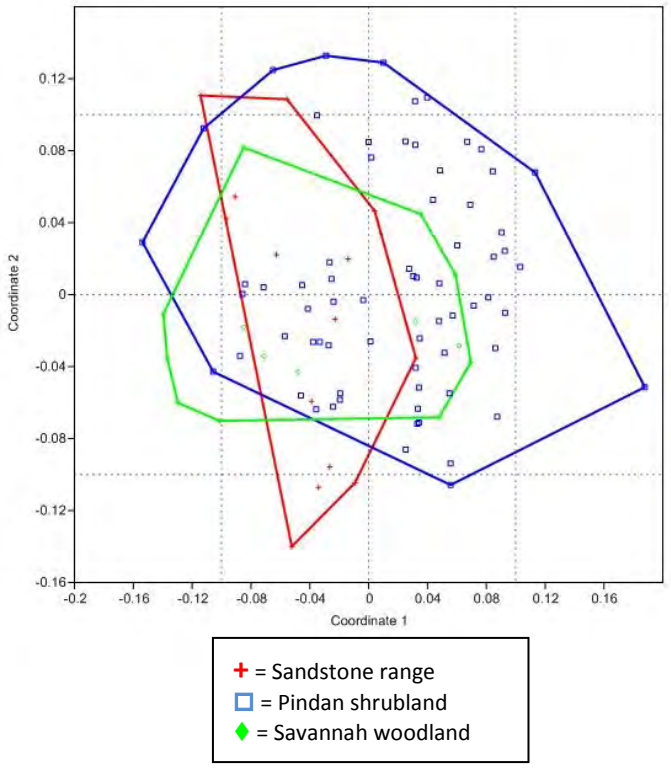


Figure 4.6 – Terrestrial vertebrates MDS plot

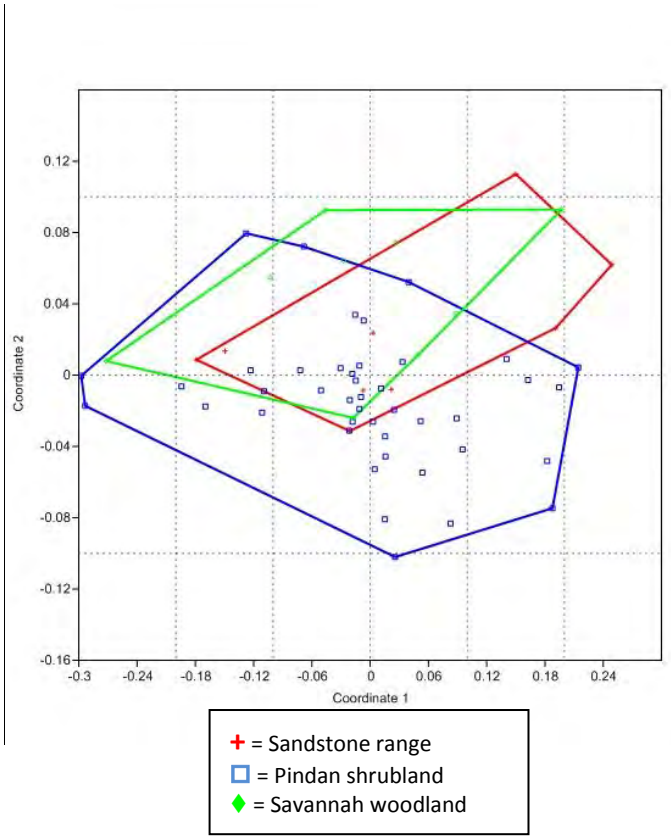


Figure 4.7 – Avifauna MDS plot

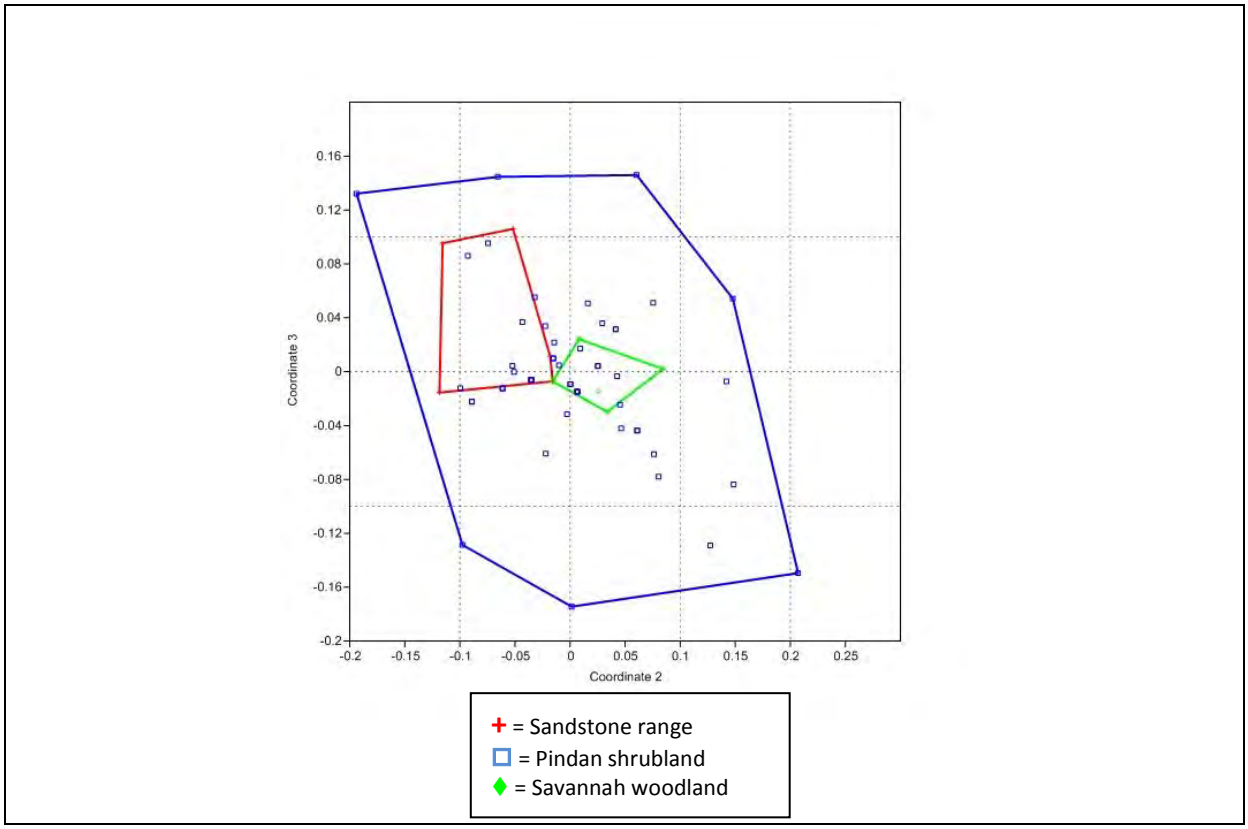


Figure 4.8 – SRE invertebrates MDS plot

4.3 FAUNA ASSEMBLAGES

A total of 16 native mammal species and four introduced mammal species, 107 bird species (27 species recorded from Mount Jowlaenga homestead only), 43 reptile species and eight frog species were recorded. All vertebrate fauna species records are shown in Appendix F, and are discussed in further detail below.

4.3.1 Mammals

A total of 16 native and four introduced mammal species were recorded during the survey. These species comprised one monotreme (egg laying mammal), one dasyurid (small, carnivorous marsupial), one peramelid (Bandicoot or Bilby), two macropods (kangaroo), eight microchiroptera (microbat), three murids (mice or rat) and four introduced mammals (Dog, House Mouse, Cat or Cow). All mammal records are shown in Appendix F. Small mammals such as murids and dasyurids were captured in pitfall and Elliott traps at systematic trapping sites. Larger mammals such as macropods were observed during diurnal and nocturnal opportunistic searches, nocturnal road spotting, secondary evidence and camera trapping. Bats were identified from calls recorded on SM2BAT recorders.

Mammal abundance was generally low, with all trappable and observable mammals recorded less than 10 times, with the exception of the Delicate Mouse, which had a total of 26 trap captures. A number of variances between the two phases of surveying are evident. The Lesser Hairy-footed Dunnart (two records), Large Footed Myotis (one site) and Dog (one record) were recorded during phase 1 only. While the Echidna (one record), Greater Bilby (one record), Euro (one record), Yellow-bellied Sheathtail Bat (two sites), Common Bentwing Bat (three sites), Short-tailed Mouse (one record) and House Mouse (nine records) were recorded during phase 2 only.

Two mammals of conservation significance were recorded, the Greater Bilby (EPBC Act Vulnerable, WC Act Schedule 1, DPaW Vulnerable) and Northern Short-tailed Mouse (DPaW Priority 4).

4.3.2 Birds

A total of 107 bird species (27 species recorded from Mount Jowlaenga homestead only) were recorded during the survey. The most well represented family of birds within the study area was the Meliphagidae family (honeyeaters), of which nine species were recorded. A further nine species were recorded from within the Anatidae family (ducks), however all these species were recorded from Mount Jowlaenga homestead only.

The most abundant species recorded was the Masked Woodswallow, with a total of 717 records made (706 records first phase, 11 records second phase). Other abundant species recorded included the Varied Lorikeet (449 records), Red-collared Lorikeet (150 records), Rufous Whistler (144 records), Brown Honeyeater (122 records), Little Corella (108 records) and Red-backed Fairy-wren (107 records).

A noticeable variation between phase one and phase two of surveying exists for the abundance and diversity of bird species recorded. Within the study area, 13 species of bird were recorded during phase 1 only, consisting of; Crested Pigeon, Tawny Frogmouth, Spotted Nightjar, Fork-tailed Swift, Spotted Harrier, Wedge-tailed Eagle, Nankeen Kestrel, Red-chested Button-quail, Little Button-quail, Budgerigar, Black Honeyeater, White-throated Honeyeater and Tree Martin. During phase 2, a total of nine bird species were recorded which weren't recorded during phase 1; Australian Hobby, Red-tailed Black Cockatoo, Varied Lorikeet, Pallid Cuckoo, Brush Cuckoo, Great Bowerbird, Variegated Fairy-wren, Banded Honeyeater and Olive-backed Oriole. Additionally, of the 27 bird species recorded from Mount Jowlaenga homestead only, 21 species were recorded only during phase 2.

Seven bird species of conservation significance were recorded (three wetland dependent species from Mount Jowlaenga homestead); Rainbow Bee-eater (EPBC Act Migratory, WC Act Schedule 3), Fork-tailed Swift (EPBC Act Migratory, WC Act Schedule 3), Wood Sandpiper (Mount Jowlaenga homestead only, EPBC Act Migratory, WC Act Schedule 3), Eastern Yellow Wagtail (Mount Jowlaenga homestead only, EPBC Act Migratory, WC Act Schedule 3), Grey Wagtail (Mount Jowlaenga homestead only, EPBC Act Migratory, WC Act Schedule 3), Bush Stone-curlew (DPaW Priority 4) and Australian Bustard (DPaW Priority 4).

4.3.3 Reptiles

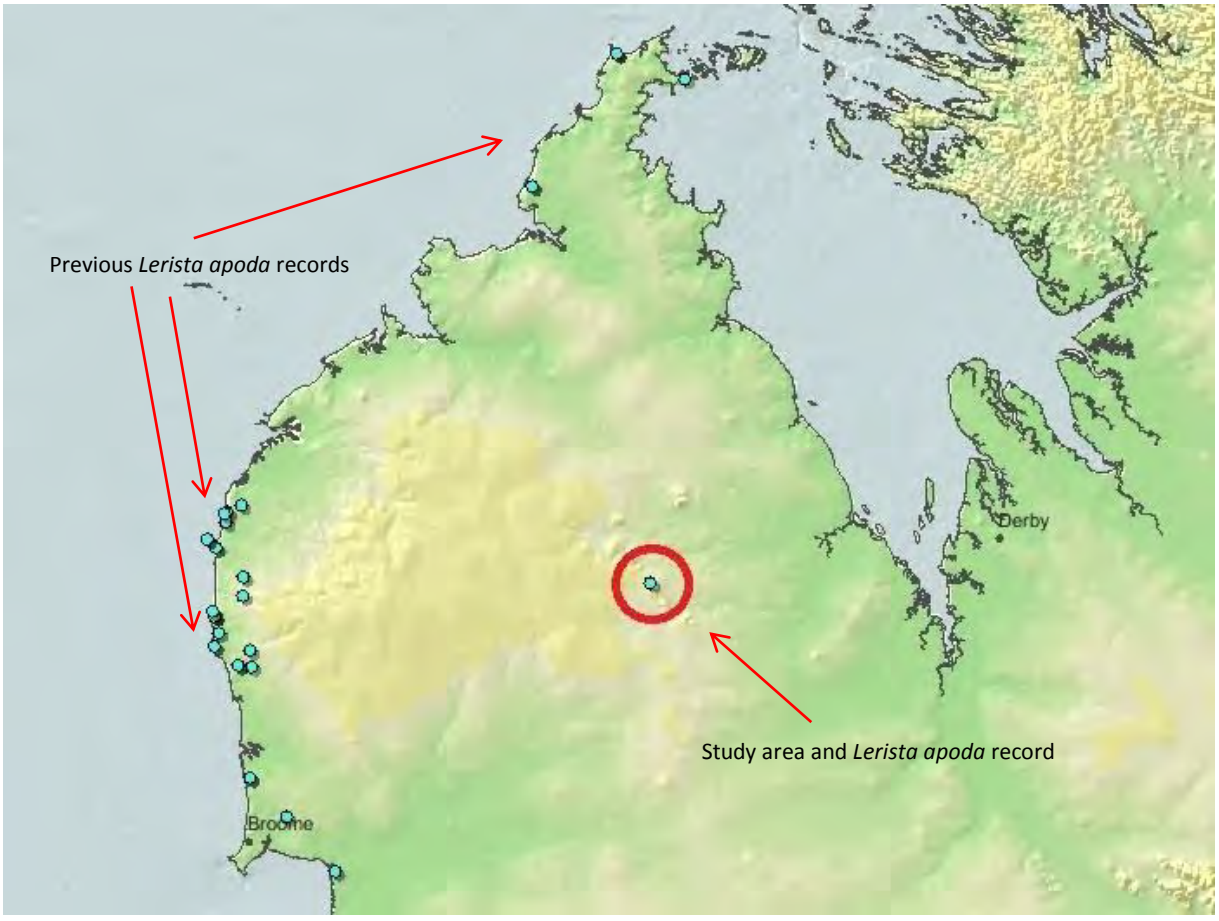
A total of 43 reptile species were recorded during the survey. These species comprised of three Diplodactylidae and three Gekkonidae (gecko) species, three Pygopodidae (legless lizard) species, 17 Scincidae (skink) species, five Agamidae (dragon) species, four Varanidae (goanna) species, one Typhlopidae (blind snake) species, one Boidae (python) species and six Elapidae (front-fanged venomous snake) species.

No reptiles of conservation significance were recorded.

4.3.4 Amphibians

A total of eight frog species from three families were recorded from the current survey (Appendix F). The abundance and diversity of frog species recorded was higher during phase one (Appendix F). Four species (Giant Frog, Long-footed Frog, Little Red Tree Frog and Mole Toadlet) were recorded during phase 1 only. One frog species was recorded during phase two only, the Northern Laughing Tree frog. The number of frog individuals for all species totalled 112 during phase one, while nine individuals were recorded during phase two. The most abundant frog species recorded were the Desert Spadefoot and Ornate Burrowing Frog. No amphibians of conservation significance were recorded.

Figure 4.9 – *Lerista apoda* recorded



Source: NatureMap (2013)

Figure 4.10 – Previous NatureMap *Lerista apoda* records

Figure 4.11 – *Ctenotus colletti* recorded

4.3.5 Short Range Endemic invertebrate fauna

The results of the SRE invertebrate fauna which were collected are summarised below and presented in Appendix F.

4.3.5.1 Mygalomorphae (Spiders)

During the survey, 13 mygalomorph specimens from the Nemesiidae family were collected. These were later classified into seven species, all of which are considered potential SREs.

4.3.5.2 Scorpiones (Scorpions)

Eighty scorpions from two families were collected. These included 77 specimens from the Buthidae family which were classified into seven species, five of which are considered potential SREs. A further three specimens from the Urodacidae family were classed into two potential SRE species.

4.3.5.3 Pseudoscorpiones (Pseudoscorpions)

The pseudoscorpion specimens include 21 individuals from three families; the Sternophoridae, Chernetidae and Olpiidae. The former two families recorded two specimens each, which were classified into two species, neither of which are considered SREs. However, 17 specimens from the Olpiidae family were classified into two species, one of which is considered a potential SRE.

4.3.5.4 Isopoda (Slaters)

Thirty six isopod specimens from the Armadillidae family were collected during the survey. These were classed into three species, all of which are considered potential SREs.

4.3.5.5 Gastropoda (Snails)

The mollusc specimens collected include 24 individuals from three families. Four specimens from the Subulinidae family and two from the Pupillidae family were classed into two species, neither of which are considered SREs. Eighteen specimens from the Camaenidae family were classified into two species, including a potential and a confirmed SRE species.

4.3.5.6 Diplopoda (Millipedes)

No diplopod specimens were collected during the survey.

4.3.5.7 Chilopoda (Centipedes)

No chilopod specimens were collected during the survey.

4.3.6 Stygofauna

Ten specimens of worm belonging to the family Naididae (Naididae sp. indet) were collected in a net haul sample from drill hole THAC 245 sampled at 60 metres (depth to water: 38 m), tapping the Broome Sandstone aquifer (Table 4.4).

Table 4.4 – Stygofauna sampling results

Sub-Phylum	Class	Family	Identification	Number of indiviuals	Site	Aquifer
Annelida	Polychaeta	Naididae	Naididae sp. indet	10	THAC 245	Broome Sandstone

4.3.6.1 Groundwater Physio-chemistry

Results of the groundwater physio-chemistry (electrical conductivity [EC], dissolved oxygen [DO], temperature [°C], acidity/alkalinity [pH], and redox potential [mV]) sampling are summarised in Table 4.5. Individual results for each bore hole are shown in Appendix G.

Table 4.5 – Summary of groundwater physio-chemistry

Bore ID	Depth to water (m)	Temp. (°C)	Conductivity (mS/cm)	DO (ppm) mg/L	pH	Salinity (PSS)	DO%	Redox (mV)	Depth of sample (m)
Average (mean)	34.80	32.44	0.23	4.06	5.60	0.12	34.56	113.29	59.64
Maximum	49	33.91	0.484	7.65	6.27	0.23	75.7	150	90
Minimum	22	30.88	0.043	2.04	5.26	0.03	3.6	24	350
Standard deviation	7.73	0.83	0.11	1.55	0.33	0.05	23.47	30.31	12.89
n	15	13	15	15	15	15	15	14	14

The pH of the groundwater measured showed slight acidic levels (average pH of 5.60), common in igneous and metamorphic sedimentary aquifers, which may not be suitable for all stygofauna (Humphreys 2008). However, during the DEC Pilbara stygofauna survey (Eberhard *et al*. 2009), stygofauna were sampled from bores where pH ranged from slightly acidic (pH 5.70). Overall, the remaining measured groundwater parameters were found to be within the habitable ranges for stygofauna (Humphreys 1999, Malard & Hervant 1999, Humphreys 2008).

4.3.7 Troglofauna

One specimen of centipede belonging to the family Cryptopidae (*Cryptops* sp.) was collected during scraping at drill hole THAC 282 (depth to water: 36 m). Additionally, a rove beetle (family Staphylinidae) was collected from a troglofauna trap at drill hole THAC 407, at a depth of 8 m (Table 4.6).

Table 4.6 – Troglofauna sampling results

Class	Order	Family	Identification	Number of indiviuals	Site	Geology
Chilopoda	Scolopendromorpha	Cryptopidae	*Cryptops* sp. indet.	1	THAC 282	Sedimentary - sandstone
Insecta	Coleoptera	Staphylinidae	Staphylinidae sp. indet.	1	THAC 407	Sedimentary - sandstone

4.4 POTENTIAL CONSERVATION SIGNIFICANT VERTEBRATE FAUNA

The literature review revealed seven mammal, 59 bird and three reptile species of conservation significance could potentially occur in the study area. A total of 44 of the 59 potential conservation significant bird species are restricted to wetland or coastal habitats. A number of these species may occur at nearby Mount Jowlaenga homestead, but will not utilise the study area directly. These wetland and coastal restricted bird species are shown separately in Table 4.8, with their conservation status shown in Appendix C. These species are therefore not discussed in further detail as they are not expected to utilise the study area directly.

All regional records of conservation significant mammals, reptiles and birds (excluding the coastal restricted birds) are mapped in Figure 4.12 and Figure 4.13.

An assessment of likelihood of occurrence of the potential seven mammal, 15 bird and two reptile species of conservation significance in the study area was completed, based on the categories outlined in Section 3.6, with the results summarised in Table 4.7.

A total of nine conservation significant species were recorded (three wetland dependent bird species from Mount Jowlaenga homestead only) during the current survey. A further four potential species are assessed as having a medium likelihood of occurrence, with none considered highly likely to occur. The remaining 15 species are considered to have a low likelihood of occurrence (Table 4.7) and are not discussed further.

Species that were recorded or assessed as having a medium likelihood of occurrence are discussed in further detail in Section 5.4

Table 4.7 – Assessment of likelihood of occurrence of potential conservation significant fauna

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence
	EPBC Act	WC Act	DPaW			
Mammals						
Northern Quoll *Dasyurus hallucatus*	EN	S1	EN	Rocky areas, also eucalypt forest and woodland.	Not previously recorded on the Dampier Peninsula, but has been recorded in similar habitat to that present, 90 km east of the study area in 2001 (NatureMap)	**LOW** Some suitable habitat in rocky hills, but not previously recorded on Dampier Peninsula.
Greater Bilby *Macrotis lagotis*	VU	S1	VU	Variety of habitats on soft soil, including spinifex grassland, acacia shrubland, open woodland, and cracking clays.	Numerous records within 100 km of study area (NatureMap), including eight records within 20 km of tenement E0402083 (DEC Rare Fauna Search), the most recent record being from 1996.	**RECORDED** Suitable habitat occurs within the study area.
Golden Bandicoot *Isoodon auratus auratus*	VU	S1		Rocky sandstone spinifex and vine thickets.	One record from 1971 on the Dampier Peninsula (NatureMap).	**LOW** Few records within 100 km, and limited suitable habitat.
Crest-tailed Mulgara *Dasycercus cristicauda*	VU	S1		Sandy areas predominately on the top of sand dunes at the base of large Canegrass clumps or Nitre Bush hummocks.	Not previously recorded within 100 km of the study area (NatureMap).	**LOW** No suitable habitat. Not previously recorded within 100 km of the study area.
Short-tailed Mouse *Leggadina lakedownensis*			P4	Spinifex and tussock grassland on cracking clays. Also acacia shrubland, samphire, woodlands, and stony ranges.	No previous records on the Dampier Peninsula (NatureMap).	**RECORDED** Recorded once at site 6, and suitable habitat occurs through most of the study area.
Mangrove Freetail Bat *Mormopterus loriae cobourgiana*			P1	Roost in mangrove stands, hunt in mangroves and forests.	Numerous recent coastal records from the northern tip of the Dampier Peninsula (NatureMap).	**LOW** No suitable habitat within the study area.
Yellow-lipped Cave Bat *Vespadelus douglasorum*			P2	Tropical woodlands of West Kimberley	Recorded near Beagle Bay, approximately 45 km north of the study area (NatureMap).	**LOW** No potential roost caves. Rarely recorded on Dampier Peninsula.

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence
	EPBC Act	WC Act	DPaW			
Birds						
Gouldian Finch *Erythrura gouldiae*	EN	S1	EN	Tropical savannahs; breed in rocky hills with hollow-bearing eucalypts near water.	Regularly recorded near Cape Leveque, 100 km north of the study area (NatureMap).	**MEDIUM** Suitable habitat occurs within the study area. However, known from very few locations on Dampier Peninsula.
Fork-tailed Swift *Apus pacificus*	M	S3		Almost entirely aerial, particularly associated with storm fronts.	Recorded 80 km west of the study area at James Price Point (*ecologia* internal database). Numerous records throughout Dampier Peninsula (NatureMap).	**RECORDED** Recorded once during the first phase, this is a relatively common summer migrant in the northwest of Australia that will occasionally forage in the aerial space above the study area.
Eastern Great Egret *Ardea modesta*	M	S3		Floodwaters, rivers, shallows of wetlands, intertidal mud-flats.	Numerous records throughout the Dampier Peninsula (NatureMap).	**LOW** Very little suitable habitat, but may occur during the wet season in flooded depressions.
Cattle Egret *Ardea ibis*	M	S3		Grassy habitats and wetlands, particularly damp pastures.	Recorded approximately 37 km south-west, and 65 km east (Derby) of the study area (NatureMap).	**LOW** Very little suitable habitat, but may occur during the wet season in open flooded depressions.
Glossy Ibis *Plegadis falcinellus*	M	S3		Shallows and adjacent flats of freshwater lakes and swamps; river pools; flooded samphire; sewage ponds. Nest in freshwater/brackish wetlands with tall, dense stands of emergent vegetation and low trees or bushes.	Recorded throughout the southern Dampier Peninsula, including a record 20 km east of the study area (NatureMap).	**LOW** Very little suitable habitat, but may occur during the wet season in flooded depressions.
Oriental Pratincole *Glareola maldivarum*	M	S3		Plains, shallow wet and dry edges in open bare wetlands, tidal mudflats, beaches.	Many recent records within 100 km (NatureMap).	**MEDIUM** Suitable habitat exists within the study area, and there are records nearby.

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence
	EPBC Act	WC Act	DPaW			
Rainbow Bee-eater *Merops ornatus*	M	S3		Open country, most vegetation types, dunes, banks.	Numerous records throughout the Dampier Penisula (NatureMap).	**RECORDED** This species was recorded throughout the study area numerous times. Some nesting habitat is present along drainage lines.
Barn Swallow *Hirundo rustica*	M	S3		Open country, agricultural land, especially near water.	Recorded approximately 37 km south-west, and 65 km east (Derby) of the study area (Birdata)	**LOW** Little suitable habitat within the study area.
Grey Falcon *Falco hypoleucos*		S1	VU	Lightly wooded coastal and riverine plains.	Two records approximately 37 km south-west, and 68 km south-east of the study area (NatureMap).	**LOW** Little suitable habitat within the study area.
Peregrine Falcon *Falco peregrinus*		S4	Other	Coastal cliffs, riverine gorges and wooded watercourses.	Recorded approximately 37 km south-west of the study area (NatureMap).	**LOW** Little suitable habitat within the study area.
Masked Owl (*Tyto novaehollandiae kimberli*)			P1	Forest, woodland, caves, mature trees with hollows.	Not recorded within 100 km of the study area (NatureMap).	**LOW** Little suitable habitat within the study area. Not known from Dampier Peninsula.
Flock Bronzewing *Phaps histrionica*			P4	Sparsely wooded plains near water. Nomadic visitor to areas of suitable habitat.	Numerous recent records within 100 km of the study area (NatureMap).	**LOW** Little suitable sparsely wooded habitat.
Australian Bustard *Ardeotis australis*			P4	Open grasslands, chenopod flats and low heathland.	Numerous records in southern Dampier Peninsula, including the nearest record of 35 km east of the study area (NatureMap).	**RECORDED** This species was recorded on six occasions during phase 1. Suitable habitat occurs throughout much of the study area.
Bush Stone-curlew *Burhinus grallarius*			P4	Lightly wooded country next to daytime shelter of thickets or long grass.	Several records approximately 37 km south-west, and 68 km south-east of the study area (NatureMap).	**RECORDED** This species was recorded numerous times across the study area. Suitable habitat occurs throughout much of the study area.

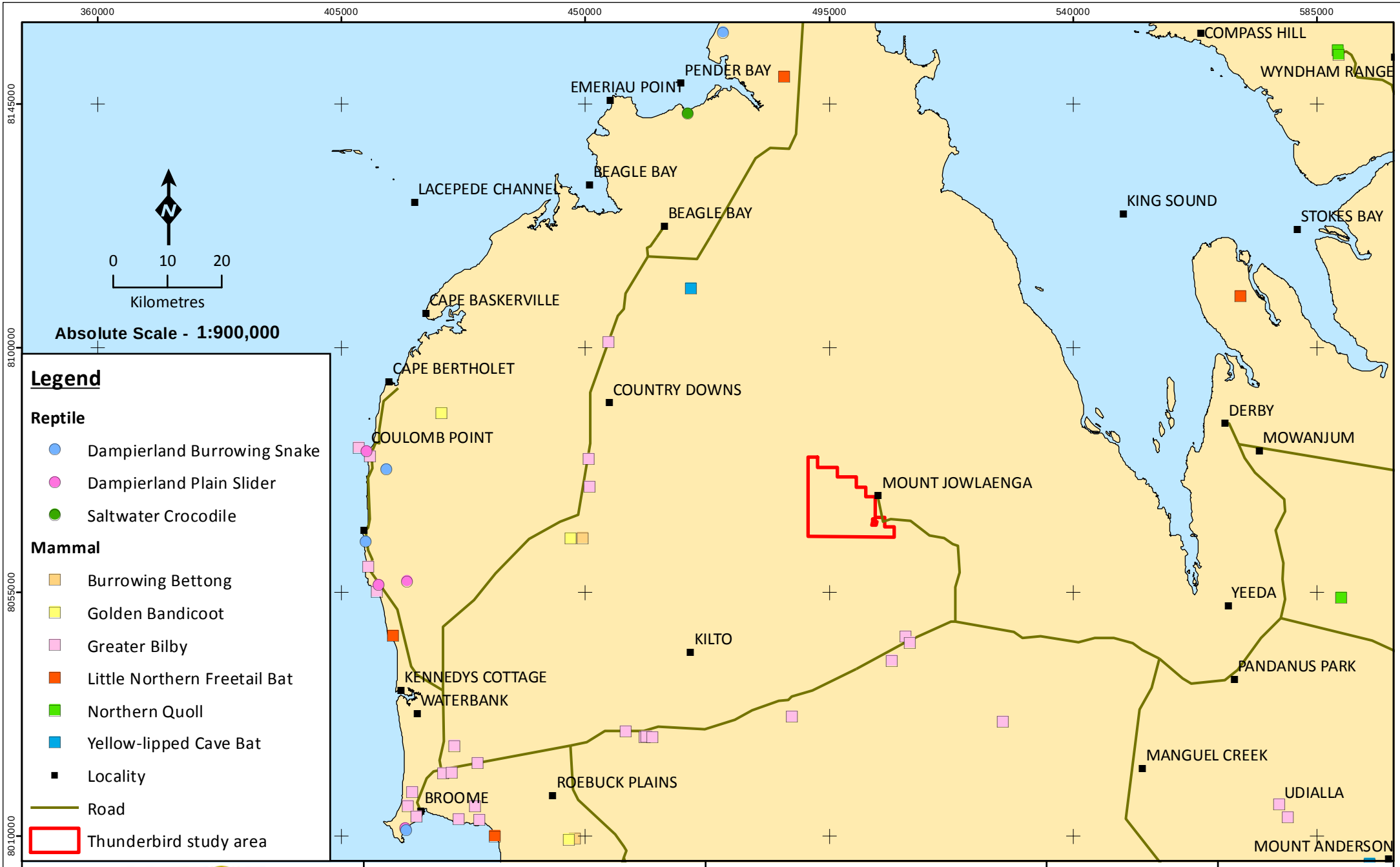
Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence
	EPBC Act	WC Act	DPaW			
Chestnut-backed Button-quail *Turnix castanota*			P4	Savannah woodlands in sandstone and lateritic country.	No records on the Dampier Peninsula (NatureMap).	**LOW** Little suitable habitat and no records nearby.
Reptiles						
Saltwater Crocodile *Crocodylus porosus*		S4	Other	Tidal rivers, coastal floodplains and channels, billabongs and swamps up to 150 km inland.	Not recorded away from coast on Dampier Peninsula, with scarce records in the region (NatureMap)	**LOW** No suitable estuarine or billabongs habitat exists within the study area.
Dampierland Plain Slider *Lerista separanda*			P2	Sandy areas of Dampierland.	Several records along the north-west coast of the Dampier Peninsula, all greater than 85 km from the study area (NatureMap).	**MEDIUM** Apparently restricted to coastal habitats, however poorly known species and sandy habitat exists within study area.
Dampierland Burrowing Snake *Simoselaps minimus*			P2	Coastal dunes or sandy areas between dunes and adjacent acacia shrublands.	Five records within 100 km of study area, all coastal between Broome and Beagle Bay (NatureMap)	**MEDIUM** Apparently restricted to coastal habitats, however poorly known species and sandy habitat exists within study area.

* Refer to Appendix C for a complete list of migratory-listed shorebird or coastal species in the families Fregatidae, Sulidae, Accipitridae, Charadriidae, Rostratulidae, Scolopacidae, Stercorariidae, Laridae and Motacillidae.
Note: Description of conservation significant codes provided in Appendix A.

Table 4.8 – Coastal and wetland conservation significant bird species

Species name	Common name	Species name	Common name
Fregata ariel	Lesser Frigatebird*	*Arenaria interpres*	Ruddy Turnstone*
Sula leucogaster	Brown Booby*	*Limnodromus semipalmatus*	Asian Dowitcher*
Egretta sacra	Eastern Reef Egret*	*Calidris tenuirostris*	Great Knot*
Haliaeetus leucogaster	White-bellied Sea-Eagle[J]	*Calidris canutus*	Red Knot*
Pluvialis fulva	Pacific Golden Plover[J]	*Calidris alba*	Sanderling*
Pluvialis squatarola	Grey Plover[J]	*Calidris ruficollis*	Red-necked Stint[J]
Charadrius leschenaultii	Greater Sand Plover*	*Calidris subminuta*	Long-toed Stint[J]
Charadrius mongolus	Lesser Sand Plover*	*Calidris melanotos*	Pectoral Sandpiper*
Charadrius veredus	Oriental Plover[J]	*Calidris acuminata*	Sharp-tailed Sandpiper[J]
Rostratula australis	Australian Painted Snipe[J]	*Calidris ferruginea*	Curlew Sandpiper[J]
Gallinago megala	Swinhoe's Snipe[J]	*Limicola falcinellus*	Broad-billed Sandpiper*
Limosa limosa	Black-tailed Godwit*	*Philomachus pugnax*	Ruff[J]
Limosa lapponica	Bar-tailed Godwit[J]	*Stercorarius parasiticus*	Arctic Jaeger*
Numenius minutus	Little Curlew[J]	*Sternula albifrons*	Little Tern*
Numenius phaeopus	Whimbrel*	*Hydroprogne caspia*	Caspian Tern*
Numenius madagascariensis	Eastern Curlew*	*Chlidonia leucopterus*	White-winged Black Tern[J]
Xenus cinereus	Terek Sandpiper*	*Sterna dougallii*	Roseate Tern*
Actitis hypoleucos	Common Sandpiper[J]	*Sterna sumatrana*	Black-naped Tern*
Tringa brevipes	Grey-tailed Tattler*	*Sterna hirundo*	Common Tern*
Tringa glareola	Wood Sandpiper[JR]	*Thalasseus bengalensis*	Lesser Crested Tern*
Tringa nebularia	Common Greenshank[J]	*Motacilla cinerea*	Grey Wagtail[JR]
Tringa stagnatilis	Marsh Sandpiper[J]	*Motacilla tschutschensis*	Eastern Yellow Wagtail[JR]

*Coastal species, unlikely to occur at Mount Jowlaenga homestead
[J]Potentially could occur at Mount Jowlaenga during suitable conditions
[JR]Recorded at Mount Jowlaenga homestead on current survey



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Regional conservation signficant mammal and reptile records

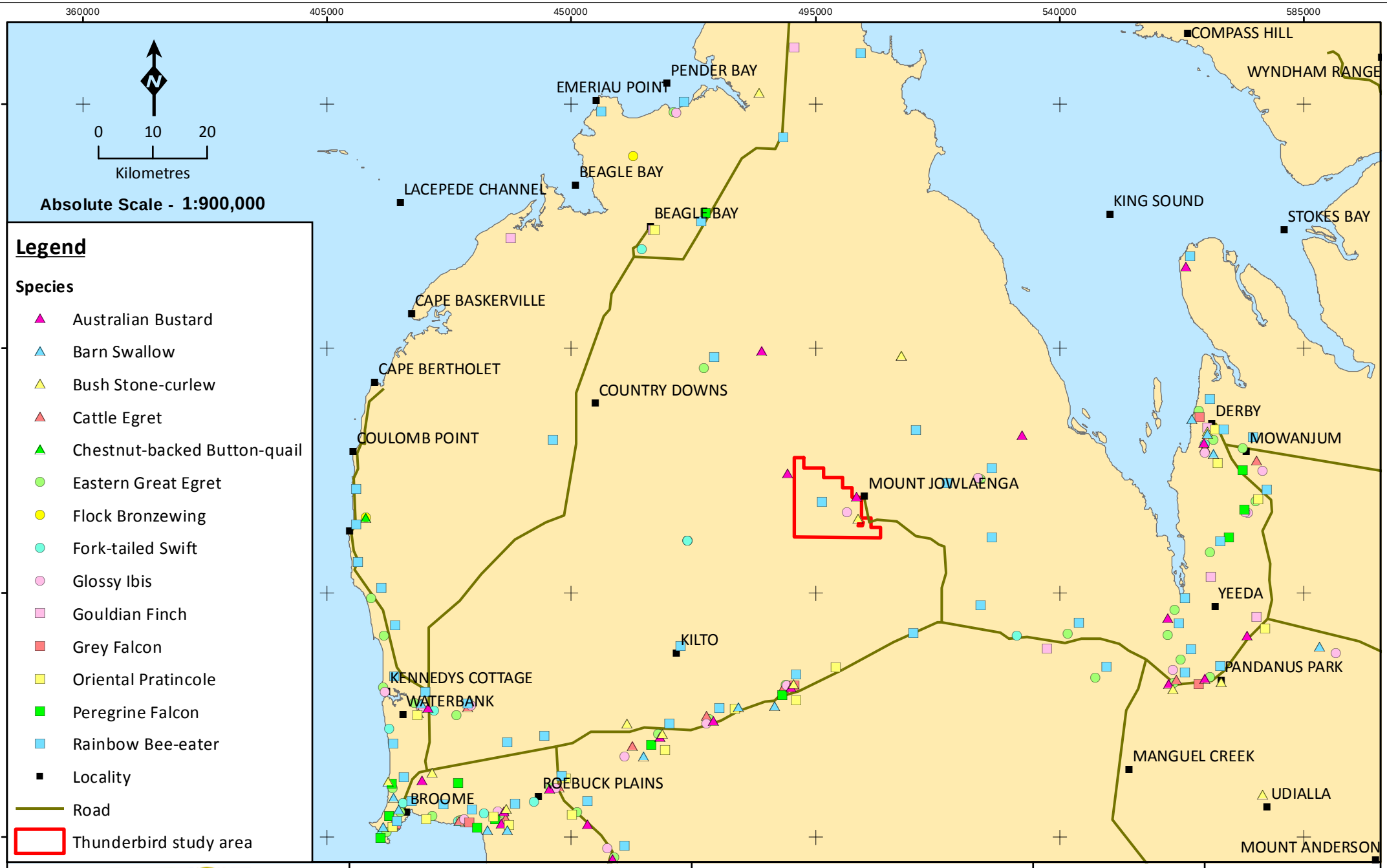
Figure: 4.12
Project ID: 1501

Drawn: NJ
Date: 25/02/2014

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ013

A4



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Regional conservation signficant bird records

Figure: 4.13
Project ID: 1501

Drawn: NJ
Date: 25/02/2014

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ013

A4

4.5 CONSERVATION SIGNIFICANT VERTEBRATE FAUNA RECORDED

Based on database searches and the results of previous biological surveys in the surrounding region, seven mammal, 15 bird (excluding wetland and coastal dependent bird species) and three reptile species of conservation significance could potentially occur within the study area.

Nine species of conservation significance were recorded (two mammals and seven bird species (three wetland dependent bird species) during the survey. These records are summarised in Table 4.7 and mapped in Figure 4.22.

Table 4.9 – Conservation significant fauna recorded

Species	Conservation status			Location			Date	Comments
	EPBC Act	WC Act	DPaW	Easting	Northing	Site		
Mammals								
Greater Bilby	S1	VU	S1	495001	8073488	TB Opp	22/10/13	Three captures (photos) of large, male Greater Bilby at entrance to small burrow. Captures on morning of 22/10/13 at 0432 & 0436 and evening at 1852 (Figure 4.14
Greater Bilby (Burrow)	S1	VU	S1	495001	8073488	TB Opp	20/10/13	Small sized burrow (Figure 4.15). Greater Bilby individual recorded at entrance of burrow.
Greater Bilby (Burrow)	S1	VU	S1	494116	8073268	TB Opp	8/4/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	494166	8073394	TB Opp	9/4/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	493555	8074935	TB Opp	9/4/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	496881	8071087	TB Opp	19/10/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	494116	8073268	TB Opp	18/10/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	494166	8073394	TB Opp	19/10/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	496807	8071018	TB Opp	18/10/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	494085	8073523	TB Opp	20/10/13	Inactive burrow
Greater Bilby (Burrow)	S1	VU	S1	495000	8073488	TB Opp	19/10/13	Inactive burrow
Greater Bilby (Scat)	S1	VU	S1	495015	8073510	TB Opp	20/10/13	Associated with fresh diggings (Figure 4.16)
Greater Bilby (Scat)	S1	VU	S1	494911	8073733	TB Opp	20/10/13	Associated with fresh diggings
Greater Bilby (Scat)	S1	VU	S1	494996	8073723	TB Opp	20/10/13	Associated with fresh diggings
Greater Bilby (Digging)	S1	VU	S1	494978	8073558	TB Opp	20/10/13	16 separate diggings within 190 metres (Figure 4.17)
Greater Bilby	S1	VU	S1	496881	8071087	TB Opp	20/10/13	Six separate diggings within

Species	Conservation status			Location			Date	Comments
	EPBC Act	WC Act	DPaW	Easting	Northing	Site		
(Digging)								260 metres
Greater Bilby (Digging)	S1	VU	S1	494169	8073407	TB Opp	20/10/13	Seven separate diggings within 160 metres
Northern Short-tailed Mouse			P4	496603	8068741	TB S6	20/10/13	One individual trapped
Birds								
Fork-tailed Swift	M	S3		503429	8067414	TB Opp	9/4/13	Two individuals recorded flying over
Wood Sandpiper[J]	M	S3		504152	8072770	Mt J	16/10/13	12 individuals recorded (Figure 4.18)
Wood Sandpiper	M	S3		503429	8067414	TB Opp	22/10/13	One individual recorded flying over
Eastern Yellow Wagtail	M	S3		504152	8072770	Mt J	20/10/13	Two individuals recorded
Grey Wagtail	M	S3		504152	8072770	Mt J	16/10/13	One individual recorded
Rainbow Bee-eater	M	S3		504152	8072770	TB OS7	7/4/13	10 individuals records
Rainbow Bee-eater	M	S3		499712	8067404	TB OS3	9/4/13	Two individuals recorded
Rainbow Bee-eater	M	S3		499903	8073523	TB Opp	15/10/13	Four individuals recorded
Rainbow Bee-eater	M	S3		499584	8073492	TB S1	9/04/13	One individual recorded
Rainbow Bee-eater	M	S3		499584	8073492	TB S1	13/04/13	Two individuals recorded
Rainbow Bee-eater	M	S3		499584	8073492	TB S1	19/10/13	Three individuals recorded
Rainbow Bee-eater	M	S3		499584	8073492	TB S1	21/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		496173	8073359	TB S2	15/10/13	One individual recorded
Rainbow Bee-eater	M	S3		496173	8073359	TB S2	19/10/13	One individual recorded
Rainbow Bee-eater	M	S3		496173	8073359	TB S2	20/10/13	One individual recorded
Rainbow Bee-eater	M	S3		496173	8073359	TB S2	18/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		493352	8073219	TB S3	11/04/13	Two individuals recorded
Rainbow Bee-eater	M	S3		493352	8073219	TB S3	14/04/13	One individual recorded
Rainbow Bee-eater	M	S3		493352	8073219	TB S3	18/10/13	One individual recorded
Rainbow Bee-eater	M	S3		491858	8073144	TB S4	19/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		491858	8073144	TB S4	11/04/13	One individual recorded

Species	Conservation status			Location			Date	Comments
	EPBC Act	WC Act	DPaW	Easting	Northing	Site		
Rainbow Bee-eater	M	S3		491858	8073144	TB S4	14/04/13	One individual recorded
Rainbow Bee-eater	M	S3		491858	8073144	TB S4	18/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		491858	8073144	TB S4	20/10/13	Four individuals recorded
Rainbow Bee-eater	M	S3		491858	8073144	TB S4	21/10/13	Three individuals recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	18/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	21/10/13	One individual recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	7/04/13	Three individuals recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	8/04/13	Four individuals recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	12/04/13	Two individuals recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	17/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		496965	8071200	TB S5	19/10/13	Three individuals recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	15/10/13	One individual recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	17/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	7/4/13	Eight individuals recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	8/4/13	One individual recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	9/4/13	Three individuals recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	12/4/13	One individual recorded
Rainbow Bee-eater	M	S3		496603	8068741	TB S6	19/10/13	Two individuals recorded
Rainbow Bee-eater	M	S3		497272	8071921	TB Opp	22/10/13	Nest on flat ground (Figure 4.19)
Rainbow Bee-eater	M	S3		496213	8066048	TB Opp	20/1013	Nest within road verge
Australian Bustard			P4	493689	8073231	TB Opp	5/4/13	Two individuals recorded
Australian Bustard			P4	495867	8063689	TB S1	5/4/13	One individual recorded
Australian Bustard			P4	498080	8073444	TB Opp	6/4/13	One individual recorded
Australian Bustard			P4	501623	8073615	TB Opp	7/4/13	One individual recorded

Species	Conservation status			Location			Date	Comments
	EPBC Act	WC Act	DPaW	Easting	Northing	Site		
Australian Bustard			P4	503137	8073511	TB Opp	8/4/13	One individual recorded
Australian Bustard			P4	498858	8073480	TB Opp	14/4/13	Two individuals recorded
Australian Bustard			P4	497167	8073401	TB Opp	15/10/13	One individual recorded
Australian Bustard			P4	499925	8073532	TB Opp	21/10/13	One individual recorded
Bush Stone-curlew			P4	504998	8067975	TB Opp	6/4/13	One individual recorded
Bush Stone-curlew			P4	503429	8067414	TB Opp	4/4/13	One individual recorded
Bush Stone-curlew			P4	503429	8067414	TB Opp	8/4/13	One individual recorded
Bush Stone-curlew			P4	503429	8067414	TB Opp	12/4/13	One individual recorded
Bush Stone-curlew			P4	496173	8073359	TB S2	15/10/13	One individual recorded
Bush Stone-curlew			P4	496173	8073359	TB S2	20/10/13	One individual recorded
Bush Stone-curlew			P4	496173	8073359	TB S2	21/10/13	One individual recorded
Bush Stone-curlew			P4	493352	8073219	TB S3	19/10/13	One individual recorded
Bush Stone-curlew			P4	491858	8073144	TB S4	15/10/13	One individual recorded
Bush Stone-curlew			P4	491858	8073144	TB S4	19/10/13	One individual recorded
Bush Stone-curlew			P4	491858	8073144	TB S4	18/10/13	One individual recorded
Bush Stone-curlew			P4	496603	8068741	TB S6	15/10/13	One individual recorded

Zone 51K
Datum GDA 94
[J]Recorded at Mount Jowlaenga homestead

Figure 4.14 – Greater Bilby recorded at active burrow via motion camera

Figure 4.15 – Active Greater Bilby burrow where an individual was recorded

Figure 4.16 – Greater Bilby scat

Figure 4.17 – Fresh digging signs from Greater Bilby

Figure 4.18 – Wood Sandpiper recorded at Mount Jowlaenga homestead

Figure 4.19 – Rainbow Bee-eater recorded at nesting burrow via motion camera

Figure 4.20 – Australian Bustard recorded

Figure 4.21 – Bush Stone-curlew recorded

485000 490000 495000 500000 505000 510000

8080000 8075000 8070000 8065000

Legend

Conservation significant species

- Northern Short-tailed Mouse
- Fork-tailed Swift
- Wood Sandpiper
- Eastern Yellow Wagtail
- Grey Wagtail
- Rainbow Bee-eater
- Rainbow Bee-eater (nest)
- Australian Bustard
- Bush Stone-curlew
- Greater Bilby (see Figure 4.22)
- Pindan shrubland
- Sandstone range
- Savannah woodland
- Mount Jowlaenga homestead
- Potential impact area
- Study area

N

0 2 4

Kilometres

Absolute Scale - 1:70,000

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Conservation significant fauna recorded

Figure: 4.22
Project ID: 1501

Drawn: BG
Date: 02/02/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: BG324

A3

490000 495000 500000

8075000

8070000

N

0 1 2

Kilometres

Absolute Scale - 1:40,000

Legend

Evidence

- Greater Bilby individual
- Scat
- Digging
- Inactive burrow
- Pindan shrubland
- Sandstone range
- Savannah woodland
- Potential impact area
- Study area

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Locations of Greater Bilby evidence recorded during the survey

Figure: 4.23
Project ID: 1501

Drawn: NJ
Date: 24/02/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ084

A3

490000 495000 500000 505000

8075000

8070000

N

0 1 2

Kilometres

Absolute Scale - 1:60,000

Legend

Mygalomorph taxa

- *Aname* 'MYG284'
- *Aname* 'MYG285'
- *Aname* 'MYG387'
- *Aname* 'MYG387?'
- *Aname* 'MYG388'
- *Aname* 'sp. indet.'
- *Aname* 'sp. juv.'
- Pindan shrubland
- Sandstone range
- Savannah woodland
- Potential impact area
- Study area

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Locations of potential SRE mygalomorph spiders recorded during the survey

Figure: 4.24
Project ID: 1501

Drawn: NJ
Date: 24/02/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ081

A3

490000 495000 500000 505000

8075000

8070000

N

0 1 2

Kilometres

Absolute Scale - 1:60,000

Legend

Scorpion taxa

- *Lychas* 'JPP'
- *Lychas* 'JPP1'
- *Lychas* 'JPP2'
- *Lychas* 'JPP3'
- *Lychas* 'broome'
- *Urodacus* 'kraepelini'
- *Urodacus* 'sp. indet.'

Pseudoscorpion taxa

- Olpiidae 'gen. indet. (juvenile)'
- Pindan shrubland
- Sandstone range
- Savannah woodland
- Potential impact area
- Study area

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Locations of potential SRE scorpions and pseudoscorpions recorded during the survey

Figure: 4.25
Project ID: 1501

Drawn: NJ
Date: 24/02/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ082

A3

490000 495000 500000 505000

8075000 8070000 8065000

0 1 2

Kilometres

Absolute Scale - **1:60,000**

Legend

Isopod taxa

- Armadillidae 'EE1501C'
- *Buddelundia* '74'
- Buddelundinae 'NE Broome'

Opilion record

- *Dampetrus* 'sp. indet.'

Land snail taxa

- *Quistrachia leptogramma*
- *Rhagada bulgana* - Confirmed SRE
- Pindan shrubland
- Sandstone range
- Savannah woodland
- Potential impact area
- Study area

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Locations of potential SRE isopods, opilions and land snails recorded during the survey

Figure: 4.26
Project ID: 1501

Drawn: NJ
Date: 24/02/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ083

A3

490000
495000
500000
505000
8075000
8070000

N

0 1 2
Kilometres

Absolute Scale - 1:60,000

Legend

Species

Cryptops 'sp. indet.'

Staphylinidae 'sp. indet.'

Potential impact area

Study area

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Locations of troglofauna recorded during the survey

Figure: 4.27
Project ID: 1501

Drawn: NJ
Date: 24/02/14

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: NJ085

A3

4.6 SURVEY ADEQUACY

All systematically obtained data sets were analysed for survey adequacy, including trapping results for terrestrial fauna and set-time surveys for birds, excluding any opportunistic data. As the subterranean fauna assessment was a pilot study, and sampling was of relatively low intensity, these analyses were excluded. Table 4.10 provides a summary of the theoretical maximum number of species resulting from seven different methods of estimating richness. The Michaelis-Menten (MM) equation is considered to provide the most accurate representation of the potential species number.

Table 4.10 – Mean estimates of total species richness of systematically sampled fauna

Richness estimators	Total richness estimate		
	Terrestrial vertebrates	Birds	SRE invertebrates
ACE	51	73	31
ICE	49	73	36
Chao-1	49	71	35
Jack-1	52	75	27
Jack-2	54	75	37
Bootstrap	48	72	21
Michaelis-Menten	48	71	22
Species Observed	**45**	**69**	**17**

4.6.1 Terrestrial vertebrates

Analysis of the terrestrial vertebrate trapping data produced a steady SAC, nearing the asymptotic plateau (Figure 4.28). At the completion of 98 trap nights, extrapolation of the MM curve suggests that 93.75% of the theoretical total of trappable terrestrial fauna species were captured (Table 4.10). These results indicate that, although the majority of species were recorded during the survey, additional trapping may detect a further three species.

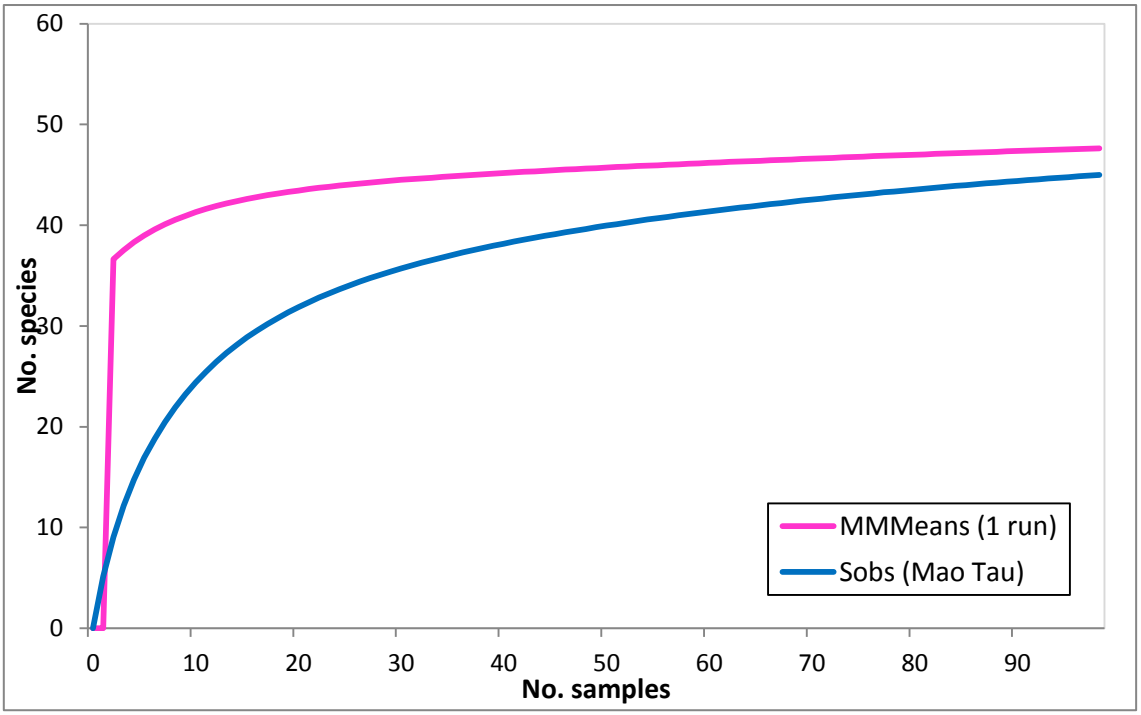

Figure 4.28 – Species accumulation curve for terrestrial vertebrates

4.6.2 Birds

Species accumulation curve analysis of the bird set-time survey dataset also produced a typical SAC, coming close to the asymptotic plateau (Figure 4.29, Table 4.10). Used as a stopping rule, the MM estimator indicated that the survey was 97.18% adequate at the completion of 57 set-time surveys, which is an unusually high result.

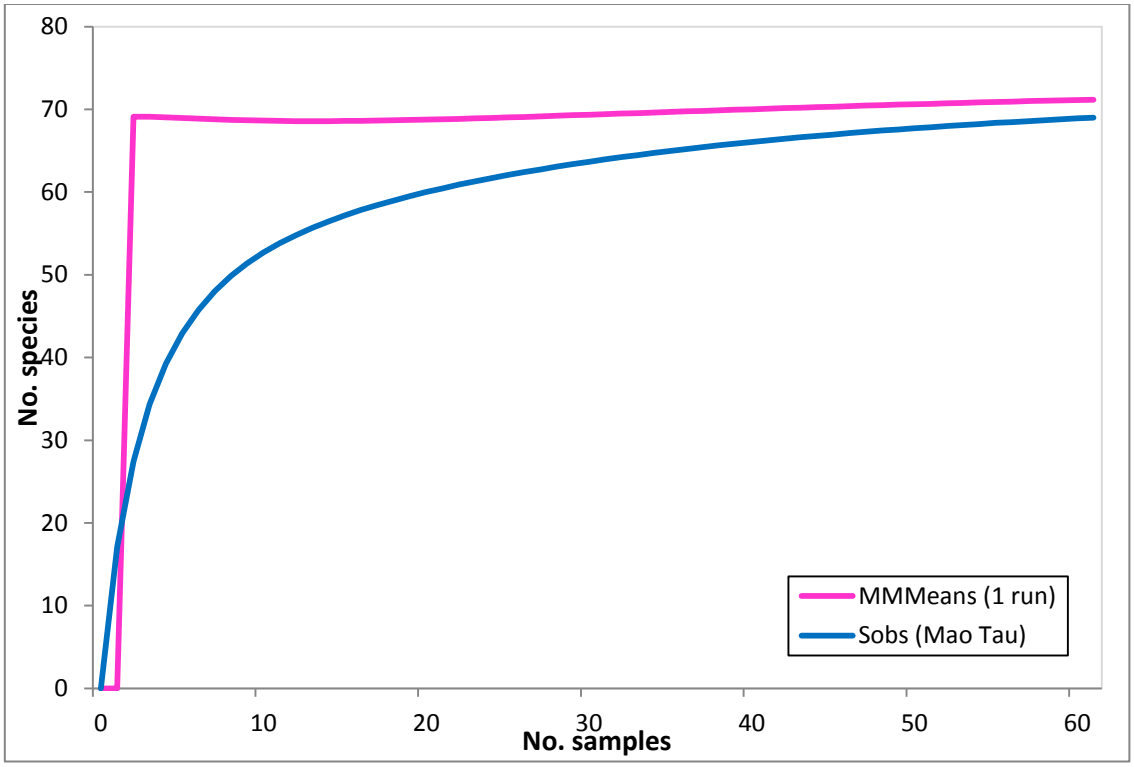

Figure 4.29 – Species accumulation curve for birds

4.6.3 SRE Invertebrate Fauna

SAC analysis of the SRE invertebrate trapping data produced a curve beginning to level to the asymptotic plateau (Figure 4.30). Used as a stopping rule, the MM estimator indicated that the survey was 77.24% adequate at the completion of 69 systematic trapping (Table 4.10), indicating further sampling may yield an additional five species. Other estimators suggest theoretical maximums of 21–37 species occur.

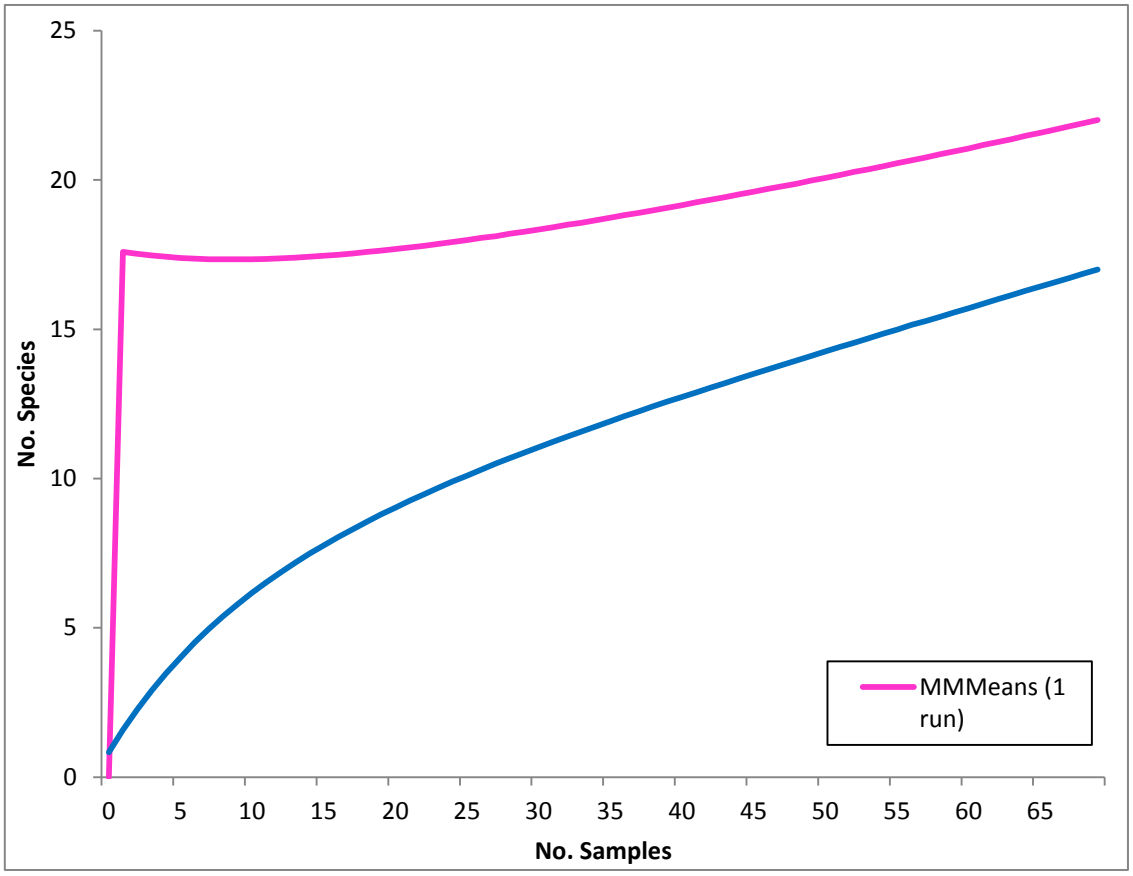

Figure 4.30 – Species accumulation curve for SRE invertebrates

5 DISCUSSION

5.1 HABITATS AND ASSOCIATED FAUNA

5.1.1 Pindan shrubland

Due to the weak soil substrate of the pindan shrubland habitat, a number of small burrowing mammals are likely to occur, including the Delicate Mouse, Western Chestnut Mouse, and Lesser Hairy-footed Dunnart. The Euro and Agile Wallaby may also occur in this habitat.

A diverse range of bird species are expected to occur in pindan shrubland, including the Red-backed Fairy-wren, Long-tailed Finch, Little Friarbird, Red-winged Parrot, Budgerigar and Zebra Finch.

Reptile species expected to favour this habitat include skinks which prefer sandy areas with leaf litter, such as *Eremiascincus isolepis*, *Morethia storri*, *Carlia munda* and *Lerista bipes*. Other skinks like *Ctenotus pantherinus* and *Ctenotus inornatus*, and the dragon *Diporiphora pindan* and the Dwarf Bearded Dragon, prefer the areas of spinifex grassland which may occur in this habitat. Similarly, the Frilled Lizard, Sand Goanna, Short-tailed Pygmy Monitor, the gecko *Strophurus ciliaris*, the Sand-plain Gecko, the Black-headed Python, Northern Shovel-nosed Snake, Mulga Snake and the whipsnake *Demansia angusticeps* are all relatively common in this habitat.

The dense vegetation and associated leaf litter contributes to high SRE invertebrate diversity within this habitat. The majority of mygalomorph spider, pseudoscorpion, scorpion, harvestmen, slater and land snail species were recorded within the pindan shrubland.

In terms of species of conservation significance, the Greater Bilby (EPBC Act Vulnerable), Short-tailed Mouse (DPaW Priority 4), Australian Bustard (DPaW Priority 4), Bush Stone-curlew (DPaW Priority 4), Fork-tailed Swift (EPBC Act Migratory, WC Act Schedule 3) and Rainbow Bee-eater (EPBC Act Migratory, WC Act Schedule 3), *Lerista separanda* (DPaW Priority 2) and the Dampierland Burrowing Snake (DPaW Priority 2) are also likely to be found within this habitat.

5.1.2 Sandstone range

The rocky substrate of the sandstone range habitat is less suitable for small mammals, although the Delicate Mouse and Western Chestnut Mouse may still occur. However, within the study area it is the preferred habitat for the Agile Wallaby and Euro, which use crevices and overhangs for shelter. Bat species such as the Northern Freetail Bat may also use crevices and caves in rock outcrops for roosting.

Bird diversity within the study area is lowest in this habitat, due to the dry, open nature of the vegetation. However, this habitat provides foraging opportunities for raptors, and during flowering periods, many honeyeaters species will be present. The Little Woodswallow is likely to nest locally on the faces of large rock outcrops.

Reptile species expected to favour this habitat include the skinks *Ctenotus pantherinus*, *Ctenotus inornatus* and *Cryptoblepharus ruber*, the Short-tailed Pygmy Monitor and Black-headed Monitor, the Dwarf Bearded Dragon, the Fat-tailed Gecko and Bynoe's Gecko, the gecko *Gehyra nana*, the Spotted Snake and the Stimson's Python.

The rocky substrate and outcrops provide cover for several SRE invertebrate species. An interesting slater (Armadillidae 'EE1501C') was observed and collected from within a rock crevice near the top of an outcrop. The termite mounds associated with the range also contained an abundance of another slater species (*Buddelundia* sp.74). Generally, leaf litter is sparse, but where it is found (i.e. under figs), species such as land snails were recorded.

Conservation significant species which may occur include the Short-tailed Mouse (DPaW Priority 4), Australian Bustard (DPaW Priority 4), Bush Stone-curlew (DPaW Priority 4), Fork-tailed Swift (EPBC Act Migratory, WC Act Schedule 3) and Rainbow Bee-eater (EPBC Act Migratory, WC Act Schedule 3), with potential for the latter to nest along drainage lines. The study area also provides suitable breeding habitat for the Gouldian Finch (EPBC Act Endangered, DPaW Priority 4).

5.1.3 Savannah woodland

Mammal species expected to occur in the savannah woodland habitat include grassland generalists such as the Delicate Mouse and Dingo. Several bat species that roost in tree hollows are likely to occur, including Gould's and Hoary Wattled Bats, and Little Broad-nosed Bats.

A diverse range of bird species are expected to occur within this habitat, including the Red-tailed Black-cockatoo, Red-winged Parrot, Varied Lorikeet, Rufous Songlark, Double-barred Finch, Australian Owlet-nightjar and Southern Boobook. Several species of raptor may also nest and forage in this habitat.

Reptile species expected to favour this habitat include the skinks *Lerista bipes*, *Ctenotus robustus* and *Carlia rufilatus*, the Frilled Lizard and *Diporiphora pindan*, the Sand Goanna, the geckos *Strophurus ciliaris* and *Lucasium stenodactylum*, the Northern Shovel-nosed Snake and the whipsnake *Demansia angusticeps*. The Ornate Burrowing Frog will also prefer the low-lying sandy areas common in this habitat.

The savannah woodlands provide good cover for SRE invertebrates, particularly around the bases, and exfoliating bark, of *Corymbia*. Five species of scorpions (*Lychas* spp. and *Urodacus* 'kraepelini') and one harvestmen (*Dampetrus* sp.) were recorded at the vertebrate trapping site in this habitat, and the confirmed SRE land snail *Rhagada bulgana* was collected from underneath fallen bark.

Of conservation significance, the Australian Bustard (DPaW Priority 4), Bush Stone-curlew (DPaW Priority 4), Fork-tailed Swift (EPBC Act Migratory, WC Act Schedule 3), Rainbow Bee-eater (EPBC Act Migratory, WC Act Schedule 3), Oriental Pratincole (EPBC Act Migratory, WC Act Schedule 3) and Gouldian Finch (EPBC Act Endangered, DPaW Priority 4) may occur in this habitat. Although it may be found in the other habitat types, the Short-tailed Mouse (DPaW Priority 4) is most likely to be found in savannah woodland within the study area.

5.2 HABITAT ANALYSIS

Statistical analysis of the systematic survey data did not indicate a significant difference between the three habitat types in terms of their respective vertebrate or SRE invertebrate fauna assemblages. This similarity between habitat types is most likely a product of two main causes: Firstly, the dominant tree, shrub and grass species of each habitat type are generally also present within the others, meaning there is relatively little niche separation between each habitat. Secondly, systematic sampling was not possible at locations with more distinct niches, such as the semi-permanent spring or rock outcrops where more highly specialised species may occur. As a result, many of the species recorded were found in all three habitat types in inconsistent abundances.

5.3 FAUNA ASSEMBLAGES

5.3.1 Vertebrate Fauna

A total of 13 previous surveys were conducted and consulted as part of the literature review (Table 2.5). The locations of these previous surveys are restricted to mainly coastal regions to the west and north of the study area. Very little information and previous survey data exists for the inland regions of the Dampier Peninsula, and as a result, it is not unexpected that a number of range extension records were made.

5.3.1.1 Mammals

When compared to the number of potential species of the region, compiled during the literature review, this survey recorded a total of 20 out of a potential 39 species. When compared to previous surveys of the region, this total is relatively high (Table 2.6).

Mammal abundance was generally low, with all trappable and observable mammals recorded less than 10 times, with the exception of the Delicate Mouse, which had a total of 26 trap captures. A number of variances between the two phases of surveying are evident. Lesser Hairy-footed Dunnart (two records), Large Footed Myotis (one site) and Dog (one record) were recorded during phase 1 only. While Echidna (one record), Greater Bilby (one record), Euro (one record), Yellow-bellied Sheathtail Bat (two sites), Common Bentwing Bat (three sites), Short-tailed Mouse (one record) and House Mouse (nine records) were recorded during phase 2 only.

A number of noteworthy records were made within the mammal fauna assemblage. The Echidna was recorded during phase 2, with a scat found within the sandstone range habitat type. There are no previous records of the Echidna shown on NatureMap, however this species was recorded on two other occasions during previous surveys (Appendix C). The Lesser Hairy-footed Dunnart has also only once been recorded in the region on one other occasion during a previous survey (Appendix C), with this species recorded twice from TB S4 during Phase 1 (Appendix F). The Common Bentwing Bat was recorded from three sites during phase 2 only (Appendix F). Although the study area falls within the known distribution of this species (Richards 2008), no previous records are shown on NatureMap on the Dampier Peninsula, with a single record from previous surveys (Appendix C). Likewise, the Northern Short-tailed Mouse was recorded once during phase 2 (Appendix F), with this species only recorded once on a previous survey (Appendix C), within the study area outside its general distribution (Moro and Kutt 2008).

5.3.1.2 Birds

When compared to the number of potential species of the region, compiled during the literature review, this survey recorded a total of 107 out of a potential 232 species. When compared to previous surveys in the region, this total is relatively high (Table 2.6).

The Hooded Robin was recorded a total of six times, from three locations (Appendix F). This species has been recorded just twice in the region during previous surveys and from Birdata (Appendix C). The Black Honeyeater was also recorded, both from this survey and the Level one assessment of the study area. The only other records for this species in the region are from the Birdata database (Appendix C).

The high quality wetland habitat at Mount Jowlaenga homestead observed during phase 2 is reflected in the records which included all nine potential waterfowl (family Anatidae) species at this location (Appendix C). Additionally, two Wagtail (*Moticilla* spp.) species were recorded at Mount Jowlaenga homestead, Eastern Yellow Wagtail and Grey Wagtail. Typically, the distribution limit of both species is southern Asia, with sightings in northern Australia regular for Eastern Yellow Wagtail but rare for Grey Wagtail (ebird 2014). Other noteworthy records from Mount Jowlaenga homestead included a high count of 25 Freckled Ducks recorded, with this species not previously recorded by previous regional surveys (Appendix C), and Comb-crested Jacana, recorded only once on a previous survey and from the Birdata database (Appendix C).

5.3.1.3 Herpetofauna

A number of noteworthy herpetofauna records were made from the survey. A total of three capture records of the burrowing fossorial skink *Lerista apoda* (Figure 4.9) were made (Appendix F). Captures were made from pitfall traps and opportunistically through raking leaf litter. Although *Lerista apoda* had been recorded on a number of previous surveys within the literature review (Appendix C), the

location of these records were all from the coastal areas of the west coast of Dampier Peninsula. Previous records from NatureMap (DPaW 2014) also show this species has previously been restricted to coastal regions (Figure 4.10), with the records from the current survey representing an approximate 80 km range extension.

Several individuals of the monitor *Varanus* aff. *brevicauda* were recorded during the survey, including one specimen vouchered at the Western Australian Museum. This taxon may represent a cryptic species, and in the future could be split from the Short-tailed Monitor (*Varanus brevicauda*). *Varanus* aff. *brevicauda* is previously known from the Kimberley (P. Doughty pers. comm.)

Frog abundance and diversity was highest following the wet season, when seven of the eight species, and 88 burrowing frog individuals were recorded. These results contrast with only four frog species, and three burrowing frog individuals recorded during the dry season survey.

5.3.1.4 SRE Invertebrate Fauna

A high diversity of invertebrate fauna from SRE groups were recorded during the survey, when compared to previous studies on the Dampier Peninsula (Appendix C). The mygalomorph spiders (*Aname* spp.) were particularly well-represented, with at least four morphospecies recorded. Within the genus, there appeared to be seasonal variations in the movements of males, as two taxa were only recorded after the wet season during phase one (*A.* 'MYG284' and *A.* 'MYG285), while two taxa were only recorded during the dry season (*A.* 'MYG387' and *A.* 'MYG388).

Scorpions were also well-represented, particularly within the pindan shrubland habitat, with five species of *Lychas* and two species of *Urodacus* collected. The sandy soils and abundant leaf litter provide suitable habitat for this group.

Termite mounds and rock crevices contained several species of isopods. One unusual species, Armadillidae 'EE1501C' was collected from inside a rock crevice near the top of a sandstone escarpment. It is likely this taxon is found in similar habitats within the sandstone range habitat.

The dense leaf litter contained four species of land snails, including the confirmed SRE *Rhagada bulgana*. Land snails were also found underneath bark in well-vegetated areas, where humidity is highest.

5.3.1.5 Subterranean Invertebrate Fauna

During the stygofauna survey (December 2013), ten specimens of Naididae worm were collected from the Broome Sandstone aquifer. Subterranean worms of the Kimberley are very poorly known, and recently barcode analyses of oligochaete species (in the Pilbara) revealed that morphological identifications are often inadequate for resolving species. To verify morphology-based identification, DNA analyses are recommended. The specific identification, distribution and conservation status of the Naididae collected therefore remains undefined, however, members of this group are commonly collected in stygofauna and other aquatic surveys, as they are opportunistically stygal.

Overall, physio-chemical groundwater parameters measured were within the tolerable ranges for stygofauna, although pH was recorded to be at acidic levels (pH 5.26–6.27). Although not all groups of stygobitic fauna can tolerate these acidic environments, surveys have sampled stygofauna from slightly acidic bores (DEC 2009).

Groundwater habitats for stygofauna are defined by hydrogeological characteristics, biogeography and hydrological exchange with the surface (Hahn and Matzke 2005). The distribution of stygofauna is controlled by the physical attributes of aquifers, physio-chemical characteristics of groundwater, historical/evolutionary factors, biological interactions, and interactions among these broad classes of elements (Strayer 1994).

The stygofauna sampling was expected to be tapping the Broome Sandstone aquifer, a non-karstic, unconfined aquifer. The majority of the study area is dominated by clays and sand strata (pindan units), which consequently suggests limited saturated habitat space beneath the water-table. Some stygal taxa, like oligochaetes and copepods, may still occur in these sand aquifers; however in these settings the individual species are (usually) not restricted at small spatial scales. At this point in time, given the absence of a diverse and abundant stygofauna community present within the study area, no stygofauna are likely to be of conservation concern in relation to the project. However, should the Broome Sandstone aquifer have secondary porosity developed in the form of fractures, and/or evidence of restricted calcareous sandstone geology with evidence of karst solution, then this could potentially provide habitat for stygofauna.

Similarly to the stygofauna, there appears to be a low diversity and abundances of troglofauna present. This is potentially due to the study area being dominated by pindan sand plain, which have little or no cavernous or vuggy habitat space and also due to the fact that the study area is relatively low-lying and of flat topography (i.e. subjected to eustatic changes, for example). At this point in time, the only species that could be of conservation concern in relation to the project are *Cryptops* sp. indet. and Staphylinidae sp. indet.. However, given the relatively continuous and expansive geology outside the potential impact area, with no obvious dispersal barriers, these species are unlikely to have restricted distributions.

5.4 CONSERVATION SIGNIFICANT VERTEBRATE FAUNA

Based on database searches and the results of previous biological surveys in the surrounding region, seven mammals, 15 birds (excluding wetland and coastal dependent bird species) and two reptile species of conservation significance could potentially occur within the study area. Nine species of conservation significance were recorded (two mammals and seven bird species (three wetland dependent bird species from Mount Jowlaenga homestead)) during this survey, with an additional four species assessed as having a medium likelihood of occurrence (Section 4.4). Species that were recorded or assessed as having a medium likelihood of occurrence are discussed in greater detail below.

5.4.1 Mammals

5.4.1.1 Greater Bilby (*Macrotis lagotis*)

Conservation status: EPBC Act Vulnerable, WC Act Schedule 1 (Vulnerable).

Distribution and habitat: Once common over 70% of mainland Australia's arid and semiarid regions, Bilbies are currently patchily distributed through the Tanami, Great Sandy and Gibson Deserts (Maxwell *et al.* 1996). Isolated populations also occur in south-west Queensland and to the north-east of Alice Springs. Bilbies occur in a variety of habitats, including spinifex grassland, *Acacia* shrubland, open woodland and cracking clays (Maxwell *et al.* 1996; Johnson 2008). The species underwent a sudden and widespread collapse in population size in the early 1900s, and the distribution may still be contracting and fragmenting. Reasons for the decline include predation by feral predators on both young and adult bilbies, competition from rabbits and livestock, reduced food as a result of changed fire regimes, and drought (Maxwell *et al.* 1996; O'Malley 2006a; Johnson 2008).

Ecology: The Greater Bilby is a nocturnal marsupial with soft, silky fur (Pavey 2006). It uses its strong forelimbs and claws to construct an extensive tunnel system of up to 3 m long and 1.8 m deep in which it shelters during the day. Its long tongue is an adaptation to its specialised diet of seeds, insects, bulbs, fruit and fungi (Johnson 2008).

Likelihood of occurrence: Recorded. An individual was recorded via a motion camera during phase 2, with a total of three captures (photos) recorded (Section 4.5). Motion camera capture records included two records from early morning (0432, 0436) on the 22/10/13, and a single evening record (1852) on the 22/10/13 (Table 4.9, Figure 4.14). The individual recorded appears to be a fully grown male, based on the size of the individual in relation to other features within the photo. This male was not observed entering the burrow, and based on three images captured, appeared to be investiagting the burrow entrance only. The active burrow it was investigating appears to be too small for a fully grown male, with this burrow more likley to be occuppied by a female or juvenile, suggesting at least two individuals were present within this immediate location.

The amount of foraging activity present also suggests multiple individuals are present within the immediate area, with a total of 16 separate diggings recorded (Table 4.9, Figure 4.22). Additionally, analysis of the separate scats recorded show a variation in size between scats, potentially representing different individuals. Scats recorded are shown in Figure 5.1, which shows larger Greater Bilby scat on the left, with smaller scats in the middle and right.

Figure 5.1 – Greater Bilby scats recorded

Three locations of clusters of activity were recorded within the study area (Figure 4.23), all within the pindan shrubland habitat type. A noticeable preference of the Greater Bilby within this habitat was a strong feeding association with tall, dense *Acacia tumida*. Consistently, diggings were found at the base of this shrub (Figure 5.2), often with extensive leaf litter. The diet of the Greater Bilby varies accordingly to availability of food items, with root-dwelling insect larvae (particularly those within *Acacia* spp.) utilised when plant foods are scarce (Southgate 2013). This is consistent with findings from this study, with the feeding association with *Acacia tumida* only recorded during phase 2.

The open understorey structure of the *Acacia tumida* microhabitat also appeared to influence the presence of the Greater Bilby. Evidence was only recorded in patches of *Acacia tumida* that had very open ground cover, which allows easy movement. Other habitat types within the study area typically contain denser ground cover, which may be less attractive to the Greater Bilby.

Active Greater Bilby evidence was only recorded during phase 2, with only old burrows recorded during phase 1. This suggests Greater Bilby activity and habitat utilisation within the study area may vary seasonally. This is consistent with literature which identifies detection of Greater Bilbies being complicated due to their mobility and spatial and temporal habitat utilisation (Southgate 2013).

Figure 5.2 – Greater Bilby diggings in *Acacia tumida* root stock

Based on the evidence recorded from the current survey, it can be confirmed the Greater Bilby is present within the study area and actively utilises areas of the pindan shrubland habitat, particularly the *Acacia tumida* microhabitat.

5.4.1.2 Short-tailed Mouse (*Leggadina lakedownensis*)

Conservation status: DPaW Priority 4.

Distribution and habitat: Populations of this small, elusive rodent are distributed across northern Australia, but records have been sporadic (Moro and Kutt 2008). They occupy a diverse range of habitats from the monsoon tropical coast to semi-arid climates, including spinifex and tussock grasslands, samphire and sedgelands, *Acacia* shrublands, tropical eucalypt and *Melaleuca* woodlands and stony ranges. However, Short-tailed Mice are usually found in seasonally inundated habitats on red or white sandy-clay soils (Moro and Kutt 2008).

Ecology: The diet of the Short-tailed Mouse consists primarily of invertebrates, with plants supplementing their water requirements (Moro and Kutt 2008). Populations fluctuate greatly in response to rainfall, sometimes reaching plague proportions. The species is nocturnal and solitary, spending the day in simple, single-chambered burrows (Moro and Kutt 2008).

Likelihood of occurrence: Recorded. – one individual was recorded at site 6 on the second phase of the survey. Within the study area, this species should predominantly occur in low-lying areas with tussock grasses. Population size will also vary considerably depending upon seasonal food availability.

5.4.2 Birds

5.4.2.1 Gouldian Finch (*Erythrura gouldiae*)

Conservation status: EPBC Act Endangered, DPaW Priority 4.

Distribution and habitat: The Gouldian Finch was formally distributed throughout the tropical savannahs of northern Australia. It is now restricted to isolated areas mostly within the Northern Territory and the Kimberley region of Western Australia (Woinarski and Palmer 2006). Known breeding habitat is characterised by rocky hills with hollow-bearing, smooth-barked gums that are close to small waterholes or springs that persist through the dry season (O'Malley 2006b).

Ecology: Gouldian finches forage on the ground, feeding on seeding grasses, particularly native *Sorghum* spp. (Pizzey and Knight 2003). Due to the restricted diet of Gouldian Finches, they are particularly vulnerable to seed shortages (O'Malley 2006b). The decline in populations of the Gouldian Finch is representative of the general decline of granivorous birds occurring as a result of current land management practices. Ongoing key threats to the Gouldian Finch are vegetation change through inappropriate fire regimes, and grazing impacts of stock and feral herbivores (O'Malley 2006b).

Likelihood of occurrence: Medium – suitable breeding and foraging habitat occurs within the study area, although vegetation degradation by livestock may be diminishing the chance Gouldian Finches occur there. Gouldian Finches have also been recorded at relatively few locations on the Dampier Peninsula, with most records at the northern tip.

5.4.2.2 Fork-tailed Swift (*Apus pacificus*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3.

Distribution and habitat: The Fork-tailed Swift is a small, insectivorous species with a white throat and rump, and a deeply forked tail (Morcombe 2000). Its distribution spans from central Siberia and throughout Asia, breeding in north-east and mid-east Asia, and wintering in Australia and south New Guinea. It is a relatively common trans-equatorial migrant from October to April throughout mainland Australia (Simpson and Day 2004). In Western Australia the species begins to arrive in the Kimberley in late September, the Pilbara in November and the South-west by mid-December (Johnstone and Storr 1998). In Western Australia the Fork-tailed Swift is considered uncommon to moderately common near the north-west, west and south-east coasts, common in the Kimberley and rare or scarce elsewhere (Johnstone and Storr 1998).

Ecology: Fork-tailed swifts are nomadic in response to broad-scale weather pattern changes. They are attracted to thunderstorms where they can be seen in flocks, occasionally of up to 2,000 birds. They rarely land, living almost exclusively in the air and feeding entirely on aerial insects, especially nuptial swarms of beetles, ants, termites and native bees (Simpson and Day 2004).

Likelihood of occurrence: Recorded – one individual was recorded on the first phase. Most commonly occurring during summer, Fork-tailed Swifts may be found in varying numbers foraging in the air above the study area.

5.4.2.3 Oriental Pratincole (*Glareola maldivarum*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3.

Distribution and habitat: The Oriental Pratincole is a non-breeding migrant to Australia. The species breeds from Mongolia, Siberia and China, south to Sri Lanka, Thailand and Vietnam. It then spends the winter period (late October to May) in northern Australia (Johnstone and Storr 1998). Oriental Pratincoles occur on open plains, bare ground around swamps, and claypans.

Ecology: Oriental Pratincoles hawk insects from the ground and can sometimes occur in huge flocks. Birds may feed in the evening until nearly dark (Johnstone and Storr 1998).

Likelihood of occurrence: Medium – although not ideal, suitable habitat exists within the study area. There are also numerous recent records around the Dampier Peninsula, where they are most likely to be recorded during summer.

5.4.2.4 Rainbow Bee-eater (*Merops ornatus*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3.

Distribution and habitat: The Rainbow Bee-eater is scarce to common throughout much of Western Australia, except for the arid interior, preferring lightly wooded, preferably sandy country near water (Johnstone and Storr 1998).

Ecology: In Western Australia the Rainbow Bee-eater can occur as a resident, breeding visitor, post-nuptial nomad, passage migrant or winter visitor. It nests in burrows usually dug at a slight angle on flat ground, sandy banks or cuttings, and often at the margins of roads or tracks (Simpson and Day 2004). Eggs are laid at the end of the metre-long tunnel from August to January (Boland 2004). Rainbow Bee-eaters are most susceptible to predation during breeding, as it spends significantly more time on the ground in this period.

Likelihood of occurrence: Recorded – this species was seen numerous times across the study area, which is mostly suitable habitat. Rainbow Bee-eaters may also breed there, particularly in the banks of drainage lines.

5.4.2.5 Australian Bustard (*Ardeotis australis*)

Conservation status: DPaW Priority 4.

Distribution and habitat: The Australian Bustard occurs Australia-wide and utilises a number of open habitats, including open or lightly wooded grasslands, chenopod flats, plains and heathlands (Johnstone and Storr 1998).

Ecology: It is a nomadic species, ranging over very large areas, and its abundance varies locally and seasonally from scarce to common, largely dependent on rainfall and food availability. The Australian Bustard has an omnivorous diet, feeding on grasses, seeds, fruit, insects and small vertebrates.

Although the population size is still substantial, there has been a large historical decline in abundance, particularly south of the tropics, but also across northern Australia (Garnett and Crowley 2000). This is a result of hunting, degradation of its grassland habitat by sheep and rabbits, and predation by foxes and cats (Frith 1976; Garnett and Crowley 2000). Australian Bustards readily desert nests in response to disturbance by humans, sheep or cattle (Garnett and Crowley 2000).

Likelihood of occurrence: Recorded – six records were taken during the first phase, although it is likely there were less individuals than this. Seasonal variability in abundance of Australian Bustards is reflected in the lack of records during the second phase. Feral species, particularly cattle, may also be diminishing their chance of occurrence in the study area.

5.4.2.6 Bush Stone-curlew (*Burhinus grallarius*)

Conservation status: DPaW Priority 4.

Distribution and habitat: The Bush Stone-curlew occurs across much of Australia, except the arid interior and central south coast, preferring lightly wooded country near thickets or long grass that acts as daytime shelter (Johnstone and Storr 1998). Historically, this species was widely distributed throughout most of WA, but has since declined, particularly in the southern part of the State. Recent

estimates indicate an Australian population of 15,000 individuals (Garnett and Crowley 2000). The Bush Stone-curlew inhabits woodlands, dry and open grasslands, and croplands with cover nearby (NSW National Parks and Wildlife Service 1999).

Ecology: The species is insectivorous, preying primarily upon beetles, although they will also eat seeds and shoots, frogs, lizards and snakes (Marchant and Higgins 1993; NSW National Parks and Wildlife Service 1999). They are usually seen in pairs, although may occasionally flock together during the breeding season (August to January) and are generally nocturnal, being especially active on moonlit nights (NSW National Parks and Wildlife Service 1999).

Since Bush Stone-curlews are a ground-dwelling and non-migratory species, they are quite susceptible to local disturbances by humans and to predation by cats and foxes (Frith 1976; Johnstone and Storr 1998). They are most common where land disturbance is minimal, and generally become rare or extinct around human settlements (Johnstone and Storr 1998).

Likelihood of occurrence: Recorded – this species was recorded a number of times during both phases. As there is also a large amount of suitable habitat, Bush Stone-curlews may occur fairly commonly in the study area, depending how heavily they are disturbed by livestock.

5.4.3 Reptiles

5.4.3.1 Dampierland Plain Slider (*Lerista separanda*)

Conservation status: DPaW Priority 2.

Distribution and habitat: *Lerista separanda* is currently known to be found in sandy soils along the south-west Kimberley coastline, between Kimbolton and Nita Downs (Wilson and Swan 2010).

Ecology: There is little information on the ecology of this species. *L. separanda* is one of the smallest species in the genus and has a fused lower eyelid (Wilson and Swan 2010). Whereas most other *Lerista* species have greatly reduced or only two limbs, *L. separanda* has four of the relatively largest limbs. This strongly suggests that it is not only able to push its way through sand but also walk across it.

Likelihood of occurrence: Medium – although the only records are from the western coast of the Dampier Peninsula, they are from a sandy loam soil with pindan shrubland habitat. This habitat is widespread and abundant across the peninsula, and is present within the study area. It is therefore possible for the distribution of *Lerista separanda* to include the study area. Similarly, *Lerista apoda* and *Lerista greeri* were previously only known from the western coastline and to the east of the Dampier Peninsula respectively, yet both were recorded during this survey.

5.4.3.2 Dampierland Burrowing Snake (*Simoselaps minimus*)

Conservation status: DPaW Priority 2.

Distribution and habitat: This snake is currently known only from the western side of the Dampier Peninsula. Its preferred habitat is on coastal dunes or the sandy areas between dunes and adjacent *Acacia* shrublands (Wilson and Swan 2010).

Ecology: Little is known of the Dampierland Burrowing Snake's ecology, but it is presumably similar to other *Simoselaps* species, which are sand-swimmers that feed mostly on *Lerista* skinks (Wilson and Swan 2010).

Likelihood of occurrence: Medium – although previous records are from the western coast of the Dampier Peninsula, they are from sandy soils. However, sandy soils extend across much of the peninsula, and are characteristic of the pindan shrubland and savannah woodland habitats found within the study area. The Dampierland Burrowing Snake may therefore occur within the study area.

5.5 SRE INVERTEBRATE FAUNA

The survey yielded a total of 178 invertebrate specimens which represented six orders, 11 families and 28 taxa. As typical in SRE surveys, 11 species were recorded in low abundance, being represented only by singletons and/or doubletons (Appendix F). One species (the land snail *Rhagada bulgana*) was assessed as a confirmed SRE, while 20 taxa were considered potential SREs. In accordance with the precautionary principle, all potential SREs should be treated as confirmed SREs. The taxonomy, distribution and SRE status of these species are discussed in the following sections.

5.5.1 Mygalomorphae (Trapdoor Spiders)

5.5.1.1 Family: Nemesiidae (Wishbone Spiders)

The most significant SRE invertebrate findings from the study included the collection of seven taxa of mygalomorph spiders of the genus *Aname*. At least four of these taxa represent distinct morphospecies based on male morphology, while the remaining three taxa were represented by female and juvenile specimens that could not be identified lower than the genus without DNA analysis.

***Aname* 'MYG284'**

SRE Status: Potential.

Four male *Aname* 'MYG284' where collected from site TB S2 (inside the potential impact area). Specimens of this morphospecies were only collected during the first phase, indicating males may be more likely to move during, or nearing the end of, the wet season. This species lacks geographical information and its current distribution is 8.5 km squared and **therefore considered a potential SRE** (WAM 2013a). Given this taxon was recorded from the extensive pindan shrubland habitat, it is likely to have a distribution that extends well beyond the study area boundary.

***Aname* 'MYG285'**

SRE Status: Potential.

One male *Aname* 'MYG285' was collected from site TB S4 (outside the potential impact area). This is a new species and therefore **considered a potential SRE** (WAM 2013a). Specimens of this morphospecies were only collected during the first phase, indicating males may be more likely to move during, or nearing the end of, the wet season. Given this taxon was recorded from the extensive pindan shrubland habitat, it is likely to have a distribution that extends well beyond the study area boundary.

***Aname* 'MYG387'**

SRE Status: Potential.

One male *Aname* 'MYG387' was collected from site TB S1 (outside the potential impact area). This species is not present in the WAM reference collection and potentially a new species, therefore **considered a potential SRE** (Phoenix 2013a). Specimens of this morphospecies were only collected during the second phase, indicating males may be more likely to move during the dry season. It is possible that the female Aname 'MYG387?' is conspecific with this taxon, which would indicate that its habitat preference includes both the extensive pindan shrubland and sandstone range habitats, and is therefore widespread in the study area.

***Aname* 'MYG387?'**

SRE Status: Potential.

A single female was collected from site TB S5 (inside the potential impact area) and has been tentatively identified as *Aname* 'MYG387'; however, conspecifity with the male species is not certain.

It is **considered a potential SRE** (Phoenix 2013a). It is possible that the female *Aname* 'MYG387?' is conspecific with this taxon, which would indicate that its habitat preference includes both the extensive pindan shrubland and sandstone range habitats, and is therefore widespread in the study area.

***Aname* 'MYG388'**

SRE Status: Potential.

A total of four specimens (two males and two females) were collected from sites TB S1, TB S2 and TB S6 (both inside and outside of the impact are). The two females show morphological characteristics conspecific with the male morphotype (Phoenix 2013a), and can therefore be identified to species level. . This species is not present in the WAM reference collection and potentially a new species, therefore **considered a potential SRE** (Phoenix 2013a). Specimens of this morphospecies were only collected during the second phase, indicating males may be more likely to move during the dry season. Given this taxon was recorded from the extensive pindan shrubland and sandstone range habitats, it is likely to have a distribution that extends well beyond the study area boundary.

***Aname* 'sp. juv.'**

SRE Status: Potential.

One juvenile specimen was collected from TB SRE6 (inside the potential impact area). Due to a lack of morphological data and sub adult stage this specimen could not be identified to species level. This specimen is **considered a potential SRE** (WAM 2013a). Given this taxon was recorded from the extensive pindan shrubland habitat, it is likely to have a distribution that extends well beyond the study area boundary.

***Aname* 'sp. indet.'**

SRE Status: Potential.

One juvenile specimen was collected opportunistically inside the potential impact area. Due to a lack of morphological data and sub adult stage this specimen could not be identified to species level. This specimen is **considered a potential SRE** (Phoenix 2014). Given this taxon was recorded from the boundary of the pindan shrubland and sandstone range habitats, it is likely to have a distribution that extends well beyond the study area boundary.

5.5.2 Pseudoscorpiones (False Scorpions or Pseudoscorpions)

5.5.2.1 Family: Olpiidae

Olpiidae 'genus indet.' (juvenile)

SRE Status: Potential.

Fifteen juvenile Olpiidae species were collected from sites TB SRE3, TB SRE4, TB SRE5 and TB SRE6 (inside the potential impact area). Some of these species may be range restricted (Harvey and Leng 2008), and due to lack of morphological data these specimens **are considered a potential SRE** (WAM 2013a). Given this taxon was recorded from the extensive pindan shrubland habitat throughout the potential impact area, it is likely to have a distribution that extends well beyond the study area boundary.

5.5.3 Scorpiones (Scorpiones)

5.5.3.1 Family: Buthidae

***Lychas* 'broome'**

SRE Status: Potential.

Lychas 'broome' is a well-defined and clearly recognised morphospecies. Few specimens are known and all records are restricted to the Broome area of WA. Insufficient records are available to assess this species as a SRE. Based on distribution patterns of species in the genus, *Lychas* 'broome' is **considered a potential SRE** (Phoenix 2013b). Within the study area, this morphospecies was only recorded at site TB S2 (inside the potential impact area). Given this taxon was recorded from the extensive pindan shrubland habitat, and is known in other locations on the Dampier Peninsula, its distribution is expected to extend well beyond the study area boundary.

***Lychas* 'JPP', 'JPP1', 'JPP2' and 'JPP3'**

SRE Status: Potential.

Four species of *Lychas* (Figure 5.3) were recorded for the first time and are only known from the study area. Three of the morphospecies were recorded both inside and outside of the potential impact area, while *Lychas* 'JPP2' was only recorded within the potential impact area at TB S2. These are **considered potential SREs** taking distribution patterns of *Lychas* into account (Phoenix 2013a). Given these taxa were recorded from the extensive pindan shrubland and savannah woodland habitats, the distributions for the four taxa are expected to extend well beyond the study area boundary.

Figure 5.3 – Representative image of *Lychas* 'JPP'

5.5.3.2 Family: Urodacidae

***Urodacus* 'kraepelini'**

SRE Status: Potential.

Urodacus 'kraepelini' was recorded during the first phase at site TB S7 (outside of the potential impact area) and is a well-defined and clearly recognised morphospecies. It is only known from around Broome. Based on distribution patterns of species in the genus, *Urodacus* 'kraepelini' is **considered a potential SRE** (Phoenix 2013b). Given this taxon was recorded from the extensive pindan shrubland habitat, and is known in other locations on the Dampier Peninsula, its distribution is expected to extend well beyond the study area boundary.

***Urodacus* 'sp. indet.'**

SRE Status: Potential.

The material included two specimens of *Urodacus* scorpions from sites TB S5 and TB SRE2 (both within the potential impact area) that could not be identified to species level. Based on distribution patterns of species with the genus and the rating of *Urodacus* 'kraepelini' from this survey as potential SRE, these two specimens are here also **considered potential SREs** (Phoenix 2013b). Given this taxon was recorded from the extensive pindan shrubland habitat, its distribution is expected to extend well beyond the study area boundary.

5.5.4 Opiliones (Harvestmen)

5.5.4.1 Family: Assamiidae

***Dampetrus* sp.**

SRE Status: Potential.

One species of *Dampetrus* (Figure 5.4) was recorded at sites TB S6 and TB S7, outside and inside of the potential impact area respectively. This morphospecies lacks taxonomic and geographical context, and as such, is **considered a potential SRE** (WAM 2013a). Given this taxon was recorded from the extensive pindan shrubland and savannah woodland habitats, its distribution is expected to extend well beyond the study area boundary.

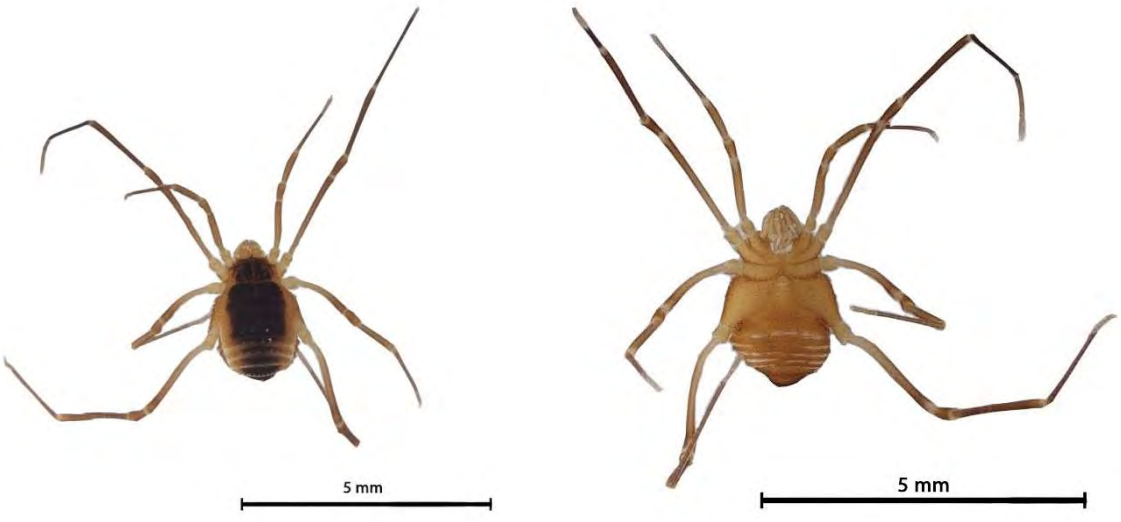

Figure 5.4 – Representative image of the harvestmen *Dampetrus* sp.

5.5.5 Isopoda (Slaters)

5.5.5.1 Family: Armadillidae

Armadillidae 'EE1501C'

SRE Status: Potential.

Armadillidae 'EE1501C' is an isopod with affinities to the genus *Cubaris*. It is only known from the single male specimen (partly damaged) from this survey. However, many individuals of this morphospecies were observed within a rock crevice where the individual was collected. This is an unusual species as it has noticeably longer uropod exopodites than other species of this type. It is

here **considered a potential SRE** based on distribution patterns seen within this group; however, the isopod fauna of the region is poorly known (Phoenix 2013a). Given this taxon was recorded in the sandstone range habitat, its distribution is likely to extend beyond the study area boundary, particularly to the north.

Buddelundiinae 'gen. indet. NE Broome'

SRE Status: Potential.

Buddelunidiinae gen. indet. represents an undescribed genus of isopods that is closely related to *Buddelundia*. *Buddelundia albomarginata*, originally described from Broome belongs to this genus. The genus is found in the Pilbara and Kimberley. Based on the original description, it remains doubtful if Buddelundiinae 'gen. indet. NE Broome' is conspecific with *B. albomarginata*. It is here considered a different species and based on the distribution patterns of other species in the Buddelundiinae gen. indet. **considered a potential SRE** (Phoenix 2013b). Given this taxon was recorded in the savannah woodland habitat, its distribution is likely to extend beyond the study area boundary, particularly to the south-east.

***Buddelundia* sp.74**

SRE Status: Potential.

Buddelundia '74' is a well-recognised morphospecies and currently only known from this survey. It was collected mainly from the sandstone range habitat outside of the potential impact area. Its SRE status can currently not be determined based on the paucity of isopod collections in the area. Based on distribution patterns within *Buddelundia*, *Buddelundia* '74' should be **considered a potential SRE** (Phoenix 2013a). Given this taxon was recorded throughout the sandstone range habitat, and adjacent pindan shrublands, its distribution is likely to extend beyond the study area boundary, particularly to the north.

5.5.6 Gastropoda (Snails)

5.5.6.1 Family: Camaenidae

Quistrachia leptogramma

SRE Status: Potential.

Ten specimens of the land snail *Quistrachia leptogramma* were collected during the survey both inside and outside the potential impact area. *Quistrachia leptogramma* has been recorded in previous surveys on the Dampier Peninsula, but is a data deficient taxon, and as such is **considered a potential SRE** (WAM 2013b). Given this taxon was recorded within the extensive pindan shrubland habitat, and is known from other locations on the Dampier Peninsula, its distribution is highly likely to extend well beyond the study area boundary.

Rhagada bulgana

SRE Status: Confirmed.

Eight specimens of the land snail *Rhagada bulgana* (Figure 5.5) were collected during the survey both inside and outside the potential impact area. *Rhagada bulgana* has been recorded in previous surveys on the Dampier Peninsula, and is a **confirmed SRE** (WAM 2013b). Given this taxon was recorded within the extensive pindan shrubland habitat, and is known from other locations on the Dampier Peninsula, its distribution is highly likely to extend well beyond the study area boundary.

Figure 5.5 – Representative image of the confirmed SRE *Rhagada bulgana*

5.6 STYGOFAUNA

Despite widespread sampling within the potential impact area, no stygofauna were recorded during the survey. It is therefore unlikely that a significant or diverse stygofauna assemblage exists within the study area.

5.7 TROGLOFAUNA

5.7.1 Scolopendromorpha (Centipedes)

5.7.1.1 Family: Cryptopidae

***Cryptops* 'sp. indet.'**

SRE Status: Potential.

One specimen of the centipede *Cryptops* sp. was collected during the survey from outside the potential impact area, at a regional drill site specially designed for troglofauna sampling. Although the geology of this drill hole is unknown, the *Cryptops* was likely inhabiting a sandstone layer up to 36m in depth (water table level). This individual lacked pigmentation, and is therefore likely to be troglobitic. The genus *Cryptops* has not previously been recorded on the Dampier Peninsula, and as it may represent an undescribed species, it is considered a **potential SRE** (WAM 2013b). However, given this taxon was recorded within the sandstone strata, which continues extensively to the east and north, its distribution is unlikely to be confined to the study area.

5.7.2 Coleoptera (Beetles)

5.7.2.1 Family: Staphylinidae

Staphylinidae 'sp. indet.'

One specimen of the rove beetle from the family Staphylinidae was collected during the survey from inside the potential impact area, at a relatively shallow depth of 8m. The likely habitat this individual was occupying is a sandstone stratum. Although this individual had eyes present, it is considered to be either a troglophile or troglobite, and not a trogloxene. Due to a lack of geographic context and resolution of taxonomy, this taxon is considered a **potential SRE** (WAM 2013b). However, given this taxon was recorded within the sandstone strata, which continues extensively to the east and north, its distribution is unlikely to be confined to the study area.

5.8 SURVEY ADEQUACY

5.8.1 Vertebrate Fauna

The results presented in Section 4.6 demonstrate that systematic survey effort was adequate for both terrestrial vertebrates and birds. Table 4.2 also shows that, although less systematic survey effort was expended in the sandstone range and savannah woodland habitats, this was supplemented by opportunistic diurnal and nocturnal searches, and motion camera trapping. Consequently, as Figure 4.28 suggests, most of the trappable terrestrial vertebrate fauna assemblage was recorded. Opportunistic survey effort recorded a further 14 species, but the majority of these are not considered trappable. Similarly, Figure 4.29 shows that nearly all of the theoretical maximum number of bird species was recorded, although the additional 11 species recorded opportunistically actually exceeds this amount. Overall, the current survey can be considered more than adequate for recording the potential vertebrate fauna assemblage of the study area.

5.8.2 SRE Invertebrate Fauna

The results presented in section 4.6 demonstrate that systematic survey effort was adequate for the SRE invertebrate fauna. Trapping effort for this fauna group was focused on the pindan shrubland habitat (Table 4.2), which comprises 79% of the potential impact area. However, additional trapping was also conducted in the savannah woodland and sandstone range habitats, and was complemented by widespread foraging in both habitats. As Figure 4.30 suggests, the majority (77%) of the estimated SRE invertebrate assemblage was recorded. As opportunistic foraging and leaf litter sampling recorded a further 11 species, the current survey can be considered more than adequate for recording the potential invertebrate fauna assemblage of the study area.

5.8.3 Subterranean fauna

Due to the absence of previous records of subterranean fauna on the Dampier Peninsula, the current survey identified that a pilot study would be sufficient in determining subterranean values. Generally, the majority of the potential impact area provides little habitat for troglofauna, and is comprised solely of sand above the water table. However, the five drill holes that do contain rock strata were sampled. Only a single specimen was recorded from within the potential impact area, while a second specimen was recorded in the sandstone ranges to the east of the potential impact area. As such, it is likely that little habitat exists for troglofauna within the potential impact area, but may occur within the extensive sandstone habitats in the ranges to the east and north. The sampling identified that the potential impact area is unlikely to contain a diverse or significant troglofauna community, and as such, no further sampling is required.

Stygofauna sampling was well spread across the potential impact area, with a total of 15 drill holes sampled. Despite the excellent coverage, no stygofauna were recorded, and it is therefore unlikely that a significant or diverse stygofauna community exists within the study area. The stygofauna survey can therefore be deemed adequate in identifying stygofauna values.

5.9 SURVEY LIMITATIONS

Limitations of the current survey are summarised below in Table 5.1. Given the few limitations encountered, it can be confirmed that an adequate level of survey has been undertaken for the purpose of this report.

Table 5.1 – Summary of survey limitations

Limitation	Relevant (yes/no)	Comment
Competency/experience of the consultant carrying out the survey.	No	All key members of the survey team were experienced in Kimberley fauna identification and fauna surveys.
Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions).	No	All fauna groups were adequately sampled.
Proportion of fauna identified, recorded and/or collected.	No	The majority of fauna species expected to occur within the survey area were recorded, as indicated by SACs (Section 4.6). Most captured vertebrate species were identified in the field.
Sources of information (previously available information as distinct from new data).	No	Thirteen other relevant biological surveys have been conducted on the Dampier Peninsula. Data from these surveys were included to provide regional context.
The proportion of the task achieved and further work which might be needed.	No	A two-phase Level 2 fauna assessment was successfully completed. All fauna habitats and groups were adequately sampled.
Timing/weather/season/cycle.	No	The two survey phases optimally covered both seasons; one immediately following the wet season, and one at the end of the dry.
Disturbances which affected results of the survey (e.g. fire, flood, accidental human intervention).	No	There were no disturbances during or between the survey phases.
Intensity (in retrospect was the intensity adequate).	No	The survey intensity was adequate, all habitat types were surveyed systematically and opportunistically, and most of the species expected to occur were recorded.
Completeness (e.g. was relevant area fully surveyed).	No	The survey area was comprehensively surveyed.
Resources (e.g. degree of expertise available in animal identification to taxon level).	No	All key zoologists were suitably qualified and experienced in identification of Kimberley fauna. There were no resource issues encountered.
Remoteness and/or access problems.	No	Most of the study area was accessible. Areas that were not accessed were in habitat that was well surveyed elsewhere.
Availability of contextual (e.g. biogeographic) information on the region.	No	There are few prior regional studies and/or limited knowledge of some taxa. There is sufficient contextual biogeographical information available on the Dampier Peninsula and the study area.
Efficacy of sampling methods (i.e. any groups not sampled by survey methods).	No	Survey methods were suitable to sample all fauna groups present.

6 CONCLUSIONS

The main conclusions from the study are as follows:

- A total of three broad-scale terrestrial habitat types have been identified within the study area; pindan shrubland, savannah woodland and sandstone range. No habitats recorded are regarded as rare or unique to the study area.
- A total of 16 native mammals, two introduced mammals, 107 bird species (27 only recorded at the Mount Jowlaenga homestead), 43 reptile species and eight amphibians were recorded during the survey.
- Nine species of conservation significant vertebrate fauna (two mammal and seven bird species) were recorded during the survey, with an additional four species assessed as having a medium likelihood of occurrence. Three of the recorded species were wetland dependent species, and only recorded at the Mount Jowlaenga homestead adjacent to the study area. The six species recorded within the study area included the Greater Bilby (EPBC Act Vulnerable), Short-tailed Mouse (DPaW Priority 4), Fork-tailed Swift (EPBC Act Migratory), Rainbow Bee-eater (EPBC Act Migratory), Australian Bustard (DPaW Priority 4) and Bush Stone-curlew (DPaW Priority 4).
- A total of 28 invertebrate taxa from six orders were submitted for identification and SRE status assessment. The results from the identifications showed one taxon is a confirmed SRE (the land snail *Rhagada bulgana*). This taxon has previously been recorded on the Dampier Peninsula. Additionally, 20 taxa are considered potential SREs (seven mygalomorph spiders, one pseudoscorpion, seven scorpions, one harvestmen, three slaters and one land snail). Due to a lack of regional surveys on the Dampier Peninsula, it is not possible to assess the true SRE status of these taxa from the available data. However, as the vegetation communities and landforms present within study area do not appear to be unique, it is unlikely that any of these taxa are geographically confined to the boundary of the proposed impact area.
- Two specimens of troglofauna were collected during the troglofauna survey including one specimen of the centipede *Cryptops '*sp. indet.', and a specimen of rove beetle from the family Staphylinidae (Staphylinidae 'sp. indet.'). Both taxa are considered to be potential SREs; however, the continuous sandstone strata are expected to extend well beyond the study area.
- Ten specimens of Naididae worms were collected during the stygofauna survey, and are opportunistically stygal. The absence of obligate stygofauna suggests there is a low likelihood of a diverse and abundant stygofauna community present within the study area.
- Systematically obtained data was analysed to determine the survey adequacy through SACs. Extrapolation of the Michaelis-Menten (MM) curve suggests that 93.8% of trappable terrestrial vertebrate fauna (reptiles and mammals), 97.2% of birds and 77.2% of SRE invertebrate fauna were recorded. These results indicate that the majority of species were recorded for all fauna groups. However, increased sampling is likely to record additional species, particularly within the SRE invertebrate group.
- No significant limitations were experienced during the surveys. Given the lack of limitations and the fact that the majority of fauna were recorded, the surveys can be considered adequate and have met their objectives.

7 REFERENCES

AECOM. 2010. Supplementary Terrestrial Fauna and Habitat Assessment: James Price Point, WA.

AECOM 2011. Browse LNG Precinct Access Road: Targeted Fauna Survey – Greater Bilby.

Allen, G. R., Midgley, S. H., and Allen, M. 2002. Field Guide to the Freshwater Fishes of Australia. CSIRO Publishing, Melbourne, VIC.

Australian Government Department of Sustainability, E., Water, Population and Communities,. 2012. Interim Biogeographic Regionalisation for Australia (IBRA), Version 7. Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra, ACT.

Bamford Consulting Ecologists 2011. Assessment of Birds Utilising Habitat within the Vine Thickets and Woodlands of James Price Point, WA. Field Report, May 2011.

Beard, J. S. 1979. Kimberley: The vegetation of the Kimberley area. Vegetation Survey of Western Australia 1:1,000,000 series, explanatory notes and map. University of Western Australia Press, Nedlands, WA.

Bettenay, E., Churchward, H. M., and McArthur, W. M. 1967. Atlas of Australian Soils – Explanatory Data for Sheet 6: Meekatharra – Hamersley Range Area *in* Commonwealth Scientific and Industrial Research Organisation (CSIRO), and Melbourne University Press, eds. Cambridge University Press, London and New York.

Biota Environmental Sciences. 2005. Barrow Island Gorgon Gas Development - Subterranean Fauna Survey. Prepared for The Gorgon Venture - October.

Biota Environmental Sciences. 2006. Mesa A and Robe Valley Troglobitic Fauna: Subterranean Fauna Assessment. Report Prepared for Robe River Iron Associates. June 2006

Biota Environmental Sciences. 2008. West Angelas and Deposit A Stygofauna Survey.

Biota Environmental Sciences. 2009. James Price Point Terrestrial Fauna Survey: Wet Season 2009.

Biota Environmental Sciences. 2010. James Price Point Browse LNG Precinct Targeted Terrestrial Fauna Survey.

Boland, C. R. J. 2004. Breeding biology of Rainbow Bee-eaters (*Merops ornatus*): a migratory, colonial, cooperative bird. The Auk. 121:811-823.

BOM. 2013. Bureau of Meteorology. Available at: http://www.bom.gov.au. Commonwealth of Australia, Canberra.

BoM. 2014. Climate Data Online. Accessed January 2014. http://www.bom.gov.au/climate/data/.

Bradbury, J. H. and Williams, W. D. 1997. The Amphipod (Crustacea) Stygofauna of Australia: Description of New Taxa (Melitidae, Neoniphargidae, Paramelitidae), and a Synopsis of Known Species. Records of the Australian Museum. 49:249-341.

Brown, A. and Saunders, G. 2013. Pestsmart. NSW Dept of Primary Industries, Invasive Animals CRC. http://www.feral.org.au/pest-species/.

Bunge, J. and Fitzpatrick, M. 1993. Estimating the number of species: A review. Journal of the American Statistical Association. 88:364-373.

Bushnell Outdoor Products. 2009. Trophy Cam Instruction Manual.

Chapman, A. D. 2009. Numbers of living species in Australia and the World. Report for the Australian Biological Resources study.

Cho, J.-L. 2010. Ten new species of the genus *Brevisomabathynella* Cho, Park and Ranga Reddy, 2006 (Malacostraca, Bathynellacea, Parabathynellidae) from Western Australia. Journal of Natural History. Volume 44.

Cho, J.-L., Park, J.-G., and Humphreys, W. F. 2005. A new genus and six new species of the Parabathynellidae (Bathenellacea, Syncarida) from the Kimberley region, Western Australia. Journal of natural History. 39:2225-2255.

Christidis, L. and Boles, W. E. 2008. Systematics and Taxonomy of Australian Birds. CSIRO Publishing, Collingwood.

Churchill, S. 1998. Australian Bats. Reed New Holland, Sydney.

Clarke, K. R. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology. 18:117-143.

Cogger, H. G. 2000. Reptiles and Amphibians of Australia. Reed New Holland, Sydney.

Colwell, R. K. 2009. EstimateS: Statistical estimation of species richness and shared species from samples. Version 8.

Colwell, R. K. and Coddington, J. A. 1994. Estimating terrestrial biodiversity through extrapolation. Philosophical Transactions of the Royal Society of London, B Biological Sciences. 345:101-118.

Commonwealth Government. 1996. The Natural Strategy for the conservation of Australia's Biological Diversity. *in* Department of the Environment, S. a. T., ed. Commonweath of Australia, canberra.

Danielopol, D. L. and Stanford, J. A., eds. 1994. Groundwater Ecology. Academic Press., San Diego.

De Laurentiis, P., Pesce, G. L., and Humphreys, W. F. 2001. Copepods from ground waters of Western Australia, VI. Cyclopidae (Crustacea: Copepoda) from the Yilgarn Region and the Swan Coastal Plain. pp. 115-131 *in* Humphreys, W. F., and Harvey, M. S., eds. Subterranean Biology in Australia. Records of the Western Australian Museum, Supplement No. 64., Perth.

DEC. 2009. Stygofauna of the Pilbara. Accessed http://www.dec.wa.gov.au/science-and-research/biological-surveys/stygofauna-of-the-pilbara.html.

Department of Water. 2010. Kimberley Regional water plan 2010-2030; Supporting detail.

Department of Water. 2012. Groundwater resource review; Dampier Peninsula. HG57.

DPaW. 2014. NatureMap: Mapping Western Australia's Biodiversity. Department of Parks and Wildlife.

DSEWPaC. 2012. Interim Biogeographic Regionalisation for Australia (IBRA) Version 7. Australian Government Department of Sustainability, Environment, Water, Population and Communites, Canberra.

Eberhard, S. 2006. Jewel Cave Precinct Management Plan. Report prepared for the Augusta-Margaret River Tourism Association.

Unpublished report prepared for URS Australia Pty Ltd. 2004. Preliminary Investigation of Stygofauna in the Blackwood Groundwater Area.

Eberhard, S. M., Halse, S. A., and Humphreys, W. F. 2005. Stygofauna in the Pilbara region, north-west Western Australia: a review. Journal of the Royal Society of Western Australia. 88:167-176.

ebird. 2014. Range and point maps. Accessed http://ebird.org/ebird/australia/map/.

ecologia Environment. 1998. West Angelas Stygofauna Assessment.

ecologia Environment. 2006a. Honeymoon Well Project Stygofauna Survey - Phase 2. Report Prepared for Lionore Australia. August 2006

ecologia Environment. 2006b. Koolan Island Stygofauna Sampling Programme. Report Prepared for Aztec Resources Ltd. 22 March 2006

Subterranean Ecology. 2012. Canning Basin Project: Stygofauna Survey and Assessment. Unpublished report prepared for Fortescue Metals Group Pty Ltd.

ENV Australia. 2008. Perpendicular Head-North Head, Packer Island, Gourdon Bay and Coulomb-Quondong Vertebrate Fauna Assessment.

ENV Australia. 2011. Browse Project Greater Bilby Survey of the James Price Point Area: Summary Report.

EPA. 2002a. Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection. Environmental Protection Authority, Perth.

EPA. 2002b. Terrestrial Biological Surveys as an Element of Biodiversity Protection *in* Environmental Protection Authority, ed, Perth.

Environmental Protection Authority. 2003. Guidance for the Assessment of Environmental Factors, Statement No. 54: Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia. December 2003

EPA. 2004. Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia *in* Environmental Protection Authority, ed, Perth.

Environmental Protection Authority. 2005. Managed Aquifer Recharge using Treated Wastewater on the Swan Coastal Plain, Perth, Western Australia.

Environmental Protection Authority. 2007. Guidance for the Assessment of Environmental Factors, Statement No. 54a (Technical Appendix to Guidance Statement no. 54): Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia.

Environmental Protection Authority. 2009. Guidance for the Assessment of Environmental Factors, Statement No. 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia.

Environmental Protection Authority. 2012. A review of subterranean fauna assessment in Western Australia.

Environmental Protection Authority. 2013. Environmental Assessment Guideline No. 12: Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia.

Environmental Protection Authority and Department of Environment and Conservation. 2010. Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment.

Frith, A. J. 1976. Reader's Digest Complete Birds of Australia. Reader's Digest, Sydney.

Garnett, S. T. and Crowley, G. M. 2000. The Action Plan for Australian Birds. Environment Australia, Canberra.

Gaston, K. J. 1996. Species richness: measure and measurement. Biodiversity, a biology of number and difference. Blackwell Science, Cambridge.

Gilbert, J., Danielopol, D. L., and Stanford, J. A., eds. 1994. Groundwater Ecology. Academic Press., London.

Graham, G. 2001. Dampierland 2 (DL2 – Pindanland subregion). A Biodiversity Audit of Western Australia's 53 Biogeographic Subregions in 2002

Department of Environment and Conservation, Perth.

Graham, G. 2002. Dampierland 2 (DL2 – Pindanland subregion). CALM.

Hahn, H. J. and Fuchs, A. 2009. Distribution patterns of groundwater communities across aquifer types in south-western Germany. Freshwater Biology. 54:848-860.

Hahn, H. J. and Matzke, D. 2005. A comparison of stygofauna communities inside and outside groundwater bores. Limnologica. 35:31-44.

Hammer, Ø., Harper, D. A. T., and Ryan, P. D. 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica. 4.

Harvey, M. S. 1988. A new troglobitic schizomid from Cape Range, Western Australia (Chelicerata: Schizomida). Records of the Western Australian Museum. 14:15-20.

Harvey, M. S. 2002. Short-range endemism among the Australian fauna: some examples from non-marine environments. Invertebrate Systematics. 16:555 - 570.

Harvey, M. S., Berry, O., Edward, K. L., and Humphreys, G. 2008. Molecular and morphological systematics of hypogean schizomids (Schizomida:Hubbardiidae) in semiarid Australia. Invertebrate Systematics. 22:167–194.

Harvey, M. S. and Leng, M. C. 2008. The first troglomorphic pseudoscorpion of the family Olpiidae (Pseudoscorpiones), with remarks on the composition of the family. Records of the Western Australian Museum. 24:387-394.

Hickman, A. H. and Kranendonk, M. 2008. Compilers, Geology, in Geological Survey of Western Australia, Pilbara 1:100 000 Geological Information Series, 2008 update: Geological Survey of Western Australia.

Howarth, F. G. 1983. Ecology of cave arthropods. Annual Review of Entomology. 28:365-389.

Howarth, F. G. 1993. High-Stress Subterranean Habitats and Evolutionary Change in Cave-Inhabiting Arthropods. The American Naturalist. 142:S65-S77.

Humphreys, W. F. 1993. Stygofauna in semi-arid tropical Western Australia: a Tethyan connection?. Mémoires de Biospéologie. 20:111 - 116.

Humphreys, W. F. 1999. Relict stygofaunas living in sea salt, karst and calcrete habitats in arid northwestern Australia contain many ancient lineages. pp. 219-227 *in* W., P., and D., L., eds. The Other 99%: The Conservation and Biodiversity of Invertebrates. Royal Zoological Society of New South Wales., Sydney.

Humphreys, W. F. 2001. Groundwater calcrete aquifers in the Australian arid zone: the context to an unfolding plethora of stygal biodiversity. Records of the Western Australian Museum. Supplement 64:63-83.

Johnson, C. 2006. Australia's Mammal Extinctions, a 50,000 Year History. Cambridge University Press, Melbourne.

Johnson, K. A. 2008. Bilby, *Macrotis lagotis*. pp. 191-193 *in* van Dyck, S., and Strahan, R., eds. The Mammals of Australia. Reed New Holland, Sydney.

Johnstone, R. E. and Storr, G. M. 1998. Handbook of Western Australian Birds, Volume I - Non-Passerines (Emu to Dollarbird). Western Australian Museum, Perth.

Karanovic, I. 2005. Towards a revision of Candoninae (Crustacea: Ostracoda): Australian representatives of the subfamily, with descriptions of three new genera and seven new species. New Zealand Journal of Marine and Freshwater Research. 39:29-75.

Karanovic, I. and Marmonier, P. 2002. On the genus, *Candonopsis* (Crustacea: Ostracoda: Candoninae) in Australia, with a key to the world recent species. Annuals of Limnology. 38:199-240.

Karanovic, I. and Marmonier, P. 2003. Three new genera and nine new species of the subfamily Candoninae (Crustacea: Ostracoda: Podocopida) from the Pilbara region (Western Australia). Beufortia. 53:1-53.

Karanovic, T. 2004. Subterranean copepods (Crustacea: Copepoda) from arid Western Australia. Crustaceana Supplement 3. 3:1 - 366.

Kenneally, K. F., Edinger, D. C., and Willing, T. 1996. Broome and Beyond: Plants and People of the Dampier Peninsula, Kimberley, Western Australia. Department of Conservation and Land Management, Western Australia.

Knott, B. 1993. Stygofauna from Cape Range peninsula, Western Australia: Tethyan relicts. The Biogeography of Cape Range Western Australia. Records of the Western Australian Museum. Supplement 45:109-127.

Main, B. Y. 1996. Terrestrial invertebrates in south-west Australian forests: the role of relict species and habitats in reserve design. Journal of the Royal Society of Western Australia. 79:277 - 280.

Main, B. Y. 1999. Biological anachronisms among trapdoor spiders reflect Australias environmental changes since the Mesozoic *in* Ponder, W., and Lunney, D., eds. The Other 99%. Transactions of the Royal Zoological Society of New South Wales, Mosman 2088.

Mamonier, P., Vervier, P., Gilbert, J., and Dole-Oliver, M. J. 1993. Biodiversity in Groundwaters. Tree. 8:392 - 395.

Marchant, S. and Higgins, P. J. 1993. Handbook of Australian, New Zealand and Antarctic Birds. Oxford University Press, Melbourne.

Martens, K. and Rossetti, G. 2002. On the Darwinulidae (Crustacea:Ostracoda) from Oceania. Invertebrate Systematics. 16:195–208.

Maxwell, S., Burbidge, A. A., and Morris, K. D., eds. 1996. The 1996 Action Plan for Australian Marsupials and Monotremes. Wildlife Australia, Canberra.

Menkhorst, P. and Knight, F. 2011. *A Field Guide to the Mammals of Australia*. Oxford University Press, Melbourne.

Moore, B. P. 1995. Two Remarkable New Genera and Species of Troglobitic Carabidae (Coleoptera) from Nullarbor Caves. Journal of the Australian Entomological Society. 34:159-161.

Morcombe, M. 2000. Field Guide to Australian Birds. Steve Parish Publishing Pty Ltd, Archerfield, Australia.

Moro, D. and Kutt, A. S. 2008. Northern Short-tailed Mouse, *Leggadina lakedownensis*. pp. 583-584 *in* van Dyck, S., and Strahan, R., eds. The Mammals of Australia. Reed New Holland, Sydney.

National Health and Medical Research Council. 2004. Australian code of practice for the care and use of animals for scientific purposes.

NSW National Parks and Wildlife Service. 1999. Bush Stone-curlew *Burhinus grallarius* (Latham, 1801). NSW National Parks and Wildlife Service, Hurstville, NSW www.npws.nsw.gov.au,.

O'Malley, C. 2006a. Australian Threatened Species, Greater Bilby, *Macrotis lagotis*.

O'Malley, C. 2006b. National Recovery Plan for the Gouldian Finch (*Erythrura gouldiae)*. WWF-Australia, Sydney and Parks and Wildlife NT, Department of Natural Resources, Environment and the Arts, NT Government.

Pavey, C. 2006. Threatened Species of the Northern Territory: Greater Bilby *Macrotis lagotis in* Department of Natural Resources Environment and the Arts, ed. Parks and Wildlife Commission - Northern Territory Government.

Phoenix Environmental Sciences. 2013a. Identification and assessment of short-range endemism of invertebrates from 80 km NE Broome (Thunderbird study area), Western Australia.

Phoenix Environmental Sciences. 2013b. Identification and assessment of short-range endemism of scorpions (Scorpiones) and slaters (Isopoda) from Broome, Western Australia.

Phoenix Environmental Sciences. 2014. Identification and assessment of short-range endemism of invertebrates from 80 km NE Broome (Thunderbird study area), Western Australia.

Pizzey, G. and Knight, F. 2003. A Field Guide to the Birds of Australia. Harper Collins Publishers, Sydney.

Ponder, W. F. and Colgan, D. J. 2002. What makes a narrow-range taxon? Insights from Australian freshwater snails. Invertebrate Systematics. 16.

Poore, G. C. B. and Humphreys, C. J. 2003. Second species of *Mangkutu* (Speleogriphacea) from north-western Australia. Records of the Western Australian Museum. 22:67-74.

Poore, G. C. B. and Humphreys, W. F. 1998. First record of Spelaeogriphacea from Australia: a new genus and species from an aquifer in the arid Pilbara of Western Australia. Crustaceana. 71:721 - 742.

Richards, G. C. 2008. Northern Bent-winged Bat (*Miniopterus schreibersii orianae*). pp. 507-508 *in* Dyck, S. V., and Strahan, R., eds. The Mammals of Australia. Reed New Holland, Sydney.

Rockwater. 2006. Stygofauna Results and Predicted Water-Level Drawdown at Proposed Mine and Borefield. Report Prepared for Grange Resources. January 2006

Rogers, D., Hassell, C., Oldland, J., Clemens, R., Boyle, A., and Rogers, K. 2009. Monitoring Yellow Sea Migrants in Australia (MYSMA): North-western Australian shorebird surveys and workshops, December 2008.

Shepherd, *et al.* 2002. Native Vegetation in Western Australia. Technical Report 249.

Short, J. and Smith, A. P. 1994. Mammal decline and recovery in Australia. Journal of Mammalogy. 75:288-297.

Simpson, K. and Day, N. 2004. Field Guide to the Birds of Australia. Penguin Group, Camberwell.

Southgate, R. 2013. Bilby behaviour and ecology and the detection and validation of bilby sign. Threatened species workshop - Bilby, Department of Parks and Wildlife, Conservation Science Center.

Storey, A. W., Halse, S. A., Shiel, R. J., and Creagh, S. C. 2011. Aquatic fauna and water chemistry of the mound springs and wetlands of Mandora Marsh, north-western Australia. Royal Society of Western Australia. 94:419-437.

Storr, G. M., Smith, L. A., and Johnstone, R. E. 1983. Lizards of Western Australia II: Dragons and Monitors. Western Australian Museum, Perth.

Storr, G. M., Smith, L. A., and Johnstone, R. E. 1990. Lizards of Western Australia III: Geckos and Pygopods. Western Australian Museum, Perth.

Storr, G. M., Smith, L. A., and Johnstone, R. E. 1999. Lizards of Western Australia I: Skinks. Western Australian Museum, Perth.

Storr, G. M., Smith, L. A., and Johnstone, R. E. 2002. Snakes of Western Australia. Western Australian Museum, Perth.

Strayer, D. L. 1994. Limits to biological distributions in groundwater. pp. 287-305 *in* Gilbert, J., Danielopol, D. L., and Stanford, J. A., eds. Groundwater Ecology. Academic Press Inc, San Diego.

Tyler, M. J. and Doughty, P. 2009. Field Guide to Frogs of Western Australia. Western Australian Museum, Perth.

van Dyck, S. and Strahan, R. 2008. *The Mammals of Australia*. Reed New Holland, Sydney.

Western Australian Museum. 2013a. WAMTS195: Arachnida/ Myriapoda, Arachnids from 80 km NE of Broome, Western Australia.

Western Australian Museum. 2013b. WAMTS195: Mollusca, Molluscs from 80 km NE of Broome, Western Australia.

Wilson, G. D. F. 2001. Australian groundwater-dependent isopod crustaceans. Records of the Western Australian Museum. Supplement 64:239-240.

Wilson, G. D. F. and Keable, S. J. 2002. New genera of Phreatoicidea (Crustacea: Isopoda) from Western Australia. Records of the Australian Museum. 54:41-70.

Wilson, S. and Swan, G. 2010. *A Complete Guide to Reptiles of Australia*. New Holland Publishers, Sydney.

Woinarski, J. C. Z. and Palmer, C. 2006. Threatened Species of the Northern Territory: Gouldian Finch *Erythrura gouldiae*. Parks and Wildlife Commission - Northern Territory Government.

APPENDIX A EXPLANATION OF CONSERVATION CODES

Appendix A1 Definitions of categories under the *Environment Protection and Biodiversity Conservation Act 1999*

Category	Definition
Endangered (EN)	The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction.
Vulnerable (VU)	Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate.
Migratory (M)	Species are defined as migratory if they are listed in an international agreement approved by the Commonwealth Environment Minister, including: • the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animal) for which Australia is a range State; • the agreement between the Government of Australian and the Government of the Peoples Republic of China for the Protection of Migratory Birds and their environment (CAMBA); or • the agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (JAMBA).

Appendix A2 Definition of Schedules under the *Wildlife Conservation Act 1950*

Schedule	Definition
Schedule 1 (S1)	Fauna which are rare of likely to become extinct, are declared to be fauna that is in need of special protection.
Schedule 2 (S2)	Fauna which are presumed to be extinct, are declared to be fauna that is in need of species protection.
Schedule 3 (S3)	Birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction, are declared to be fauna that is in need of species protection.
Schedule 4 (S4)	Declared to be fauna that is in need of species protection, otherwise than for the reasons mentioned above.

Appendix A3 Definition of DPaW Threatened and Priority Fauna Codes

Threatened	**Definition**
Critically Endangered (CR)	Considered to be facing an extremely high risk of extinction in the wild.
Endangered (EN)	Considered to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	Considered to be facing a high risk of extinction in the wild.
Priority	**Definition**
Priority 1 (P1)	*Taxa with few, poorly known populations on threatened lands.* Taxa which are known from few specimens or sight records from one or a few localities, on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 2 (P2)	*Taxa with few, poorly known populations on conservation lands.* Taxa which are known from few specimens or sight records from one or a few localities, on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 3 (P3)	*Taxa with several, poorly known populations, some on conservation lands.* Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 4 (P4)	*Taxa in need of monitoring.* Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could if present circumstances change. These taxa are usually represented on conservation lands.
Priority 5 (P5)	*Taxa in need of monitoring.* Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

APPENDIX B DAILY WEATHER DATA DURING THE SURVEY

Broome				Derby		
	Temperature (°C)		Rainfall (mm)	Temperature (°C)		Rainfall (mm)
	Min	Max		Min	Max	
April						
4th	22.6	27.2	7	23.5	27.7	0.4
5th	22.6	32.4	0.2	22.9	32.7	2.2
6th	22	33.7	0	22.3	34.5	0
7th	23.1	35.6	0	24.5	36.2	0
8th	25.7	36.7	0	26.2	36.7	0
9th	27	36.9	0	24.7	36.9	0
10th	25.4	37	0	22.7	37.3	0
11th	21.3	36.7	0	23.2	37	0
12th	19	35.8	0	20.4	36	0
13th	19.2	34.9	0	19.5	36.3	0
14th	20.6	34.5	0	18.5	37	0
15th	20.6	35.2	0	18.4	37	0
October						
14th	21.8	41	0	24.4	38.3	0
15th	24.5	35.8	0	25.2	35.8	0
16th	24	32.6	0	24.4	37.2	0
17th	22.6	33	0	23.2	39.7	0
18th	26.7	34.9	0	25.9	43	0
19th	27.5	36.3	0	28.2	36.6	0
20th	23.5	34.4	0	25.6	39.3	0
21th	24.3	33.5	0	23.6	38.6	0
22th	25	39.1	0	24.9	42.9	0
23th	22	38	0	23.2	42.5	0

Note: climate data recorded from Broome (3003) and Derby Aero (3032) weather stations (BoM 2014).

APPENDIX C RESULTS OF LITERATURE REVIEW AND DATABASE SEARCHES

Appendix E1: Mammals

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (AECOM 2011)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW											
TACHYGLOSSIDAE															
Tachyglossus aculeatus	Echidna					S				●					S
DASYURIDAE															
Dasyurus hallucatus	Northern Quoll	EN	S1	EN										●	
Dasycercus cristicauda	Crest-tailed Mulgara	VU	S1	VU										●	
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart				●										●
PERAMELIDAE															
Isoodon auratus	Golden Bandicoot	VU	S1	VU									●		
THYLACOMYIDAE															
Macrotis lagotis	Greater Bilby	VU	S1	VU	S	S	S			S	S	●	●		●
PHALANGERIDAE															
Trichosurus vulpecula arnhemensis	Northern Brushtail Possum				●					●					
POTOROIDAE															
Bettongia lesueur	Burrowing Bettong	VU	S1	VU								●			
MACROPODIDAE															
Macropus agilis	Agile Wallaby				S	●		●	●	●					●
Macropus robustus	Euro				●					●		●			●
Macropus rufus	Red Kangaroo									●					
EMBALLONURIDAE															

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (AECOM 2011)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW											
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat				●			●		●					●
Taphozous georgianus	Common Sheathtail Bat									●					
MOLOSSIDAE															
Chaerophon jobensis	Northern Freetail Bat				●			●		●					●
Mormopterus beccarii	Beccari's Freetail Bat									●					
Mormopterus loriae	Little Northern Freetail Bat			P1						●					
Tadarida australis	White-striped Freetail Bat									●					
VESPERTILIONIDAE															
Chalinolobus gouldii	Gould's Wattled Bat				●			●		●					●
Chalinolobus nigrogriseus	Hoary Wattled Bat				●			●		●					●
Miniopterus schreibersii orianae	Common Bentwing Bat									●					●
Myotis macropus	Large-footed Myotis														●
Nyctophilus arnhemensis	Arnhem Land Long-eared Bat							●		●					
Nyctophilus geoffroyi	Lesser Long-eared Bat				●					●					●
Pipistrellus westralis	Northern Pipistrelle									●					
Scotorepens greyii	Little Broad-nosed Bat				●			●		●					●
Scotorepens sanborni	Northern broad-nosed Bat							●		●					
Vespadelus caurinus	Western Cave Bat									●					
Vespadelus douglasorum	Yellow-lipped Cave Bat			P2	●										
Vespadelus finlaysoni	Finlayson's Cave Bat									●					
MURIDAE															

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (AECOM 2011)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW											
Leggadina lakedownensis	Lakeland Downs Mouse			P4						●					●
Pseudomys delicatulus	Delicate Mouse				●	S		●	●	●					●
Pseudomys nanus	Western Chestnut Mouse				●					●		●			●
Rattus tunneyi	Pale Field Rat									●	●				
CANIDAE															
Canis lupus dingo	Dog/Dingo				●	●		●	●	●					●
INTRODUCED MAMMALS															
Mus musculus	House Mouse							●		●					●
Rattus rattus	Black Rat					●				●					
Vulpes vulpes	Red Fox									●					
Felis catus	Cat				●	●		●	●	●					●
Equus asinus	Donkey				●					●					
Bos taurus	Cow				●	●				●					●

S = signs only (scats/tracks etc.)

Appendix E2: Birds

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
PHASIANIDAE															
Coturnix ypsilophora	Brown Quail				●	●	●	●	●		●			●	●
ANSERANATIDAE															
Anseranas semipalmata	Magpie Goose										●			●	●
ANATIDAE															
Dendrocygna eytoni	Plumed Whistling-duck								●	●	●			●	J
Dendrocygna arcuata	Wandering Whistling-duck								●	●				●	J
Stictonetta naevosa	Freckled Duck														J
Chenonetta jubata	Australian Wood Duck									●				●	J
Malacorhynchus membranaceus	Pink-eared Duck									●				●	J
Nettapus pulchellus	Green Pygmy-Goose									●				●	J
Anas gracilis	Grey Teal				●				●	●	●			●	J
Anas superciliosa	Pacific Black Duck				●				●	●				●	J
Aythya australis	Hardhead								●	●	●			●	J
PODICIPEDIDAE															
Tachybaptus novaehollandiae	Australasian Grebe								●	●	●			●	J
Poliocephalus poliocephalus	Hoary-headed Grebe									●				●	
COLUMBIDAE															
Phaps histrionica	Flock Bronzewing			P4	●				●					●	

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Ocyphaps lophotes	Crested Pigeon				●	●	●	●	●		●			●	●
Geopelia cuneata	Diamond Dove				●		●	●	●		●			●	●
Geopelia striata	Peaceful Dove				●	●	●	●	●		●			●	●
Geopelia humeralis	Bar-shouldered Dove				●	●	●	●	●					●	
PODARGIDAE															
Podargus strigoides	Tawny Frogmouth				●	●	●	●	●		●			●	●
EUROSTOPODIDAE															
Eurostopodus argus	Spotted Nightjar					●			●					●	●
AEGOTHELIDAE															
Aegotheles cristatus	Australian Owlet-nightjar				●	●		●	●		●			●	●
APODIDAE															
Apus pacificus	Fork-tailed Swift	M	S3		●	●		●					●	●	●
FREGATIDAE*															
Fregata ariel	Lesser Frigatebird	M	S3		●	●	●		●	●			●	●	
SULIDAE*															
Sula leucogaster	Brown Booby	M	S3		●				●	●				●	
ANHINGIDAE															
Anhinga novaehollandiae	Australasian Darter								●	●				●	
PHALACROCORACIDAE															
Microcarbo melanoleucos	Little Pied Cormorant				●				●	●				●	J

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Phalacrocorax carbo	Great Cormorant													●	
Phalacrocorax sulcirostris	Little Black Cormorant								●	●				●	
Phalacrocorax varius	Pied Cormorant					●			●	●				●	
PELECANIDAE															
Pelecanus conspicillatus	Australian Pelican				●	●			●	●	●			●	J
CICONIIDAE															
Ephippiorhynchus asiaticus	Black-necked Stork								●	●				●	
ARDEIDAE															
Ardea pacifica	White-necked Heron				●				●	●	●			●	J
Ardea modesta	Eastern Great Egret	M	S3						●	●			●	●	
Egretta picata	Pied Heron								●					●	
Egretta novaehollandiae	White-faced Heron				●	●			●	●				●	J
Ardea ibis	Cattle Egret	M	S3						●				●	●	
Butorides striatus	Striated Heron								●	●				●	
Egretta garzetta	Little Egret								●	●				●	
Egretta sacra	Eastern Reef Egret	M	S3						●	●				●	
Nycticorax caledonicus	Nankeen Night Heron						●							●	
THRESKIORNITHIDAE															
Plegadis falcinellus	Glossy Ibis	M	S3						●	●	●			●	
Threskiornis molucca	Australian White Ibis								●	●	●			●	

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Threskiornis spinicollis	Straw-necked Ibis				●	●			●	●	●			●	J
Platalea regia	Royal Spoonbill									●				●	J
ACCIPITRIDAE*															
Pandion cristatus	Eastern Osprey					●	●		●					●	
Elanus axillaris	Black-shouldered Kite					●			●					●	
Lophoictinia isura	Square-tailed Kite				●		●		●					●	
Hamirostra melanosternon	Black-breasted Buzzard				●						●			●	
Haliaeetus leucogaster	White-bellied Sea-Eagle	M	S3		●	●	●	●	●				●	●	
Haliastur sphenurus	Whistling Kite				●	●			●		●			●	J
Haliastur indus	Brahminy Kite				●	●		●	●					●	
Milvus migrans	Black Kite				●	●			●		●			●	J
Accipiter fasciatus	Brown Goshawk				●	●	●	●	●		●			●	●
Accipiter cirrhocephalus	Collared Sparrowhawk				●				●					●	●
Circus assimilis	Spotted Harrier								●					●	●
Circus approximans	Swamp Harrier								●					●	
Aquila audax	Wedge-tailed Eagle				●						●			●	●
Hieraaetus morphnoides	Little Eagle				●				●					●	
FALCONIDAE															
Falco cenchroides	Nankeen Kestrel				●	●	●		●		●			●	●
Falco berigora	Brown Falcon				●	●	●	●	●		●			●	●

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		EPBC Act	WC Act	DPaW											
Falco longipennis	Australian Hobby					●								●	●
Falco hypoleucos	Grey Falcon			P4										●	
Falco peregrinus	Peregrine Falcon		S4			●	●		●			●		●	
GRUIDAE															
Grus rubicunda	Brolga				●				●	●	●			●	
RALLIDAE															
Porphyrio porphyrio	Purple Swamphen								●					●	
Rallina fasciata	Red-legged Crake								●						
Gallirallus philippensis	Buff-banded Rail								●					●	
Fulica atra	Eurasian Coot									●				●	J
OTIDIDAE															
Ardeotis australis	Australian Bustard			P4	●				●			●		●	●
BURHINIDAE															
Burhinus grallarius	Bush Stone-curlew			P4	●		●		●			●		●	●
Esacus magnirostris	Beach Stone-curlew					●			●					●	
HAEMATOPODIDAE															
Haematopus longirostris	Australian Pied Oystercatcher				●	●	●		●	●				●	
Haematopus fuliginosus	Sooty Oystercatcher				●	●			●	●				●	
RECURVIROSTRIDAE															
Himantopus himantopus	Black-winged Stilt								●	●	●			●	J

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		EPBC Act	WC Act	DPaW											
Recurvirostra novaehollandiae	Red-necked Avocet									●				●	
CHARADRIIDAE*															
Pluvialis fulva	Pacific Golden Plover	M	S3						●	●				●	
Pluvialis squatarola	Grey Plover	M	S3						●	●				●	
Charadrius leschenaultii	Greater Sand Plover	M	S3			●			●	●				●	
Charadrius mongolus	Lesser Sand Plover	M	S3			●				●				●	
Charadrius ruficapillus	Red-capped Plover				●				●	●				●	
Charadrius veredus	Oriental Plover	M	S3							●			●	●	
Elseyornis melanops	Black-fronted Dotterel				●	●			●	●				●	J
Erythrogonys cinctus	Red-kneed Dotterel								●	●				●	J
Vanellus miles	Masked Lapwing				●	●			●	●	●			●	J
JACANIDAE															
Irediparra gallinacea	Comb-crested Jacana								●					●	J
ROSTRATULIDAE*															
Rostratula australis	Australian Painted Snipe	VU	S1	VU									●	●	
SCOLOPACIDAE*															
Gallinago megala	Swinhoe's Snipe	M	S3							●				●	
Limosa limosa	Black-tailed Godwit	M	S3							●				●	
Limosa lapponica	Bar-tailed Godwit	M	S3			●			●	●				●	
Numenius minutus	Little Curlew	M	S3							●				●	

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		EPBC Act	WC Act	DPaW											
Numenius phaeopus	Whimbrel	M	S3			●			●	●				●	
Numenius madagascariensis	Eastern Curlew	M	S3	P4		●			●	●				●	
Xenus cinereus	Terek Sandpiper	M	S3							●				●	
Actitis hypoleucos	Common Sandpiper	M	S3				●		●	●				●	
Tringa brevipes	Grey-tailed Tattler	M	S3			●			●	●				●	
Tringa glareola	Wood Sandpiper	M	S3			●				●				●	●
Tringa nebularia	Common Greenshank	M	S3			●			●	●				●	
Tringa stagnatilis	Marsh Sandpiper	M	S3							●				●	
Arenaria interpres	Ruddy Turnstone	M	S3			●			●	●				●	
Limnodromus semipalmatus	Asian Dowitcher	M	S3							●				●	
Calidris tenuirostris	Great Knot	M	S3						●	●				●	
Calidris canutus	Red Knot	M	S3							●				●	
Calidris alba	Sanderling	M	S3			●			●	●				●	
Calidris ruficollis	Red-necked Stint	M	S3			●			●	●				●	
Calidris subminuta	Long-toed Stint	M	S3							●				●	
Calidris melanotos	Pectoral Sandpiper	M	S3							●				●	
Calidris acuminata	Sharp-tailed Sandpiper	M	S3			●				●				●	
Calidris ferruginea	Curlew Sandpiper	M	S3							●				●	
Limicola falcinellus	Broad-billed Sandpiper	M	S3							●				●	
Philomachus pugnax	Ruff	M	S3							●				●	

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		EPBC Act	WC Act	DPaW											
TURNICIDAE															
Turnix maculosus	Red-backed Button-quail							●	●					●	
Turnix castanotus	Chestnut-backed Button-quail			P4		●									
Turnix pyrrhothorax	Red-chested Button-quail				●	●								●	●
Turnix velox	Little Button-quail				●				●					●	●
Turnix sp.	Button-quail sp.														●
GLAREOLIDAE															
Glareola maldivarum	Oriental Pratincole	M	S3							●			●	●	
Stiltia isabella	Australian Pratincole								●	●	●			●	
STERCORARIIDAE*															
Stercorarius parasiticus	Arctic Jaeger	M	S3											●	
LARIDAE*															
Sternula albifrons	Little Tern	M	S3			●			●	●				●	
Sternula nereis	Fairy Tern								●					●	
Gelochelidon nilotica	Gull-billed Tern					●			●	●				●	
Hydroprogne caspia	Caspian Tern	M	S3							●				●	
Chlidonias hybrida	Whiskered Tern								●	●				●	
Chlidonia leucopterus	White-winged Black Tern	M	S3						●	●				●	
Sterna dougallii	Roseate Tern	M	S3						●	●				●	
Sterna sumatrana	Black-naped Tern	M	S3						●						

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		EPBC Act	WC Act	DPaW											
Sterna hirundo	Common Tern	M	S3		●	●				●				●	
Thalasseus bengalensis	Lesser Crested Tern	M	S3		●	●			●	●				●	
Thalasseus bergii	Crested Tern				●	●			●	●				●	
Chroicocephalus novaehollandiae	Silver Gull					●			●	●				●	
CACATUIDAE (PSITTACIDAE)															
Calyptorhynchus banksii	Red-tailed Black-Cockatoo				●	●			●					●	●
Eolophus roseicapillus	Galah				●				●					●	●
Cacatua sanguinea	Little Corella				●	●			●		●			●	●
Nymphicus hollandicus	Cockatiel				●									●	●
PSITTACIDAE															
Trichoglossus haematodus	Rainbow Lorikeet				●		●	●						●	
Trichoglossus haematodus rubritorquis	Red-collared Lorikeet				●	●			●		●				●
Psitteuteles versicolor	Varied Lorikeet				●		●		●					●	●
Aprosmictus erythropterus	Red-winged Parrot				●	●	●	●	●					●	●
Melopsittacus undulatus	Budgerigar				●				●					●	●
CUCULIDAE															
(Centropodidae) *Centropus phasianinus*	Pheasant Coucal				●	●	●	●	●					●	●
Scythrops novaehollandiae	Channel-billed Cuckoo					●								●	
Chalcites basalis	Horsfield's Bronze-Cuckoo				●	●	●		●					●	●
Chalcites osculans	Black-eared Cuckoo					●	●							●	

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		EPBC Act	WC Act	DPaW											
Chalcites minutillus	Little Bronze-Cuckoo				●				●					●	●
Cacomantis pallidus	Pallid Cuckoo				●	●			●					●	●
Cacomantis variolosus	Brush Cuckoo				●	●	●		●					●	●
Cuculus optatus	Oriental Cuckoo					●								●	
STRIGIDAE															
Ninox connivens	Barking Owl								●					●	
Ninox novaeseelandiae	Southern Boobook				●				●					●	●
TYTONIDAE															
Tyto longimembris	Eastern Grass Owl								●					●	
Tyto novaehollandiae	Masked Owl			P4									●		
HALCYONIDAE															
Dacelo leachii	Blue-winged Kookaburra				●	●	●		●					●	●
Todiramphus pyrrhopygius	Red-backed Kingfisher					●	●		●					●	●
Todiramphus sanctus	Sacred Kingfisher				●	●	●	●	●					●	●
Todiramphus chloris	Collared Kingfisher								●					●	
MEROPIDAE															
Merops ornatus	Rainbow Bee-eater	M	S3		●	●	●	●	●				●	●	●
CORACIIDAE															
Eurystomus orientalis	Dollarbird				●	●	●							●	●
CLIMACTERIDAE															

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		EPBC Act	WC Act	DPaW											
Climacteris melanura	Black-tailed Treecreeper				●				●		●			●	●
PTILINORHYNCHIDAE															
Ptilonorhynchus nuchalis	Great Bowerbird				●	●	●	●	●					●	●
MALURIDAE															
Malurus lamberti	Variegated Fairy-wren				●	●	●	●	●					●	●
Malurus melanocephalus	Red-backed Fairy-wren				●	●	●		●		●				●
ACANTHIZIDAE															
Smicrornis brevirostris	Weebill				●		●		●		●			●	●
Gerygone levigaster	Mangrove Gerygone					●			●					●	
Gerygone fusca	Western Gerygone								●					●	
Gerygone tenebrosa	Dusky Gerygone								●					●	
Gerygone albogularis	White-throated Gerygone				●	●	●	●	●					●	●
PARDALOTIDAE															
Pardalotus rubricatus	Red-browed Pardalote				●	●	●		●		●			●	●
Pardalotus striatus	Striated Pardalote				●		●	●	●		●			●	●
MELIPHAGIDAE															
Certhionyx variegatus	Pied Honeyeater								●						
Lichenostomus virescens	Singing Honeyeater				●	●	●	●	●		●			●	●
Lichenostomus unicolor	White-gaped Honeyeater				●	●	●	●	●					●	
Lichenostomus plumulus	Grey-fronted Honeyeater						●								

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		EPBC Act	WC Act	DPaW											
Lichenostomus flavescens	Yellow-tinted Honeyeater				●		●		●		●			●	●
Lichenostomus penicillatus	White-plumed Honeyeater					●	●								
Manorina flavigula	Yellow-throated Miner								●					●	
Conopophila rufogularis	Rufous-throated Honeyeater				●	●	●		●		●			●	●
Epthianura tricolor	Crimson Chat								●						
Sugomel niger	Black Honeyeater				●									●	●
Myzomela erythrocephala	Red-headed Honeyeater					●			●					●	
Cissomela pectoralis	Banded Honeyeater				●						●			●	●
Lichmera indistincta	Brown Honeyeater				●	●	●	●	●		●			●	●
Melithreptus gularis	Black-chinned Honeyeater				●	●	●	●	●					●	●
Melithreptus albogularis	White-throated Honeyeater				●	●			●		●			●	●
Philemon argenticeps	Silver-crowned Friarbird					●			●						
Philemon citreogularis	Little Friarbird				●	●	●	●	●		●			●	●
POMATOSTOMIDAE															
Pomatostomus temporalis	Grey-crowned Babbler				●	●	●	●	●		●			●	●
NEOSITTIDAE															
Daphoenositta chrysoptera	Varied Sittella				●	●	●		●		●			●	●
CAMPEPHAGIDAE															
Coracina novaehollandiae	Black-faced Cuckoo-shrike				●	●	●	●	●		●			●	●
Lalage sueurii	White-winged Triller				●	●		●	●					●	●

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		EPBC Act	WC Act	DPaW											
PACHYCEPHALIDAE															
Pachycephala melanura	Mangrove Golden Whistler								●					●	
Pachycephala rufiventris	Rufous Whistler				●	●	●	●	●					●	●
Pachycephala lanioides	White-breasted Whistler								●					●	
Colluricincla harmonica	Grey Shrike-thrush				●	●	●	●	●					●	●
Oreoica gutturalis	Crested Bellbird								●						
ORIOLIDAE															
Oriolus sagittatus	Olive-backed Oriole				●	●			●					●	●
ARTAMIDAE															
Artamus leucorhynchus	White-breasted Woodswallow					●	●	●	●					●	J
Artamus personatus	Masked Woodswallow				●			●	●					●	●
Artamus superciliosus	White-browed Woodswallow				●				●					●	
Artamus cinereus	Black-faced Woodswallow				●	●	●	●	●					●	●
Artamus minor	Little Woodswallow				●	●	●	●	●					●	●
Cracticus torquatus	Grey Butcherbird						●							●	
Cracticus nigrogularis	Pied Butcherbird				●	●	●	●	●		●			●	●
RHIPIDURIDAE (DICRURIDAE)															
Rhipidura albiscapa	Grey Fantail				●				●					●	
Rhipidura phasiana	Mangrove Grey Fantail								●					●	
Rhipidura rufiventris	Northern Fantail				●	●	●	●	●					●	

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Rhipidura leucophrys	Willie Wagtail				●	●	●		●		●			●	●
CORVIDAE															
Corvus bennetti	Little Crow				●				●					●	
Corvus orru	Torresian Crow				●	●	●	●	●		●			●	●
MONARCHIDAE (DICRURIDAE)															
Myiagra ruficollis	Broad-billed Flycatcher								●					●	
Myiagra rubecula	Leaden Flycatcher				●	●	●							●	
Myiagra nana	Paperbark Flycatcher				●	●	●	●	●		●			●	●
Grallina cyanoleuca	Magpie-lark				●	●			●		●			●	●
PETROICIDAE															
Microeca fascinans	Jacky Winter				●	●	●		●		●			●	●
Microeca flavigaster	Lemon-bellied Flycatcher								●					●	
Melanodryas cucullata	Hooded Robin				●				●					●	●
ALAUDIDAE															
Mirafra javanica	Horsfield's Bushlark								●					●	
CISTICOLIDAE (SYLVIIDAE)															
Cisticola exilis	Golden-headed Cisticola						●							●	
ACROCEPHALIDAE (SYLVIIDAE)															
Acrocephalus australis	Australian Reed-Warbler								●					●	
MEGALURIDAE (SYLVIIDAE)															

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Megalurus timoriensis	Tawny Grassbird								●					●	
Cincloramphus mathewsi	Rufous Songlark				●			●	●					●	●
Cincloramphus cruralis	Brown Songlark				●				●					●	
TIMALIIDAE (ZOSTEROPIDAE)															
Zosterops luteus	Yellow White-eye					●		●	●					●	
HIRUNDINIDAE															
Hirundo rustica	Barn Swallow	M	S3								●			●	
Petrochelidon ariel	Fairy Martin				●				●					●	
Petrochelidon nigricans	Tree Martin				●		●	●	●					●	●
NECTARINIIDAE (DICAEIDAE)															
Dicaeum hirundinaceum	Mistletoebird				●	●		●	●					●	●
ESTRILDIDAE															
Taeniopygia guttata	Zebra Finch				●		●	●	●		●			●	●
Taeniopygia bichenovii	Double-barred Finch				●		●		●		●			●	
Poephila acuticauda	Long-tailed Finch				●	●	●		●		●			●	●
Emblema pictum	Painted Finch													●	
Erythrura gouldiae	Gouldian Finch	EN	S1	EN		●	●	●	●				●	●	
Lonchura castaneothorax	Chestnut-breasted Mannikin													●	
MOTACILLIDAE*															
Motacilla cinerea	Grey Wagtail	M	S3												J

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	Birdata	This survey
		EPBC Act	WC Act	DPaW											
Motacilla tschutschensis	Eastern Yellow Wagtail	M	S3						•	•				•	J

* = Families incorporating shorebird or coastal species not included in Table 4.7
J = Found at Mt. Jowleanga homestead only

Appendix E3: Reptiles

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW									
CROCODYLIDAE													
Crocodylus porosus	Salt-water Crocodile		S4						●			●	
DIPLODACTYLIDAE													
Diplodactylus conspicillatus	Fat-tailed Gecko				●	●	●	●	●				●
Lucasium stenodactylum	Sand-plain Gecko				●		●	●	●				●
Oedura rhombifer						●			●				
Rhynchoedura ornata	Beaked Gecko				●								
Strophurus ciliaris					●	●	●	●	●				●
Strophurus jeanae									●				
Strophurus taeniatus									●				
GEKKONIDAE													
Gehyra australis					●								
Gehyra nana									●				●
Gehyra pilbara					●		●		●				●
Gehyra punctata							●		●				
Gehyra variegata						●			●				
Heteronotia binoei	Bynoe's Gecko				●		●	●	●				●
**Hemidactylus frenatus*	Asian House Gecko								●				
PYGOPODIDAE													
Delma borea									●				
Delma tincta							●		●				●
Lialis burtonis					●	●	●	●	●				●

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW									
Pygopus nigriceps					●								
Pygopus steelescotti	Northern Hooded Scaly-foot						●						●
SCINCIDAE													
Carlia munda					●				●				●
Carlia rufilatus					●		●	●	●				●
Carlia triacantha					●								
Cryptoblepharus carnabyi					●								
Cryptoblepharus metallicus									●				
Cryptoblepharus ruber	Tawny Snake-eyed Skink				●		●	●	●				●
Cryptoblepharus sp.													●
Ctenotus colletti									●				●
Ctenotus helenae									●				
Ctenotus inornatus					●	●	●	●	●	●			●
Ctenotus pantherinus					●								●
Ctenotus robustus													●
Ctenotus serventyi					●		●						●
Eremiascincus isolepis					●	●	●	●	●				●
Eremiascincus richardsonii	Banded Skink								●				
Lerista apoda					●		●	●					●
Lerista bipes					●		●	●	●				●
Lerista greeri									●				●
Lerista griffini					●		●	●					
Lerista labialis									●				

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW									
Lerista separanda	Dampierland Plain Slider			P2			●		●				
Menetia greyii								●					
Menetia maini													●
Morethia ruficauda									●				
Morethia storri					●		●						●
*Morethia*sp.					●								
Proablepharus tenuis							●						●
Tiliqua multifasciata	Central Blue-tongue						●		●				
Tiliqua scincoides	Common Blue-tongue				●	●	●	●	●				●
AGAMIDAE													
Amphibolurus gilberti	Gilbert's Dragon				●	●	●	●	●				●
Chelosania brunnea	Chameleon Dragon								●				
Chlamydosaurus kingii	Frilled Lizard				●	●	●	●	●	●			●
Ctenophorus caudicinctus	Ring-tailed Rock Dragon								●				
Ctenophorus isolepis	Military Dragon								●	●			
Ctenophorus nuchalis	Central Netted Dragon								●				
Diporiphora magna					●					●			●
Diporiphora pindan					●	●	●	●	●				●
Diporiphora sp.					●								
Pogona minor	Dwarf Bearded Dragon				●	●	●	●	●				●
VARANIDAE													
Varanus acanthurus	Spiny-tailed Monitor					●			●				●
Varanus brevicauda	Short-tailed Pygmy Monitor				●		●						●

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW									
Varanus gouldii	Gould's Monitor				●	●	●		●				●
Varanus panoptes	Yellow-spotted Monitor					●	●						
Varanus scalaris	Spotted Tree Monitor				●								
Varanus tristis	Black-headed Monitor				●	●	●	●	●				●
TYPHLOPIDAE													
Ramphotyphlops diversus					●		●	●	●				
Ramphotyphlops sp.													●
BOIDAE													
Antaresia stimsoni	Stimson's Python				●	●	●		●				●
Aspidites melanocephalus	Black-headed Python				●			●	●	●			
Liasis olivaceus	Olive Python								●				
COLUBRIDAE													
Dendrelaphis punctulata	Common Tree Snake							●	●				
ELAPIDAE													
Brachyurophis roperi	Northern Shovel-nosed Snake				●		●	●					●
Demansia angusticeps					●		●	●					●
Demansia olivacea	Olive Whipsnake								●				
Demansia psammophis	Yellow-faced Whipsnake								●				
Ephalophis greyae	Mangrove Sea Snake											●	
Furina ornata	Moon Snake				●		●	●	●				●
Pseudechis australis	Mulga Snake				●		●	●	●	●			●
Pseudonaja mengdeni	Western Brown Snake				●								●
Pseudonaja nuchalis	Northern Brown Snake						●		●				

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (AECOM 2010)	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW									
Simoselaps anomalus	Desert Banded Snake								•				
Simoselaps minimus	Dampierland Burrowing Snake			P2			•		•				
Suta punctata	Spotted Snake						•	•	•	•			•

Appendix E4: Amphibians

Family and Species	Common name	Conservation Status			*ecologia* internal database	James Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DEC Threatened and Priority Fauna Search	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW								
HYLIDAE												
Cyclorana australis	Giant Frog				●	●		●				●
Cyclorana longipes	Long-footed Frog					●						●
Litoria caerulea	Green Tree Frog				●	●		●				●
Litoria coplandi	Rock Frog							●				
Litoria meiriana	Rockhole Frog							●				
Litoria rothii	Northern Laughing Tree Frog							●				●
Litoria rubella	Little Red Tree Frog				●			●				●
LIMNODYNASTIDAE												
Notaden nichollsi	Desert Spadefoot											●
Platyplectrum ornatum	Ornate Burrowing Frog				●	●	●	●				●
MYOBATRACHIDAE												
Uperoleia talpa	Mole Toadlet				●			●	●			●

Appendix E5: SRE invertebrates

Class/Order, Family and Species	SRE Status	*ecologia* internal database	James Price Point (Biota 2009)	James Price Point (Biota 2010)	WAM Mollusc Database	WAM Arachnid Database	WAM Crustacean Database	This survey
Arachnida (Mygalamorphae) - Actinopodidae								
Missulena 'sp. (female)'	Undetermined			●				
Arachnida (Mygalamorphae) - Barychelidae								
Synothele 'MYG179'	Potential	●		●				
Synothele 'MYG179 female'	Potential			●				
Arachnida (Mygalamorphae) - Ctenizidae								
Conothele 'sp. (female sp. 1)'	Undetermined			●				
Conothele 'sp. (female sp. 2)'	Undetermined			●				
Conothele 'sp. (juv sp. 1)'	Undetermined			●				
Conothele 'sp. (juv sp. 2)'	Undetermined			●				
Arachnida (Mygalamorphae) - Nemesiidae								
Aname 'MYG231'	Potential	●						
Aname 'MYG232'	Potential	●						
Aname 'MYG284'	Potential							●
Aname 'MYG285'	Potential							●
Aname 'MYG387'	Potential							●
Aname 'MYG387?'	Potential							●
Aname 'MYG388'	Potential							●
Aname 'sp. indet.'	Potential							●
Aname 'sp. juv'	Potential							●
Aname 'sp. (female'	Undetermined			●				
Aname 'sp (juv).'	Undetermined			●				

Class/Order, Family and Species	SRE Status	*ecologia* internal database	James Price Point (Biota 2009)	James Price Point (Biota 2010)	WAM Mollusc Database	WAM Arachnid Database	WAM Crustacean Database	This survey
Arachnida (Mygalamorphae) - Scytodidae								
Scytodes sp.	No			●				
Arachnida (Mygalamorphae) - Idiopidae								
?*Aganippe* 'sp. (female)'	Undetermined			●				
Arachnida (Pseudoscorpiones) - Sternophoridae								
Afrosternophorus 'sp. indet.'	No							●
Arachnida (Pseudoscorpiones) - Olpiidae								
Austrohorus sp.	No	●						
Beierolpium 'sp. 8/4'	No	●						●
Beierolpium 'sp. (juv)'	No	●						
Olpiidae 'genus indet. (juvenile)'	Potential							●
Euryolpium sp.	No	●		●				
Indolpium sp.	No	●						
Arachnida (Pseudoscorpiones) - Chernetidae								
Haplochernes 'sp. Indet'	No							●
Arachnida (Scorpiones) - Buthidae								
Lychas 'annulatus'	No							●
Lychas 'broome'	Potential							●
Lychas 'JPP'	Potential	●						●
Lychas 'JPP1'	Potential							●
Lychas 'JPP2'	Potential							●
Lychas 'JPP3'	Potential							●
Lychas 'multipunctatus'	No	●						●
Arachnida (Scorpiones) - Urodacidae								
Urodacus 'kraepelini'	Potential							●
Urodacus 'sp. indet.'	Potential							●

Class/Order, Family and Species	SRE Status	*ecologia* internal database	James Price Point (Biota 2009)	James Price Point (Biota 2010)	WAM Mollusc Database	WAM Arachnid Database	WAM Crustacean Database	This survey
Urodacus 'rugosus'	Potential	●		●				
Urodacus 'sp, JP'	Potential	●		●				
Urodacus 'sp. indet.'	Undetermined	●						
Arachnida (Opiliones) - Assamiidae								
Dampetrus sp.	Potential	●						●
Chilipoda - Scutigeridae								
Pilbarascutigera incola	No			●				
Chilipoda - Scolopendridae								
Scolopendra laeta	No	●						
Diplopoda (Spirobolida) - Pachybolidae								
Pachybolidae 'genus?' 'sp. (female)'	Undetermined			●				
Pachybolidae 'genus?' 'sp. (juv)'	Undetermined			●				
Pachybolidae 'genus?'	Undetermined			●				
Malacostraca (Isopoda) - Armadillidae								
Armadillidae 'EE1501C'	Potential							●
Buddelundiinae 'Gen. indet. NE Broome'	Potential							●
Buddelundia 'sp. 1'	Potential	●						
Buddelundia 'sp.74'	Potential							●
Mollusca (Gastropoda) - Subulinidae								
Eremopeas interioris	No							●
Mollusca (Gastropoda) - Pupillidae								
Pupoides pacificus	No							●
Mollusca (Gastropoda) - Camaenidae								
Quistrachia leptogramma	Potential	●	●	●	●			●
Quistrachia sp.	Potential				●			
Rhagada bulgana	Confirmed	●	●	●	●			●
Rhagada reinga	No		●					

Class/Order, Family and Species	SRE Status	*ecologia* internal database	James Price Point (Biota 2009)	James Price Point (Biota 2010)	WAM Mollusc Database	WAM Arachnid Database	WAM Crustacean Database	This survey
Rhagada sp.	Potential			●	●			
Mollusca (Gastropoda) – Punctidae								
Magilaoma sp. nov.	Potential				●			

APPENDIX D SURVEY SITE DESCRIPTIONS

Vegetation and Fauna Habitat Description	Site Photo
Systematic trap site	
TBS1 **Fauna habitat type: Sandstone range** Open eucalypt woodland on flat gently sloping plain. Scattered tree species consisting of *Eucalyptus tectifica* and *Corymbia greeniana* over shrub species consisting of *Acacia platycarpa, Bauhinia cunninghamii* and *Dolichandrone heterophylla* over *Chrysopogon pallidus, Triodia sp.* and *Eriachne obtusa* open tussock grassland. Soil consisting of lose sandy clay of pinkish colour with some surface crusting. Isolated minor sandstone outcropping and stones. No obvious disturbance.	
TBS2 **Fauna habitat type: Pindan shrubland** Low, open woodland on flat plain. Dominant tree species *Corymbia greeniana* and *Grevillea pyramidalis* over various shrub species including; *Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta*. Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	

Vegetation and Fauna Habitat Description	Site Photo
TBS3 **Fauna habitat type: Pindan shrubland** Moderately dense shrubland on flat plain. Dominant tree species consisting of *Corymbia greeniana* and *Corymbia zygophylla,* scattered throughout. Moderately dense *Acacia tumida*, with other shrub species consisting of *Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta.* Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	
TBS4 **Fauna habitat type: Pindan shrubland** Open shrubland on flat plain. Dominant shrub species *Acacia tumida,* with other species consisting of *Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta.* Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	

Vegetation and Fauna Habitat Description	Site Photo
TBS5 **Fauna habitat type: Pindan shrubland** Dense shrubland on gently sloping plain. Dominant shrub species *Acacia tumida,* with scattered shrub species consisting of *Dodonaea hispidula, Erythrophlem chlorostachys* and *Grevillea refracta.* Scattered tussock grass consisting of *Sorghum timorense* and scattered hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. Relatively recent fire evidence (0-5 years fire age).	
TBS6 **Fauna habitat type: Savannah woodland** Open woodland on flat plain. Scattered tree species consisting of *Eucalyptus tectifica* and *Brachychiton diversifolius.* Open to moderate dense shrubs, with dominant species being *Acacia platycarpa.* Other shrub species consisting of *Bauhinia cunninghami* and *Dolichandrone heterophyll*. Grasses consisting of tussock *Sorghum timorense*. Soil consisiting of brown-white sand clay of firm strength. No rocks present. No obvious signs of disturbance.	

Vegetation and Fauna Habitat Description	Site Photo
TBS7 **Fauna habitat type: Pindan shrubland** Dense shrubland on flat plain. Few tree species present, with scattered *Brachychiton diversifolius* and *Eucalyptus tectifica*. Dominant shrub species of dense *Acacia tumida,* other shrub species including *Acacia platycarpa, Bauhinia cunninghami, Dolichandrone heterophyll* and *Erythrophleum chlorostachys*. Scattered tussock grass consisting of *Sorghum timorense* and scattered hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	

Vegetation and Fauna Habitat Description	Site Photo
Targeted SRE dry pitfall	
TB SRE1 **Fauna habitat type: Pindan shrubland** Open shrubland on flat plain. Dominant tree species *Corymbia greeniana*. Various shrub species including *Acacia* tumida, *Grevillea pyramidalis Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta*. Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	
TB SRE2 **Fauna habitat type: Pindan shrubland** Open woodland on flat plain. Dominant tree species consisting of *Corymbia greeniana* and *Corymbia zygophylla,* scattered throughout. Scattered shrub species consisiting of *Acacia tumida*, *Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta.* Dense tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	

Vegetation and Fauna Habitat Description	Site Photo
TB SRE3 **Fauna habitat type: Pindan shrubland** Dense shrubland on flat plain. Dense *Acacia tumida*, with other shrub species consisting of *Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta.* Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance. Abundant leaf litter covering ground surface.	
TB SRE4 **Fauna habitat type: Pindan shrubland** Open shrubland on flat plain. Dominant tree species *Corymbia greeniana*. Various shrub species including *Acacia* tumida, *Grevillea pyramidalis Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta*. Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance.	

Vegetation and Fauna Habitat Description	Site Photo
TB SRE5 **Fauna habitat type: Pindan shrubland** Dense shrubland on flat plain. Dominant shrub species *Acacia tumida,* with scattered shrub species consisting of *Dodonaea hispidula, Erythrophlem chlorostachys* and *Grevillea refracta*. Scattered tussock grass consisting of *Sorghum timorense* and scattered hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. Relatively recent fire evidence (0-5 years fire age). Dense leaf litter on ground surface.	
TB SRE6 **Fauna habitat type: Pindan shrubland** Shrubland on flat plain. Dominant tree species *Corymbia greeniana*. Various shrub species including *Acacia* tumida, *Grevillea pyramidalis Acacia monticola, Erythrophlem chlorostachys, Acacia hippuroide* and *Grevillea refracta*. Sparse tussock grass of *Sorghum timorense* and sparse hummock grass of *Triodia caelestialis*. Soil consisting of red-brown sandy loam of firm strength. No rocks present. No obvious disturbance. Abundant leaf litter on the ground surface.	

APPENDIX E VOUCHER SPECIMENS LODGED WITH WA MUSEUM

WAM Voucher Number	Species
R173110	*Ctenotus colletti*
R173111	*Proablepharus tenuis*
R173112	*Morethia storri*
R173113	*Morethia storri*
R173114	*Morethia storri*
R173115	*Varanus* aff. *brevicauda*

APPENDIX F FAUNA RECORDED DURING THE SURVEY

Appendix F1: Mammals

Family and species	Common name	Conservation status			Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Opp	
		EPBC Act	WC Act	DPaW	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
TACHYGLOSSIDAE																				
Tachyglossus aculeatus	Echidna																			S
DASYURIDAE																				
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart										2									
THYLACOMYIDAE																				
Macrotis lagotis	Greater Bilby	VU	S1	VU																1
MACROPODIDAE																				
Macropus agilis	Agile Wallaby																		1	S
Macropus robustus	Euro																			1
EMBALLONURIDAE																				
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat									•				•						
MOLOSSIDAE																				
Chaerophon jobensis	Northern Freetail Bat				•	•	•	•	•		•	•	•	•	•	•			•	
VESPERTILIONIDAE																				
Chalinolobus gouldii	Gould's Wattled Bat						•	•	•	•	•	•		•	•	•	•	•		
Chalinolobus nigrogriseus	Hoary Wattled Bat					•	•	•	•	•		•	•	•	•	•		•	•	
Miniopterus schreibersii orianae	Common Bentwing Bat													•		•		•		
Myotis macropus	Large-footed Myotis				•															
Nyctophilus geoffroyi	Lesser Long-eared Bat				•						•			•		•	•			
Scotorepens greyii	Little Broad-nosed Bat				•	•	•	•	•	•	•	•	•	•	•	•	•	•		
MURIDAE																				

Family and species	Common name	Conservation status			Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Opp	
		EPBC Act	WC Act	DPaW	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
Leggadina lakedownensis	Short-tailed Mouse			P4												1				
Pseudomys delicatulus	Delicate Mouse					4	1		7	1	3	2	2	1	2	3				
Pseudomys nanus	Western Chestnut Mouse										1	3				1				
CANIDAE																				
Canis lupus	Dog/Dingo																		1	
INTRODUCED MAMMALS																				
Mus musculus	House Mouse					1				1		5						1		1
Felis catus	Cat																	1	1	2
Bos taurus	Cow																		20	2

● = bat species recorded on SM2s at these locations

Appendix F2: Birds

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
PHASIANIDAE																						
Coturnix ypsilophora	Brown Quail					3	2	2														
ANSERANATIDAE																						
Anseranas semipalmata	Magpie Goose																		2			
ANATIDAE																						
Dendrocygna eytoni	Plumed Whistling-Duck*																				25	2
Dendrocygna arcuata	Wandering Whistling-Duck*																					84
Stictonetta naevosa	Freckled Duck*																					63
Chenonetta jubata	Australian Wood Duck*																					1
Malacorhynchus membranaceus	Pink-eared Duck*																					9
Nettapus pulchellus	Green Pygmy-Goose*																					5
Anas gracilis	Grey Teal*																					140
Anas superciliosa	Pacific Black Duck*																				1	20
Aythya australis	Hardhead*																					60
PODICIPEDIDAE																						
Tachybaptus novaehollandiae	Australasian Grebe*																				5	39
COLUMBIDAE																						
Ocyphaps lophotes	Crested Pigeon														1				1			
Geopelia cuneata	Diamond Dove				10	1	9		2		6		4	2	6	2	12	3	3			
Geopelia striata	Peaceful Dove				5	3	4	6	2				3	2	4	7		4				21
PODARGIDAE																						

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Podargus strigoides	Tawny Frogmouth																		2			
EUROSTOPODIDAE																						
Eurostopodus argus	Spotted Nightjar																		1			
AEGOTHELIDAE																						
Aegotheles cristatus	Australian Owlet-nightjar											1			1		1			3		
APODIDAE																						
Apus pacificus	Fork-tailed Swift	M	S3																2			
PHALACROCORACIDAE																						
Microcarbo melanoleucos	Little Pied Cormorant*																					3
PELECANIDAE																						
Pelecanus conspicillatus	Australian Pelican*																					2
ARDEIDAE																						
Ardea pacifica	White-necked Heron*																				1	5
Egretta novaehollandiae	White-faced Heron*																					3
ACCIPITRIDAE																						
Threskiornis spinicollis	Straw-necked Ibis*																				3	41
Platalea regia	Royal Spoonbill*																					2
ACCIPITRIDAE																						
Haliastur sphenurus	Whistling Kite*																					1
Milvus migrans	Black Kite*																				4	
Accipiter fasciatus	Brown Goshawk									1					1							
Accipiter cirrhocephalus	Collared Sparrowhawk				1			1														
Circus assimilis	Spotted Harrier														1							

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Aquila audax	Wedge-tailed Eagle																		1			
FALCONIDAE																						
Falco cenchroides	Nankeen Kestrel										1						1			1		
Falco berigora	Brown Falcon								1	2						3				1	1	
Falco longipennis	Australian Hobby																					
RALLIDAE																						
Fulica atra	Eurasian Coot*																					50
OTIDIDAE																						
Ardeotis australis	Australian Bustard			P4		1													8	1		
BURHINIDAE																						
Burhinus grallarius	Bush Stone-curlew			P4				3		1		3				1			4			
RECURVIROSTRIDAE																						
Himantopus himantopus	Black-winged Stilt*																					1
CHARADRIIDAE																						
Elseyornis melanops	Black-fronted Dotterel*																					2
Erythrogonys cinctus	Red-kneed Dotterel*																					13
Vanellus miles	Masked Lapwing*																					8
JACANIDAE																						
Irediparra gallinacea	Comb-crested Jacana*																					4
SCOLOPACIDAE																				**1**		
Tringa glareola	Wood Sandpiper	M	S3																1			12
TURNICIDAE																						
Turnix pyrrhothorax	Red-chested Button-quail																		1			

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Turnix velox	Little Button-quail								1													
Turnix sp.	Button-quail sp.				1		1															
CACATUIDAE (PSITTACIDAE)																						
Calyptorhynchus banksii	Red-tailed Black-Cockatoo											3										
Eolophus roseicapillus	Galah						2								5	3				4		
Cacatua sanguinea	Little Corella					27		9				3		10		4						55
Nymphicus hollandicus	Cockatiel				2						8				8				2			
PSITTACIDAE																						
Trichoglossus haematodus	Red-collared Lorikeet				12	13	2	10	8	3		4	8	24		13	2	51				
Psitteuteles versicolor	Varied Lorikeet					94		76		55		42		81		42		39		20		
Aprosmictus erythropterus	Red-winged Parrot				5	17	6	3	1	3			3		2	10						
Melopsittacus undulatus	Budgerigar				8		4		4		37		23		23		1		2			
CUCULIDAE																						
Centropus phasianinus	Pheasant Coucal					2		4		2			1	3		2			1			1
Chalcites basalis	Horsfield's Bronze-Cuckoo					2		2				2		3	1	3		1		1		
Chalcites minutillus	Little Bronze-cuckoo																					
Cacomantis pallidus	Pallid Cuckoo					3		2		1		7		4		3		1		5		
Cacomantis variolosus	Brush Cuckoo					3		3		3		4		8		1		3				
STRIGIDAE																						
Ninox novaeseelandiae	Southern Boobook																		2	1		
HALCYONIDAE																						
Dacelo leachii	Blue-winged Kookaburra					6		9						5		1			1	2		
Todiramphus pyrrhopygius	Red-backed Kingfisher				1	2				1						1			1			

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Todiramphus sanctus	Sacred Kingfisher					7		1		2		4		1		3		4	1	2		
MEROPIDAE																						
Merops ornatus	Rainbow Bee-eater	M	S3		3	5		5	3	1	2	11	9	8	13	5	3		2	4	10	
CORACIIDAE																						
Eurystomus orientalis	Dollarbird							1								3		1	1			
CLIMACTERIDAE																						
Climacteris melanura	Black-tailed Treecreeper				1	1						2			3	4			1			
PTILINORHYNCHIDAE																						
Ptilonorhynchus nuchalis	Great Bowerbird					1						1										
MALURIDAE																						
Malurus lamberti	Variegated Fairy-wren													10								
Malurus melanocephalus	Red-backed Fairy-wren				8	7	12	6		2	7	17	6	12	9	5	9	4	3			
ACANTHIZIDAE																						
Smicrornis brevirostris	Weebill				1	7		1			3	3	9	2	10	4			2			
Gerygone albogularis	White-throated Gerygone				3				1	5			1	1	2	5		3				
PARDALOTIDAE																						
Pardalotus rubricatus	Red-browed Pardalote				1						1									3		
Pardalotus striatus	Striated Pardalote				3	1			2		1		6	2	4	2	1		1			
MELIPHAGIDAE																						
Lichenostomus virescens	Singing Honeyeater					3	6	23	4	8	7	13		3	1		7	8				
Lichenostomus flavescens	Yellow-tinted Honeyeater				6	3							4		2	4		1	2			10
Conopophila rufogularis	Rufous-throated Honeyeater				3	12		4				2		2		13	1	2				

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Sugomel niger	Black Honeyeater								1													
Cissomela pectoralis	Banded Honeyeater					4						11				11		6				
Lichmera indistincta	Brown Honeyeater				17	5	17	5	7	2	1	11	13	9	3	2	8	14	1		5	2
Melithreptus gularis	Black-chinned Honeyeater				2	6	4		1				2		4	2		4	1			
Melithreptus albogularis	White-throated Honeyeater																		1			
Philemon citreogularis	Little Friarbird				4	18	3	14		7		8	3	13	2	13		6				
POMATOSTOMIDAE																						
Pomatostomus temporalis	Grey-crowned Babbler				5	10	4	11		2	4	2	14	10	13			2	4			
NEOSITTIDAE																						
Daphoenositta chrysoptera	Varied Sittella					10	2	6			2	1		5	2	7	3	2				
CAMPEPHAGIDAE																						
Coracina novaehollandiae	Black-faced Cuckoo-shrike				2	6		4		3	1	3	3	4	2	6	1			5		
Lalage sueurii	White-winged Triller					10		3	1	3	2	7	2	2		12	1	10		3		
PACHYCEPHALIDAE																						
Pachycephala rufiventris	Rufous Whistler				7	7	2	12	7	19	3	15	6	11	4	9	6	19	2	15		
Colluricincla harmonica	Grey Shrike-thrush				1	5	3	7	3	5	2	4	3		4	4		5				
ORIOLIDAE																						
Oriolus sagittatus	Olive-backed Oriole					2		4						6		6		3				
ARTAMIDAE																						
Artamus leucorhynchus	White-breasted Woodswallow*																					12
Artamus personatus	Masked Woodswallow				90		35		103		181		12	6	117	5	130		38			
Artamus cinereus	Black-faced Woodswallow					7	3	5		3		4	5	11	1	10	10	1		4		

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Artamus minor	Little Woodswallow					6		1				7			4	1						
Cracticus nigrogularis	Pied Butcherbird				3	4	3	4	5	1	1	2	6	7	3	9						
RHIPIDURIDAE (DICRURIDAE)																						
Rhipidura leucophrys	Willie Wagtail				1	1	1	3	3	2	1	3	1	1	1	2	2	3	1			
CORVIDAE																						
Corvus orru	Torresian Crow					1		4		5				3		3					2	24
MONARCHIDAE (DICRURIDAE)																						
Myiagra nana	Paperbark Flycatcher				1	8	1		1			1	2		2	3					2	7
Grallina cyanoleuca	Magpie-lark				1	1								2	3	2			2			5
PETROICIDAE																						
Microeca fascinans	Jacky Winter				3	13	1	6	1	3		4		5		5	4	1	3	4		
Melanodryas cucullata	Hooded Robin												2				1	3				
MEGALURIDAE (SYLVIIDAE)																						
Cincloramphus mathewsi	Rufous Songlark					7		1					1			5						
HIRUNDINIDAE																						
Petrochelidon nigricans	Tree Martin										2						2		5			
NECTARINIIDAE (DICAEIDAE)																						
Dicaeum hirundinaceum	Mistletoebird				1	1	2	3	1	1		4	1	5	1	1	1	6				
ESTRILDIDAE																						
Taeniopygia guttata	Zebra Finch					4		6				14			10	6	4		3			
Poephila acuticauda	Long-tailed Finch					9		2			4		2	7	6	2	1		6			
MOTACILLIDAE																						
Motacilla cinerea	Grey Wagtail*	M	S3																			1

Family and species	Common name	Conservation status			TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		TB Opp		TB J	
		EPBC Act	WC Act	DPaW	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2	Ph1	Ph2
Motacilla tschutschensis	Eastern Yellow Wagtail*	M	S3																			2

*Recorded from Mount Jowlaenga homestead only

Appendix F3: Reptiles

Family and species	Common name	Conservation status			Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Opp	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
DIPLODACTYLIDAE																				
Diplodactylus conspicillatus	Fat-tailed Gecko									6	3	2	1	2						
Lucasium stenodactylum	Sand-plain Gecko					4	1	2	2	2	1	1				1			1	2
Strophurus ciliaris						2		3	1	11	1	8		8		2		8		1
GEKKONIDAE																				
Gehyra nana						1	2	1		1		1	1			1	1		18	2
Gehyra pilbara																			4	
Heteronotia binoei	Bynoe's Gecko				2	12	1	5					1	2		3			14	1
PYGOPODIDAE																				
Delma tincta									1		1									
Lialis burtonis							1	2		4								2		1
Pygopus steelescotti	Northern Hooded Scaly-foot									1		1				1		1		
SCINCIDAE																				
Carlia munda						1	4	3		1	1	1	2	1	2	3		1	1	
Carlia rufilatus						1	4	2	1	6		2	5	1	9	1	5	1		1
Cryptoblepharus ruber	Tawny Snake-eyed Skink					1										1				
Cryptoblepharus sp.																			1	
Ctenotus colletti								1	1	1			1							
Ctenotus inornatus					17	2	17	24	9	4	11	6	9	10	3	11	6	8		1
Ctenotus pantherinus					4		1	1		1										
Ctenotus robustus					11	5	21		6		6		18	3	25	1	3		3	
Ctenotus serventyi					1		1						1		3	1	3			1
Eremiascincus isolepis								2			3	2	2		2	2		1	1	

Family and species	Common name	Conservation status			Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Opp	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
Lerista apoda																1			2	
Lerista bipes										6		2		11		9		7		
Lerista greeri									2				1		4		6		1	
Menetia maini										1										
Morethia storri					3			1	9	3	4	1		1	3	1	7	7		
Proablepharus tenuis							1		1	2				5		1	1	1		
Tiliqua scincoides	Common Blue-tongue								1										2	1
AGAMIDAE																				
Amphibolurus gilberti	Gilbert's Dragon																		1	1
Chlamydosaurus kingii	Frilled Lizard																		2	3
Diporiphora magna								1	1	2	1			4			2	3		
Diporiphora pindan					3	2	4	4	1	10		6	8	5		3	5	7	3	
Pogona minor	Dwarf Bearded Dragon				1	1	1		1	2	1			2	1	1		2		
VARANIDAE																				
Varanus acanthurus	Spiny-tailed Monitor				1		3	1		1										
Varanus brevicauda	Short-tailed Pygmy Monitor					2					2	2	1	1	1		3			
Varanus gouldii	Gould's Monitor																		2	1
Varanus tristis	Black-headed Monitor					1		1	1										1	
TYPHLOPIDAE																				
Ramphotyphlops sp.						1										1				
BOIDAE																				
Antaresia stimsoni	Stimson's Python																		3	
ELAPIDAE																				

Family and species	Common name	Conservation status			Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Opp	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
Brachyurophis roperi	Northern Shovel-nosed Snake				1		2			3		4		1	1	2		1		
Demansia angusticeps					1		5			1	1				3		1	1		
Furina ornata	Moon Snake													1				2		
Pseudechis australis	Mulga Snake																		1	
Pseudonaja mengdeni	Western Brown Snake																		1	
Suta punctata	Spotted Snake				1															

Appendix F4: Amphibians

Family and species	Common name	Conservation status			Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7		Opp	
		EPBC Act	WC Act	DEC	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2	Ph 1	Ph 2
HYLIDAE																				
Cyclorana australis	Giant Frog																		8	
Cyclorana longipes	Long-footed Frog												1							
Litoria caerulea	Green Tree Frog				1														10	4
Litoria rothii	Northern Laughing Tree Frog																			3
Litoria rubella	Little Red Tree Frog																		1	
LIMNODYNASTIDAE																				
Notaden nichollsi	Desert Spadefoot				43	1							1						1	
Platyplectrum ornatum	Ornate Burrowing Frog				1		1						7		24		9		2	2
MYOBATRACHIDAE																				
Uperoleia talpa	Mole Toadlet				1										1					

Appendix F5: SRE Invertebrates

Class/Order, Family & Species	SRE Status	TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		SRE 1		SRE 2		SRE 3		SRE 4		SRE 5		SRE 6		Opp	
		P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2
Arachnida (Mygalamorphae) - Nemesiidae																													
Aname 'MYG284'	Potential			4																									
Aname 'MYG285'	Potential							1																					
Aname 'MYG387'	Potential		1																										
Aname 'MYG387?'	Potential										1																		
Aname 'MYG388'	Potential		1		1								2																
Aname 'sp. indet.'	Potential																												1
Aname 'sp. juv.'	Potential																									1			
Arachnida (Pseudoscorpiones) - Sternophoridae																													
Afrosternophorus sp. indet.	No																												2
Arachnida (Pseudoscorpiones) - Olpiidae																													
Beierolpium 'sp. 8/4'	No																							1					4
Olpiidae 'genus indet. (juvenile)'	Potential																			1		5		4		2			
Arachnida (Pseudoscorpiones) - Chernetidae																													
Haplochernes sp. Indet	No																												2
Arachnida (Scorpiones) - Buthidae																													
Lychas 'annulatus'	No			1				26				3		9															
Lychas 'broome'	Potential			4																									
Lychas 'JPP'	Potential				1		3		2		1		2		2														
Lychas 'JPP1'	Potential								1																				
Lychas 'JPP2'	Potential				6																								
Lychas 'JPP3'	Potential				1		2				1		2		1														
Lychas 'multipunctatus'	No			1		1		1		1		1		3				1											

Class/Order, Family & Species	SRE Status	TB S1		TB S2		TB S3		TB S4		TB S5		TB S6		TB S7		SRE 1		SRE 2		SRE 3		SRE 4		SRE 5		SRE 6		Opp	
		P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2
Arachnida (Scorpiones) - Urodacidae																													
Urodacus 'kraepelini'	Potential													1															
Urodacus sp. indet.	Potential									1								1											
Arachnida (Opiliones) - Assamiidae																													
Dampetrus sp.	Potential											3		1															
Malacostraca (Isopoda) - Armadillidae																													
Armadillidae 'EE1501C'	Potential																												1
Buddelundiinae 'genus indet. NE Broome'	Potential											1							5										
Buddelundia sp.74	Potential																											16	13
Mollusca (Gastropoda) - Subulinidae																													
Eremopeas interioris	No																					4							
Mollusca (Gastropoda) - Pupillidae																													
Pupoides pacificus	No																									2			
Mollusca (Gastropoda) - Camaenidae																													
Quistrachia leptogramma	Potential								1											7								1	1
Rhagada bulgana	Confirmed								2																			2	4

APPENDIX G STYGOFAUNA DRILL HOLE GROUNDWATER PHYSIO-CHEMICAL RESULTS

Bore ID	Depth to water (m)	Temperature (°C)	Conductivity (mS/cm)	DO (ppm) mg/L	pH	Salinity (PSS)	DO%	Redox (mV)	Depth of sample taken (m)
THAC 243	32	32.34	0.258	3.6	5.42	0.13	4.5	128	55
THAC232	22	32.07	0.309	7.65	5.67	0.15	6.03	106	60
THAC235	30	32.64	0.244	4.17	6.13	0.12	53.2	108	35
THAC238	28	32.97	0.171	4.21	5.38	0.09	56.5	118	60
THAC241	39	33.91	0.224	3.28	5.34	0.11	40.9	150	53
THAC245	38	31.8	0.297	2.82	5.35	0.15	31.5	132	60
THAC247	41	33.21	0.27	5.54	5.27	0.14	59.2	145	60
THAC252	49	32.72	0.04	2.32	5.26	0.03	30.20	128	90
THAC280	42	31.45	0.484	2.04	5.98	0.23	26.8	-	60
THAC285	44	30.88	0.32	2.08	6.27	0.15	21.2	98	52
THAC322	23	33.1	0.273	5.89	5.58	0.13	75.7	105	50
THAC357	32	-	0.235	4.21	5.57	0.12	3.6	24	60
THAC390	33	31.75	0.111	5.09	5.46	0.06	5	115	-
THAC406	30	32.9	0.045	3.52	5.96	0.03	44.5	100	60
THAC408	39	-	0.182	4.52	5.39	0.09	59.6	129	80
Average (mean)	**34.80**	**32.44**	**0.23**	**4.06**	**5.60**	**0.12**	**34.56**	**113.29**	**59.64**
Maximum	**49**	**33.91**	**0.484**	**7.65**	**6.27**	**0.23**	**75.7**	**150**	**90**
Minimum	**22**	**30.88**	**0.043**	**2.04**	**5.26**	**0.03**	**3.6**	**24**	**350**
Standard deviation	**7.73**	**0.83**	**0.11**	**1.55**	**0.33**	**0.05**	**23.47**	**30.31**	**12.89**
Total	**15**	**13**	**15**	**15**	**15**	**15**	**15**	**14**	**14**

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APPENDIX 4: FLORA AND FAUNA ASSESSMENT, ECOLOGIA, 2015

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TABLE OF CONTENTS

1 INTRODUCTION 1
1.1 PROJECT BACKGROUND 1
1.2 LEGISLATIVE FRAMEWORK 1
1.3 SURVEY OBJECTIVES 3
1.4 SIGNIFICANT FLORA 3
1.5 SIGNIFICANT VEGETATION AND COMMUNITIES 5
1.6 SIGNIFICANT FAUNA 6
2 METHODOLOGY 7
2.1 GUIDING PRINCIPLES 7
2.2 SURVEY TIMING 7
2.3 STUDY TEAM AND LICENCES 8
2.4 DATABASE SEARCHES 8
2.5 FLORA AND VEGETATION ASSESSMENT 9
2.6 VERTEBRATE FAUNA ASSESSMENT 13
3 EXISTING ENVIRONMENT 21
3.1 CLIMATE 21
3.2 BIOGEOGRAPHIC REGIONS 23
3.3 LAND SYSTEMS 25
3.4 REGIONAL VEGETATION 28
4 LITERATURE REVIEW 31
4.1 FLORA 31
4.2 TECS AND PECS 35
4.3 CONSERVATION RESERVES 35
4.4 ENVIRONMENTALLY SENSITIVE AREAS 35
4.5 FAUNA 38
5 RESULTS 41
5.1 FLORA 41
5.2 VEGETATION 45
5.3 FAUNA 60
6 DISCUSSION 79
6.1 FLORA CONSERVATION SIGNIFICANCE ASSESSMENT 79
6.1 VEGETATION CONSERVATION SIGNIFICANCE ASSESSMENT 79
6.2 CONSERVATION SIGNIFICANT FAUNA SPECIES DESCRIPTIONS 80

7 CONCLUSIONS 89

8 REFERENCES 91

TABLES

Table 1.1 – Control categories for Declared Pests (Weeds) 4
Table 2.1 – Study team and licences 8
Table 2.2 – Fauna databases searched 9
Table 2.3 – Previous vertebrate fauna survey reports within 100 km of the study area 9
Table 2.4 – Vegetation condition assessment 12
Table 2.5 – Factors likely to influence survey design 13
Table 2.6 – Criteria used to assess likelihood of occurrence of conservation significant fauna 14
Table 2.7 – Criteria used to assess likely status of conservation significant fauna within study area 14
Table 2.8 – Fauna sampling sites 16
Table 2.9 – References used for identification 19
Table 3.1 – Land systems of the study area 26
Table 3.2 –Vegetation association units of the study area 29
Table 4.1 – Criteria used to assess likelihood of occurrence of significant flora 31
Table 4.2 – Priority flora recorded within 50 km of the Thunderbird study area 31
Table 4.3 – TECs and PECs recorded within 60 km of the Thunderbird study area 35
Table 5.1 – Vegetation units of the study area 46
Table 5.2 – Vertebrate fauna recorded in the study area 60
Table 5.3 – Fauna habitats at the study area 62
Table 5.4 – Likelihood of occurance assessment of potential conservation significant fauna 67
Table 5.5 – Conservation significant fauna recorded 73
Table 5.6 – Summary of potential conservation significant fauna habitat at the study area 78

FIGURES

Figure 1.1 - Location of the study area 2
Figure 2.1 – Flora quadrats completed 11
Figure 2.2 – Camera trap set up in study area 15
Figure 2.3 – SM2Bat device set up in study area 15
Figure 2.4 – Fauna sampling locations 17
Figure 2.5 – Motion camera set up on active Greater Bilby burrow 18
Figure 3.1 – Climate data for Derby and Broome (BoM 2015) 22
Figure 3.2 – Biogeographic sub-regions of the study area 24
Figure 3.3 – Land systems of the study area 27

Figure 3.4 –Vegetation association units of the study area 30
Figure 4.1 – Significant flora recorded within 50 km of the study area 34
Figure 4.2 – PECs within 50 km of the study area 36
Figure 4.3 – Conservation Reserves in the vicinty of the study area 37
Figure 4.4 – Regional conservation significant mammal and reptile records 39
Figure 4.5 – Regional conservation significant bird records 40
Figure 5.1 – SAC analysis for the study area 41
Figure 5.2 – Priority flora recorded at the study area 43
Figure 5.3 – Introduced flora recorded at the study area 44
Figure 5.4 – Vegetation units mapped at the study area 57
Figure 5.5 – Dendogram used to define the vegetation units 58
Figure 5.6 – Vegetation condition mapped at the study area 59
Figure 5.7 – Fauna habitats 63
Figure 5.8 – Example of pindan shrubland habitat type 64
Figure 5.9 – Example of dense, mature Acacia tumida var tumida within pindan shrubland 64
Figure 5.10 – Example of savannah woodland habitat type 65
Figure 5.11 – Example of sandstone range and footslopes habitat type 65
Figure 5.12 – Greater Bilby digging (top left), scat (top right) and active burrow (bottom) 74
Figure 5.13 – Rainbow Bee-eater recorded from the study area 74
Figure 5.14 – Australian Bustard recorded from the study area 75
Figure 5.15 – Conservation significant fauna recorded 76
Figure 5.16 – Greater Bilby records 77

APPENDICES

Appendix A Conservation Codes 95
Appendix B Fauna Literature Review Results 101
Appendix C Greater Bilby Records 127
Appendix D Coastal habitat restricted conservation significant bird species 131
Appendix E Flora Species List 133
Appendix F Quadrat Data 135
Appendix G Signficant Flora and weed Locations 153
Appendix H Sheffield Resources Thunderbird Project *Varanus sparnus* Memo 155

ACRONYMS

BAM Act	*Biosecurity and Agriculture Management Act 2007*
BOM	Bureau of Meteorology
DAFWA	Department of Agriculture and Food Western Australia
DEC	Department of Environment and Conservation (now DPaW)
DoE	The Department of Environment (formerly DSEWPaC)
DPaW	Department of Parks and Wildlife
DSEWPaC	Department of the Sustainability, Environment, Water, Population and Communities (now DoE)
ESA	Environmentally Sensitive Area
ESCAVI	Executive Steering Committee for Australia Vegetation Information
EPA	Environmental Protection Authority
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
NVIS	National Vegetation Information System
PEC	Priority Ecological Community
TEC	Threatened Ecological Community
TPFL	Threatened and Priority Flora Database
TPList	Threatened and Priority Flora List
WA	Western Australia
WAHERB	Western Australian Herbarium
WAOL	Western Australian Organism List
WC Act	*Wildlife Conservation Act 1950*
WONS	Weeds of National Significance

EXECUTIVE SUMMARY

Sheffield Resources Limited (Sheffield) is a rapidly emerging mineral sands company with significant additional nickel, talc and iron assets, all located within the state of Western Australia. Sheffield are currently validating extensive historical work and undertaking biological surveys at an early stage to aid their project pathway for their Thunderbird project. Sheffield previously commissioned *ecologia* Environment (*ecologia*) to conduct flora and vegetation, vertebrate, SRE invertebrate and subterranean fauna assessments for their Thunderbird project.

To service the Thunderbird project, a proposed haul road and accommodation camp (study area) has been identified by Sheffield. Sheffield commissioned *ecologia* to undertake a Level 2 flora and vegetation and Level 1 and targeted fauna assessment of the study area.

The flora, vegetation and fauna assessment was carried out in accordance with EPA Guidance and encompassed both desktop and field assessments. The flora and vegetation assessment was carried out in accordance with a Level 2 survey and the fauna assessment was carried out in accordance with a Level 1 survey. The survey was conducted by a suitably qualified and experienced botanist and zoologist over five days from 11 to 15 May 2015.

Flora

A total of 16 quadrats (50 x 50 m) were sampled at the study area to determine the flora and vegetation characteristics of the study area. Quadrat locations were selected using a combination of aerial photography, topographic features, land systems, field observations and accessibility to represent the diversity of vegetation and habitats present. Significant flora taxa identified during the database searches were targeted by using aerial imagery to identify suitable habitat as well as the locations of previous records.

A total of 162 vascular plant taxa (including species, infraspecific taxa, and phrase name taxa) were recorded at the study area, representing 97 genera and 41 families. This includes two Priority Flora species: *Pterocaulon intermedium* (Priority 3) and *Triodia caelestialis* (Priority 3) and four introduced species: **Malvastrum americanum*, **Stylosanthes hamata*, **Stylosanthes scabra* and **Tridax procumbens*.

Communities

A search of Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs) within and adjacent to the study area was undertaken as part of the literature review. Two Priority 3 PECs were recorded within 60 km of the study area: “Vegetation assemblages of Lolly Well Springs wetland complex” and “Assemblages of Disaster Bay organic mound springs”. Niether of these two PECs occur within the study area. The study area does not intersect with any conservation areas or reserves. A search of DER’s online Native Vegetation Viewer was undertaken to determine the locations of any ESAs within the study area. No ESAs occur at the study area.

Fauna

Vertebrate fauna was sampled via active searches (including bird surveys), camera trapping and bat echolocation recordings via SongMeter2 devices. Targeted searches for potential conservation significant fauna identified during the literature review were carried out according to appropriate species specific survey methodology.

The literature review identified a total of 383 fauna species with the potential to occur in the study area. This includes 32 native and six introduced mammal species, 249 bird species, 82 reptiles and 14 amphibians. Included in the species recorded in the literature review are a total of 69 conservation significant vertebrate fauna species have the potential to occur in the study area, comprising six mammal species, 59 bird species, and four reptile species.

The field survey recorded a total of 79 fauna species from both direct sightings and secondary evidence such as scats and calls, comprised of 13 mammal, 63 bird and three reptile species. Three

broad habitat types were identified within the study area; pindan shrubland, sandstone range and footslopes and savannah woodland. Four conservation significant fauna species were recorded: Greater Bilby (EPBC Act Vulnerable); Rainbow Bee-eater (EPBC Migratory, WC Act Schedule 3, DPaW International Agreement); Common Greenshank (EPBC Migratory, WC Act Schedule 3, DPaW International Agreement) and Australian Bustard (DPaW Priority 4).

The Greater Bilby was only recorded from the haul road sections within the current Thunderbird study area. It is unlikely to occur within the remainder of the haul road study area, due to the narrow linear corridor and lack of dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat and sandy soil substrate. Locations where Greater Bilby was recorded are likely to be part of a resident breeding population. However the occupancy of these areas will be determined by fire history and therefore will continue to change temporally.

Of the 69 conservation significant fauna that may potentially occur within the study area, a total of 46 species were assessed as low likelihood, 16 species as medium likelihood and seven species recoded as high likelihood or recorded during current survey. Conservation significant fauna species recorded or assessed as high likelihood of occurrence were; Greater Bilby (*Macrotis lagotis*), Lakeland Downs Mouse (Short-tailed Mouse) (*Leggadina lakedownensis*), Rainbow Bee-eater (*Merops ornatus*), Fork-tailed Swift (*Apus pacificus*), Common Greenshank (*Tringa nebularia*), Australian Bustard (*Ardeotis australis*) and Dampier Peninsula Goanna (*Varanus sparnus*).

1 INTRODUCTION

1.1 PROJECT BACKGROUND

Sheffield Resources Limited (Sheffield) is a rapidly emerging Western Australian mineral sands company, also with significant nickel, talc and iron assets, all located within the state of Western Australia. Sheffield is undertaking biological surveys at an early stage to aid their project pathway for their Thunderbird project.

Sheffield has previously commissioned *ecologia* Environment (*ecologia*) to undertake a two-phase Level 2 terrestrial (vertebrate and SRE invertebrate) and subterranean fauna survey of its Thunderbird Project, located 70 kilometres west of Derby on the Dampier Peninsula. Level 2 assessments were completed in 2014.

In order to service the Thunderbird project, proposed haul road otions and an accommodation camp (study area) has been identified by Sheffield. Sheffield commissioned *ecologia* to undertake a Level 2 flora and vegetation and Level 1 and targeted fauna assessment of the haul road and accommodation camp study area. Sections of the proposed haul road and the entire accommodation camp are within the previously surveyed Thunderbird project study area. The study area totals an area of 538.4 ha inside the existing Thunderbird study area, with 810.9 ha outside the existing Thunderbird study area (1,349.3 ha total). A location map of the study area is shown in Figure 1.1.

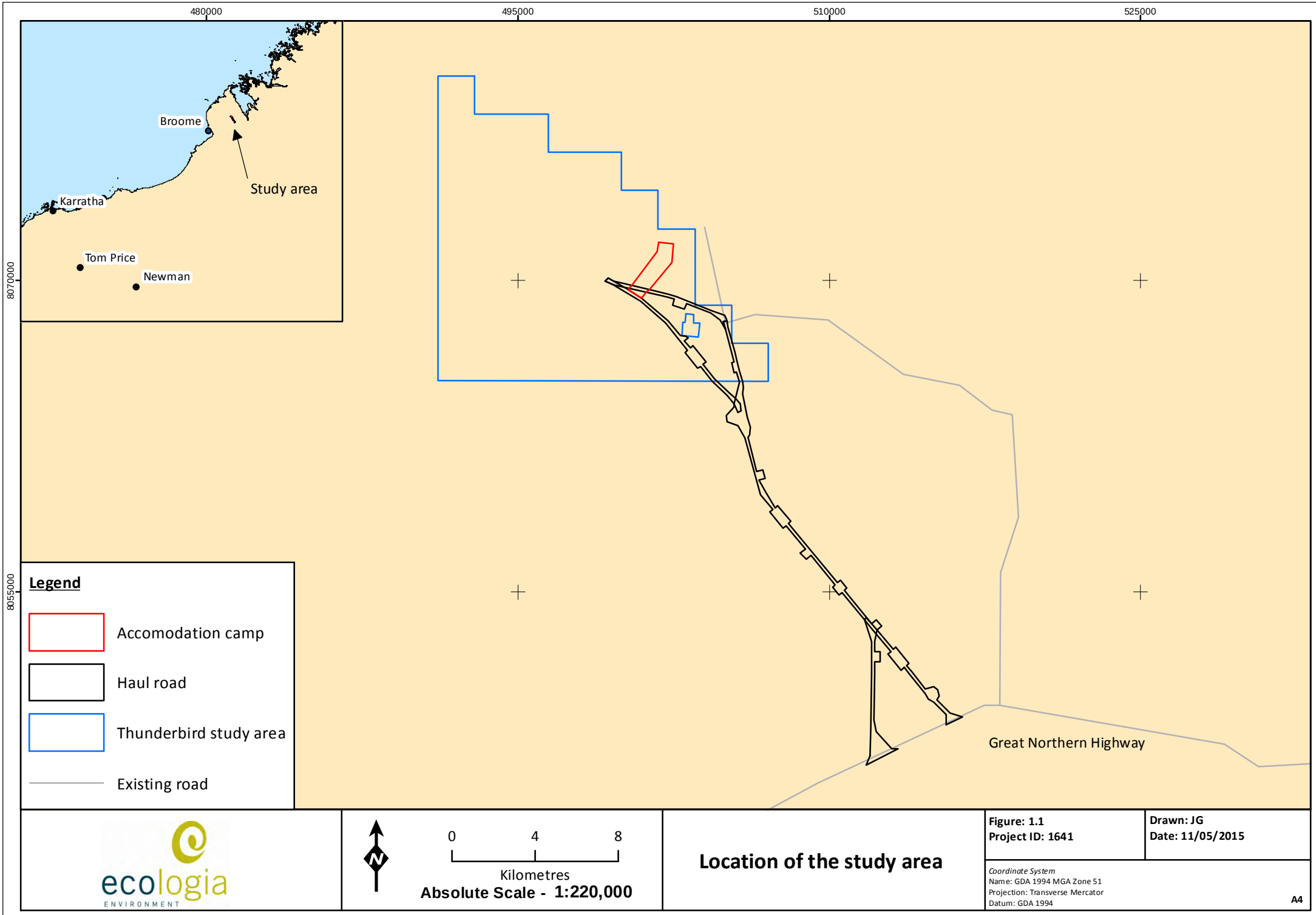
1.2 LEGISLATIVE FRAMEWORK

Commonwealth and State legislation applicable to the conservation of native flora and fauna in Western Australia (WA) includes, but is not limited to, the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the Western Australian *Wildlife Conservation Act 1950* (WC Act) and the *Environment Protection Act 1986* (EP Act). Section 4a of the EP Act requires that developments take into account the following principles applicable to native flora and fauna:

- **The Precautionary Principle:** Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- **The Principles of Intergenerational Equity:** The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations; and
- **The Principle of the Conservation of Biological Diversity and Ecological Integrity:** Conservation of biological diversity and ecological integrity should be a fundamental consideration of development projects.

The EPBC Act was developed to provide for the protection of the environment, particularly those aspects of the environment that are matters of National environmental significance, to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources; and to promote the conservation of biodiversity. The EPBC Act includes provisions to protect native species (in particular to prevent the extinction and promote the recovery of threatened species) and to ensure the conservation of migratory species. In addition to the principles outlined in Section 4a of the EP Act, Section 3a of the EPBC Act includes the principle of ecologically sustainable development; that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations.

The WC Act was developed to provide for the conservation and protection of wildlife in Western Australia. Under the WC Act, all native flora and fauna are protected in WA; however, the Minister may, via a notice published in the Government Gazette, declare a list of flora and fauna identified as likely to become extinct, or as rare, or otherwise in need of special protection. The current listing was gazetted on 2 December 2014.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495000
510000
525000
8070000
8055000
Broome
Karratha
Tom Price
Newman
Study area
Great Northern Highway
Legend
Accomodation camp
Haul road
Thunderbird study area
Existing road
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0
4
8
Kilometres
Absolute Scale - 1:220,000
Location of the study area
Figure: 1.1
Project ID: 1641
Drawn: JG
Date: 11/05/2015
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
A4

1.3 SURVEY OBJECTIVES

The Environmental Protection Authority's (EPA) objectives with regard to the management of native flora, fauna and vegetation are to:

- Avoid adverse impacts on biological diversity comprising the different plants and animals and the ecosystems they form, at the levels of genetic, species and ecosystem diversity;
- Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities;
- Protect Threatened Flora and Fauna consistent with the provisions of the WC Act; and
- Protect other flora and fauna species of conservation significance.

The primary objective of this flora, fauna and vegetation assessment is to provide sufficient information to the EPA to assess the impact of the proposed development on the vegetation, flora and fauna communities of the study area, thereby ensuring that the EPA objectives will be upheld.

1.4 SIGNIFICANT FLORA

Significant flora as described in EPA Guidance Statement 51 (EPA 2004a) includes Threatened and Priority Flora as well as range extensions, keystone species, relic species, potential new species, restricted subspecies, varieties or naturally occurring hybrids, local endemics or poorly reserved species. These are described below.

1.4.1 Threatened Flora

***Environment Protection and Biodiversity Conservation Act,* 1999 (Commonwealth of Australia)**

At a Commonwealth level, Threatened Flora are protected under the EPBC Act, which lists species that are considered Critically Endangered, Endangered, Conservation Dependant, Extinct, or Extinct in the Wild (Appendix A).

***Wildlife Conservation Act, 1950* (Western Australia)**

Flora taxa which have been adequately searched for and are deemed to either be rare, in danger of extinction, or otherwise in need of special protection in the wild, are gazetted as Threatened (Declared Rare) Flora under the WC Act. Threatened Flora are further categorised according to their level of threat using the International Union for Conservation of Nature (IUCN) Red List criteria:

- Critically Endangered: considered to be facing an extremely high risk of extinction in the wild;
- Endangered: considered to be facing a very high risk of extinction in the wild; and
- Vulnerable: considered to be facing a high risk of extinction in the wild.

Threatened Flora taxa are legally protected and their removal or impact to their surroundings cannot be conducted without Ministerial approval, obtained specifically on each occasion for each population (Appendix A).

1.4.2 Priority Flora

The Department of Parks and Wildlife (DPaW) maintains a list of Priority Flora, which are considered poorly known, uncommon or under threat but for which there is insufficient justification, based on known distribution and population sizes, listing as Threatened under the WC Act. Priority Flora taxa are assigned to one of five priority categories (Appendix A).

1.4.3 Range Extensions

Taxa that are outside of their known distribution are identified as range extensions. The distribution and range extensions have been subdivided into three categories:

- Bioregional Extension: indicates the taxon has not been previously recorded in the Interim Biogeographic Regionalisation for Australia (IBRA) Bioregion;
- Range Extension: indicates the records are at least 100 km from the boundary of the known distribution based on herbarium lodged records; and
- Bridging Record: indicates records between known populations, but at least 100 km from the nearest population.

1.4.4 Introduced Flora

Weeds of National Significance (WONS)

At a national level there are 32 weeds listed as Weeds of National Significance (WONS). *The Commonwealth National Weeds Strategy: A Strategic Approach to Weed Problems of National Significance* (2012b) describes broad goals and objectives to manage these weeds.

Declared Pests (Weeds)

The *Biosecurity and Agriculture Management Act 2007* (BAM Act) (Department of Agriculture and Food Western Australia (DAFWA) 2007) seeks to prevent serious animal and plant pests and diseases from entering the State and becoming established, and to minimise the spread and impact of any that are already present. The BAM Act (and associated regulations) replaces the *Agriculture and Related Resources Protection Act 1976* (and associated regulations). The BAM regulations were enacted on 1 May 2013, placing organisms into four categories:

- Permitted organism (listed under Section 11): permitted in WA subject to regulations;
- Prohibited organism (listed under Section 12): prohibited in WA subject to regulations (i.e. is a Declared Pest for the whole of State);
- Permitted organism: permit required (under regulation 73): must not be imported unless in accordance with an import permit ; and
- Permitted organism: Declared Pest (under Section 22): can apply to part of or the whole of the State.

The current Western Australian Organism List (WAOL) was published on 1 May 2013 (DAFWA 2013) and lists organisms in each of these categories. Unlisted organisms must not be imported (unless in accordance with an import permit and regulations). The BAM Act further categorises Declared Pests in one of three control categories; C1 Exclusion, C2 Eradication and C3 Management (Table 1.1).

Table 1.1 – Control categories for Declared Pests (Weeds)

Declared plant category	Description
C1 - Exclusion	Pests assigned to this category are not established in WA and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.
C2 - Eradication	Pests assigned to this category are present in WA in low enough numbers or in sufficiently limited areas that their eradication is still a possibility.
C3 - Management	Pests assigned to this category are established in WA but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.

Environmental Weeds

A second and much more extensive categorisation of weeds has been developed by the DPaW in the State Environmental Weed Strategy (The Department of Conservation and Land Management

(CALM) 1999). Species considered to adversely affect the communities they invade are evaluated based on the following criteria:

- Invasiveness: ability to invade bushland in good to excellent condition or ability to invade waterways (scored as yes or no);
- Distribution: wide current or potential distribution including consideration of known history of widespread distribution elsewhere in the world (scored as yes or no); and
- Environmental impacts: ability to change the structure, composition and function of ecosystems. In particular an ability to form a monoculture in a vegetation community (scored as yes or no).

Weeds listed as Environmental Weeds are ranked into four categories using the above criteria and the scoring system:

- High: a species which scores yes to all three of the above criteria. A rating of high indicates a species that should be prioritised for control and/or research;
- Moderate: a species which scores yes for two of the above criteria. A rating of moderate indicates a species which should be monitored. Control or research should be directed to it if funds are available;
- Mild: a species which scores yes to one of the criteria. A mild rating indicates monitoring or control if appropriate; and
- Low: a species which does not score yes for any of the criteria. A low rating indicates a low requirement for monitoring.

1.5 SIGNIFICANT VEGETATION AND COMMUNITIES

1.5.1 Threatened and Priority Ecological Communities

Nationally Listed Threatened Ecological Communities

Ecological communities are naturally occurring biological assemblages associated with a particular type of habitat (Department of Environment and Conservation (DEC) 2010) . At a national level, flora and Threatened Ecological Communities (TEC) are protected under the Commonwealth EPBC Act. An ecological community may be categorised into one of three sub-categories:

- Critically Endangered: if it is facing an extremely high risk of extinction in the wild in the immediate future;
- Endangered: if it is not critically endangered and is facing a very high risk of extinction in the wild in the near future and
- Vulnerable: if it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future.

State Listed Threatened Ecological Communities

DPaW also maintains a list of state listed TECs which are further categorised into three subcategories, much like those of the EPBC Act. Within the Western Australian classification, an ecological community will be listed as Vulnerable "when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future".

State Listed Priority Ecological Communities

DPaW maintains a list of Priority Ecological Communities (PEC). PECs include potential TECs that do not meet survey criteria, or that are not adequately defined.

1.5.2 Conservation Estate

The National Reserve System is a network of protected areas managed for conservation under international guidelines. The objective of placing areas of bushland into the Conservation Estate is to achieve and maintain a comprehensive, adequate and representative reserve system for Western Australia. Areas vested in the Conservation Estate are managed by the Conservation Commission.

1.5.3 Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are areas that require special protection due to aspects such as landscape, wildlife of historical value. ESAs are declared under the *Environmental Protection (Clearing of Native Vegetation) Regulation 2004*.

1.6 SIGNIFICANT FAUNA

1.6.1 Threatened Fauna

Species of fauna are defined as Threatened where their populations are under threat, require protection or are protected under an international agreement between federal governments. Threats of extinction to fauna species are recognised at a Commonwealth level and are categorised according to the EPBC Act, administered by the Department of Environment (DoE). Categories of Threatened species are summarised in Appendix A.

DPaW recognises these threats of extinction and consequently applies regulations towards population and species protection. Schedule 1 Threatened fauna are further ranked by DPaW according to their threat using IUCN Red List criteria. Threatened fauna species are protected under the WC Act and the categories are defined in Appendix A.

1.6.2 Priority Fauna

Priority fauna not listed as Threatened (Scheduled) under the WC Act, but are poorly known or poorly represented in the conservation estate are regarded as priority and attention is given to their conservation by DPaW. The five classifications of Priority fauna are listed in Appendix A.

1.6.3 Migratory Fauna

Migratory species are matters of Commonwealth environmental significance under the EPBC Act. Recognised migratory species include any native species identified in an international agreement approved by the Minister and those listed under:

- The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention);
- The China-Australia Migratory Bird Agreement (CAMBA); and
- The Japan-Australia Migratory Bird Agreement (JAMBA).

2 METHODOLOGY

The flora, vegetation and fauna assessment was carried out in accordance with EPA Guidance and encompassed both desktop and field assessments. The flora and vegetation assessment was carried out in accordance with a Level 2 survey and the fauna assessment was carried out in accordance with a Level 1 survey.

2.1 GUIDING PRINCIPLES

This survey was undertaken as part of the Environmental Impact Assessment process in WA and is required to address the following government legislation:

- EPA Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004a);
- EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2002a); and
- EPA Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002b).

Specifically providing:

- A review of background information (including literature and database searches);
- An inventory of flora and fauna species observed at the study area;
- An inventory and a map of species of biological and conservation significance recorded or likely to occur within the study area and surrounds;
- An inventory and a map of introduced flora species recorded at the study area;
- An inventory of vegetation types and flora and fauna species occurring at the study area, incorporating recent published and unpublished records;
- A map and detailed description of vegetation types (to National Vegetation Information Systems (NVIS) Level V: Association) occurring in the study area and an assessment of which vegetation units potentially represent TEC or PECs;
- A map and detailed description of fauna habitats at the study area;
- A map of the vegetation condition and discussion on the type of disturbances encountered;
- An appraisal of the current knowledge base for the area, including a review of previous surveys conducted in the area relevant to the current study; and
- A review of regional and biogeographical significance, including the conservation status of species recorded at the study area.

2.2 SURVEY TIMING

The field component of the flora and fauna assessment was conducted by one botanist and one zoologist over five days between the 11 to 15 May 2015. A survey effort equivalent to 10 person days was expended.

2.3 STUDY TEAM AND LICENCES

The flora and fauna assessment described in this document was planned, coordinated and executed by those summarised and under the following licences listed in Table 2.1.

Table 2.1 – Study team and licences

Project Staff			
Name	**Qualification**	**Role**	**Project role**
Matthew Macdonald	PhD	Principal Ecologist	Project management, field survey and reporting
Bruce Greatwich	BSc.	Senior Zoologist	Field survey and reporting
Melissa Hay	BSc. (Hons)	Senior Botanist	Reporting and vegetation mapping
John Graff	BSc. (Hons)	Zoologist	Reporting
Palitha Jayasekara	PhD	Botanist/Taxonomist	Flora identifications
Licences			
The flora, fauna and vegetation assessment described in this report was conducted under the authorisation of the following licences issued by DPaW:			
Name	**Licence Number**	**Licence**	
Matthew Macdonald	SL011413	Licence to take flora for scientific purposes	
Bruce Greatwich	SF010318	Regulation 17 licence	

2.4 DATABASE SEARCHES

2.4.1 Flora

Using a shapefile of the study area, searches of the following databases were undertaken to determine species and communities of significance recorded in the vicinity of the study area:

- DoE EPBC Act Protected Matters Database flora searches (buffer 40 km);
- Department of Parks and Wildlife (DPaW), Threatened and Priority Flora Database (TPFL) (Search reference 15-0313FL) with a 50 km buffer around the Sheffield Thunderbird study area;
- DPaW Threatened and Priority Flora List (TPList) (Search reference 15-0313FL) with a 50 km buffer around the Sheffield Thunderbird study area;
- DPaW Western Australian Herbarium Specimen Database (WAHERB) (Search reference 15-0313FL) with a 50 km buffer around the Sheffield Thunderbird study area; and
- DPaW Threatened and Priority Ecological Communities Database with a 50 km buffer around the Sheffield Thunderbird study area.

2.4.2 Fauna

Three databases were consulted in the preparation of potential fauna lists (Table 2.2). The online database NatureMap (DPaW 2015a) encompasses several datasets, including the Western Australian Museum, the DPaW Threatened Fauna database and the DPaW Survey Return database. The results from 14 previous vertebrate fauna surveys within 100 km of the study area were also consulted.

Table 2.2 – Fauna databases searched

Database	Custodian	Search Details
NatureMap (includes DPaW Threatened Fauna Database)	DPaW	Search co-ordinates: 17° 34' 03" S, 123° 04' 44" S Buffer (radius): 40 km Date accessed: 08/05/2015
EPBC Act Protected Matters Search Tool	DoE	Search co-ordinates: 17° 34' 03" S, 123° 04' 44" S Buffer (radius): 40 km Date accessed: 08/05/2015
Birdata	BirdLife Australia	Records within the one degree grid square containing the point 17° 34' 03" S, 123° 04' 44" S Date accessed: 08/05/2015

Table 2.3 – Previous vertebrate fauna survey reports within 100 km of the study area

Survey location and author(s)	Distance from study area (km)	Comments
ecologia internal database	0 – 85	Two Level 1 and three single phase Level 2 surveys
Thunderbird Project Terrestrial and Subterranean Fauna Assessment (*ecologia* 2014b)	0	Two phase Level 2 survey
Perpendicular Head-North Head, Packer Island, Gourdon Bay and Coulomb-Quondong Vertebrate Fauna Assessment (ENV 2008)	70	Single phase Level 2 survey
James Price Point Terrestrial Fauna Survey (Biota 2009)	85	Single phase Level 2 survey
James Price Point Browse LNG Precinct Targeted Terrestrial Fauna Survey (Biota 2010)	85	Single phase Level 2 survey
Supplementary Terrestrial Fauna and Habitat Assessment (AECOM 2010)	85	Single phase Level 1 survey
Browse LNG Precinct Access Road: Targeted Fauna Survey – Greater Bilby (AECOM 2011)	85	Targeted Greater Bilby survey
Monitoring Yellow Sea Migrants in Australia (MYSMA) (Rogers *et al.* 2009)	85 - 435	Targeted shorebird survey
Assessment of Birds Utilising Habitat within the Vine Thickets and Woodlands of James Price Point (Bamford 2011)	85	Targeted bird survey
Browse Project Greater Bilby Survey of the James Price Point Area - Summary Report (ENV 2011)	85	Targeted Greater Bilby survey

2.5 FLORA AND VEGETATION ASSESSMENT

A single phase Level 2 flora and vegetation assessment was conducted at the study area to gather data allowing for vegetation mapping and undertake floristic analysis of the entire study area. Methodologies were formulated based on the legislative framework listed in Section 1.2.

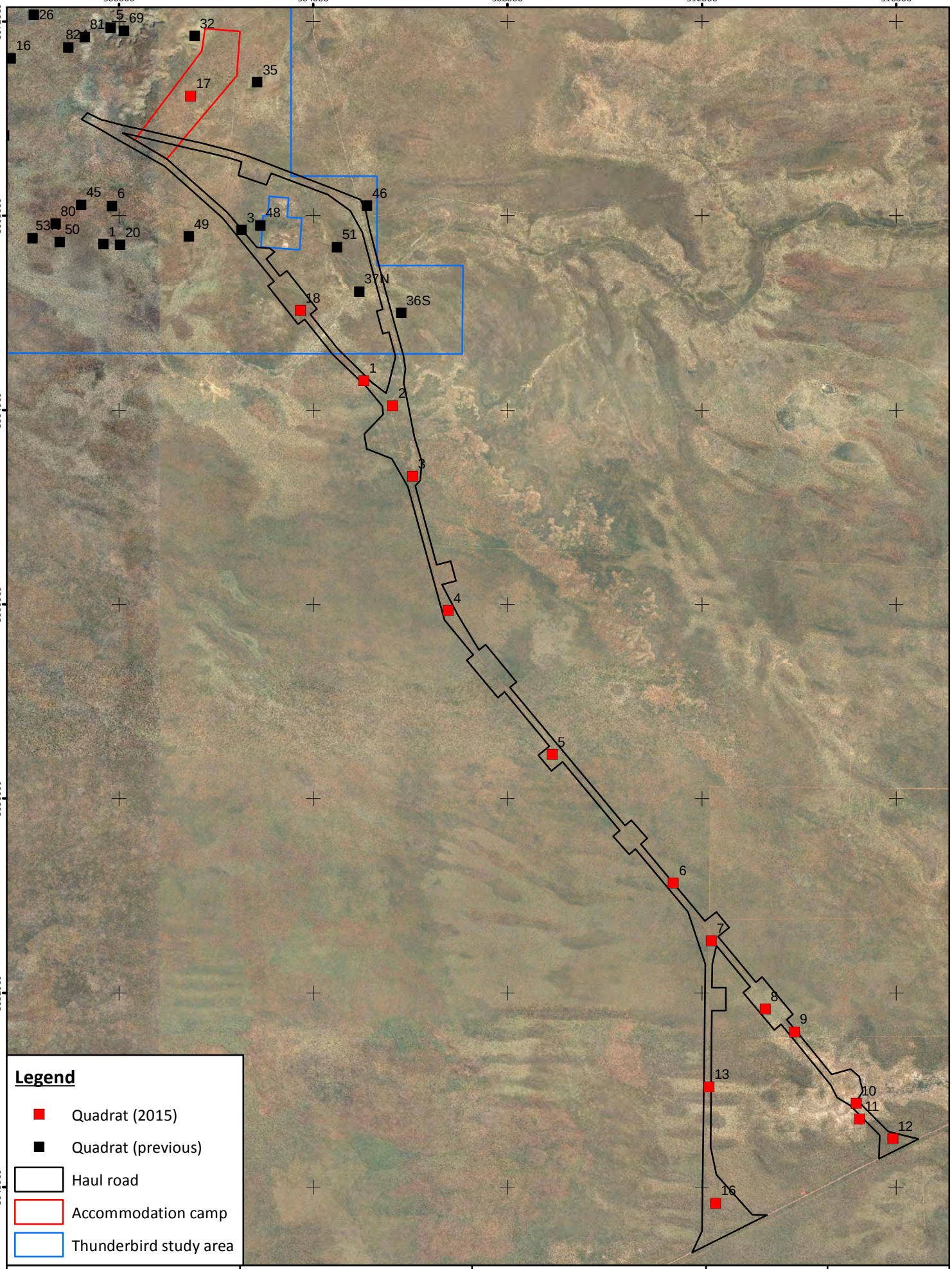
2.5.1 Quadrats

A total of 16 quadrats were sampled at the study area (Figure 2.1). Quadrat locations were selected using a combination of aerial photography, topographic features, land systems, field observations and accessibility to represent the diversity of vegetation and habitats present.

All quadrats were 50 x 50 m (2,500 m^2) in dimension. The following paramters were recorded from each quadrat:

- All observed flora species and the average height, percentage cover and observable presence/absence of fruit/flowers for each;
- Vegetation structure (National Vegetation Information System (NVIS), Section 2.5.4);
- Vegetation condition scale of Trudgen (1991), which is based on the criteria in Table 2.4;

- Estimated time since fire;
- GPS co-ordinate for the north-west corner;
- Digital photograph of the quadrat, taken from the north-west corner facing south-east;
- The landform element that the quadrat occupies;
- The presence of rock outcrops (type and abundance);
- Soil type (colour, profile, field texture and surface type); and
- Position, slope and aspect.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Legend
Quadrat (2015)
Quadrat (previous)
Haul road
Accommodation camp
Thunderbird study area
ecologia
ENVIRONMENT
0
1.5
3
Kilometres
Absolute Scale - 1:100,000
N
Flora quadrats completed
Figure: 2.1
Project ID: 1641
Drawn: BG
Date: 7/5/15
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
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2.5.2 Targeted Significant and Additional Flora Searches

Significant flora identified during the database searches were targeted by interpreting aerial imagery to identify suitable habitat (listed for each taxon in Table 4.2) as well as the locations of previous records. The targeted flora searches involved a series of transects which were traversed on foot to locate flora of conservation significance, introduced flora and to provide opportunistic collections of taxa not recorded within the quadrats. Previous records of significant flora were also visited where possible.

2.5.3 Taxonomy

Nomenclature of the species recorded follow the protocols of the West Australian Herbarium (Western Australian Herbarium 1998-2015). An atypical form of *Triodia schinzii*, informally recognised as *Triodia schinzii* (Broome variant) is reported as *Triodia schinzii* - all specimens of this taxon from this project are referrable to *Triodia schinzii* (Broome variant).

2.5.4 Vegetation Mapping

Vegetation mapping is the delineation of plant communities based on distinctive characteristics that these communities share such as the vegetation structure, dominant species and species composition.

Vegetation units are described based on the NVIS methodology (ESCAVI 2003). They are described to the broad floristic formation (level III) and the association (level V) with the dominant growth form, height and crown cover for three species are described for three strata levels (upper, middle and ground).

2.5.5 Vegetation Condition Mapping

The vegetation condition at the study area was mapped using the average condition of the quadrats that were conducted in each vegetation unit. Condition is assessed based on criteria listed in Table 2.4 as described by Trudgen (1991).

Table 2.4 – Vegetation condition assessment

Vegetation Condition	Criteria
Pristine	Pristine or nearly so, no obvious sign of disturbance.
Excellent	Vegetation structure intact; disturbance affecting individual species; weeds are non-aggressive species.
Very good	Vegetation structure altered; obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires; the presence of some more aggressive weeds; dieback; logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires; the presence of some very aggressive weeds at high density; partial clearing; dieback and grazing.
Degraded or Poor	Very few values remaining.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as “parkland cleared” with the flora comprising weed or crop species with isolated native trees or shrubs.

2.5.6 Statistical Analysis

Quadrat data was used to produce a dendrogram of dissimilarity in floristic composition among quadrats. The dendrogram was divided into groups which correspond to the vegetation units. A combination of aerial photography, the vegetation unit grouping and ground truthing was used to interpret the vegetation patterns of the study area and formed the basis of the vegetation mapping.

Multivariate floristic analysis provides an objective means of defining vegetation units and provides insight into the hierarchical relationship between communities based on the degree of similarity in species composition and abundance.

Multivariate analysis was conducted using the site by species matrix from quadrats completed by *ecologia* during the 2015 field survey and data previously collected in 2012 (*ecologia* 2012) and 2014 (*ecologia* 2014a). Cluster analysis used cover-weighted site by species matrix with Spearman rank correlation (SYSTAT 12). The data from the species by site matrix was manipulated for analysis in the following ways:

- Taxa of the same genus, but with not fully identified species, varieties or subspecies were grouped or removed from the analysis; and
- Annual taxa were removed (except *Sorghum timorense*, which was combined with the perennial *Sorghum plumosum* for the statistical analysis.

2.6 VERTEBRATE FAUNA ASSESSMENT

Prior to the development of survey methods, a review was undertaken of the factors likely to influence survey design and intensity (EPA (2004c), Table 2.5). Based on this review, a Level 1 fauna survey in accordance with EPA Guidance Statement 56 (EPA 2004b) was considered to be appropriate, incorporating a desktop assessment and Level 1 field survey.

Table 2.5 – Factors likely to influence survey design

Factor	Comment
Bioregion – level of existing survey-knowledge of the region and associated ability to predict accurately	*ecologia* has previously completed a two-phase Level 2 survey of the adjacent Thunderbird study area. A number of previous surveys have been completed on the Dampier Peninsula.
Landform special characteristics/specific fauna/specific context of the landform characteristics and their distribution and rarity in the region	The landforms associated with the study area are typical for the region and do not represent any rare or unique characteristics.
Lifeforms, life cycles, types of assemblages and seasonality (e.g. migration) of species likely to be present	Not applicable to a Level 1 survey of this nature; survey was largely habitat-based assessment and targeted conservation significant fauna assessment.
Level of existing knowledge and results of previous regional sampling (e.g. species accumulation curves, species/area curves)	Total of 10 previous surveys of the Dampier Peninsula incorporated in to literature review plus relevant databases providing good existing knowledge.
Number of different habitats or degree of similarity between habitats within a study area	The survey was undertaken to determine the different habitat types present in the study area.
Climatic constraints (e.g. temperature or rainfall that preclude certain sampling methods)	No climatic constraints were experienced.
Sensitivity of the environment to the proposed activities	No ESAs at the study area.
Size, shape and location of the proposed activities	The haul road study area largely consists of widening existing roads, therefore limiting potential impacts and therefore a Level 1 survey was deemed adequate.
Scale and impact of the proposal	As above, impact will largely be restricted to development of existing roads, therefore minimising potential impacts.

2.6.1 Potential conservation significant fauna likelihood of occurrence assessment

An assessment of likelihood of occurrence for conservation significant fauna recorded during the desktop assessment was determined by examining the following:

- Fauna habitats known to exist within the study area and their condition as assessed during the survey;
- Distance of previously recorded conservation significant species from the study area;

- Frequency of occurrence of conservation significant species records in the region; and
- Time passed since conservation significant species were recorded within, or nearby the study area.

Each conservation or biologically significant fauna species potentially occurring in the study area was assigned a likelihood of occurrence based on the four categories described in Table 2.6. The likelihood of occurrence is then further categorised in to most likely potential habitat usage of the species within the study area (Table 2.7)

Table 2.6 – Criteria used to assess likelihood of occurrence of conservation significant fauna

Likelihood of occurrence	Criteria
RECORDED	Species recorded during the current survey at the study area.
HIGH	Species recorded within, or in proximity to, the study area within 20 years; suitable habitat occurs in the study area.
MEDIUM	Species recorded within, or in proximity to, the study area more than 20 years ago. Species recorded outside study area, but within 50 km; suitable habitat occurs in the study area.
LOW	Species rarely or not recorded, within 50 km, and/or suitable habitat does not occur in the study area.

Table 2.7 – Criteria used to assess likely habitat usage of conservation significant fauna

Likely status	Criteria
Resident – Breeding	Species is resident within the study area and has been recorded or is likely to breed within the study area.
Resident – Non-breeding	Species is resident within the study area but is unlikely to breed within the study area.
Migratory visitor	Migratory species which regularly occurs within the study area during appropriate times of the year.
Transient visitor	Species occurs infrequently in the study area, and is unlikely to be resident. Utilises the study area on a temporary basis only.
Nomadic visitor	Species occurs within the study area during favourable environmental conditions, may include breeding.

The level of available information for each species was also taken into consideration so that species were not allocated a low likelihood of occurring due to insufficient survey information or cryptic behaviours and ecology, in accordance with the precautionary principle.

2.6.2 Sampling methods

The survey methods adopted by *ecologia* are aligned with EPA Guidance Statement No. 56, Position Statement No. 3 (EPA 2002a) and *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010). A variety of opportunistic survey methods were undertaken.

Diurnal active searching

Active searches for mammal and reptile species were completed throughout the study area. Search techniques included checking beneath the bark of dead trees, investigating old logs, stumps and dead free-standing trees, raking leaf litter, investigating burrows and over-turning logs and stones. Tracks, diggings, scats, burrows and nests were also recorded where possible. Bird species were also recorded during active searches. Bird point counts were conducted at water points.

Camera trapping

A total of four motion sensor cameras were set up throughout the study area. Cameras were baited with universal bait mix in an attempt to lure animals to the area, or placed in areas to target

conservation significant fauna. Reconyx HC500 Hyperfire motion cameras were used. All cameras are triggered by movement using highly sensitive passive infra-red motion sensors that function both during the day and at night.

Figure 2.2 – Camera trap set up in study area

Bat echolocation call recordings

Two nights of recordings were made via a Song Meter 2 (SM2Bat) device. Bat echolocation calls were recorded and then subsequently analysed via SongScope.

Figure 2.3 – SM2Bat device set up in study area

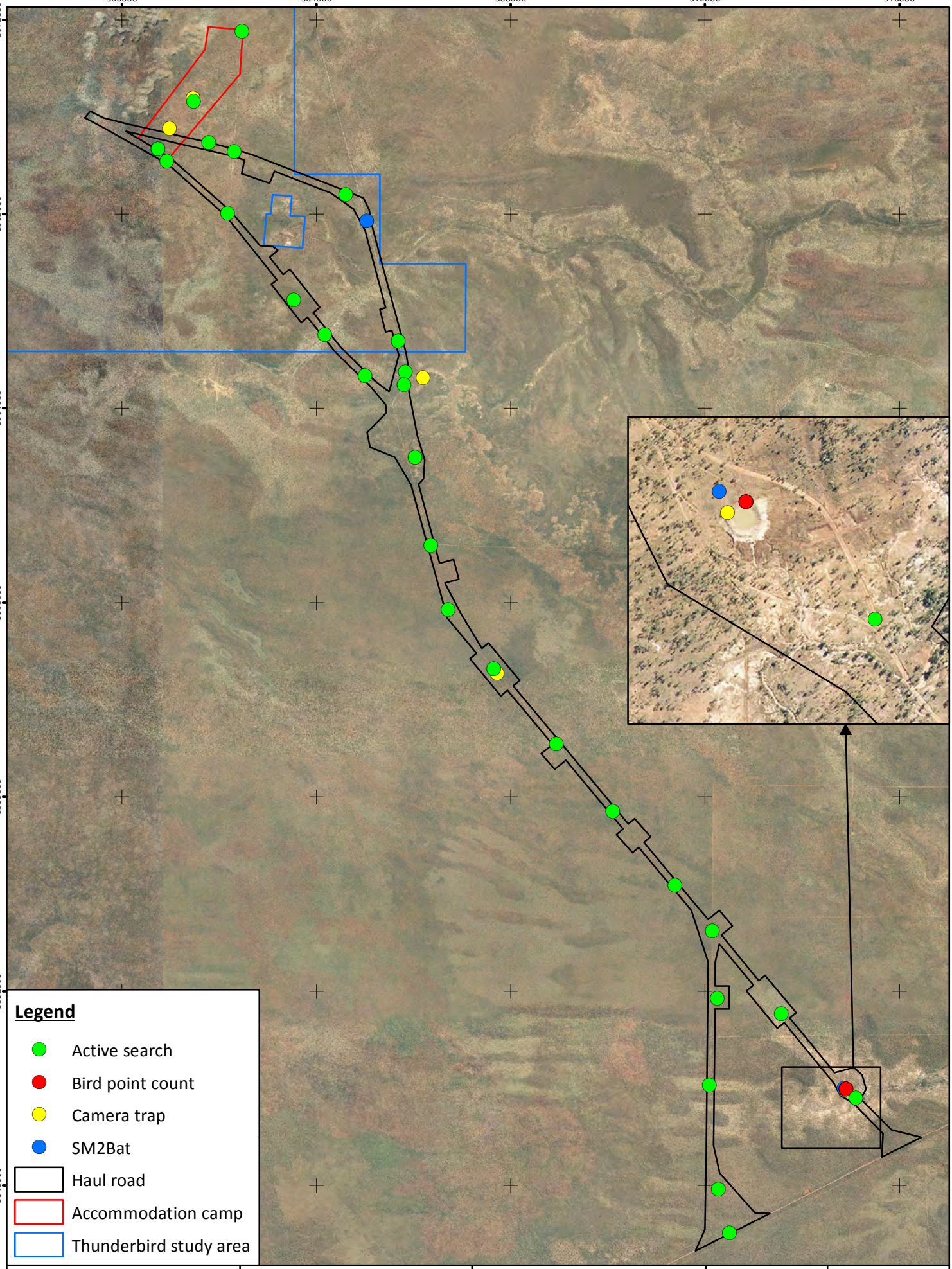
2.6.3 Sampling sites

Vertebrate fauna sampling sites are shown in Table 2.8 and mapped in Figure 2.4.

Table 2.8 – Fauna sampling locations

Site	Easting	Northing
Camera trap 1	514872	8049964
Camera trap 2	506192	8064632
Camera trap 3	507719	8058546
Camera trap 4	514901	8049981
Camera trap 5	500978	8069759
Camera trap 6	501456	8070386
SM2 1	514859	8049997
SM2 2	505036	8067859
Bird point count 1	514901	8049981
Bird point count 2	504295	8072673
Diurnal active search 1	505687	8065383
Diurnal active search 2	505003	8064661
Diurnal active search 3	515105	8049795
Diurnal active search 4	512148	8053238
Diurnal active search 5	505829	8064742
Diurnal active search 6	506037	8062986
Diurnal active search 7	505805	8064486
Diurnal active search 8	506712	8059846
Diurnal active search 9	506356	8061172
Diurnal active search 10	507652	8058640
Diurnal active search 11	510099	8055699
Diurnal active search 12	502470	8071752
Diurnal active search 13	504605	8068400
Diurnal active search 14	508941	8057088
Diurnal active search 15	502308	8069288
Diurnal active search 16	513569	8051532
Diurnal active search 17	511372	8054171
Diurnal active search 18	512506	8047022
Diurnal active search 19	504174	8065510
Diurnal active search 20	503536	8066226
Diurnal active search 21	502171	8068020
Diurnal active search 22	500922	8069082
Diurnal active search 23	512249	8051851
Diurnal active search 24	512273	8047917
Diurnal active search 25	512086	8050058
Diurnal active search 26	501471	8070313
Diurnal active search 27	501781	8069467
Diurnal active search 28	500737	8069336

Datum: GDA 1994 MGA Zone 51



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Fauna sampling locations

Figure: 2.4
Project ID: 1641

Drawn: BG
Date: 7/5/15

Coordinate System
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Projection: Transverse Mercator
Datum: GDA 1994

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2.6.4 Targeted conservation significant fauna surveying

Prior to the commencement of the field survey, the preferred habitat of conservation significant species potentially occurring in the study area was determined. These habitats were identified and then targeted during the field survey. In particular, targeted surveys for species assessed as having a high likelihood of occurrence or were previously recorded during the Thunderbird project Level 2 assessment were conducted. These species consisting of Greater Bilby, Gouldian Finch, Rainbow Bee-eater, Australian Bustard, Dampierland Burrowing Snake and *Lerista separanda.*

Greater Bilby (*Macrotis lagotis*) (EPBC Act Vulnerable, WC Act Schedule 1, DPaW Vulnerable)

The survey methodology undertaken for Greater Bilby was in accordance with recommended guidelines (DSEWPaC 2011). Areas that represented suitable habitat were searched on foot by completing transects searching for secondary evidence (diggings, tracks and scats). Where active secondary evidence was observed, the area was searched intensely for burrows. Two active burrows were monitored for one night with motion cameras (Figure 2.5).

Figure 2.5 – Motion camera set up on active Greater Bilby burrow

Gouldian Finch (*Erythrura gouldiae*) (EPBC Act Endangered, DPaW Priority 4)

Survey methodology for Gouldian Finch was in accordance with recommended guidelines (DSEWPaC 2010). Bird surveys were conducted throughout the study area in conjunction with active searches. Bird point counts were made at water points in the study area in an attempt to recorded individuals coming in to drink. In addition, two motion cameras were established on the water's edge for three days in an attempt to record individuals coming in to drink (Figure 2.2).

Rainbow Bee-eater (*Merops ornatus*) (EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement)

Survey methodology for Gouldian Finch was in accordance with recommended guidelines (DSEWPaC 2010). Bird surveys were conducted throughout the study area in conjunction with active searches. Opportunistic recordings were made when individuals were encountered.

Australian Bustard (*Ardeotis australis*) (DPaW Priority 4)

Bird surveys were conducted throughout the study area in conjunction with active searches. Opportunistic recordings were made when individuals were encountered. Secondary evidence in the form of tracks were searched for and recorded when encountered.

Dampierland Burrowing Snake (*Simoselaps minimus*) and *Lerista separanda* (DPaW Priority 2)

As both species inhabit fossorial habitats, they were searched for in conjunction. Species were searched for during diurnal active searches, by raking leaf litter and searching under logs and wood litter.

2.6.5 Fauna habitat mapping

A fauna habitat type broadly describes an area of habitat that is distinguishable in its vegetation and land features from its surroundings, and is likely to support a different fauna assemblage to that found in other fauna habitat types. Particular attention is also paid to the likelihood that certain species are present which tend to be found only in that specific habitat type. Fauna habitat types were identified, described and mapped using the following existing information:

- IBRA subregions;
- Aerial photography; and
- Beard vegetation associations (Shepherd *et al.* 2001).

During the survey, additional information was also collected to aid in habitat mapping, including:

- Landform;
- Vegetation type and structure; and
- Composition of terrestrial fauna community.

2.6.6 Fauna taxonomy and nomenclature

Nomenclature for mammals, reptiles and amphibians within this report follows the *Western Australian Museum Checklist of the Vertebrates of Western Australia* and birds according to Christidis and Boles (2008). References used for fauna identification are listed in Table 2.9.

Table 2.9 – References used for identification

Fauna group	Reference
Mammals	Menkhorst and Knight (2011), Van Dyck and Strahan (2008)
Bats	Churchill (1998), Menkhorst and Knight (2011)
Birds	Morecombe (2000), Pizzey & Knight (2013)
Reptiles	Wilson and Swan (2010), Cogger (2000)
Amphibians	Tyler and Doughty (2009), Cogger (2000)

2.6.7 Animal ethics

Surveying was conducted as per *ecologia*'s Animal Ethics Code of Practice, which conforms to Section 5 of the *Australian code of practice for the care and use of animals for scientific purposes* (NHMRC 2004).

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3 EXISTING ENVIRONMENT

3.1 CLIMATE

The study area is situated in the Kimberley region of Western Australia at the south-east edge of the Dampier Peninsula. The area has a dry, hot, tropical climate with two distinct seasons: the 'wet' from around December to March, and the 'dry' for the remainder of the year. Rainfall is highly variable in the region due to the inconsistent nature of the movement and occurrence of thunderstorms and tropical systems. Tropical cyclones can occur as late as April, but are most common in January and February. Rainfall during the cooler months is usually associated with cloud bands originating from tropical waters to the north-west (BoM 2015). The average temperature over summer is over 33 °C, with warm overnight minima of around 26 °C (BoM 2015). Winter temperatures are quite mild, with average maximum and minimum temperatures in July being 26.9 °C and 12.0 °C respectively (BoM 2015).

The nearest Bureau of Meteorology (BoM) weather stations (with full data sets) to the study area are Derby Aero (BoM Station 3032) and Broome Airport (BoM Station 3003). Derby Aero is located 70 km east of the study area with Broome Airport located 95 km to the south-west. These stations were selected as a reference to provide the best indication of the local climatic conditions of the study area (Figure 3.1).

The mean annual rainfall for Broome is 612.0 mm, but highly variable with the majority of the annual rainfall usually falling between January and March (BoM 2015). The mean number of rainfall days (≥1 mm) a year is only 35.1. Generally, the wettest months are January and February, with mean rainfall of 181.6 mm and 178.8 mm respectively. The hottest month is April and the coldest is July, with means of 34.3 °C and 28.8 °C, respectively.

The mean annual rainfall for Derby is 682.9 mm, with the majority of the annual rainfall usually falling between December and March (BoM 2015). The mean number of rainfall days (≥1 mm) per year is 38. January and February are generally the wettest months of the year, recording a mean rainfall of 199.0 mm and 199.6 mm respectively. The hottest month is November and the coldest is June, with mean maximum temperatures of 38.1^{o}C and 30.4^{o}C, respectively.

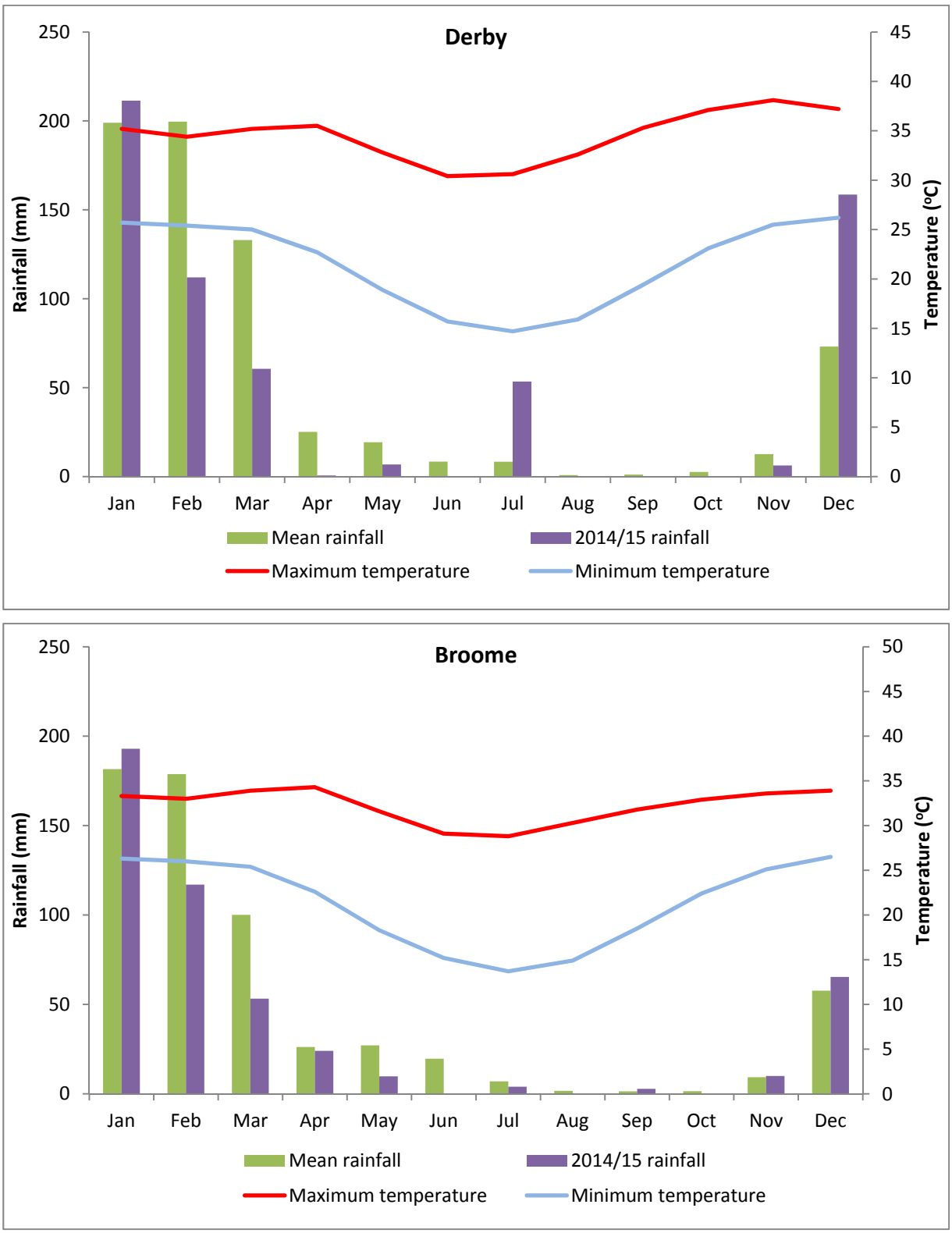
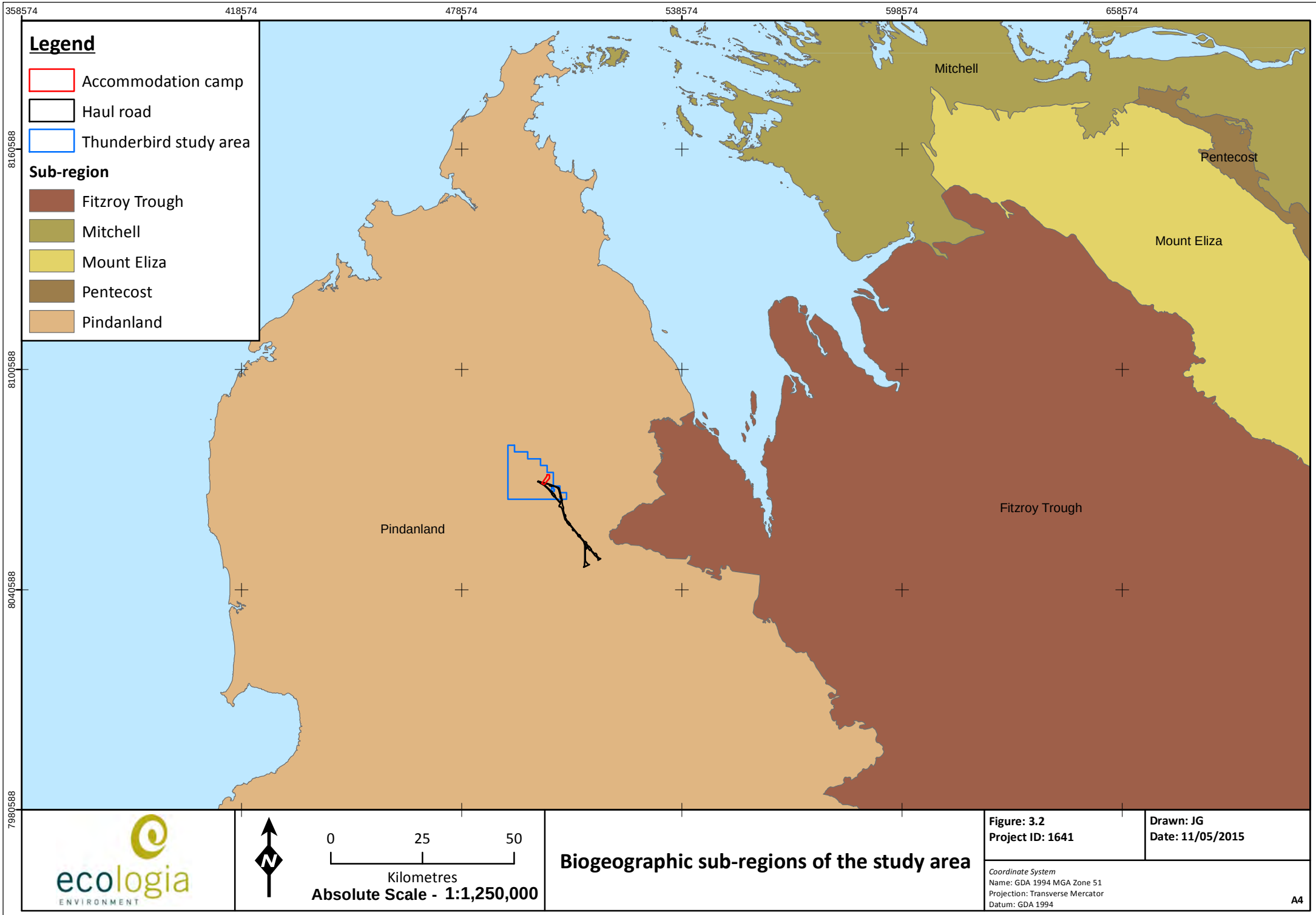


Figure 3.1 – Climate data for Derby and Broome (BoM 2015)

3.2 BIOGEOGRAPHIC REGIONS

The Interim Biogeographic Regionalisation for Australia (IBRA) (Version 7) classifies the Australian continent into bioregions of similar geology, landform, vegetation, fauna and climate characteristics (DSEWPaC 2012a). The study area lies within the Dampierland bioregion. The Dampierland bioregion is further subdivided into two subregions, these being the Fitzroy Trough (DL1) and Pindanland (DL2) subregions. The study area lies entirely within the Pindanland subregion of the Dampierland Bioregion (Figure 3.2).

The Pindanland subregion covers approximately 59% of the Dampierland bioregion. This subregion consists of sandplains of a fine-textured sand-sheet with subdued dunes and includes the paleodelta of the Fitzroy River. The vegetation is described primarily as pindan (Graham 2002). The dominant land uses are grazing, unallocated crown land, crown reserves and native pastures.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Biogeographic sub-regions of the study area
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Project ID: 1641
Drawn: JG
Date: 11/05/2015
Coordinate System
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Projection: Transverse Mercator
Datum: GDA 1994
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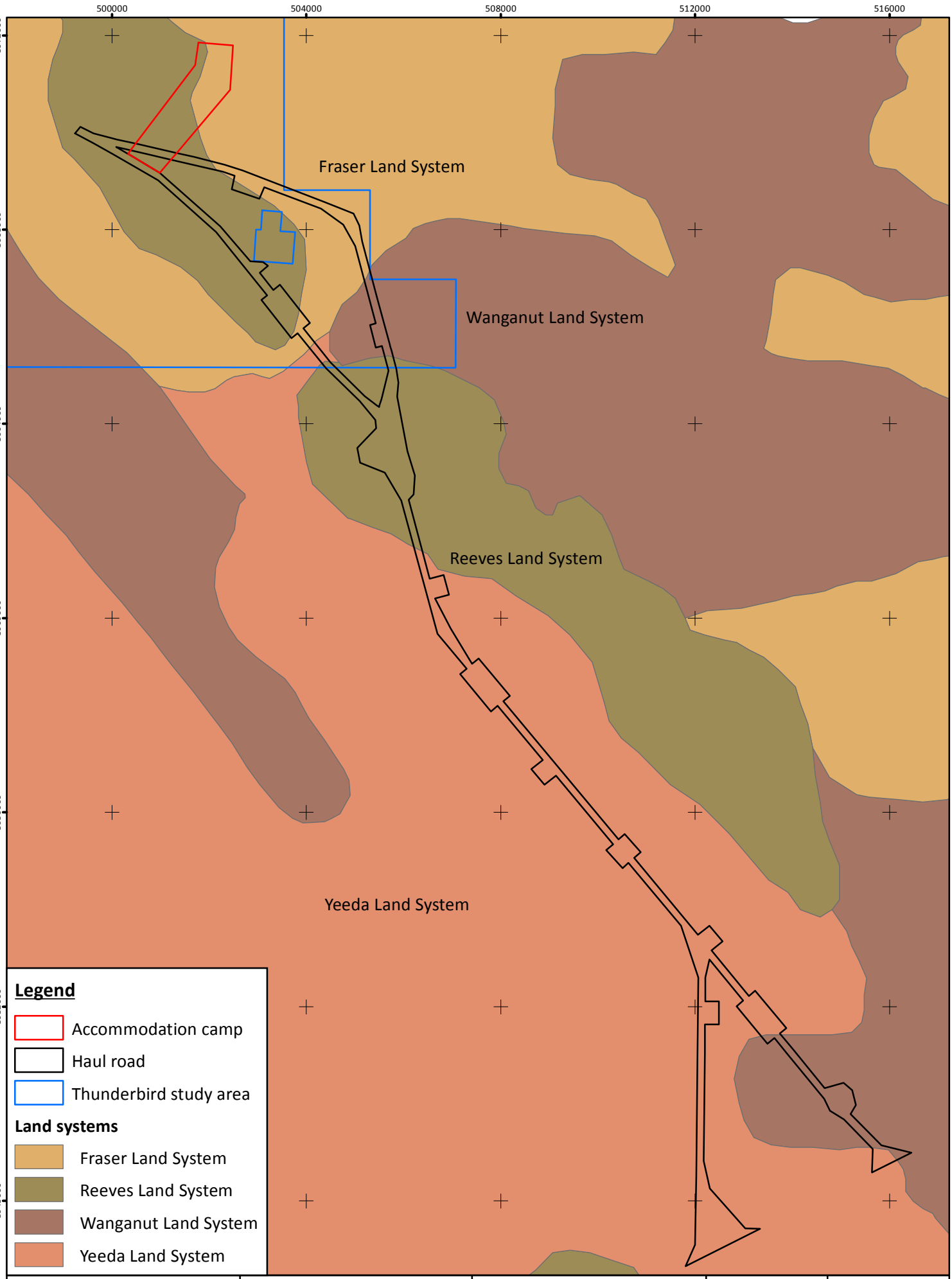
3.3 LAND SYSTEMS

Land systems are described using the biophysical characteristic of geology, landform, vegetation and soils. The study areas fall across four of these land systems; Fraser, Reeves, Waganut and Yeeda. The haul road study area encompasses all four of the listed land systems, while the camp study area covers two land system types; Fraser and Reeves. A brief description and details on the extent of each land system within the study area are provided in Table 3.1 and mapped in Figure 3.3. All four land systems are quite widely distributed within the region; Reeves land system has the highest proportion of its total extent located within the study areas; approximately 1.1% in total.

Table 3.1 – Land systems of the study area

Land System	Description	Total area in Dampierland (ha)	Study area (outside Thunderbird) (ha)	Study area (inside Thunderbird) (ha)	Total area (ha)	Proportion in study area (%)	Percentage of total extent within Dampierland (%)
Fraser	Sand plain with irregular dunes and local stony surfaces, pindan and low grassy woodlands.	73,275	0.6	189.5	190.1	14.1	0.259
Reeves	Sand plain with scattered hills and minor plateaux, reddish sandy soils, pindan.	44,794	185.0	309.1	494.1	36.6	1.103
Waganut	Low lying sandplains and dune fields with through going drainage supporting pindan *Acacia* shrublands with emergent eucalypt trees.	518,511	83.5	33.3	116.8	8.7	0.023
Yeeda	Sandplains with red and yellow sands supporting pindan *Acacia* shrublands with emergent eucalypt trees.	1,653,086	541.7	6.6	548.3	40.6	0.033
Total	**N/A**	**N/A**	**810.8**	**538.5**	**1,349.3**	**100%**	**N/A**



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Land systems of the study area

Figure: 3.3
Project ID: 1641

Drawn: BG
Date: 7/5/15

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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3.4 REGIONAL VEGETATION

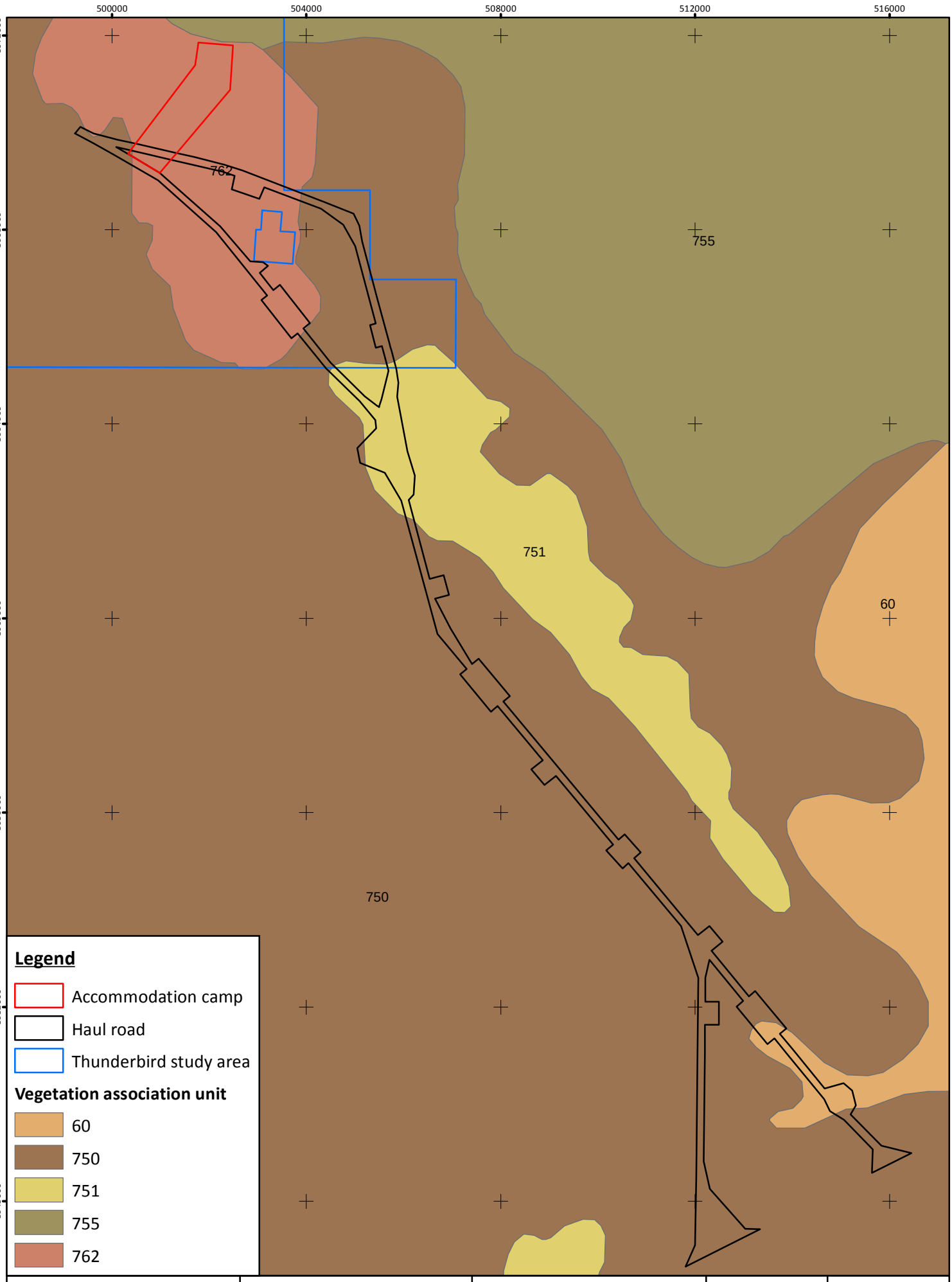
The Dampier Peninsula on which the study area is located lies within the Northern Botanical Province of Western Australia. The vegetation of Western Australia was originally mapped at the 1:1,000,000 scale by Beard (1979), and was subsequently reinterpreted and updated to reflect the NVIS standards (Shepherd *et al.* 2001). Four of the vegetation types identified by (Shepherd *et al.* 2001) are found within the study area: vegetation associations 60, 750, 751, and 762. The majority of the camp study area (99.7%) consists of vegetation association 762, whilst association 750 is the most extensive association within the haul road study area, covering 61.5% of the area (Figure 3.4, Table 3.2).

Vegetation associations 750 and 762 collectively comprise 82.1% of the study area and are described as having similar vegetation; typically that of pindan shrubland with *Acacia tumida* and other *Acacia* species, with open eucalypt woodlands over ribbon grass and curly spinifex (Shepherd *et al.* 2001).

In a regional context, three vegetation units occur extensively outside of the study areas. Unit 762 is the least extensive of the four units, with the study area representing 7.75% of its total extent.

Table 3.2 –Vegetation association units of the study area

Shepherd Veg. Unit	Description	Total area in Dampierland (ha)	Study area (outside Thunderbird) (ha)	Study area (inside Thunderbird) (ha)	Total area (ha)	Proportion in study area (%)	Percentage of total extent within Dampierland (%)	Total current extent (ha)	Pre-European extent (ha)	Remaining (%)
60	Grasslands; tall bunch grass savannah woodland, grey box & cabbage gum over ribbon grass	8,278.5	70.0	-	70	5.2	0.85	179,276.6	179,256.7	99.99
750	Shrublands, pindan; *Acacia tumida* shrubland with grey box & cabbage gum medium woodland over ribbon grass & curly spinifex	1,218,427.5	570.8	125.0	695.8	51.6	0.06	1,231,155.5	1,225,687.5	99.56
751	Hummock grasslands, shrub steppe; *Acacia eriopoda* over soft spinifex	15,994.7	169.4	1.9	171.3	12.7	1.07	15,994.7	16,045.3	99.68
762	Shrublands, pindan; *Acacia eriopoda & A. tumida* shrubland with scattered low *Eucalyptus confertifolia* over curly spinifex	5,319.6	0.6	411.6	412.2	30.5	7.75	6,807.4	6,811.4	99.94
Total	**N/A**	**N/A**	**810.9**	**538.5**	**1,349.3**	**100**	**N/A**	**N/A**	**N/A**	**N/A**



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Vegetation association units of the study area

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Date: 7/5/15

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Projection: Transverse Mercator
Datum: GDA 1994

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4 LITERATURE REVIEW

4.1 FLORA

A search of the DPaW's Threatened and Priority Flora Database (DPaW search reference 15-0313) and a literature review of previous projects in the vicinity was conducted with a buffer of 50 km around the Thunderbird study area.

Currently, 74 Threatened or Priority flora taxa are listed as occurring in the Dampierland bioregion (Western Australian Herbarium, July 2015). A database search of the DPaW Threatened (Declared Rare) and Priority Flora Database indicated that 26 Priority Flora have previously been recorded within 50 km of the study area, however the previously Priority 3 taxon *Eriachne* sp. Dampier Peninsula (K.F. Kenneally 5946) is no longer considered to be a Priority flora taxon. Two additional Priority taxa were found to occur within 50 km of the study area from the literature review of three *ecologia* reports within the vicinity of the study area (*ecologia* 2004a, b, 2012, 2014a). The likelihood of a conservation significant species being present within the study area (categorised by Table 4.1) was determined by examining the following:

- Potential habitats, and their condition, known to exist within the study area;
- Distance of previously recorded locations from the study area;
- Frequency of occurrence of records in the region; and
- Time elapsed since recorded within, or surrounding, the study area.

Of the 27 Priority Flora recorded within 50 km of the Thunderbird project study area (Table 4.2), five have previously been recorded within the Thunderbird study area by *ecologia* in previous surveys completed in 2012 (*ecologia* 2012) and 2014 (*ecologia* 2014a): *Fuirena nudiflora* (Priority 1), *Fuirena nudiflora* (Priority 1), *Pterocaulon intermedium* (Priority 3), *Tephrosia valleculata* (Priority 3) and *Triodia caelestialis* (Priority 3).

Table 4.1 – Criteria used to assess likelihood of occurrence of significant flora

Likelihood of Occurrence	Criteria
Recorded	The taxon has been recorded within the study area.
Probable	Due to the proximity of previous records (0-5 km) and the presence of suitable habitat, the taxon is considered highly likely to occur within the study area.
Likely	Given the presence of suitable habitat and moderate proximity (2-5 km) of previous records, the taxon is considered likely to occur within the study area.
Possible	The habitat specificity of the taxon is only broadly defined, or is not defined and/or there are no current records within 5-10 km. However there is insufficient information available to exclude the possibility of occurrence within the study area.
Unlikely	The habitat specificity of the taxon is well defined from previous records and the habitat is considered unlikely to be present within the study area.

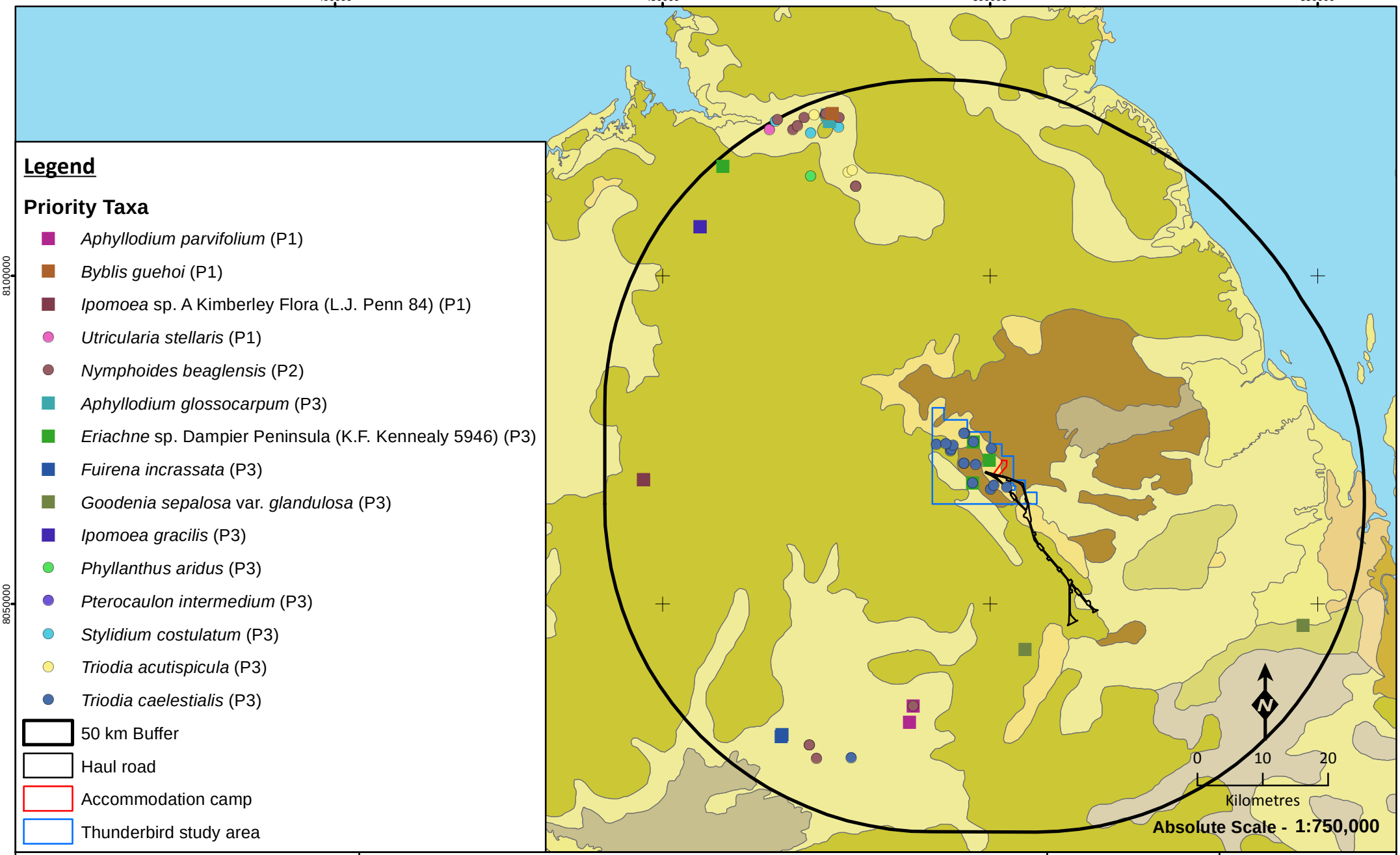
Table 4.2 – Priority flora recorded within 50 km of the Thunderbird study area

Taxon	DPaW Status	Preferred Habitat	Distribution	Likelihood of Occurrence
Aphyllodium parvifolium	P1	Occurs in sand and clay, can be close to water.	Broome, McLarty Hills	Unlikely
Byblis guehoi	P1	Occurs in sand and silt-loam soils that are waterlogged in the wet season but dry soon after.	Dampier Peninsula	Possible
Cyperus haspan subsp. *haspan*	P1	Occurs in peat bank on the edge of spring	Dampier Peninsula	Unlikely
Ipomoea gracilis	P1	Occurs on clay or irrigated sand, close to rivers.	Kununurra, Ord River.	Unlikely

Taxon	DPaW Status	Preferred Habitat	Distribution	Likelihood of Occurrence
Ipomoea sp. A Kimberley Flora (L.J. Penn 84)	P1	Occurs in shallow soils on sandstone	Dampier Peninsula	Possible
Jacquemontia sp. Broome (A.A. Mitchell 3028)	P1	Occurs in woodlands on Pindan plain	Dampier Peninsula	Likely
Nicotiana heterantha	P1	Black clay. Seasonally wet flats.	Broome, Dampier Peninsula, Roy Hill, Mandora, Anna Plains	Possible
Parsonsia kimberleyensis	P1	Occurs on vine thickets	Dampier Peninsula	Unlikely
Thespidium basiflorum	P1	Occurs in sandy soil creek beds	Dampier Peninsula	Unlikely
Utricularia stellaris	P1	Occurs in swampy areas, commonly submerged in water.	Wyndham, Dampier Peninsula, Mitchell Plateau	Possible
Nymphoides beaglensis	P2	In shallow freshwater. Edges of permanent waterholes or in seasonally inundated claypans & depressions.	Dampier Peninsular, Beagle Bay, Lake Campion, Yabbagoody Clay Pan	Unlikely
Acacia sp. Riddell Beach (T. Willing 71)	P3	Occurs on cliffs and gullys, and close to roads. In sand, loam and rocky soil.	Broome, Dampier Peninsula	Unlikely
Aphyllodium glossocarpum	P3	Occurs in sand verging onto cleared areas and open grassland fringes	Dampier Peninsula	Possible
Cupaniopsis anacardioides	P3	Vine thickets	Dampier Peninsula, Mitchell Plateau, Middle Osborn Is., Bouganville Peninsula, NT, QLD	Possible
Dendrophthoe odontocalyx	P3	Occurs in swamp areas and woodlands.	Koolan Is., Dampier Peninsula, Prince Regent N.R.,	Likely
†*Eriachne* sp. Dampier Peninsula (K.F. Kenneally 5946)	P3	Plain. Red-brown sandy loam. Pindan Sands	Scattered on Dampierland an in the Fitzroy Trough	Recorded
Fuirena incrassata	P3	Occurs in sand and claypans, generally close to water	Googhenama Creek, Broome	Unlikely
Gomphrena pusilla	P3	Occurs on coastal sand dunes, with either calcrete sands or fine shell grit	Dampier Peninsula, Pt Hedland	Likely
Goodenia sepalosa var. *glandulosa*	P3	Occurs in Pindan sand or loam	Derby, Lake Argyle, Robinson River, Fitzroy Crossing, Yeeda	Possible
Lophostemon grandiflorus subsp. *grandiflorus*	P3	Occurs in damp habitats	Dampier Peninsula, Edgar Range	Likely
Phragmites karka	P3	Edges of pools and creeks	Scattered throughout the Kimberley and Pilbara	Unlikely
Phyllanthus aridus	P3	Rangeland and hillside. Sandstone. Red sand and ironstone gravel. With exposed rocks	Broome, Derby-West Kimberley, East Pilbara, Halls Creek, Wyndham-East Kimberley.	Likely
Pterocaulon intermedium	P3	Flat plains and sometimes claypans. In pindan red sand - loam.	Broome, Derby-West Kimberley, Port Hedland, Wyndham-East Kimberley.	Recorded
Stylidium costulatum	P3	Sandy or clayey soils. Creeks or seasonally wet areas.	Dampier Peninsula, Beverley Springs Stn, Mt Barnett Stn, Coulomb Point	Possible
Triodia acutispicula	P3	Sandy soils. River levees, pindan plains, rocky hillslopes & outcrops.	Scattered throughout Western Kimberley	Possible

Taxon	DPaW Status	Preferred Habitat	Distribution	Likelihood of Occurrence
Triodia caelestialis	P3	Red-brown, sand-silt-clay and pindan soils usually in low plains	Central Kimberley, Dampierland, Northern Kimberley. Broome, Derby-West Kimberley.	Recorded
Haemodorum gracile	P4	Occurs in sand, and sandy clay in open woodlands and creek banks	Cahmpagny Is., Yampi Peninsula, Dampier Peninsula, Edkins Range, Kimbolton Stn.,Prince Regent River N.R., Derby	Unlikely
Pittosporum moluccanum	P4	White sand. Sand dunes	Dampier Peninsula, N of Broome, Berthier Is., Maret Is., N.T., SE Asia	Unlikely

†*Eriachne* sp. Dampier Peninsula (K.F. Kenneally 5946) is no longer considered to be a Priority flora taxon.



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Previously Recorded Priority Flora (includes DPaW Search: 15-0313)

Figure: 4.1
Project ID: 1641

Drawn: MM
Date: 10/07/2015

Coordinate System
Name: GDA 1994 MGA Zone 51
Datum: GDA 1994

A4

4.2 THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

A search of Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs) within and adjacent to the study area was undertaken as part of the literature review. Two priority 3 PECs were recorded within 60 km of the study area; vegetation assemblages of Lolly Well Springs wetland complex and assemblages of Disaster Bay organic mound springs (Table 4.3, Figure 4.2).

Table 4.3 – TECs and PECs recorded within 60 km of the Thunderbird study area

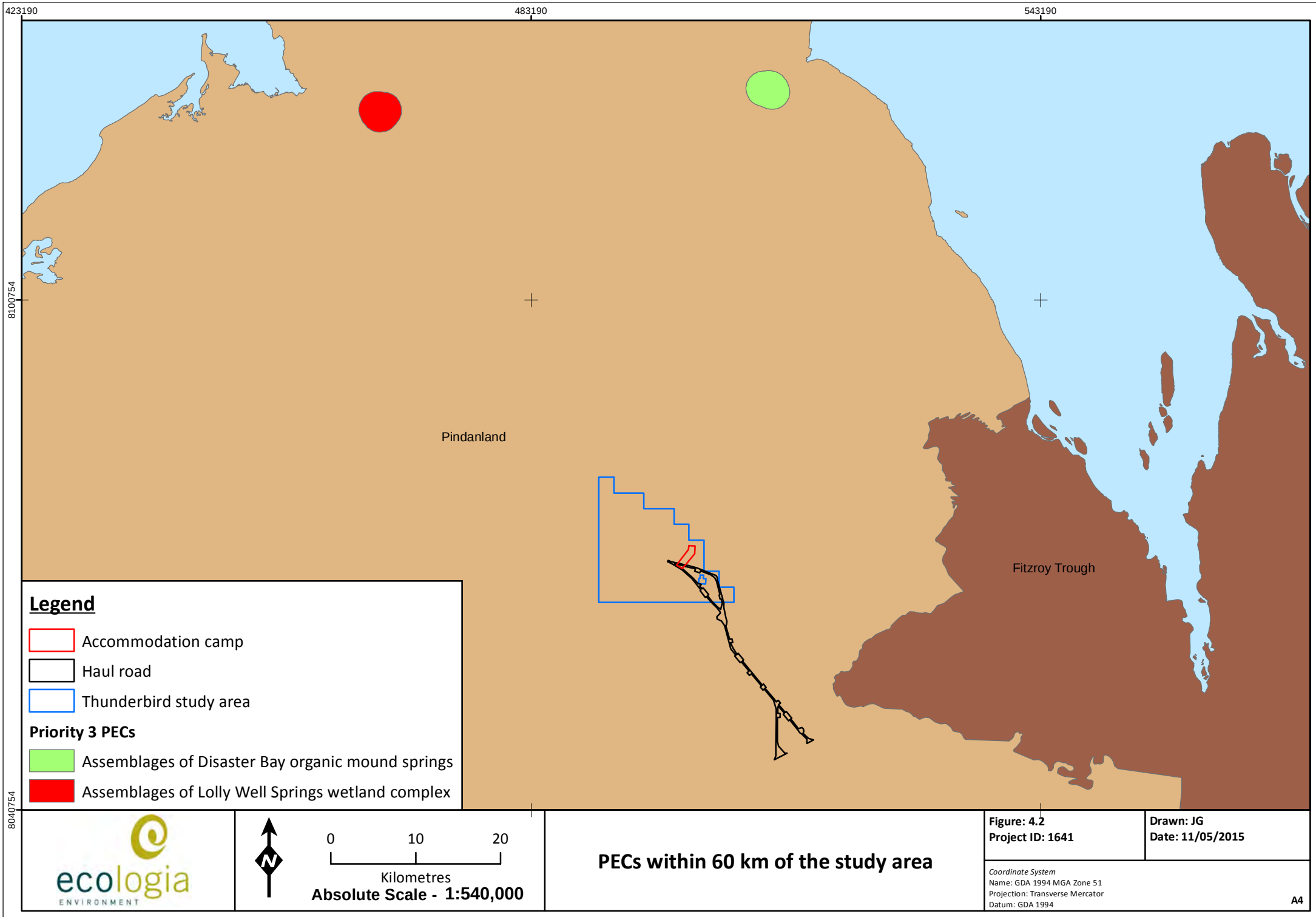
Status	Description	Distance from study area
PEC (Priority 3)	Assemblages of Disaster Bay organic mound springs	50 km NNE
PEC (Priority 3)	Assemblages of Lolly Well Springs wetland complex	60 km NW

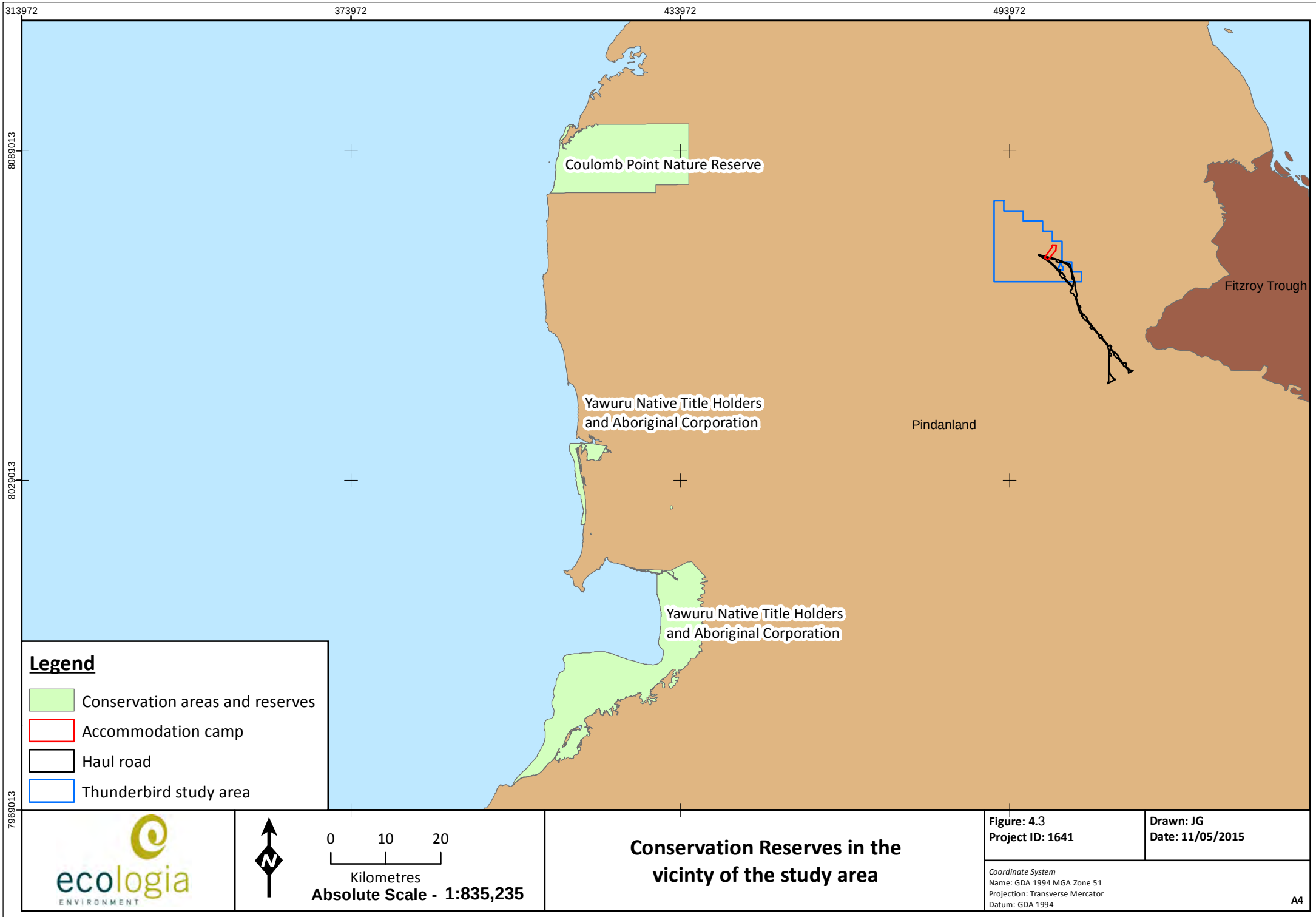
4.3 CONSERVATION RESERVES

The study area does not intersect with any conservation areas or reserves. The Coulomb Point Nature Reserve is situated approximately 65 km west of the study area, while two reserves belonging to the Yawuru Native Title Holders and Aboriginal Corporation are located approximately 90 km south-west of the study area (Figure 4.3).

4.4 ENVIRONMENTALLY SENSITIVE AREAS

Environmentally Sensitive Areas (ESAs) are declared by notice under Section 51B of the *Environmental Protection Act 1986* (EP Act). A search of DER's online Native Vegetation Viewer (DER 2014) was undertaken to determine the locations of any ESAs within the study area. No ESAs occur at the study area.


423190
483190
543190
8100754
8040754
Pindanland
Fitzroy Trough
Legend
Accommodation camp
Haul road
Thunderbird study area
Priority 3 PECs
Assemblages of Disaster Bay organic mound springs
Assemblages of Lolly Well Springs wetland complex
ecologia
ENVIRONMENT
N
0
10
20
Kilometres
Absolute Scale - 1:540,000
PECs within 60 km of the study area
Figure: 4.2
Project ID: 1641
Drawn: JG
Date: 11/05/2015
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
A4

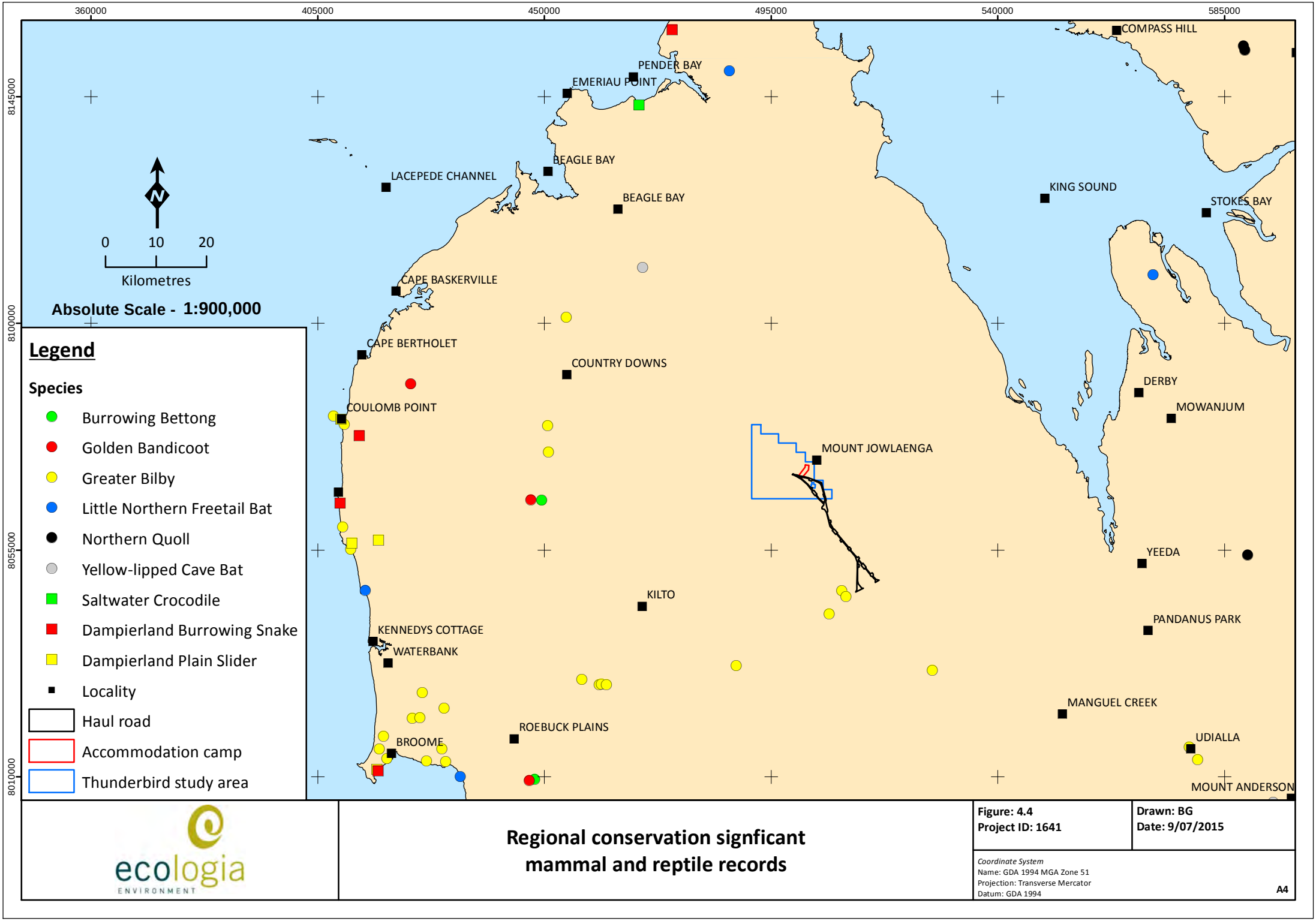

313972
373972
433972
493972
8089013
8029013
7969013
Coulomb Point Nature Reserve
Yawuru Native Title Holders and Aboriginal Corporation
Yawuru Native Title Holders and Aboriginal Corporation
Pindanland
Fitzroy Trough
Legend
Conservation areas and reserves
Accommodation camp
Haul road
Thunderbird study area
ecologia ENVIRONMENT
N
0 10 20
Kilometres
Absolute Scale - 1:835,235
Conservation Reserves in the vicinty of the study area
Figure: 4.3
Project ID: 1641
Drawn: JG
Date: 11/05/2015
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
A4

4.5 FAUNA

The literature review identified a total of 383 fauna species as potentially occurring in the study area. This includes 32 native and six introduced mammal species, 249 bird species, 82 reptiles and 14 amphibians. A comprehensive list of potentitally occurring species is provided in Appendix B.

Included in the species recorded from the literature review are a total of 69 conservation significant vertebrate fauna species, comprising six mammal species, 59 bird species, and four reptile species. Previous records of conservation significant fauna recorded in the region are mapped in Figure 4.4 and Figure 4.5.

All potential conservation significant species recorded from the literature review had their likelihood of occurrence assessed, based on the methodology described in Section 2.6.1. The results of this analysis are discussed in Section 5.3.3



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Regional conservation signficant mammal and reptile records

Figure: 4.4
Project ID: 1641

Drawn: BG
Date: 9/07/2015

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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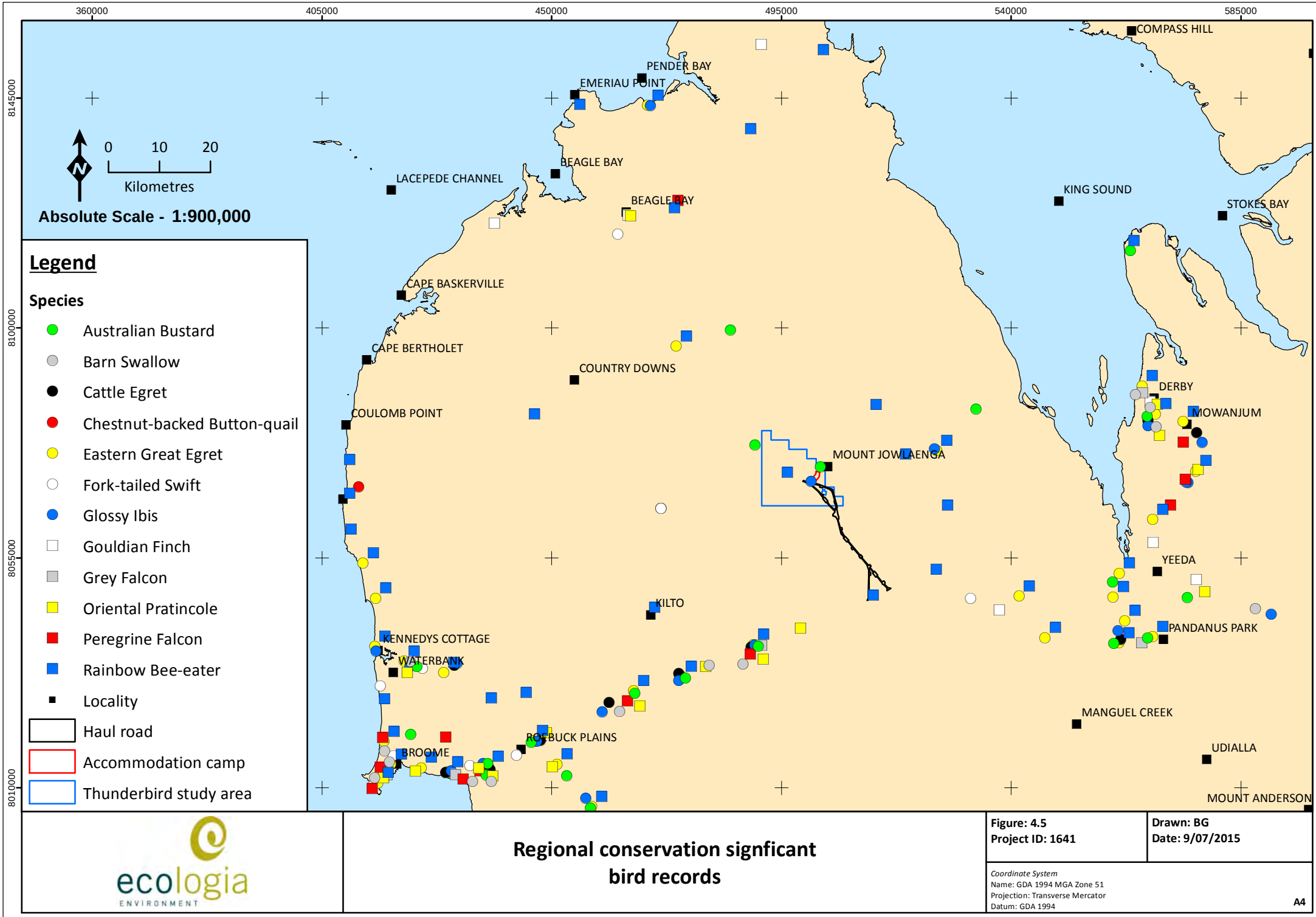

ecologia ENVIRONMENT

Regional conservation signficant bird records

Figure: 4.5
Project ID: 1641

Drawn: BG
Date: 9/07/2015

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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5 RESULTS

5.1 FLORA

A total of 162 vascular plant taxa (including species, infraspecific taxa, and phrase name taxa) were recorded from the study area, representing 97 genera and 41 families. This includes two Priority Flora species: *Pterocaulon intermedium* (Priority 3) and *Triodia caelestialis* (Priority 3) and four introduced species: **Malvastrum americanum*, **Stylosanthes hamata*, **Stylosanthes scabra* and **Tridax procumbens*. A complete list of taxa recorded, including opportunistic collections and partially identified specimens, is included in Appendix E. The most species rich families are Poaceae and Fabaceae with 31 and 30 taxa respectively, and the most species rich genus is *Acacia,* with seven taxa.

Species richness within quadrats ranged from 16 to 31 taxa, with a mean species richness of 22.7 (± 3.9 standard deviation). The quadrat with the highest species richness of 31 taxa was quadrat 1 and the quadrat with the lowest species richness of 16 taxa was quadrat 16. Site descriptions for each quadrat are provided in Appendix F.

5.1.1 Survey Adequacy

When using the 16 quadrats completed at the study area, the predicted taxa richness, as calculated by Chao 2 Mean is 196 taxa. The total number of taxa recorded from quadrats within the study area is 138 (excluding opportunistic collections and potential duplicates), which represents between 71% of the expected taxa richness for the study area (Figure 5.1). When combined with the previous Thunderbird data from 2012 (*ecologia* 2012) and 2014 (*ecologia* 2014a) the expected number of taxa (Chao 2 Mean) is 340, of which the 282 collected from the combined projects represents 83%.

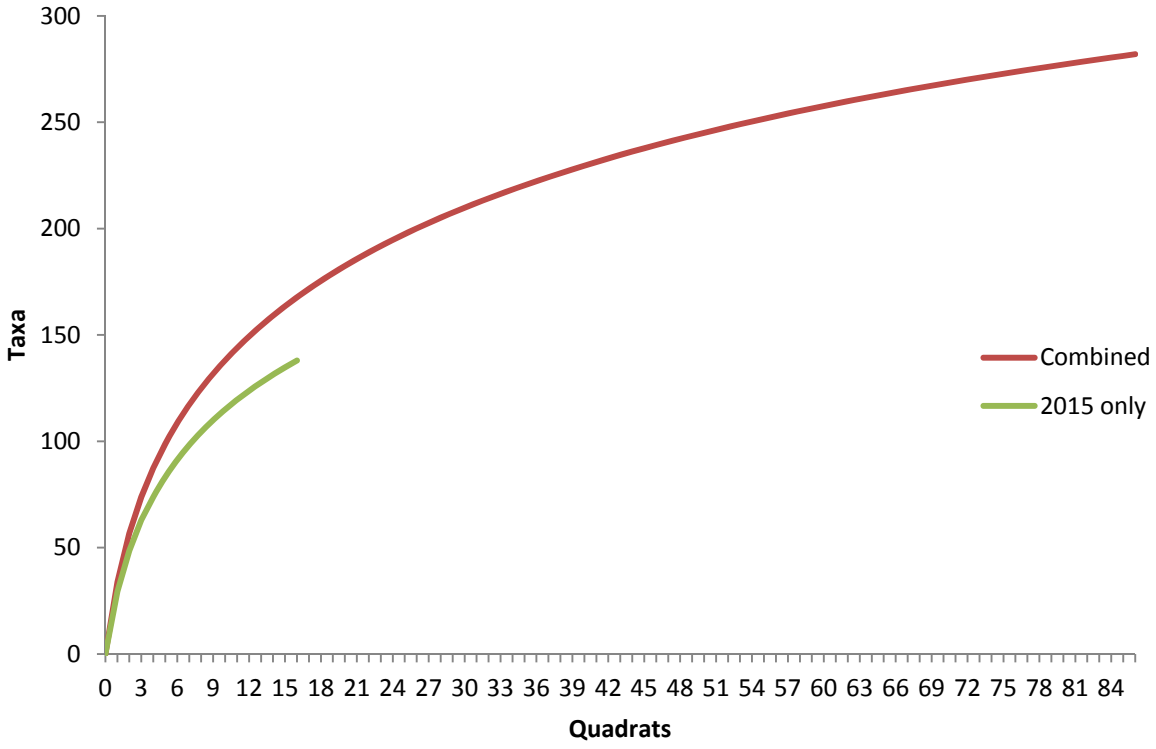


Figure 5.1 – SAC analysis for the study area

5.1.2 Flora of Conservation Significance

Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth of Australia)

No EPBC Act listed Threatened Flora taxa were recorded at the study area.

Wildlife Conservation Act 1950 (Western Australia)

No WC Act listed Threatened Flora taxa were recorded at the study area.

Priority Flora

Two Priority flora species were recorded at the study area: *Pterocaulon intermedium* (Priority 3) and *Triodia caelestialis* (Priority 3). Both of these species were recorded during previous assessments at Thunderbird (*ecologia* 2012, 2014a). Coordinates and abundance of Priority flora records are provided in Appendix G, and locations mapped in Figure 5.2.

Pterocaulon intermedium (Priority 3) was recorded at 14 locations (representing 14 individuals) across the study area, on red sandy plains.

Triodia caelestialis (Priority 3) recorded at 25 locations representing 8,271 individuals, and is the dominant understorey species in some of the vegetation units identified in the study area, such as *GpAmStTc*.

5.1.3 Introduced Flora

Weeds of National Significance

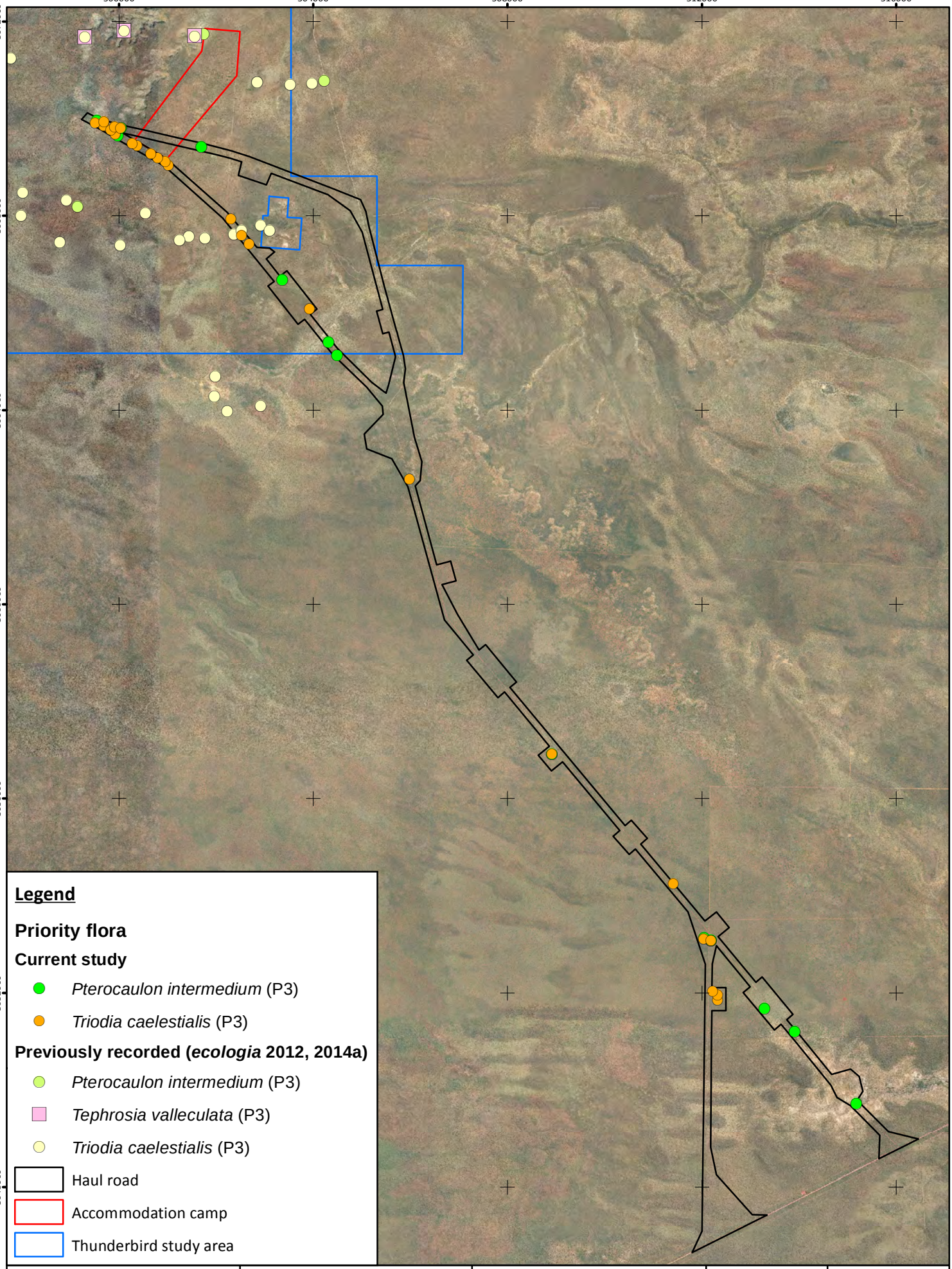
No WONs were recorded at the study area.

Declared Pest (Weeds)

No Declared Pests (Weed) species were recorded at the study area.

Environmental Weeds

Four environmental weeds were recorded at the study area: **Malvastrum americanum*, **Stylosanthes hamata*, **Stylosanthes scabra* and **Tridax procumbens*. Coordinates and abundance of Priority flora records are provided in Appendix G, and locations mapped in Figure 5.3.



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0 1.5 3

Kilometres

Absolute Scale - 1:100,000

Priority flora locations

Figure: 5.2
Project ID: 1641

Drawn: MM
Date: 10/7/15

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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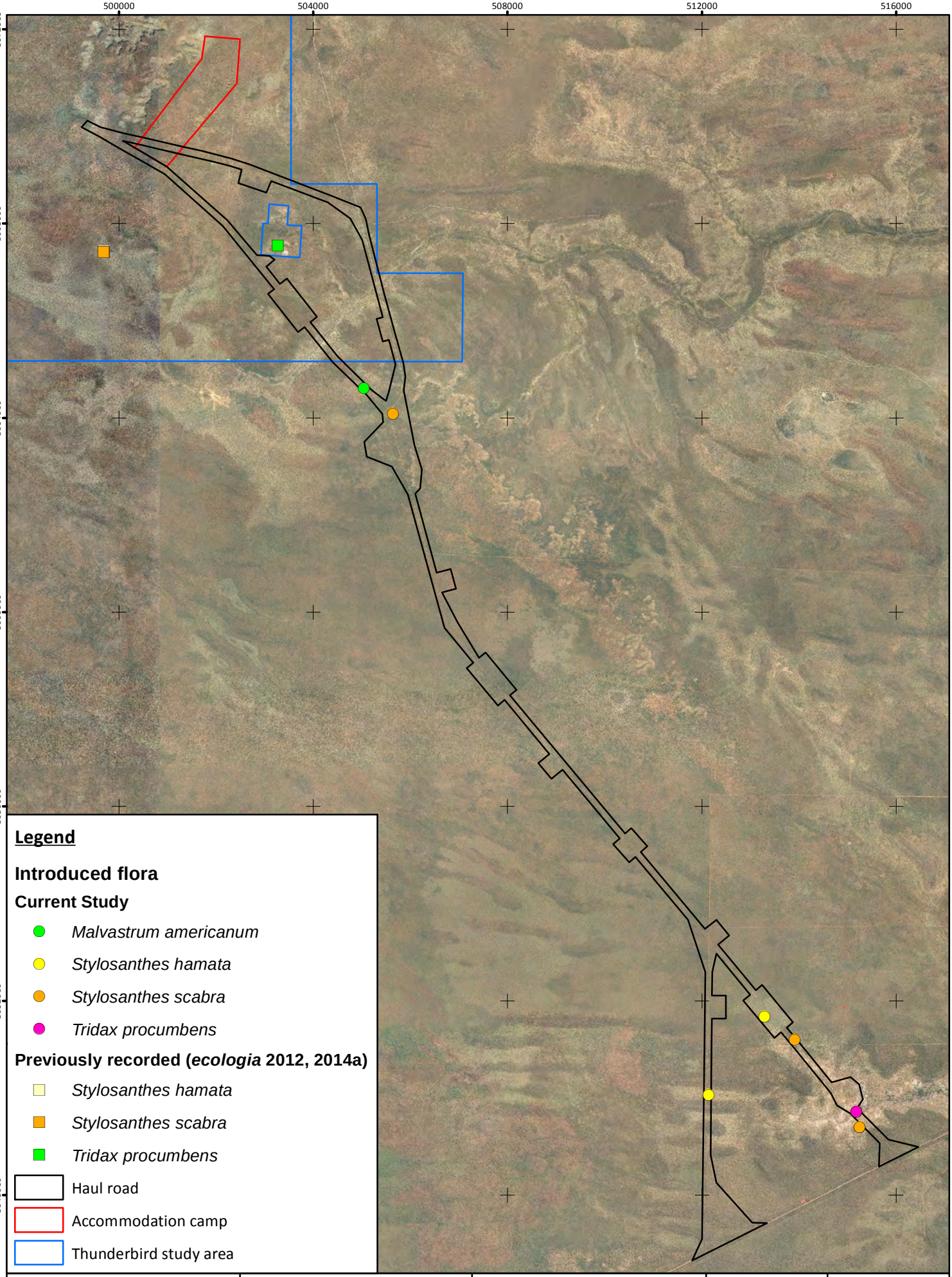


ecologia ENVIRONMENT

0 1.5 3

Kilometres

Absolute Scale - 1:100,000

Introduced flora locations

Figure: 5.3
Project ID: 1641

Drawn: MM
Date: 10/7/15

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

A4

5.2 VEGETATION

5.2.1 Vegetation Units

Eleven vegetation units were mapped from the study area and are described in Table 5.1 and mapped on Figure 5.4. Nine of these units are identical to those described in the previous Level 2 flora and vegetation assessment of the Thunderbird project (*ecologia* 2014a). Two vegetation units: *AtStCpHc* and *CgDhHc* are not described in the previous Level 2 flora and vegetation assessment of the Thunderbird project (*ecologia* 2014a)

The most abundant vegetation unit at the study area *AtStCpHc*, comprising 46.3% of the study area (and represented by 8 quadrats in the study area), followed by *EcAtSt* (13.6% of the study area) and *GpAmStTc* (13.1% of the study area).

The least abundant vegetation units in the study area are *EtApStCpEo*, *CdTcTc* and *CgApSt*, each occupying less than 0.5% of the study area, but relatively well represented in the Thunderbird project area.

The two newly mapped vegetation units *AtStCpHc* and *CgDhHc* are both wholly within the study area, but as they are associated with widespread landforms in the region (i.e. sandy plains), they are not expected to be restricted to the study area and are likely to represent vegetation that is abundant in the surrounding landscape.

The dendrogram used to map the vegetation at the study area is shown in Figure 5.5 – Dendogram used to define the vegetation units.

5.2.2 Vegetation Condition

The majority of the vegetation at the study area was rated as of “Very Good” condition, representing 56% of the study area. Of the remainder, 25% was mapped as “Good” and 19% as “Excellent”. The vegetation condition has been mapped in Figure 5.6.

Table 5.1 – Vegetation units of the study area

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
AtStCpHC	1 3 4 5 7 16 17 18	Landform: Sandy plain *Acacia tumida* var. *tumida* tall shrubland, over *Sorghum timorense, Chrysopogon pallidus* and *Heteropogon contortus* tussock grassland. Average species richness = 22.1 ± 5.6 Sample size = 8	*Brachychiton diversifolius subsp. diversifolius* *Corymbia greeniana* *Dolichandrone heterophylla* *Eriachne obtusa* *Erythrophleum chlorostachys* *Galactia tenuiflora* *Grevillea refracta subsp. refracta* *Microstachys chamaelea* *Terminalia canescens*	625	625 (100%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
BdEcAtApSt	None from 2015 survey	Landform: Sandy plain *Brachychiton diversifolius* subsp. *diversifolius* and *Erythrophleum chlorostachys* low open woodland over *Acacia tumida* var. *tumida* and *Acacia platycarpa* tall, sparse shrubland over *Sorghum timorense* sparse tussock grassland Average species richness = 32.2 ± 3.8 Sample size = 5	*Acacia platycarpa* *Acacia tumida var. tumida* *Brachychiton diversifolius subsp. diversifolius* *Chrysopogon pallidus* *Corchorus sidoides subsp. vermicularis* *Corymbia greeniana* *Dodonaea hispidula var. arida* *Erythrophleum chlorostachys* *Microstachys chamaelea* *Sorghum timorense*	35	541 (6.4%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
BdEcAtSt	2	Landform: Sandy plain *Brachychiton diversifolius* subsp. *diversifolius* and *Erythrophleum chlorostachys* low open woodland over *Acacia tumida* var. *tumida* sparse shrubland over *Sorghum timorense* sparse tussock grassland Average species richness = 22.2 ± 1.3 Sample size = 10	*Acacia platycarpa* *Aristida hygrometrica* *Bauhinia cunninghamii* *Chrysopogon pallidus* *Corymbia greeniana* *Dolichandrone heterophylla* *Eragrostis eriopoda* *Eriachne obtusa* *Grevillea refracta subsp. refracta* *Solanum cunninghamii* *Spermacoce occidentalis* *Waltheria indica*	75	2,111 (3.6%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
CdTcTc	None from 2015 survey	Landform: Hillslope - midslope or ridgetop *Corymbia* dendromerinx and *Terminalia canescens* low, open woodland, over *Triodia caelestialis* (P3) open hummock grassland Average species richness = 24.9 ± 1.7 Sample size = 12	*Corymbia dendromerinx* *Eriachne obtusa* *Gomphrena canescens subsp. canescens* *Grevillea pyramidalis subsp. pyramidalis* *Indigofera linifolia* *Sorghum timorense* *Stemodia lythrifolia* *Terminalia canescens* *Triodia caelestialis* *Wrightia saligna*	4.1	1,308 (0.3%)
					

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
CgApSt	None from 2015 survey	Landform: Sandy plain *Corymbia greeniana* mid, open woodland, over *Acacia platycarpa* tall, sparse shrubland, over *Sorghum timorense* open tussock grassland Average species richness = 18.3 ± 2.2 Sample size = 6	*Acacia platycarpa* *Aristida hygrometrica* *Chrysopogon pallidus* *Corymbia dendromerinx* *Corymbia greeniana* *Erythrophleum chlorostachys* *Grevillea refracta subsp. refracta* *Microstachys chamaelea* *Solanum cunninghamii* *Sorghum timorense*	4.2	1,155 (0.4%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
CgDhHc	8 9 11 13	Landform: Floodplains adjacent to ephemeral waterways *Corymbia greeniana* low open forest over *Dolichandrone heterophylla* sparse shrubland, over *Heteropogon contortus* sparse tussock grassland. Average species richness = 23.8 ± 2.8 Sample size = 4	*Acacia colei* *Acacia drepanocarpa* *Acacia tumida var. tumida* *Aristida inaequiglumis* *Bauhinia cunninghamii* *Brachychiton diversifolius subsp. diversifolius* *Chrysopogon pallidus* *Eriachne obtusa* *Gomphrena canescens* *Indigofera linifolia* *Stylosanthes hamata* *Triodia schinzii*	110.7	110.7 (100%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
CgDhSt	12 6	Landform: Sandy plain *Corymbia greeniana* low open woodland over *Dolichandrone heterophylla* sparse shrubland over *Sorghum timorense* tussock grassland Average species richness = 19.1 ± 1.5 Sample size = 12	*Acacia tumida var. tumida* *Bauhinia cunninghamii* *Brachychiton diversifolius subsp. Diversifolius* *Chrysopogon pallidus* *Corymbia zygophylla* *Eriachne obtusa* *Erythrophleum chlorostachys* *Galactia tenuiflora* *Triodia caelestialis* *Wrightia saligna*	97	2,041 (4.8%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
EcAtSt	None from 2015 survey	Landform: Sandy plain *Erythrophleum chlorostachys* low, open woodland, over *Acacia tumida* var. *tumida* mid, sparse shrubland, over *Sorghum timorense* open tussock grassland Average species richness = 24.1 ± 2.4 Sample size = 10	*Acacia tumida var. tumida* *Aristida hygrometrica* *Dodonaea hispidula var. arida* *Erythrophleum chlorostachys* *Grevillea refracta subsp. refracta* *Microstachys chamaelea* *Sorghum timorense* *Spermacoce occidentalis* *Terminalia canescens* *Wrightia saligna*	183	4,106 (4.5%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
EtApStCpEo	None from 2015 survey	Landform: Sandy floodplain *Eucalyptus tectifica* low, open woodland, over *Acacia platycarpa* tall, over *Sorghum timorense*, *Chrysopogon pallidus* and *Eriachne obtusa* open tussock grassland Average species richness = 23.6 ± 1.9 Sample size = 7	*Acacia platycarpa* *Bauhinia cunninghamii* *Brachychiton diversifolius subsp. diversifolius* *Chrysopogon pallidus* *Dolichandrone heterophylla* *Eriachne obtusa* *Eucalyptus tectifica* *Glycine tomentella* *Sorghum timorense* *Spermacoce occidentalis*	1.6	1,760 (0.1%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
GpAmStTc	None from 2015 survey	Landform: Gravelly plains *Grevillea pyramidalis* subsp. *pyramidalis* low, open woodland, over *Acacia monticola* mid, sparse shrubland, over *Sorghum timorense* sparse tussock grassland and *Triodia caelestialis* (P3) sparse hummock grassland. Average species richness = 25.0 ± 1.6 Sample size = 7	*Acacia hippuroides* *Acacia monticola* *Chrysopogon pallidus* *Corchorus sidoides subsp. vermicularis* *Corymbia greeniana* *Grevillea pyramidalis subsp. pyramidalis* *Grevillea refracta subsp. refracta* *Microstachys chamaelea* *Sorghum timorense* *Triodia caelestialis*	177	1,634 (10.8%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
MaMvEtCpCc	10	Landform: Sandy floodplain *Melaleuca alsophila* or *Melaleuca viridiflora* and *Eucalyptus tectifica* low open woodland, over *Chrysopogon pallidus* sparse tussock grassland and *Cyperus conicus* sparse sedgeland Average species richness = 17.5 ± 2.5 Sample size = 3	*Acacia colei* *Aristida hygrometrica* *Bauhinia cunninghamii* *Chrysopogon pallidus* *Cyperus conicus* *Eragrostis cumingii* *Eriachne obtusa* *Eucalyptus tectifica* *Grevillea striata* *Sorghum timorense* *Stylosanthes hamata* *Xerochloa laniflora*	37	353 (10.4%)

500000
505000
510000
515000
8070000
8065000
8060000
8055000
8050000

CdTcTc
GpAmStTc
EtApStCpEo
EcAtSt
BdEcAtSt
MaMvEtCpCc
BdEcAtApSt
CgApSt
AtStCpHc
CgDhSt
CgDhHc

Legend

- Quadrat (2015)
- Haul road
- Accommodation camp
- Thunderbird study area

Vegetation Unit

- AtStCpHc
- BdEcAtApSt
- BdEcAtSt
- CdTcTc
- CgApSt
- CgDhHc
- CgDhSt
- EcAtSt
- EtApStCpEo
- GpAmStTc
- MaMvEtCpCc

N

0 1.5 3

Kilometres

Absolute Scale - 1:75,000

ecologia ENVIRONMENT

Vegetation Units

Figure: 5.4
Project ID: 1641

Drawn: MM
Date: 10/07/2015

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

A3

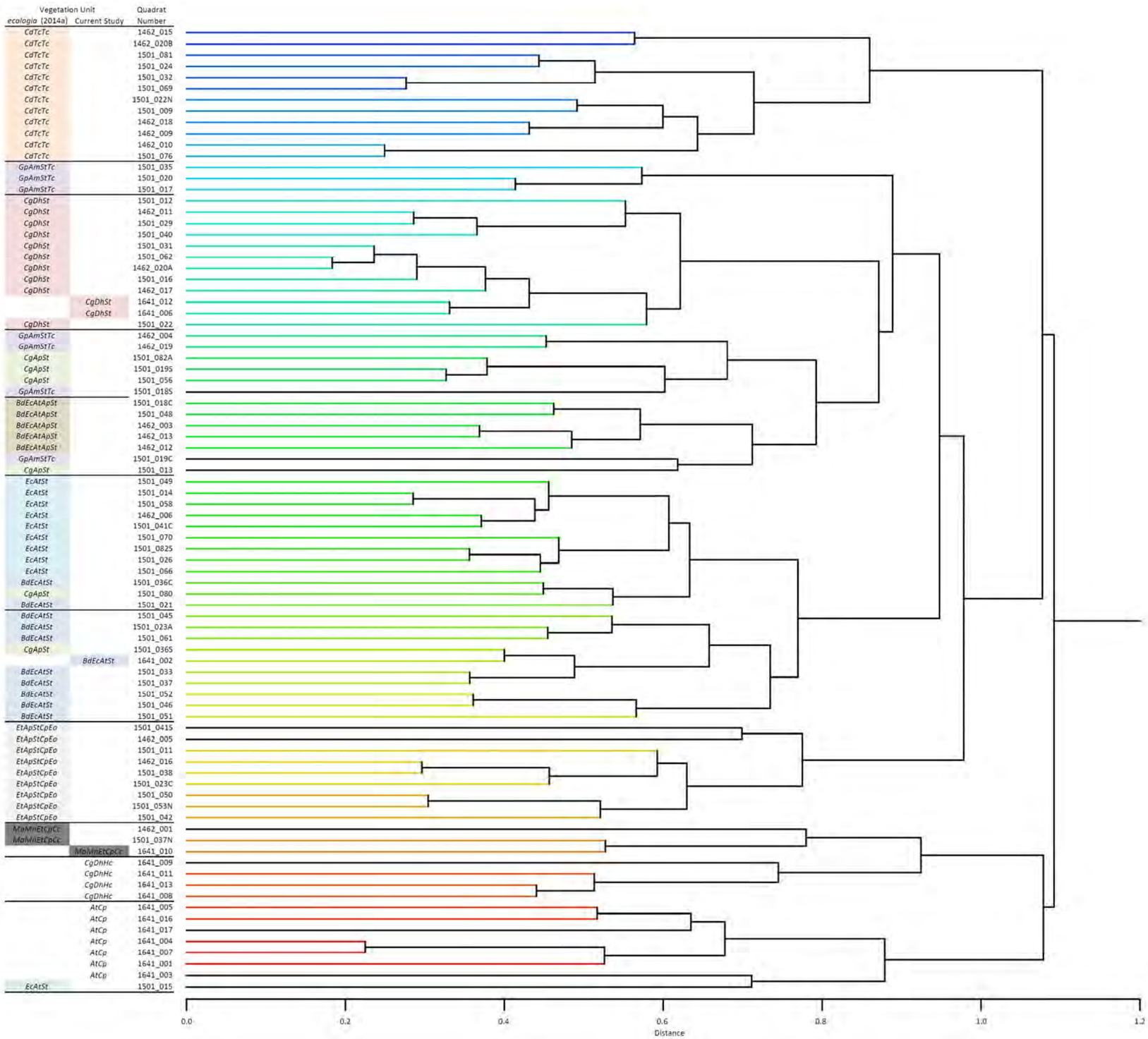
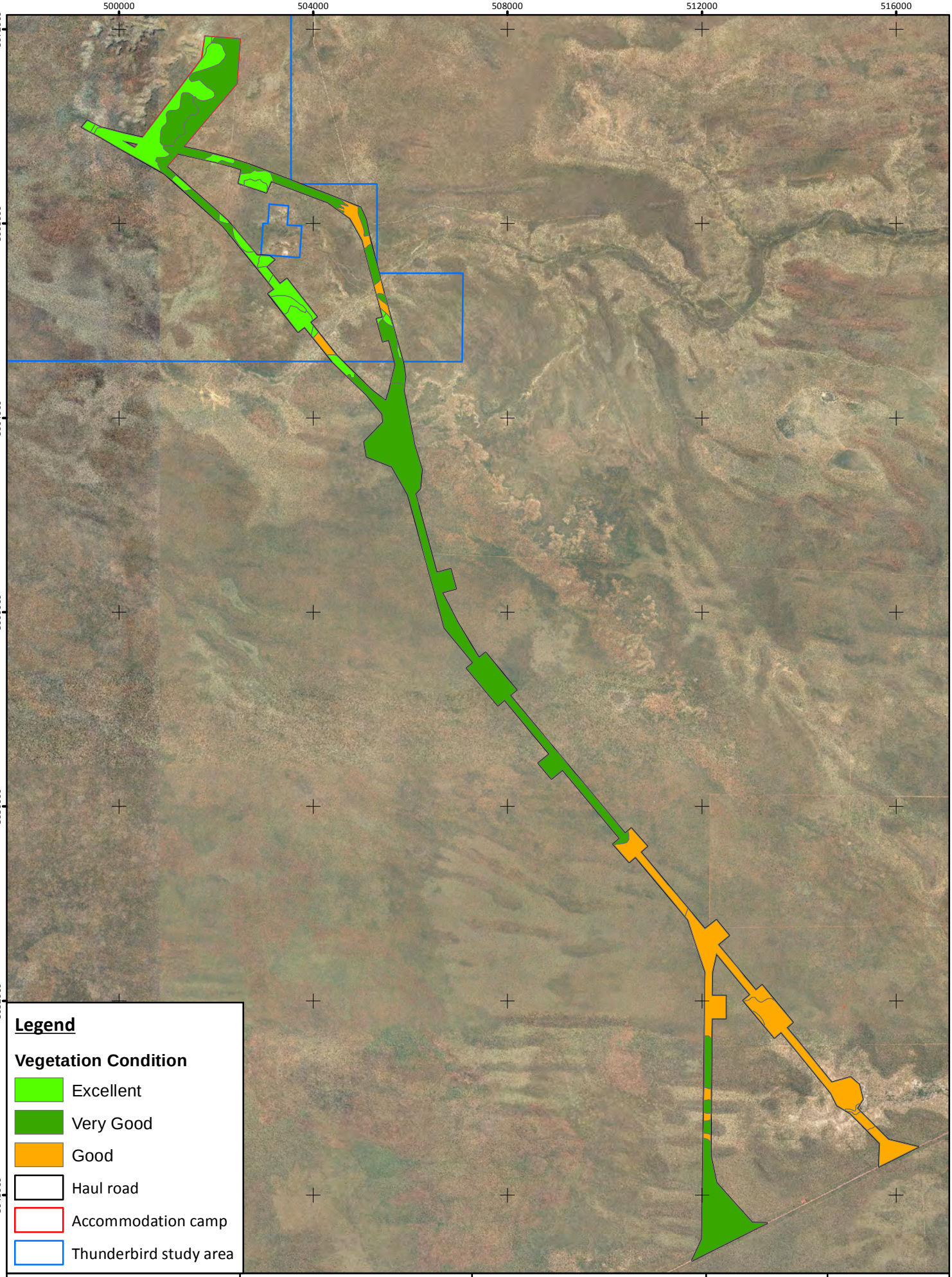


Figure 5.5 – Dendogram used to define the vegetation units



ecologia ENVIRONMENT

0 1.5 3

Kilometres

Absolute Scale - 1:100,000

Vegetation Condition

Figure: 5.5
Project ID: 1641

Drawn: MM
Date: 10/7/15

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

A4

5.3 FAUNA

5.3.1 Species recorded

The field survey recorded a total of 79 fauna species from direct sightings and secondary evidence such as scats and tracks, including 13 mammal, 63 bird and three reptile species (Table 5.2).

Table 5.2 – Vertebrate fauna recorded in the study area

Common name	Scientific name
Mammals	
Short-beaked Echidna^	*Tachyglossus aculeatus*
Greater Bilby^	*Macrotis lagotis*
Agile Wallaby	*Macropus agilis*
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*
Gould's Wattled Bat	*Chalinolobus gouldii*
Hoary Wattled Bat	*Chalinolobus nigrogriseus*
Lesser Long-eared Bat	*Nyctophilus geoffroyi*
Little Broad-nosed Bat	*Scotorepens greyii*
Northern Freetail Bat	*Chaerophon jobensis*
Delicate Mouse	*Pseudomys delicatulus*
European Cattle*	*Bos taurus*
Dog/dingo*	*Canis lupus*
Cat*	*Felis catus*
Birds	
Crested Pigeon	*Ocyphaps lophotes*
Diamond Dove	*Geopelia cuneata*
Peaceful Dove	*Geopelia striata*
Tawny Frogmouth	*Podargus strigoides*
Spotted Nightjar	*Eurostopodus argus*
White-necked Heron	*Ardea pacifica*
Straw-necked Ibis	*Threskiornis spinicollis*
Square-tailed Kite	*Lophoictinia isura*
Black-breasted Buzzard	*Hamirostra melanosternon*
Whistling Kite	*Haliastur sphenurus*
Black Kite	*Milvus migrans*
Wedge-tailed Eagle	*Aquila audax*
Nankeen Kestrel	*Falco cenchroides*
Brown Falcon	*Falco berigora*
Australian Hobby	*Falco longipennis*
Australian Bustard	*Ardeotis australis*
Bush Stone-curlew	*Burhinus grallarius*
Common Greenshank	*Tringa nebularia*
Red-tailed Black-Cockatoo	*Calyptorhynchus banksii*
Galah	*Eolophus roseicapillus*
Little Corella	*Cacatua sanguinea*
Cockatiel	*Nymphicus hollandicus*
Red-collared Lorikeet	*Trichoglossus haematodus rubritorquis*
Varied Lorikeet	*Psitteuteles versicolor*
Red-winged Parrot	*Aprosmictus erythropterus*
Budgerigar	*Melopsittacus undulatus*
Blue-winged Kookaburra	*Dacelo leachii*
Rainbow Bee-eater	*Merops ornatus*

Common name	Scientific name
Black-tailed Treecreeper	*Climacteris melanura*
Red-backed Fairy-wren	*Malurus melanocephalus*
Variegated Fairy-wren	*Malurus lamberti*
Weebill	*Smicrornis brevirostris*
White-throated Gerygone	*Gerygone albogularis*
Red-browed Pardalote	*Pardalotus rubricatus*
Striated Pardalote	*Pardalotus striatus*
Singing Honeyeater	*Lichenostomus virescens*
Yellow-tinted Honeyeater	*Lichenostomus flavescens*
Brown Honeyeater	*Lichmera indistincta*
Black-chinned Honeyeater	*Melithreptus gularis*
Grey-crowned Babbler	*Pomatostomus temporalis*
Varied Sittella	*Daphoenositta chrysoptera*
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*
White-bellied Cuckoo-shrike	*Coracina papuensis*
White-winged Triller	*Lalage sueurii*
Rufous Whistler	*Pachycephala rufiventris*
Grey Shrike-thrush	*Colluricincla harmonica*
Olive-backed Oriole	*Oriolus sagittatus*
White-breasted Woodswallow	*Artamus leucorynchus*
Black-faced Woodswallow	*Artamus cinereus*
Little Woodswallow	*Artamus minor*
Pied Butcherbird	*Cracticus nigrogularis*
Australian Magpie	*Cracticus tibicen*
Grey Fantail	*Rhipidura albiscapa*
Willie Wagtail	*Rhipidura leucophrys*
Torresian Crow	*Corvus orru*
Paperbark Flycatcher	*Myiagra nana*
Magpie-lark	*Grallina cyanoleuca*
Jacky Winter	*Microeca fascinans*
Hooded Robin	*Melanodryas cucullata*
Tree Martin	*Petrochelidon nigricans*
Mistletoebird	*Dicaeum hirundinaceum*
Zebra Finch	*Taeniopygia guttata*
Long-tailed Finch	*Poephila acuticauda*
Reptiles	
Skink	*Ctenotus inornatus*
Sand Goanna	*Varanus gouldii*
Mulga Snake^	*Pseudichis australis*

^ Recorded from secondary evidence (scats, tracks, nest sites etc)
* Introduced species

5.3.2 Fauna Habitats

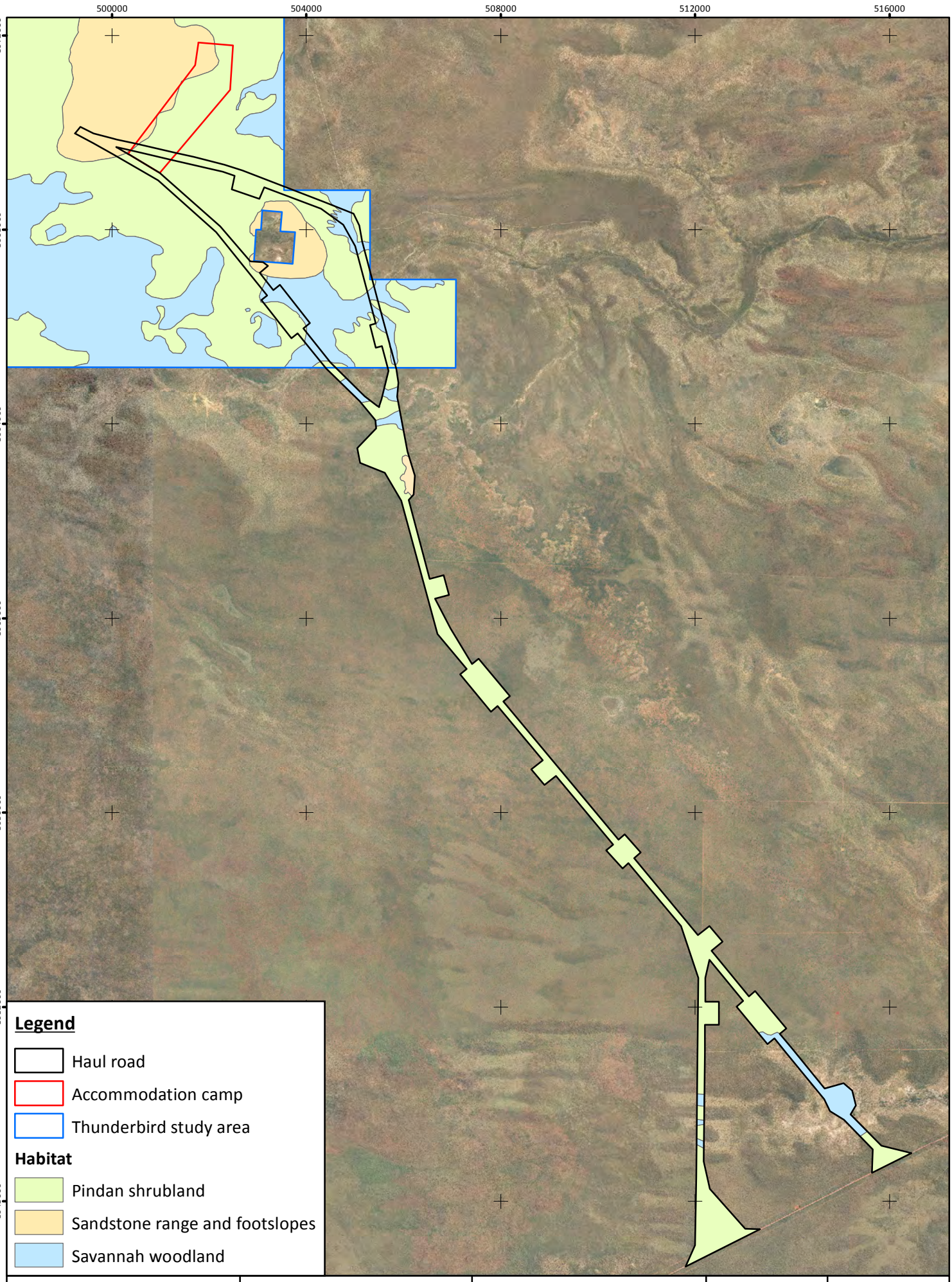
Three broad habitat types were identified within the study area based upon the information outlined in Section 2.6.5. Habitats were assessed against the previous Thunderbird assessment (*ecologia* 2014b) and in order of consistency applied to this assessment where practical. The details of each habitat type are shown in Table 5.3 and mapped in Figure 5.7 below.

The study area contains the following habitat types:

- Pindan shrubland;
- Sandstone range and footslopes; and,
- Savannah woodland.

Table 5.3 – Fauna habitats at the study area

Fauna habitat	Area outside Thunderbird Assessment (ha)	Area inside Thunderbird Assessment (ha)	Total (ha)	Percentage of total study area (%)
Pindan shrubland	691.6	401.2	1,092.8	80.9
Savannah woodland	104.4	62.3	166.7	12.4
Sandstone range and footslopes	15.0	74.9	89.9	6.7
Total	**811**	**538.4**	**1,349.4**	**100%**



ecologia ENVIRONMENT

0 1.5 3

Kilometres

Absolute Scale - 1:100,000

N

Fauna habitats

Figure: 5.7
Project ID: 1641

Drawn: BG
Date: 7/5/15

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

A4

Pindan shrubland

The pindan shrubland habitat is the most extensive fauna habitat type identified within the study area, comprising 80.9% (1,092.8 ha) of the total study area (Figure 5.7). The landscape feature of this habitat type is a flat plain, with soil substrate weak orange to red sandy-loam soils. Subtle differences exist in the soil substrate with some areas more clayey and therefore harder. The dominant tree species is scattered *Corymbia greeniana*, over a moderately open to dense shrub layer consisting primarily of *Acacia tumida* var. *tumida*, *Acacia platycarpa* and *Grevillea refracta*. The ground vegetation layer consists of a mix of grasses including *Triodia caelestialis*, *Aristida holathera* var. *holathera*, *Chrysopogon* sp., *Eriachne obtusa* and *Sorghum plumosum*. Leaf litter density is highly variable as a result of fire history and patchy shrub density.

A mosaic of vegetation as a result of fire history exists within this habitat type, and appears older fire age (>2 years) is characterised by large, dense mature *Acacia tumida* var. *tumida* forming a dense canopy layer but relatively open ground cover (Figure 5.9). In contrast, areas within this habitat type which appear to have been burnt more frequently are characterised by dense ground vegetation.

Figure 5.8 – Example of pindan shrubland habitat type

Figure 5.9 – Example of dense, mature Acacia tumida var tumida within pindan shrubland

Savannah woodland

The savannah woodland habitat is second most extensive, covering 12.4% (166.7 ha) of the study area. It is characterised by plains in the low-lying areas in the south and north of the study area, with firm brown-white sandy clay soils. The dominant vegetation consists of scattered *Eucalyptus tectifica* and *Brachychiton diversifolius*, with open to moderately dense shrubs of mainly *Acacia platycarpa*. There is a ground vegetation layer of *Eriachne obtusa* tussock grassland and *Triodia caelestialis* hummock grassland, and termite mounds are frequently present. A number of minor drainage lines exist within

this habitat type which was not deemed unique enough to be included as a separate habitat type. These drainage lines are likely to contain water during periods of the wet season.

Figure 5.10 – Example of savannah woodland habitat type

Sandstone range and footslopes

The sandstone range and footslopes habitat is the least widespread within the study area, covering 6.7% (89.9 ha) of the total study area. It is found in one location in the northern section of the study area. The geology is sandstone rocks, with outcropping and boulders present on the upper hills, while the footslopes contain isolated rocks and sandy soil substrate. The vegetation in this habitat is characterised by sparse *Corymbia dendromerinx* over moderately dense *Acacia drepanocarpa* subsp. *latifolia* over a ground vegetation layer of dense *Triodia caelestialis* hummock grassland and *Sorghum plumosum* tussock grassland (Figure 5.11).

Figure 5.11 – Example of sandstone range and footslopes habitat type

5.3.3 Potential conservation significant fauna likelihood of occurrence assessment

Based on the methodology described in Section 2.6.1 and the habitats recorded within the study area (Section 5.3.2), the likelihood of occurrence for all potential conservation significant fauna has been assessed and summarised in Table 5.4.

A total of 46 species were recorded as low likelihood, 16 species as medium likelihood and seven species recoded as high likelihood or recorded during current survey.

Species assessed as a medium or high likelihood of occurrence, or were recorded on the current survey, are discussed in greater detail in Section 6.2. Species assessed as having a low likelihood of occurrence are not discussed further.

Table 5.4 – Likelihood of occurance assessment of potential conservation significant fauna

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence[#]
	EPBC Act	WC Act	DPaW			
Mammals						
Northern Quoll *Dasyurus hallucatus*	EN	S1	EN	Most common on dissected rocky escarpments, but also found in eucalypt forest and woodland, and around human settlements (Oakwood 2008).	Not previously recorded on the Dampier Peninsula, but has been recorded in similar habitat to that present, 90 km east of the study area in 2001 (NatureMap).	**LOW**
Greater Bilby *Macrotis lagotis*	VU	S1	VU	Variety of habitats on soft soil including spinifex hummock grassland, acacia shrubland, open woodland and cracking clays (Johnson 2008; Menkhorst and Knight 2011)	Numerous regional records, including over 50 records from 2012 25-30 km SW of the study area, one recent record (2013) c. 5 km NW of the northern end of the study area, and a cluster of several records (most recent 1996) within 1 km of the southern end of the study area (DPaW 2015a). recorded during Thunderbird assessment (*ecologia* 2014b).	**RECORDED** **Resident – breeding**
Golden Bandicoot *Isoodon auratus auratus*	VU	S1		Rocky sandstone spinifex and vine thickets.	One record from 1971 on the Dampier Peninsula (NatureMap).	**LOW**
Little Northern Freetail Bat *Mormopterus loriae cobourgiana*			P1	Mangrove stands, particularly those that include mature Grey Mangrove (*Avicennia marina*), and adjacent vegetation (Milne *et al.* 2008; Menkhorst and Knight 2011).	Recorded on the Dampier Peninsula (ENV 2008), but no records within 75 km of the study area (DPaW 2015a).	**LOW**
Yellow-lipped Cave Bat *Vespadelus douglasorum*			P2	Forages in tropical woodlands, particularly in association with *Melaleuca* and *Pandanus*-lined waterways and streams (Churchill 2008; Menkhorst and Knight 2011). Use both sandstone and limestone caves for roosting, usually near water (Churchill 2008).	One record from c. 50 km NW of the northern end of the study area (*ecologia* 2004c; DPaW 2015b).	**LOW**
Lakeland Downs Mouse (Short-tailed Mouse) *Leggadina lakedownensis*			P4	Spinifex and tussock grassland on cracking clays. Also acacia shrubland, samphire and woodlands (Moro and Kutt 2008; Menkhorst and Knight 2011).	One record c. 2 km north of the northern end of the study area, from Sheffield's Thunderbird project (*ecologia* 2014b; DPaW 2015b).	**HIGH** **Resident – breeding**

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence[#]
	EPBC Act	WC Act	DPaW			
Birds						
Gouldian Finch *Erythrura gouldiae*	EN		P4	Tropical woodlands and forest, with grassy understorey; usually near water. Breed in eucalypt hollows, usually in stony hilled areas (Garnett and Crowley 2000; Johnstone and Storr 2004)	Species or species habitat likely to occur in the area (DoE 2015a). Numerous records from far northern Dampier Peninsula (Cape Leveque), but only two old records within 50 km of the study area; both c. 30 km E of the southern end of the study area from 1973 (DPaW 2015a).	**MEDIUM**
Australian Painted Snipe *Rostratula australis*	EN, M	S1, S3	EN	Shallow, vegetated wetlands (Garnett and Crowley 2000)	Seven records (most recent 1999) from within 50 km of the study area, all from Roebuck Plains to the WSW of the study area; closest c. 25 km SW of southern end of study area from 1994 (DPaW 2015a).	**LOW**
Red Goshawk *Erythrotriorchis radiatus*	VU	S1	VU	Open forests and woodlands, tropical savannas traversed by wooded rivers, rainforest margins, and gorge and escarpment country (Garnett and Crowley 2000)	Species or species habitat likely to occur in the area (DoE 2015a). No records within 100 km of the study area (DPaW 2015a).	**LOW**
Masked Owl (Kimberley subspecies) *Tyto novaehollandiae kimberli*	VU		P1	Rainforest and gallery forest, open forest, paperbark swamps, mangrove fringes (Johnstone and Storr 1998; Garnett and Crowley 2000).	Species or species habitat likely to occur in the area (DoE 2015a). No records within 100 km of the study area (DPaW 2015a).	**LOW**
Rainbow Bee-eater *Merops ornatus*	M	S3	IA	Open country, most vegetation types, dunes, banks; prefer lightly wooded, preferably sandy, country near water (Johnstone and Storr 1998; Pizzey and Knight 2003).	Numerous records from the Dampier Peninsula (DPaW 2015a). Previously recorded during Thunderbird assessment including breeding burrows (*ecologia* 2014b).	**RECORDED** **Resident – breeding**
Fork-tailed Swift *Apus pacificus*	M	S3	IA	Aerial over a variety of habitat types, movements often associated with summer storm fronts (Johnstone and Storr 1998; Pizzey and Knight 2003)	Numerous records from western Dampier Peninsula; two records within 50 km of study area, one from within 5 km of the northern end of the study area from Sheffield's Thunderbird project in 2013 and one record c. 30 km E of the study area from 2006 (*ecologia* 2014b; DPaW 2015b).	**HIGH** **Migratory visitor**

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence[#]
	EPBC Act	WC Act	DPaW			
Eastern Great Egret *Ardea modesta*	M	S3	IA	Wide range of wetland habitats, including floodwaters, rivers, shallows of wetlands, intertidal mudflats (Johnstone and Storr 1998).	Numerous records throughout the Dampier Peninsula region; nearest are 12 records c. 25 km SW of the study area, most recently from 2007 (DPaW 2015a).	**MEDIUM**
Cattle Egret *Ardea ibis*	M	S3	IA	Grassy habitats, shallow wetlands and waterbodies, particularly damp pastures (Johnstone and Storr 1998).	11 records within 50 km of the study area, nearest are two records (most recent from 2007) from c. 25 km SW of southern end of study area (DPaW 2015a).	**MEDIUM**
Glossy Ibis *Plegadis flacinellus*	M	S3	IA	Shallows and adjacent flats of freshwater wetlands; also river pools, flooded samphire and sewage ponds (Johnstone and Storr 1998).	Numerous records throughout the southern Dampier Peninsula region; nearest are 31 records c. 25 km SW of the study area, most recently from 2013 (DPaW 2015a).	**LOW**
Eastern Osprey *Pandion cristatus*	M			Coasts, estuaries, coastal and offshore islands, and the lower reaches of rivers (Johnstone and Storr 1998).	Several records along the coast of the Dampier Peninsula, but no records within 75 km of study area (DPaW 2015a).	**LOW**
White-bellied Sea-Eagle *Haliaeetus leucogaster*	M	S3	IA	Offshore islands, coasts, estuaries, coastal lakes. Occasionally inland along larger watercourses (Johnstone and Storr 1998).	Numerous records throughout the southern Dampier Peninsula region; nearest are seven records c. 25 km SW of the study area, most recently from 2010 (DPaW 2015a).	**LOW**
Oriental Plover *Charadrius veredus*	M	S3	IA	Open plains, including samphire; bare rolling country; bare claypans; open ground near inland swamps.	Number of relatively recent records within 50 km SW of the study area (DPaW 2015a).	**MEDIUM**
Australian Painted Snipe *Rostratula australis*	EN, M	S1, S3	EN	Shallow, vegetated wetlands (Garnett and Crowley 2000).	A few records within 50 km SW of the study area within the last 15 years (DPaW 2015a).	**LOW**
Swinhoe's Snipe *Gallinago megala*	M	S3	IA	Shallow freshwater wetlands of various kinds including paddy fields and sewage farms, with bare mud or shallow water for feeding, with nearby vegetation cover (Johnstone and Storr 1998)..	One record within 50 km of the study area (DPaW 2015a).	**LOW**

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence[#]
	EPBC Act	WC Act	DPaW			
Little Curlew *Numenius minutus*	M	S3	IA	Short dry grasslands, including artificial grassed areas.	Number of relatively recent records within 50 km SW of the study area (DPaW 2015a).	**MEDIUM**
Wood Sandpiper *Tringa glareola*	M	S3	IA	Mainly shallow, fresh waters, river pools, claypans; occasionally brackish swamps; rarely salt lakes, estuaries and intertidal mudflats.	Number of relatively recent records within 50 km SW of the study area (DPaW 2015a), recorded at Mt Jowlaenga during Thunderbird assessment (*ecologia* 2014).	**MEDIUM**
Common Greenshank *Tringa nebularia*	M	S3	IA	Intertidal mudflats, estuaries, freshwater and saline wetlands along the coast and inland.	Many records within the regional area of the study area.	**RECORDED Transient visitor**
Red-necked Stint *Calidris ruficollis*	M	S3	IA	Costal areas: sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks; also saline and freshwater inland wetlands.	Number of relatively recent records within 50 km SW of the study area (DPaW 2015a).	**MEDIUM**
Long-toed Stint *Calidris subminuta*	M	S3	IA	Shallow water surrounded by dense low vegetation.	Number of relatively recent records within 50 km SW of the study area (DPaW 2015a).	**MEDIUM**
Sharp-tailed Sandpiper *Calidris acuminata*	M	S3	IA	Coasts and well-watered parts of the interior. Prefer grassy areas of non-tidal fresh or brackish wetlands, coastal marshes and tidal flats.	Number of relatively recent records within 50 km SW of the study area (DPaW 2015a).	**MEDIUM**
Pectoral Sandpiper *Calidris melanotos*	M	S3	IA	Uncommon in WA. Shallow, fresh waters, often with low grass or other herbage; swamp margins, flooded pastures, sewage ponds; occasionally tidal areas, saltmarshes. Breeds in Arctic.	Few nearby records within 50 km of the study area (DPaW 2015a).	**LOW**
Oriental Pratincole *Glareola maldivarum*	M	S3	IA	Plains, shallow wet and dry edges in open bare wetlands, tidal mudflats, beaches.	Numerous recent records within 50 km SW of the study area (DPaW 2015a).	**MEDIUM**
White-winged Black Tern *Chlidonias leucopterus*	M	S3	IA	Mainly estuaries and sheltered seas in north, freshwater lakes and swamps in south.	Few surrounding records (DPaW 2015a).	**LOW**

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence[#]
	EPBC Act	WC Act	DPaW			
Barn Swallow *Hirundo rustica*	M	S3	IA	In Australia, primarily around towns and wetlands (Johnstone and Storr 2004).	13 records within 50 km of the study area; nearest are three records (most recent from 2010) c. 25 km SW of the study area, most recently from 2010 (DPaW 2015a).	**LOW**
Eastern Yellow Wagtail *Motacilla tschutschensis*	M	S3	IA	Short grasslands (usually damp or watered), swamp margins, sewage ponds, bore overflows, and irrigated areas (Johnstone and Storr 1998)	Few surrounding records (DPaW 2015a), but recorded during previous Thunderbird assessment (*ecologia* 2014b).	**MEDIUM**
Grey Wagtail *Motacilla cinerea*	M	S3	IA	Predominantly banks and rocky areas along flowing freshwater habitats (Johnstone and Storr 1998); however, uses a variety of habitats in Australia, all usually close to water	Few surrounding records (DPaW 2015a), but recorded during previous Thunderbird assessment (*ecologia* 2014b).	**MEDIUM**
Coastal restricted conservation significant birds* (Appendix D)	M	S3	IA	Near coastal habitats.	-	**LOW**
Grey Falcon *Falco hypoleucos*		S1	VU	Lightly wooded plains (Johnstone and Storr 1998), typically nesting in tall trees along watercourses (Garnett and Crowley 2000)	One record c. 25 km to the SW of the southern end of the study area from 2008, and one record c. 55 km SE of the southern end of the study area from 1999 (DPaW 2015a).	**MEDIUM**
Peregrine Falcon *Falco peregrinus*		S4	Other	Wide variety of habitats; woodlands, treed grasslands, wetlands, timbered watercourses, rocky gorges, cities. Breeds on ledges on cliffs, outcrops, quarries, and city buildings, in hollow trees, or in abandoned nests of other raptors (Johnstone and Storr 1998; Pizzey and Knight 2003).	Five records within 50 km of the study area; nearest are three records (most recent from 2005) c. 25 km SW of the study area, most recently from 2010 (DPaW 2015a).	**MEDIUM**

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence[#]
	EPBC Act	WC Act	DPaW			
Australian Bustard *Ardeotis australis*			P4	Open grasslands, shrublands, chenopod flats and low heathland (Johnstone and Storr 1998; Simpson and Day 2010).	Numerous records from the Dampier Peninsular (DPaW 2015a), including a number of records within or very close to the northern end of the study area from 2014 (*ecologia* 2014b).	**RECORDED Resident – breeding**
Star Finch (western subspecies) *Neochmia ruficauda subclarescens*			P4	Long grass and reeds in and around wetlands; also irrigated crops and pastures, sewage ponds, and rank grasslands (Johnstone and Storr 2004).	One record (undated) c. 65 km E of the study area (Derby), and one old record (1975) c. 90 km W of the study area (DPaW 2015a).	**LOW**
Chestnut-backed Button-quail *Turnix castanota*			P4	Savannah woodlands in sandstone and lateritic country.	No records on the Dampier Peninsula (DPaW 2015a), but recorded at James Price Point (AECOM 2010).	**LOW**
Reptiles						
Saltwater Crocodile *Crocodylus porosus*	M	S4	Other	Coastal rivers and swamps, extending inland along major rivers to floodplains and billabongs (Cogger 2000)	Recorded on the Dampier Peninsula (ENV 2008), but no records within 75 km of the study area (DPaW 2015a).	**LOW**
Lerista separanda			P2	Consolidated coastal dunes, and other sandy coastal areas (Cogger 2000; Wilson and Swan 2013).	Several records near the coast on the Dampier Peninsula, but no records within 75 km of the study area (DPaW 2015a).	**MEDIUM**
Dampierland Burrowing Snake *Simoselaps minimus*			P2	Coastal dunes and sandy areas between dunes and adjacent acacia shrublands (Wilson and Swan 2013).	Several records near the coast on the Dampier Peninsula, but no records within 75 km of the study area (DPaW 2015a).	**MEDIUM**
Dampier Peninsula Goanna^ *Varanus sparnus*	^	^	^	Pindan shrubland with sandy soils (Doughty *et al.* 2014).	Species recently described, currently restricted to four point locations of specimes used to describe species. Includes coastal areas at Coulomb Point and 90 km east to central Dampier Peninsula (Doughty *et al.* 2014).	**HIGH Resident – breeding**

*28 Conservation significant coastal and shorebird species assessed as low likelihood listed in (Appendix D)
^Species not formally protected and listed as conservation significant under current legislation. However species recently described and currently has restricted distribution. Species may carry conservation significant status in the future so included in this assessment. Appendix H details the recent description and clarifies the Dampier Peninsula Goanna's occurrence in relation to the Thunderbird project.
[#]Likely habitat utilisation category assigned to species assessed as high likelihoof of occurrence or recorded species only (Section 2.6.1).

5.3.4 Conservation significant fauna species records

A total of four species of conservation significance were recorded during the field study; Greater Bilby (EPBC Act Vulnerable, WC Act Schedule 1, DPaW Vulnerable), Common Greenshank (EPBC Act Migratory,WC Act Schedule 3, DPaW Internation Agreement), Rainbow Bee-eater (EPBC Act Migratory,WC Act Schedule 3, DPaW Internation Agreement) and Australian Bustard (Priority 4). These records are summarised in Table 5.5 and Appendix C (Greater Bilby) and are mapped in Figure 5.15 and Figure 5.16.

Greater Bilby was recorded on the basis of secondary evidence only. These records consisted of diggings, scats and active burrows (Figure 5.12). Common Greenshank, Rainbow Bee-eater (Figure 5.13) and Australian Bustard (Figure 5.14) were all recorded from visual observations.

Table 5.5 – Conservation significant fauna recorded

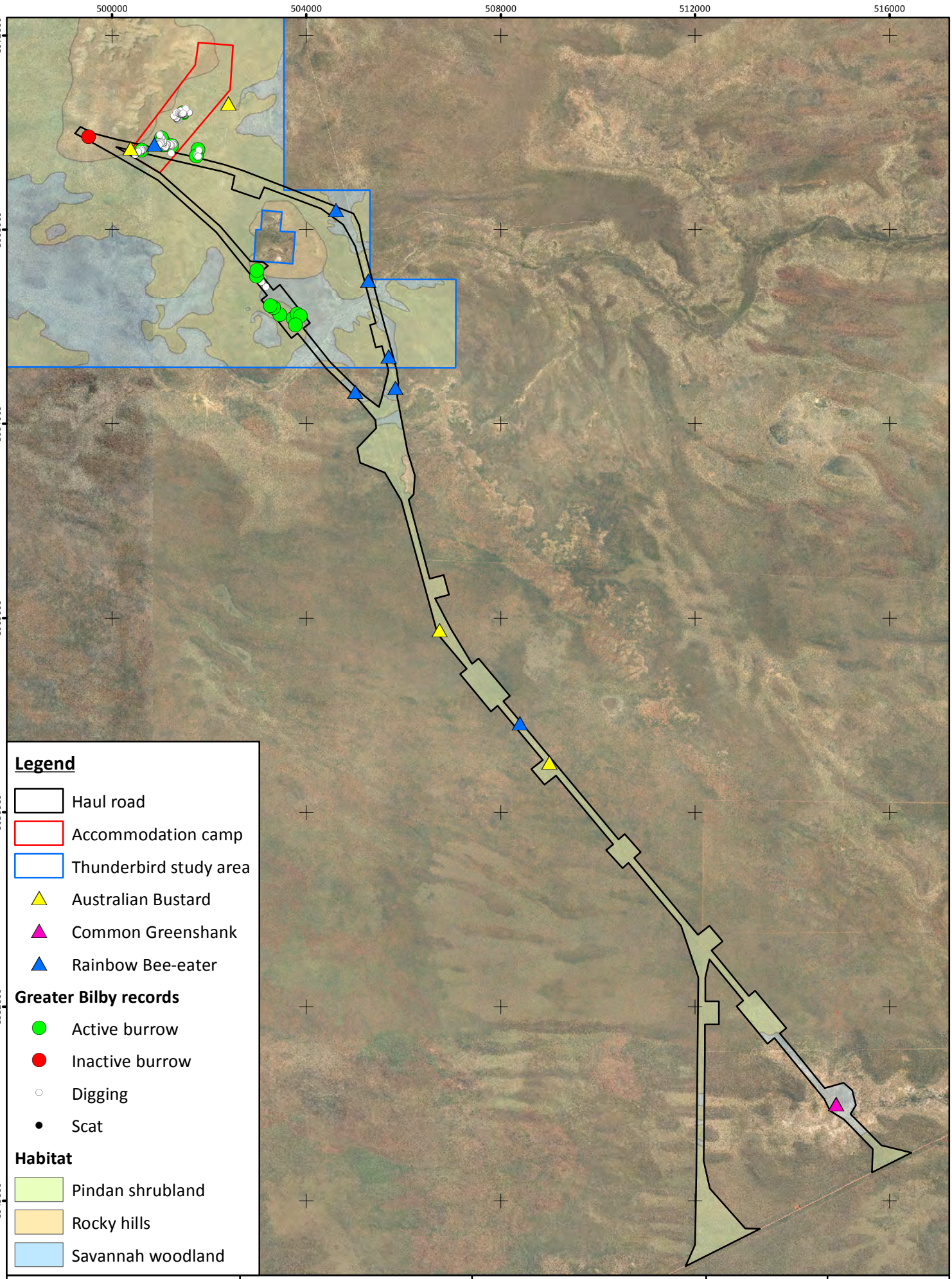
Species	Count	Date	Location Name	Easting	Northing	Notes
Mammals						
Greater Bilby (Appendix C)	-	-	-	-	-	A total of 18 active burrows and numerous diggings (Appendix C).
Birds						
Common Greenshank	2	14/5/2015	Opportunistic	514901	8049981	Two individuals foraging along shoreline of turkey nest.
Rainbow Bee-eater	1	13/05/2015	Opportunistic	505271	8066951	-
Rainbow Bee-eater	1	14/05/2015	Opportunistic	500867	8069754	-
Rainbow Bee-eater	3	11/05/2015	Opportunistic	508388	8057835	-
Rainbow Bee-eater	3	12/05/2015	Diurnal active search 2	505003	8064661	-
Rainbow Bee-eater	1	12/05/2015	Diurnal active search 1	505687	8065383	-
Rainbow Bee-eater	3	12/05/2015	Diurnal active search 5	505829	8064742	-
Rainbow Bee-eater	1	13/05/2015	Bird point count 1	514901	8049981	-
Rainbow Bee-eater	2	13/05/2015	Diurnal active search 13	504605	8068400	-
Rainbow Bee-eater	1	15/05/2015	Bird point count 1	514901	8049981	-
Australian Bustard	1	13/05/2015	Opportunistic	506739	8059754	-
Australian Bustard	1	14/05/2015	Opportunistic	502389	8070589	-
Australian Bustard	2	15/05/2015	Opportunistic	500379	8069674	-
Australian Bustard	1	12/05/2015	Opportunistic	508998	8057021	-

Datum: GDA 1994 MGA Zone 51

Figure 5.12 – Greater Bilby digging (top left), scat (top right) and active burrow (bottom)

Figure 5.13 – Rainbow Bee-eater recorded from the study area

Figure 5.14 – Australian Bustard recorded from the study area



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0 1.5 3

Kilometres

Absolute Scale - 1:100,000

N

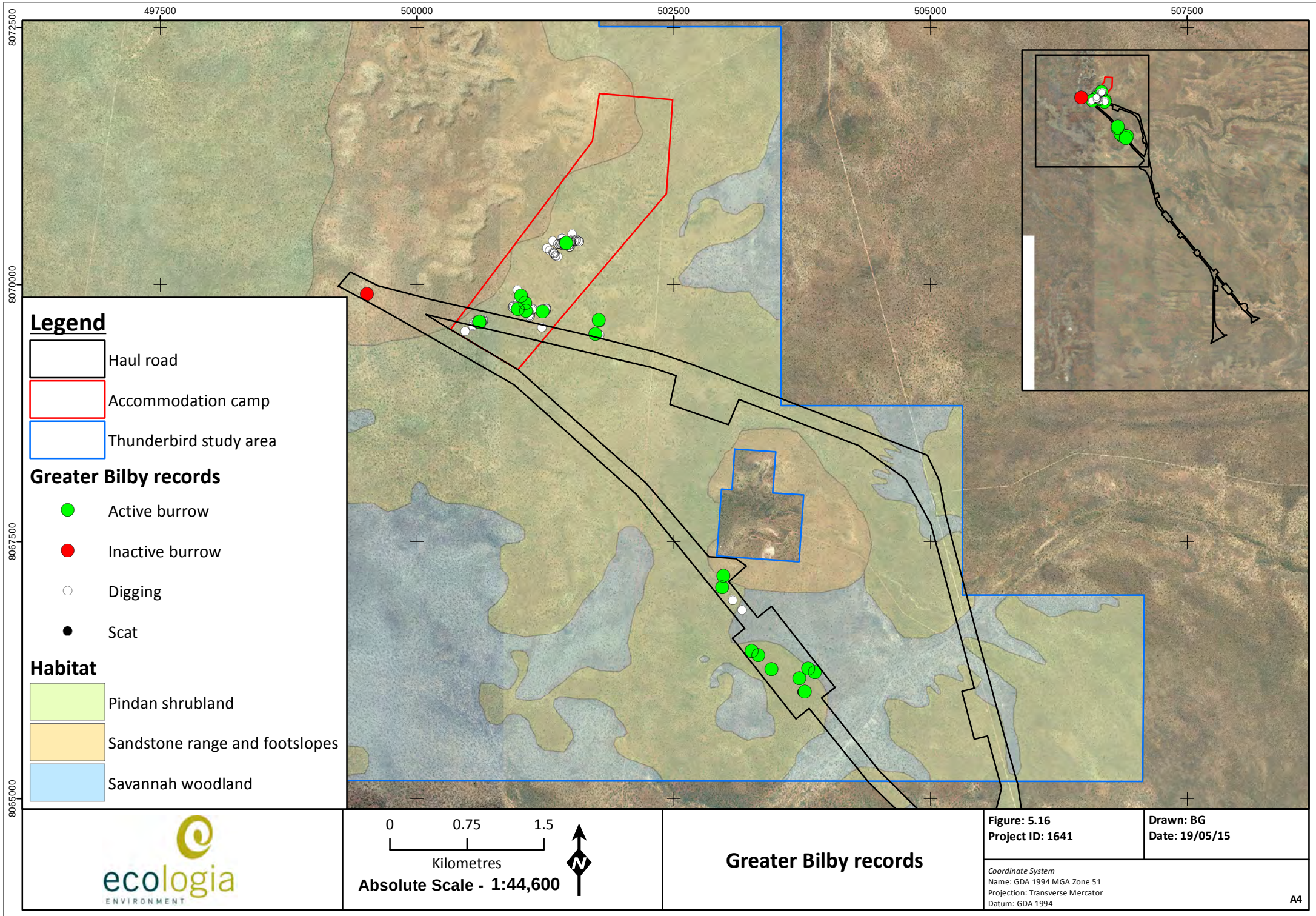
Conservation significant fauna recorded

Figure: 5.15
Project ID: 1641

Drawn: BG
Date: 7/5/15

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

A4



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Greater Bilby records

Figure: 5.16
Project ID: 1641

Drawn: BG
Date: 19/05/15

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

A4

5.3.5 Conservation significant fauna habitat utilisation

A summary of the habitat types recorded and potential usage of conservation significant fauna is provided in Table 5.6. Only species recorded during the current survey or were assessed as high likelihood of occurrence were assessed.

Table 5.6 – Summary of potential conservation significant fauna habitat at the study area

Species	Critical habitat types(breeding/roosting)	Area of critical habitat within study area (ha)*	Non-critical habitat types(foraging/dispersal)	Area of non-critical habitat within study area (ha)*
Greater Bilby *Macrotis lagotis*	• Pindan shrubland	1,092.8	• Savannah woodland • Sandstone range and footslopes	256.6
Lakeland Downs Mouse *Leggadina lakedownensis*	• Pindan shrubland • Savannah woodland	1,259.5	-	-
Rainbow Bee-eater *Merops ornatus*	• Pindan shrubland	1,092.8	• Savannah woodland • Sandstone range and footslopes	256.6
Fork-tailed Swift *Apus pacificus*	-	-	• Pindan shrubland • Savannah woodland • Sandstone range and footslopes	1,349.4
Common Greenshank^ *Tringa nebularia*	-	-	• Savannah woodland	166.7
Australian Bustard *Ardeotis australis*	• Pindan shrubland • Savannah woodland	1,259.5	• Sandstone range and footslopes	89.9
Dampier Peninsula Goanna *Varanus sparnus*	• Pindan shrubland • Savannah woodland	1,259.5	• Sandstone range and footslopes	89.9

*Total area within study area used, which includes area previously assessed within Thunderbird assessment
^Suitable habitat within Savannah woodland only during wet season if woodland floods.

6 DISCUSSION

6.1 FLORA CONSERVATION SIGNIFICANCE ASSESSMENT

6.1.1 Flora of National and State Significance

National significance refers to those features of the environment which are recognised under legislation as being of importance to the Australian community; in particular, species & TECs listed under the *EPBC Act* are regarded as nationally significant.

No taxa listed under the EPBC Act or of National significance were recorded at the study area.

State significance refers to those features of the environment that are recognised under State legislation as being of importance to the Western Australian community, in particular, species listed as Threatened and communities as TECs or PECs under the *WC Act* are of state significance.

No taxa listed under WC Act or of State significance were recorded at the study area.

6.1.2 Flora of Regional and Local Significance

Regional significance addresses the representation of species and habitats at a biogeographic regional level. Species or vegetation communities that are restricted to the Dampierland IBRA region and whose distributions are limited or unknown are considered regionally significant.

Local significance is when a species is confined to a specialised habitat type that is not common and potentially restricted to the local area and whose disturbance or removal may lead to local extinction.

Pterocaulon intermedium (Priority 3) was recorded from 14 locations (representing 14 individuals) across the study area, on red sandy plains. *Pterocaulon intermedium* has previously been recorded at nine additional locations within the Thunderbird project (*ecologia* 2014a), and 23 records on Flora Base (Western Australian Herbarium 1998-2015). It is distributed relatively widely across northern WA and also in the Northern Territory and Queensland.

Triodia caelestialis (Priority 3) was recorded from 25 locations representing 8,271 individuals, and is the dominant understorey species in some of the vegetation units identified in the study area, such as *GpAmStTc*. *Triodia caelestialis* has previously been recorded at 79 additional locations within the Thunderbird project (*ecologia* 2014a), and 18 records on Flora Base (Western Australian Herbarium 1998-2015). It is distributed across northern WA in the Dampierland, Central Kimberley and Northern Kimberley bioregions.

Neither of these Priority species is confined to specialised habitats, occurring on widespread pindan sandplains in the study area. Both species are expected to also occur in similar habitat outside the study area, and therefore the project does not pose the threat of extinction to the local populations.

6.1 VEGETATION CONSERVATION SIGNIFICANCE ASSESSMENT

6.1.1 Vegetation of National and State Significance

No ecological communities listed under the EPBC Act or listed as TECs or PECs in Western Australia were recorded at the study area.

6.1.2 Vegetation of Regional and Local Significance

The proposed Thunderbird Haul road and camp study area covers approximately 10% or less of the nine vegetation units mapped in the study area previously described by *ecologia* (2014a). The two vegetation units described from the Haul Road and Camp study area which were not previously described (*AtStCpHc* and *CgDhHc*) are associated with widespread landforms, extensive and plains

(*AtStCpHc*) and floodplains adjacent to ephemeral waterways (*CgDhHc*). These two vegetation units are therefore considered likely to be represented extensively in the surrounding landscape, where such landforms are widespread.

6.2 CONSERVATION SIGNIFICANT FAUNA SPECIES DESCRIPTIONS

Seventeen conservation significant vertebrate fauna species were evaluated as having a medium or high likelihood of occurrence (or were recorded from within the study area, Table 5.4). These species are discussed in further detail below.

6.2.1 Mammals

Greater Bilby (*Macrotis lagotis*)

Conservation status: EPBC Act Vulnerable, WC Act Schedule 1 (Vulnerable).

Distribution and habitat: Once common over 70% of mainland Australia's arid and semiarid regions, the Greater Bilby is currently patchily distributed through the Tanami, Great Sandy and Gibson Deserts, extending north onto the Dampier Peninsula near Broome, west to the eastern Pilbara, and south to approximately Warburton (Maxwell *et al.* 1996; Johnson 2008). Isolated populations also occur in south-west Queensland and to the north-east of Alice Springs. Bilbies occur in a variety of habitats, including spinifex grassland, *Acacia* shrubland, open woodland and cracking clays (Maxwell *et al.* 1996; Johnson 2008). The species underwent a sudden and widespread collapse in population size in the early 1900s, and the distribution may still be contracting and fragmenting. Reasons for the decline include predation by feral predators on both young and adult Bilbies, competition from rabbits and livestock, reduced food as a result of changed fire regimes, and drought (Maxwell *et al.* 1996; O'Malley 2006a; Johnson 2008).

Biology: The Bilby is a nocturnal marsupial with soft, silky fur (Pavey 2006b). It uses its strong forelimbs and claws to construct an extensive tunnel system of up to 3 m long and 1.8 m deep in which it shelters during the day. Its long tongue is an adaptation to its specialised diet of seeds, insects, bulbs, fruit and fungi (Johnson 2008).

Likelihood of occurrence: Recorded (resident – breeding). The Greater Bilby was recorded via secondary evidence from numerous locations within the study area (Figure 5.16, Appendix C). These records build on information gathered relatig to Greater Bilby occupation of the Thunderbird study area from the previous assessment (*ecologia* 2014b). Habitat utilisation was consistent with previous records of the study area. Active burrows were predominately located within the pindan shrubland habitat type (Figure 5.16), and more specifically within the dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat within the broader pindan shrubland (Section 5.3.2, Figure 5.9).

It appears that the dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat is a product of fire age. Stands of *Acacia tumida* var. *tumida* were observed in areas that had been burnt within the previous year, with a resultant open canopy with dense ground covering vegetation. These areas are unlikely to be suitable to support Greater Bilby in their current condition. However, as these areas mature and increase in fire age, the *Acacia tumida* var. *tumida* shrubs mature and form a canopy layer with ground vegetation becoming sparser, which would then provide suitable habitat for the Greater Bilby to occupy.

The dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat is suitable habitat for Greater Bilby as it provides habitat and a food source. The lack of ground covering vegetation allows for easy movement for the Greater Bilby, the sandy soil substrate allows for the construction of burrows and the canopy allows for protection from aerial predators. Additionally, it was observed a strong feeding association exists between *Acacia tumida* var. *tumida* plants and the Greater Bilby, as numerous diggings were observed at the base of these plants (Figure 5.12). It is likely Greater Bilby are extracting root dwelling insect larvae from these plants, an important food source for the Greater Bilby (Pavey 2006a). This feeding association and general habitat characteristics and utilisation are

consistent with *ecologia's* previous experience with the Greater Bilby on the Dampier Peninsular and the Pilbara.

The Greater Bilby was only recorded from haul road sections of the Thunderbird study area. It is unlikely to occur within the remainder of the haul road study area, due to the narrow linear corridor and lack of dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat and sandy soil substrate. Evidence of Greater Bilby is likely to indicate part of a resident breeding population, however occupation at these areas will be dictated by fire history and will therefore continue to fluctuate accordingly.

Lakeland Downs Mouse (*Leggadina lakedownensis)*

Conservation status: DPaW Priority 4.

Distribution and habitat: Populations of this small, elusive rodent are distributed across northern Australia, but records have been sporadic (Moro and Kutt 2008). They occupy a diverse range of habitats from the monsoon tropical coast to semiarid climates, including spinifex and tussock grasslands, samphire and sedgelands, *Acacia* shrublands, tropical eucalypt and *Melaleuca* woodlands and stony ranges. However, Short-tailed Mice are usually found in seasonally inundated habitats on red or white sandy-clay soils (Moro and Kutt 2008).

Biology: The diet of the Short-tailed Mouse consists primarily of invertebrates, with plants supplementing their water requirements (Moro and Kutt 2008). Populations fluctuate greatly in response to rainfall, sometimes reaching plague proportions. The species is nocturnal and solitary, spending the day in simple, single-chambered burrows (Moro and Kutt 2008).

Likelihood of occurrence: High (resident – breeding). The Lakeland Downs Mouse was recorded during the previous Thunderbird assessment (*ecologia* 2014b). No trapping was completed during this assessment and therefore this species would be difficult to detect. It is likely to occur within pindan shrubland and savannah woodland habitat types, where it will be a resident breeding population.

6.2.2 Birds

Gouldian Finch (*Erythrura gouldiae*)

Conservation status: EPBC Act Endangered, DPaW Priority 4.

Distribution and habitat: The Gouldian Finch was formally distributed throughout the tropical savannahs of northern Australia. It is now restricted to isolated areas mostly within the Northern Territory and the Kimberley region of Western Australia (Woinarski and Palmer 2006). Known breeding habitat is characterised by rocky hills with hollow-bearing, smooth-barked gums that are close to small waterholes or springs that persist through the dry season (O'Malley 2006b).

Biology: Gouldian finches forage on the ground, feeding on seeding grasses, particularly native *Sorghum* spp. (Pizzey and Knight 2003). Due to the restricted diet of Gouldian Finches, they are particularly vulnerable to seed shortages (O'Malley 2006b). The decline in populations of the Gouldian Finch is representative of the general decline of granivorous birds occurring as a result of current land management practices. Ongoing key threats to the Gouldian Finch are vegetation change through inappropriate fire regimes, and grazing impacts of stock and feral herbivores (O'Malley 2006b).

Likelihood of occurrence: Medium. The Gouldian Finch is rarely recorded on the Dampier Peninsular with the exception of the Northern tip. The study area contains suitable foraging and breeding habitat, however given the scarcity in surrounding records, it is only a medium likelihood to occur, and based on current knowledge most likely to be a transient visitor.

Rainbow Bee-eater (*Merops ornatus*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: The Rainbow Bee-eater is scarce to common throughout much of Western Australia, except for the arid interior, preferring lightly wooded, preferably sandy country near water (Johnstone and Storr 1998).

Biology: In Western Australia the Rainbow Bee-eater can occur as a resident, breeding visitor, post-nuptial nomad, passage migrant or winter visitor. It nests in burrows usually dug at a slight angle on flat ground, sandy banks or cuttings, and often at the margins of roads or tracks (Simpson and Day 2004). Eggs are laid at the end of the metre-long tunnel from August to January (Boland 2004). Rainbow Bee-eaters are most susceptible to predation during breeding, as it spends significantly more time on the ground in this period.

Likelihood of occurrence: High (resident – breeding). The Rainbow Bee-eater was recorded on nine occasions during the current survey (Table 5.5), and was recorded within breeding burrows during previous assessment (*ecologia* 2014b). It is likely to forage in all habitat types and construct breeding burrows in any habitats where suitable sandy substrate exists.

Fork-tailed Swift (*Apus pacificus*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: The Fork-tailed Swift is a small, insectivorous species with a white throat and rump, and a deeply forked tail (Morcombe 2000). Its distribution spans from central Siberia and throughout Asia, breeding in north-east and mid-east Asia, and wintering in Australia and south New Guinea. It is a relatively common trans-equatorial migrant from October to April throughout mainland Australia (Simpson and Day 2004). In Western Australia the species begins to arrive in the Kimberley in late September, the Pilbara in November and the South-west by mid-December (Johnstone and Storr 1998). In Western Australia the Fork-tailed Swift is considered uncommon to moderately common near the north-west, west and south-east coasts, common in the Kimberley and rare or scarce elsewhere (Johnstone and Storr 1998).

Biology: Fork-tailed swifts are nomadic in response to broad-scale weather pattern changes. They are attracted to thunderstorms where they can be seen in flocks, occasionally of up to 2,000 birds. They rarely land, living almost exclusively in the air and feeding entirely on aerial insects, especially nuptial swarms of beetles, ants, termites and native bees (Simpson and Day 2004).

Likelihood of occurrence: High (migratory visitor). The Fork-tailed Swift has a high likelihood of occurrence within the study area during summer months when this species is present in Australia. As this species is completely aerial whilst in Australia, it will not utilise habitats within the study area directly.

Eastern Great Egret (*Ardea modesta*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: Eastern Great Egrets mainly inhabit shallow waterbodies; both fresh (lakes, lagoons, swamps and floodwaters) and saline (mangrove creeks, estuaries and tidal pools) (Johnstone and Storr 1998). They occur across a large part of Western Australia, including the South-west, Kimberley and Pilbara (Johnstone and Storr 1998). The Eastern Great Egret is common to very common in the well-watered Kimberley flatlands, and scarce to moderately common elsewhere within its range (Johnstone and Storr 1998).

Biology: This species' diet consists predominantly of small fish and crustaceans. Eastern Great Egrets breed colonially in trees standing in water around wooded swamps and river pools, 4-13 m above water (Morcombe 2000). The nest is built as a rough, loose, shallow platform. Four eggs are laid in summer in the Kimberley and during the spring in regions further south (Johnstone and Storr 1998).

Likelihood of occurrence: Medium. The Eastern Great Egret has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species.

Cattle Egret (*Ardea ibis*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: The Cattle Egret has a worldwide distribution, occurring across India, south-east Asia, Papua New Guinea, Australia and New Zealand (Johnstone and Storr 1998; McKilligan 2005; Seedikkoya *et al.* 2005). The Cattle Egret is a partial migrant occurring in the better-watered areas of Australia. In Western Australia Cattle Egrets are casual visitors to the Kimberley and also occasionally to the south-west corner, principally in autumn (Johnstone and Storr 1998).

Biology: Cattle Egrets occur typically in small flocks in grassy habitats and wetlands, particularly damp pastures, and are usually found in the company of cattle or other livestock (Johnstone and Storr 1998; Seedikkoya *et al.* 2005). Unlike most herons, they feed largely on insects such as grasshoppers, but also eat many other invertebrates. Cattle Egrets breed in colonies, usually with other waterbirds. Their nests, rough, loose platforms of sticks, can be found in trees and bushes in wetland areas (Morcombe 2000; RPS 2008).

Likelihood of occurrence: Medium. The Cattle Egret has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features. The open grassland features of this habitat type provides suitable foraging habitat.

Oriental Plover (*Charadrius veredus*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: The Oriental Plover is a lightly built shorebird with long, yellowish legs and a distinctly upright stance (Johnstone and Storr 1998; Simpson and Day 2004). In Western Australia, this species occurs in the Kimberley, north-eastern interior (Lake Gregory) and north-west coastal plains.

Biology: The preferred habitat of the Oriental Plover consists of sparsely vegetated plains, including samphire and short-grass flats, where it feeds largely on insects (Johnstone and Storr 1998). They often forage at night and roost during the day with other waders on beaches or mudflats (Morcombe 2000). Oriental Plovers breed in Mongolia, south Siberia and north China, returning to northern Australia during summer. They are uncommon to common, being most common in the drier parts of their range, occurring usually in flocks of up to 200 birds.

Likelihood of occurrence: Medium. The Oriental Plover has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species, along with permanent open and bare areas.

Little Curlew (*Numenius minutus*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: Little Curlews may be found throughout coastal areas of Australia, but are most frequently recorded on the northern and eastern coasts. The species is typically found on short, dry grasslands and often on artificially grassed areas; also on the dry grass edges of freshwater wetlands (Geering *et al.* 2007). Little Curlew flocks are highly mobile, often congregating in wetlands to drink in hot conditions (Geering *et al.* 2007).

Biology: This shorebird is the smallest curlew, which forms small to huge, mobile flocks in northern Australia in short, dry grasslands and sedges (Pizzey and Knight 2003; Geering *et al.* 2007). Little Curlews breed in north-eastern Siberia, with most of the population migrating to the sub-coastal plains of northern Australia in winter (September to April) (Pizzey and Knight 2003; Geering *et al.* 2007). Little Curlews exhibit wary behaviour, walking rapidly, and squatting, freezing or flushing with quick calls.

Likelihood of occurrence: Medium. The Little Curlew has a medium likelhood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species, along with permanent open and bare areas.

Wood Sandpiper (*Tringa glareola*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and Habitat: The Wood Sandpiper breeds in the Europe and northern Asia during the austral winter, migrating south to Africa, south Asia and Australia for the austral summer (Johnstone and Storr 1998). The species is a regular migrant to Western Australia in small numbers, mostly from August to May (Johnstone and Storr 1998). It occurs most commonly in coastal, better-watered regions of the state but will visit areas of suitable habitat in the interior (Johnstone and Storr 1998). In Australia, the species typically occurs around the muddy or grassy margins of freshwater wetlands, including swamps, lagoons, river pools, dams, bore overflows and sewage ponds (Johnstone and Storr 1998; Pizzey and Knight 2003).

Biology: The Wood Sandpiper is a sharp-tailed wader with long legs, a black bill and a long neck, dark brown back and wings and white spots (Simpson and Day 2004)The Wood Sandpiper is a transequatorial migrant, breeding in the northern hemisphere and migrating long distances to winter in the southern hemisphere. In Australia, the species typically occurs in singles, pairs or small parties (Johnstone and Storr 1998).

Likelihood of Occurrence: Medium. The Wood Sandpiper has a medium likelhood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species.

Common Greenshank (*Tringa nebularia*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: The Common Greenshank is a non-breeding visitor to well-watered regions of Australia that can be observed in all months. It is uncommon to moderately common on coasts and coastal plains and rare to scarce elsewhere (Johnstone and Storr 1998). It can be found in shallow, fresh waters (e.g. claypans, swamps, river pools) and salt waters (e.g. estuaries, samphire flats, reef flats).

Biology: Like most waders, Common Greenshanks feed on small invertebrates, but will also take small fish (Johnstone and Storr 1998; Pizzey and Knight 2003).

Likelihood of Occurrence: Recorded (transient visitor). Two individuals of the Common Greenshank were recorded during the current survey (Table 5.5). The individuals were recorded flying in to land at a relatively small man made turkey nest containing water, in the southern section of the haul road, within the savannah woodland habitat type (Figure 5.15). Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species.

Red-necked Stint (*Calidris ruficollis*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: Red-necked Stints are primarily coastal, occurring on the edge of sheltered estuaries, beaches and saltlakes both on the mainland and on offshore islands. They can also occasionally occur on inland saltlakes and freshwater swamps. The species is a non-breeding migrant, arriving from Siberia and Alaska in October and returning in March, and is common to very common on most coasts, rare in the northern interior and moderately common in the southern interior (Johnstone and Storr 1998).

Biology: The species typically occurs in small flocks and is highly gregarious with other species. They are omnivorous, feeding on insects and molluscs captured from exposed mudflats as well as seeds and plant matter.

Likelihood of Occurrence: Medium. The Red-necked Stint has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species.

Long-toed Stint (*Calidris subminuta*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: Long-toed Stints are primarily coastal with scattered inland records. They occur in a variety of terrestrial wetlands, prefering shallow freshawater or brackish waters including lakes, swamps, river floodplains, streams lagoons and sewage works (DoE 2015b).

Biology: Long-toed Stints are omnivorous, feeding on seeds, insects, crustaceans and molluscs captured within freshwater habitats where they forage singly or in small flocks (DoE 2015b).

Likelihood of Occurrence: Medium. The Long-toed Stint has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species.

Sharp-tailed Sandpiper (*Calidris acuminata*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: The Sharp-tailed Sandpiper is a non-breeding visitor to Australia. The species is widespread in a variety of freshwater and saline habitats, and is more often found on the coasts than in the interior, where it prefers well-watered areas (Higgins and Davies 1996; Johnstone and Storr 1998). Sharp-tailed Sandpipers are widespread from Cape Arid to Carnarvon, around coastal and subcoastal plains of Pilbara Region to the south-west and east Kimberley Division. Inland records indicate the species is widespread and scattered from Newman, east to Lake Cohen, south to Boulder and west to Meekatharra (Higgins and Davies 1996).

In Australasia, the Sharp-tailed Sandpiper prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation. They may be attracted to mats of algae and water weed either floating or washed up around terrestrial wetlands and coastal areas with much beachcast seaweed (Higgins and Davies 1996).

Biology: The Sharp-tailed Sandpiper is migratory, breeding in northern Siberia and moving to non-breeding areas south of the equator (Higgins and Davies 1996). They are usually found in ones, twos or small parties, occasionally flocks of up to 300, and rarely in large aggregations of up to 20,000 soon after arrival or shortly before departure (Johnstone and Storr 1998).

Likelihood of Occurrence: Medium. The Sharp-tailed Sandpiper has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small

drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species.

Oriental Pratincole (*Glareola maldivarum*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: The Oriental Pratincole is a non-breeding migrant to Australia. The species breeds from Mongolia, Siberia and China, south to Sri Lanka, Thailand and Vietnam. It then spends the winter period (late October to May) in northern Australia (Johnstone and Storr 1998). Oriental Pratincoles occur on open plains, bare ground around swamps, and claypans.

Biology: Oriental Pratincoles hawk insects from the ground and can sometimes occur in huge flocks. Birds may feed in the evening until nearly dark (Johnstone and Storr 1998).

Likelihood of occurrence: Medium. The Oriental Pratincole has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species, along with permanent open and bare areas.

Eastern Yellow Wagtail (*Motacilla tschutschensis*) and Grey Wagtail (*Motacilla cinerea*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: Both wagtail species are a relatively uncommon non-breeding migrant to Australia. The Eastern Yellow Wagtail typically occurs in damp, short-grass flats, while the Grey Wagtail more typically occurs along freshwater habitats such as creeks and streams, however both species could occur in any habitats during migration (Johnstone and Storr 2004).

Biology: Both species forage along the ground surface where they pick small insects from the ground after a short chase or bounce in the air (Johnstone and Storr 2004)..

Likelihood of occurrence: Medium. Both wagtail species have a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species, along with permanent open and bare areas.

Grey Falcon (*Falco hypoleucos*)

Conservation status: WC Act Schedule 1, DPaW Vulnerable.

Distribution and habitat: Grey Falcons are a rare, nomadic species sparsely distributed across much of arid and semi-arid Australia. In Western Australia, they are restricted to the northern half, occurring in a variety of habitats ranging from wooded drainage systems through to open spinifex plains. Grey Falcons once occurred across much of Western Australia, with sightings as far south as York and New Norcia during colonial times. However, the current distribution is now thought to be restricted to north of 26 °S (Johnstone and Storr 1998). Because the distribution of this species is scarce over an extremely large area, sightings of this species are very uncommon.

The Grey Falcon occurs in a wide variety of arid habitats, including open woodlands and open acacia shrubland, hummock and tussock grasslands and low shrublands, and may also be seen around swamps and waterholes that attract prey (Ehmann and Watson 2008).

Biology: Like other falcons, this species preys primarily on birds such as parrots and pigeons, although reptiles and mammals are also taken (Ehmann and Watson 2008). Two to three eggs are laid in winter in the nests of other birds of prey and ravens, typically in tall eucalypt trees near water (Garnett and Crowley 2000; Ehmann and Watson 2008).

Likelihood of occurrence: Medium. The low density and scarce sightings of the Grey Falcon suggest this species has a medium likelihood of occurrence within the study area. Utilisation of the study would most likely be of a transient foraging nature.

Peregrine Falcon (*Falco hypoleucos*)

Conservation status: WC Act Schedule 4, DPaW Specially Protected Fauna.

Distribution and habitat: This nomadic or sedentary falcon is widespread in many parts of Australia and some of Australia's continental islands, but absent from most deserts and the Nullarbor Plain. The species is considered to be moderately common in the Stirling Range, uncommon in the Kimberley, Hamersley and Darling Ranges, and rare or scarce elsewhere (Johnstone and Storr 1998). The Peregrine Falcon occurs most commonly near cliffs along coasts, rivers and ranges, and around wooded watercourses and lakes.

Biology: Peregrine Falcons feed almost entirely on birds, especially parrots and pigeons. They nest primarily on ledges on cliffs, granite outcrops and in quarries, but may also nest in tree hollows around wetlands. Eggs are predominantly laid in September (Johnstone and Storr 1998; Olsen *et al.* 2006).

Likelihood of occurrence: Medium. The low density and scarce sightings of the Peregrine Falcon suggest this species has a medium likelihood of occurrence within the study area. Utilisation of the study would most likely be of a transient foraging nature.

Australian Bustard (*Ardeotis australis*)

Conservation status: DPaW Priority 4.

Distribution and habitat: The Australian Bustard occurs almost Australia-wide and utilises a number of open habitats, including open or lightly wooded grasslands, chenopod flats, plains and heathlands (Johnstone and Storr 1998).

Biology: It is a nomadic species, ranging over very large areas, and its abundance varies locally and seasonally from scarce to common, largely dependent on rainfall and food availability. The Australian Bustard has an omnivorous diet, feeding on grasses, seeds, fruit, insects and small vertebrates.

Although the population size is still substantial, there has been a large historical decline in abundance, particularly south of the tropics, but also across northern Australia (Garnett and Crowley 2000). This is a result of hunting, degradation of its grassland habitat by sheep and rabbits, and predation by foxes and cats (Frith 1976; Garnett and Crowley 2000). Australian Bustards readily desert nests in response to disturbance by humans, sheep or cattle (Garnett and Crowley 2000).

Likelihood of occurrence: Recorded (resident – breeding). The Australian Bustard was recorded on four occasions during the current survey (Table 5.5). This species is likely to be resident within the study area, and when conditions are suitable likely to breed within the study area.

6.2.3 Reptiles

Dampierland Plain Slider (*Lerista separanda*)

Conservation status: DPaW Priority 2.

Distribution and habitat: *Lerista separanda* is currently known to be found in sandy soils along the south-west Kimberley coastline, between Kimbolton and Nita Downs (Wilson and Swan 2010).

Biology: There is little information on the biology of this species. *L. separanda* is one of the smallest species in the genus and has a fused lower eyelid (Wilson and Swan 2010). Whereas most other *Lerista* species have greatly reduced or only two limbs, *L. separanda* has four of the relatively largest limbs. This strongly suggests that it is not only able to push its way through sand but also walk across it.

Likelihood of occurrence: Medium. Although the only records are from the western coast of the Dampier Peninsula, they are from a sandy loam soil with pindan shrubland habitat. This habitat is widespread and abundant across the peninsula, and is present within the study area. It is therefore possible for the distribution of *Lerista separanda* to include the study area. Similarly, *Lerista apoda* and *Lerista greeri* were previously only known from the western coastline and to the east of the Dampier Peninsula respectively, yet both were recorded during the previous Thunderbird assessment (*ecologia* 2014b).

Dampierland Burrowing Snake (*Simoselaps minimus*)

Conservation status: DPaW Priority 2.

Distribution and habitat: This snake is currently known only from the western side of the Dampier Peninsula. Its preferred habitat is on coastal dunes or the sandy areas between dunes and adjacent *Acacia* shrublands (Wilson and Swan 2010).

Biology: Little is known of the Dampierland Burrowing Snake's biology, but it is presumably similar to other *Simoselaps* species, which are sand-swimmers that feed mostly on *Lerista* skinks (Wilson and Swan 2010).

Likelihood of occurrence: **Medium.** Although previous records are from the western coast of the Dampier Peninsula, they are from sandy soils. Given sandy soils extend across much of the peninsula, and are characteristic of the pindan shrubland and savannah woodland habitats found within the study area, the Dampierland Burrowing Snake may therefore occur within the study area.

Dampierland Peninsula Goanna (*Varanus sparnus*)

Conservation status: DPaW Priority 2.

Distribution and habitat: The Dampier Peninsula Goanna is currently only known from four point locations, which represent the specimens used to describe the species (Doughty *et al.* 2014). The known distribution extends from coastal areas at Coulomb Point, 90 km, east to central Dampier Peninsula. Specimens were collected from habitats broadly described as pindan shrubland with sandy soils associated with alluvial or sandstone deposits (Doughty *et al.* 2014). The previous Thunderbird assessment recorded *Varanus sparnus/brevicauda* across all habitat types present (pindan shrubland, savannah woodland, sandstone range and footslopes) (*ecologia* 2014b).

Biology: The Dampier Peninsula Goanna which weighs approximately 16 grams is the smallest known *Varanus* species in the world. It has been observed to be an active burrower in captivity, with a highly prehensile tail, possibly for assisting in navigation through spinifex clumps (Doughty *et al.* 2014).

Likelihood of occurrence: **High (resident – breeding).** The Dampier Peninsula Goanna was not recorded on the current survey. However the sampling methods sonducted were unlikely to record this cryptic species. Given the species was recorded within the Thunderbird project study area; it is likely to occur within the current study area where there is likely to be a resident breeding population. Appendix H details the recent description and clarifies the Dampier Peninsula Goanna's occurrence in relation to the Thunderbird project.

7 CONCLUSIONS

The key results and conclusions of the flora, vegetation and fauna assessment are as follows:

- No Threatened Flora taxa were recorded in the study area;
- Two Priority flora taxa were recorded at the study area; *Pterocaulon intermedium* (Priority 3) and *Triodia caelestialis* (Priority 3).
- No WONS or Declared Pests (Weeds) were recorded at the study area, but four introduced species of flora were recorded at the study area: **Malvastrum americanum*, **Stylosanthes hamata*, **Stylosanthes scabra* and **Tridax procumbens*.
- No TECs or PECs were recorded, or are considered likely to occur in the study area.
- Approximately 10% or less of the currently mapped extent of nine of the eleven vegetation units described in the study area is covered by the study area. The other two vegetation units, which were not described in the previous Thunderbird assessments (*AtStCpHc* and *CgDhHc*), are associated with widespread landforms: extensive and plains (*AtStCpHc*) and floodplains adjacent to ephemeral waterways (*CgDhHc*). These two vegetation units are therefore considered likely to be represented extensively in the surrounding landscape, where such landforms are widespread.
- The literature review identified a total of 383 fauna species that may potentially to occur within the study area, including 32 native and six introduced mammal species, 249 bird species, 82 reptiles and 14 amphibians. Species recorded from the literature review include a total of 69 conservation significant vertebrate fauna species, comprising six mammal species, 59 bird species and four reptile species.
- Three broad fauna habitat types were identified and delineated for the study area; pindan shrubland, savannah woodland and sandstone range and footslopes. All fauna habitat types were recorded during the previous Thunderbird assessment and are extensive through the region.
- Four conservation significant fauna species were recorded; Greater Bilby (EPBC Act Vulnerable), Rainbow Bee-eater (EPBC Migratory, WC Act Schedule 3, DPaW International Agreement), Common Greenshank (EPBC Migratory, WC Act Schedule 3, DPaW International Agreement) and Australian Bustard (DPaW Priority 4).
- The Greater Bilby was only recorded from the haul road sections of the current Thunderbird project study area. It is unlikely to occur within the remainder of the haul road study area, due to the narrow linear corridor and absence of dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat and sandy soil substrate. Locations where Greater Bilby were recorded may be part of a resident breeding population, however occupation at these areas will be determined by fire history and will therefore continue to fluctuate accordingly.
- Of the 69 conservation significant fauna species that may potentially occur within the study area, a total of 46 species were assessed as having a low likelihood, 16 species as medium likelihood and seven species as high likelihood or were recorded during the current survey.

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8 REFERENCES

AECOM. 2010. Supplementary Terrestrial Fauna and Habitat Assessment: James Price Point, WA.

AECOM 2011. Browse LNG Precinct Access Road: Targeted Fauna Survey – Greater Bilby.

Bamford Consulting Ecologists 2011. Assessment of Birds Utilising Habitat within the Vine Thickets and Woodlands of James Price Point, WA. Field Report, May 2011.

Beard, J. S. 1979. Kimberley: The vegetation of the Kimberley area. Vegetation Survey of Western Australia 1:1,000,000 series, explanatory notes and map. University of Western Australia Press, Nedlands, WA.

Biota Environmental Sciences. 2009. James Price Point Terrestrial Fauna Survey: Wet Season 2009.

Biota Environmental Sciences. 2010. James Price Point Browse LNG Precinct Targeted Terrestrial Fauna Survey.

Boland, C. R. J. 2004. Breeding biology of Rainbow Bee-eaters (*Merops ornatus*): a migratory, colonial, cooperative bird. The Auk. 121:811-823.

BoM. 2015. Climate Data Online. Available at http://www.bom.gov.au/. Bureau of Meteorology.

CALM. 1999. Environmental Weed Strategy for Western Australia. Department of Conservation and Land Management, Government of Western Australia, Western Australia.

Christidis, L. and Boles, W. E. 2008. Systematics and Taxonomy of Australian Birds. CSIRO Publishing, Collingwood.

Churchill, S. 1998. Australian Bats. Reed New Holland, Sydney.

Churchill, S. 2008. Australian Bats. Jacana Books, Crows Nest NSW.

Cogger, H. G. 2000. Reptiles and Amphibians of Australia. Reed New Holland, Sydney.

DAFWA. 2007. Biosecurity and Agriculture Management Act 2007. As at 01 May 2013. Department of Agriculture and Food Western Australia. Government of Western Australia, South Perth.

DAFWA. 2013. Western Australian Organism List (WAOL) - Declared pest list. Available at http://www.biosecurity.wa.gov.au/organisms/export/PER-DP. Department of Agriculture and Food Western Australia. Government of Western Australia., South Perth.

DEC. 2010. Definitions, categories and criteria for Threatened and Priority Ecological Communities. Department of Environment and Conservation. Government of Western Australia.

DER. 2014. Native Vegetation Viewer. Accessed August. http://maps.dec.wa.gov.au/idelve/nv/index.jsp

DoE. 2015a. EPBC Act Protected Matters Search Tool (*custom search*). Department of Environment.

DoE. 2015b. Species Profile and Threats Database. *Calidris subminuta* - Long-toed Stint. Accessed http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=861.

Doughty, P., Kealley, L., Fitch, A., and Donnellan, C. 2014. A new diminutive species of *Varanus* from the Dampier Peninsula, western Kimberley region, Western Australia. Records of the Western Australian Museum. 29:128-140.

DPaW. 2015a. NatureMap: Mapping Western Australia's Biodiversity, Department of Parks and Wildlife. Department of Parks and Wildlife.

DPaW. 2015b. NatureMap: Mapping Western Australia's Biodiversity. Available at http://naturemap.dpaw.wa.gov.au/. Department of Parks and Wildlife.

DSEWPaC. 2010. Survey Guidelines for Australia's Threatened Birds. Department of Sustainability, Environment, Water, Population and Communities.

DSEWPaC. 2011. Survey guidelines for Australia's Threatened Mammals. Department of Sustainability, Environment, Water, Population and Communities.

DSEWPaC. 2012a. Interim Biogeographic Regionalisation for Australia (IBRA), Version 7. Australian Government Department of Sustainability, Environment, Water, Population and Communities.

DSEWPaC. 2012b. Weeds of National Significance (WONS). Department of Sustainability, Environment, Water, Population and Communities. Commonwealth of Australia. Available at: http://www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/wons.html.

ecologia. 2004a. Beagle Bay Big Tree Country Timber Plantation Flora Assessment Survey. Ecologia Environment.

ecologia. 2004b. Beagle Bay Big Tree Country Timber Plantation Groundwater Dependent Ecosystems Flora Assessment. Ecologia Environment.

ecologia Environment. 2004c. Beagle Bay Big Tree Country Tropical Timber Plantation Project. Fauna Assessment Survey. 18/02/2005

ecologia. 2012. Thunderbird Dampier Peninsula Project Level 1 Flora and Fauna Assessment. Not yet published.

ecologia. 2014a. Thunderbird Project Level 2 Flora and Vegetation Assessment. Report by *ecologia* Environment for Sheffield Resources.

ecologia Environment. 2014b. Thunderbird Project Terrestrial and Subterranean Fauna Assessment. Unpublished report for Sheffield Resources Ltd.

Ehmann, H. and Watson, M. 2008. Grey Falcon, *Falco hypoleuca*.

ENV Australia. 2008. Perpendicular Head-North Head, Packer Island, Gourdon Bay and Coulomb-Quondong Vertebrate Fauna Assessment.

ENV Australia. 2011. Browse Project Greater Bilby Survey of the James Price Point Area: Summary Report.

EPA. 2002a. Terrestrial Biological Surveys as an Element of Biodiversity Protection *in* Environmental Protection Authority, ed, Perth.

EPA. 2002b. Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3. Environmental Protection Authority, Western Australia.

EPA. 2004a. Guidance for the Assessment of Environmental Factors. Guidance Statement 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. Environmental Protection Authority, Western Australia.

EPA. 2004b. Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia *in* Authority, E. P., ed.

EPA. 2004c. Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia - Guidance Statement No. 56. Environmental Protection Authority, Perth.

EPA and DEC. 2010. Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment. Environmental Protection Authority and Department of Environment and Conservation *in* Hyder, B. M., Dell, J., Cowan, M. A., ed. Environmental Protection Authority and Department of Environment and Conservation.

ESCAVI. 2003. Australian Vegetation Attribute Manual: National Vegetation Information System (NVIS). Executive Steering Committee for Australian Vegetation Information System (ESCAVI), Australian Government Department of Environment and Heritage, Canberra.

Frith, A. J. 1976. Reader's Digest Complete Birds of Australia. Reader's Digest, Sydney.

Garnett, S. T. and Crowley, G. M. 2000. The Action Plan for Australian Birds. Environment Australia, Canberra.

Geering, A., Agnew, L., and Harding, S. 2007. Shorebirds of Australia. CSIRO Publishing, Sydney.

Graham, G. 2002. Dampierland 2 (DL2 – Pindanland subregion). Department of Conservation and Land Management, Perth, Western Australia.

Higgins, P. J. and Davies, S. J. J. F. 1996. Handbook of Australian, New Zealand and Antarctic Birds. Volume 3: Snipe to Pigeons. Oxford University Press, Melbourne.

Johnson, K. A. 2008. Bilby, *Macrotis lagotis*. pp. 191-193 *in* van Dyck, S., and Strahan, R., eds. The Mammals of Australia. Reed New Holland, Sydney.

Johnstone, R. E. and Storr, G. M. 1998. Handbook of Western Australian Birds, Volume I - Non-Passerines (Emu to Dollarbird). Western Australian Museum, Perth.

Johnstone, R. E. and Storr, G. M. 2004. Handbook of Western Australian Birds, Volume II - Passerines (Blue-winged Pitta to Goldfinch). Western Australian Museum, Perth.

Maxwell, S., Burbidge, A. A., and Morris, K. D., eds. 1996. The 1996 Action Plan for Australian Marsupials and Monotremes. Wildlife Australia, Canberra.

McKilligan, N. 2005. Herons, Egrets and Bitterns: their biology and conservation in Australia. CSIRO Publishing, Collingwood.

Menkhorst, P. and Knight, F. 2011. *A Field Guide to the Mammals of Australia*. Oxford University Press, Melbourne.

Milne, D. J., Armstrong, K. N., and McKenzie, N. L. 2008. Western Little Free-tailed Bat, *Mormopterus loriae cobourgiana*. pp. 488-489 *in* Van Dyck, S., and Strahan, R., eds. The Mammals of Australia. Reed New Holland, Sydney.

Morcombe, M. 2000. Field Guide to Australian Birds. Steve Parish Publishing Pty Ltd, Archerfield, Australia.

Moro, D. and Kutt, A. S. 2008. Northern Short-tailed Mouse, *Leggadina lakedownensis*. pp. 583-584 *in* van Dyck, S., and Strahan, R., eds. The Mammals of Australia. Reed New Holland, Sydney.

NHMRC. 2004. Australian code of practice for the care and use of animals for scientific purposes. National Health and Medical Research Council. National Health and Medical Research Council, Canberra.

O'Malley, C. 2006a. Australian Threatened Species, Greater Bilby, *Macrotis lagotis*.

O'Malley, C. 2006b. National Recovery Plan for the Gouldian Finch (*Erythrura gouldiae)*.

Oakwood, M. 2008. Northern Quoll, *Dasyurus hallucatus*. pp. 57-59 *in* van Dyck, S., and Strahan, R., eds. The Mammals of Australia. Reed New Holland, Sydney.

Olsen, J., Fuentes, E., Dykstra, R., and Rose, A. B. 2006. Male Peregrine Falcon *Falco peregrinus* fledged from a cliff-nest found breeding in a stick-nest. Australian Field Ornithology. 23:8-14.

Pavey, C. 2006a. National Recovery Plan for the Greater Bilby *Macrotis lagotis*. Northern Territory Department of Natural Resources, Environment and the Arts.

Pavey, C. 2006b. Threatened Species of the Northern Territory: Greater Bilby *Macrotis lagotis in* Department of Natural Resources Environment and the Arts, ed. Parks and Wildlife Commission - Northern Territory Government.

Pizzey, G. and Knight, F. 2003. A Field Guide to the Birds of Australia. Harper Collins Publishers, Sydney.

Pizzey, G., Pizzey, S., and Knight, F. 2013. Field Guide to the Birds of Australia. HarperCollins Publishers, Australia.

Rogers, D., Hassell, C., Oldland, J., Clemens, R., Boyle, A., and Rogers, K. 2009. Monitoring Yellow Sea Migrants in Australia (MYSMA): North-western Australian shorebird surveys and workshops, December 2008.

RPS. 2008. Migratory Birds *in* Bridgewater North ODP, ed. EBPC Referral,.

Seedikkoya, K., Azeez, P. A., and Shukkur, E. A. A. 2005. Cattle Egret, *Bubulcus ibis,* habitat use and association with cattle. Forktail. 21:174-176.

Shepherd, D. P., Beeston, G. R., and Hopkins, A. J. M. 2001. Native vegetation in Western Australia: Extent, type and status. Technical Report 249. Department of Agriculture, South Perth, Western Australia.

Simpson, K. and Day, N. 2004. Field Guide to the Birds of Australia. Penguin Group, Camberwell.

Simpson, K. and Day, N. 2010. Field Guide to the Birds of Australia. Penguin Group, Camberwell.

Trudgen, M. E. 1991. Vegetation Condition Scale. In: National Trust (WA) 1993 Urban Bushland Policy. National Trust of Australia (WA), Wildflower Society of WA (Inc.), and the Tree Society (Inc.), Perth, Western Australia.

Tyler, M. J. and Doughty, P. 2009. Field Guide to Frogs of Western Australia. Western Australian Museum, Perth.

van Dyck, S. and Strahan, R. 2008. *The Mammals of Australia*. Reed New Holland, Sydney.

Western Australian Herbarium. 1998-2015. FloraBase - The Western Australian Flora. Government of Western Australia Department of Parks and Wildlife. Available at: http://florabase.dpaw.wa.gov.au/.

Wilson, S. and Swan, G. 2010. *A Complete Guide to Reptiles of Australia*. New Holland Publishers, Sydney.

Wilson, S. and Swan, G. 2013. *A Complete Guide to Reptiles of Australia*. New Holland Publishers, Sydney.

Woinarski, J. C. Z. and Palmer, C. 2006. Threatened Species of the Northern Territory: Gouldian Finch *Erythrura gouldiae*. Parks and Wildlife Commission - Northern Territory Government.

APPENDIX A CONSERVATION CODES

Definition of codes for Threatened and Priority Flora (DPaW)

Code	Definition
T	**Threatened Flora – (Declared Rare Flora – Extant)** Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection and have been gazetted as such (Schedule 1 under the *Wildlife Conservation Act 1950*).
X	**Presumed Extinct Flora (Declared Rare Flora - Extinct)** Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such Schedule 2 under the *Wildlife Conservation Act 1950*).
P1	**Priority One – Poorly Known Species** Species that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.
P2	**Priority Two – Poorly Known Species** Species that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.
P3	**Priority Three – Poorly Known Species** Species that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.
P4	**Priority Four – Rare, Near Threatened and other species in need of monitoring** (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.
P5	**Priority Five - Conservation Dependent species** Species that are not threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Definition of codes for Commonwealth Listed Threatened Flora

Code	Definition
Ex	**Extinct** Taxa which at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
ExW	**Extinct in the Wild** Taxa which is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
CE	**Critically Endangered** Taxa which at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	**Endangered** Taxa which is not critically endangered and it is facing a very high risk of extinction in the wild in the immediate or near future, as determined in accordance with the prescribed criteria.
V	**Vulnerable** Taxa which is not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	**Conservation Dependent** Taxa which at a particular time if, at that time, the species is the focus of a specific conservation programme, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

Definition of codes for Threatened Ecological Communities

Code	Definition
PD: Presumed Totally Destroyed	An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant
CR: Critically Endangered	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future.
EN: Endangered	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future.
VU: Vulnerable	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future.

Definition of codes for Priority Ecological Communities

Code	Definition
P1: Priority One	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or Pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
P2: Priority Two	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
P3: Priority Three	(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (iii) Communities made up of large, and/or widespread occurrences that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
P4: Priority Four	Ecological communities that are adequately known, Rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring. (a) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands. (b) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Ecological communities that have been removed from the list of threatened communities during the past five years. P5: Priority Five Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.
P5: Priority Five	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Definition of codes for Threatened Fauna (WC Act)

Code	Definition
T (Schedule 1)	Fauna that is rare or likely to become extinct Taxa that have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction or otherwise in need of special protection, and have been gazetted as such. Further categorised as: • CR Critically Endangered – considered to be facing an extremely high risk of extinction in the wild • EN Endangered – considered to be facing a very high risk of extinction in the wild • VU Vulnerable – considered to be facing a high risk of extinction in the wild.
X (Schedule 2)	Presumed Extinct Fauna Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such.
IA (Schedule 3)	Birds protected under an international agreement. Birds that are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction are declared to be fauna that is in need of special protection.
S (Schedule 4)	Other specially protected fauna Fauna that is in need of special protection, otherwise than for the reasons mentioned [in Schedule 1 – 3].]

Definition of codes for Priority Fauna

Code	Definition
P1	**Priority One** Taxa with few, poorly known populations on threatened lands. Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
P2	**Priority Two** Taxa with few, poorly known populations on conservation lands. Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
P3	**Priority Three** Taxa with several, poorly known populations, some on conservation lands. Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
P4	**Priority Four** Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.
P5	**Priority Five** Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Definition of codes for Threatened Fauna (EPBC Act)

Code	Definition
Ex	**Extinct** Taxa not definitely located in the wild during the past 50 years
ExW	**Extinct in the Wild** Taxa known to survive only in captivity
CE	**Critically Endangered** Taxa facing an extremely high risk of extinction in the wild in the immediate future
E	**Endangered** Taxa facing a very high risk of extinction in the wild in the near future
V	**Vulnerable** Taxa facing a high risk of extinction in the wild in the medium-term
NT	**Near Threatened** Taxa that risk becoming Vulnerable in the wild
CD	**Conservation Dependent** Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened.
DD	**Data Deficient (Insufficiently Known)** Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

APPENDIX B FAUNA LITERATURE REVIEW RESULTS

Mammals

Species and family	Common name	EPBC Act	WC Act	DEC	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	J ames Price Point (AECOM 2010)	James Price Point (AECOM 2011)	Jmes Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	This survey
TACHYGLOSSIDAE																	
Tachyglossus aculeatus	Echidna					●		S				●		●			S
DASYURIDAE																	
Dasyurus hallucatus	Northern Quoll	**EN**	**S1**	**EN**												●	
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart					●	●							●			
PERAMELIDAE																	
Isoodon auratus	Golden Bandicoot	**VU**	**S1**	**VU**											●		
THYLACOMYIDAE																	
Macrotis lagotis	Greater Bilby	**VU**	**S1**	**VU**		●	**S**	S	S			S	S	●	●	●	S
PHALANGERIDAE																	
Trichosurus vulpecula arnhemensis	Northern Brushtail Possum						●					●					
MACROPODIDAE																	
Macropus agilis	Agile Wallaby					●	**S**	●		●	●	●		●			●
Macropus robustus	Euro				●	●						●		●			
Macropus rufus	Red Kangaroo											●					
EMBALLONURIDAE																	
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat					●	●			●		●					
Taphozous georgianus	Common Sheathtail Bat											●					
MOLOSSIDAE																	
Chaerophon jobensis	Northern Freetail Bat				●	●	●			●		●		●			
Mormopterus beccarii	Beccari's Freetail Bat											●					

Species and family	Common name	EPBC Act	WC Act	DEC	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	J ames Price Point (AECOM 2010)	James Price Point (AECOM 2011)	Jmes Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	This survey
Mormopterus loriae	Little Northern Freetail Bat			**P1**								●					
Tadarida australis	White-striped Freetail Bat											●					
VESPERTILIONIDAE																	
Chalinolobus gouldii	Gould's Wattled Bat				●	●	●			●		●		●			
Chalinolobus nigrogriseus	Hoary Wattled Bat				●	●	●			●		●		●			
Miniopterus schreibersii orianae	Common Bentwing Bat					●						●					
Myotis macropus	Large-footed Myotis					●											
Nyctophilus arnhemensis	Arnhem Land Long-eared Bat									●		●					
Nyctophilus geoffroyi	Lesser Long-eared Bat					●	●					●					
Pipistrellus westralis	Northern Pipistrell											●					
Scotorepens greyii	Little Broad-nosed Bat				●	●	●			●		●		●			
Scotorepens sanborni	Northern broad-nosed Bat									●		●					
Vespadelus caurinus	Western Cave Bat											●					
Vespadelus douglasorum	Yellow-lipped Cave Bat			**P2**			●										
Vespadelus finlaysoni	Finlayson's Cave Bat											●		●			
MURIDAE																	
Leggadina lakedownensis	Lakeland Downs Mouse			**P4**		●						●		●			
Pseudomys delicatulus	Delicate Mouse					●	●	S		●	●	●		●			●
Pseudomys nanus	Western Chestnut Mouse					●	●					●		●			
Rattus tunneyi	Pale Field Rat											●	●				
CANIDAE																	
Canis lupus dingo	Dog/Dingo				●	●	●	●		●	●	●		●			●

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INTRODUCED MAMMALS																	
Mus musculus	House Mouse					●				●		●		●			
Rattus rattus	Black Rat							●				●					
Vulpes vulpes	Red Fox											●					
Felis catus	Cat				●	●	●	●		●	●	●		●			●
Equus asinus	Donkey						●					●					
Bos taurus	Cow				●	●		●				●		●			●

Birds

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	Birdata	This survey
PHASIANIDAE																	
Coturnix ypsilophora	Brown Quail					●	●	●	●	●	●		●			●	
ANSERANATIDAE																	
Anseranas semipalmata	Magpie Goose					●							●			●	
ANATIDAE																	
Dendrocygna eytoni	Plumed Whistling-duck					●					●	●	●			●	
Dendrocygna arcuata	Wandering Whistling-duck					●					●	●	●			●	
Stictonetta naevosa	Freckled Duck					●							●				
Cygnus atratus	Black Swan												●				
Chenonetta jubata	Australian Wood Duck					●						●	●			●	
Malacorhynchus membranaceus	Pink-eared Duck					●						●	●			●	
Nettapus pulchellus	Green Pygmy-Goose					●						●	●			●	
Anas gracilis	Grey Teal				●	●					●	●	●			●	
Anas superciliosa	Pacific Black Duck				●	●					●	●	●			●	
Aythya australis	Hardhead					●					●	●	●			●	
PODICIPEDIDAE																	
Tachybaptus novaehollandiae	Australasian Grebe					●					●	●	●			●	
Poliocephalus poliocephalus	Hoary-headed Grebe											●	●			●	
Podiceps cristatus	Great Crested Grebe												●				
COLUMBIDAE																	

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	Birdata	This survey
Phaps chalcoptera	Common Bronzewing												●				
Phaps histrionica	Flock Bronzewing						●				●		●			●	
Ocyphaps lophotes	Crested Pigeon				●	●		●	●	●	●		●			●	●
Geopelia cuneata	Diamond Dove				●	●	●		●	●	●		●			●	●
Geopelia striata	Peaceful Dove				●	●	●	●	●	●	●		●			●	●
Geopelia humeralis	Bar-shouldered Dove						●	●	●	●	●		●			●	
PODARGIDAE																	
Podargus strigoides	Tawny Frogmouth					●	●	●	●	●	●		●			●	●
EUROSTOPODIDAE																	
Eurostopodus argus	Spotted Nightjar					●		●			●		●			●	●
AEGOTHELIDAE																	
Aegotheles cristatus	Australian Owlet-nightjar					●	●	●		●	●		●			●	
APODIDAE																	
Apus pacificus	Fork-tailed Swift	**M**	**S3**	**IA**		●	●	●		●			●		●	●	
FREGATIDAE																	
Fregata ariel	Lesser Frigatebird	**M**	**S3**	**IA**			●	●	●		●	●			●	●	
SULIDAE																	
Sula leucogaster	Brown Booby	**M**	**S3**	**IA**			●				●	●				●	
ANHINGIDAE																	
Anhinga novaehollandiae	Australasian Darter										●	●				●	
PHALACROCORACIDAE																	
Microcarbo melanoleucos	Little Pied Cormorant				●	●					●	●	●			●	

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Phalacrocorax carbo	Great Cormorant															●	
Phalacrocorax sulcirostris	Little Black Cormorant										●	●	●			●	
Phalacrocorax varius	Pied Cormorant							●			●	●				●	
PELECANIDAE																	
Pelecanus conspicillatus	Australian Pelican					●	●	●			●	●	●			●	
CICONIIDAE																	
Ephippiorhynchus asiaticus	Black-necked Stork										●	●	●			●	
ARDEIDAE																	
Ardea pacifica	White-necked Heron				●	●					●	●	●			●	●
Ardea modesta	Eastern Great Egret	**M**	**S3**	**IA**							●	●	●		●	●	
Egretta picata	Pied Heron										●					●	
Egretta novaehollandiae	White-faced Heron				●	●		●			●	●	●			●	
Ardea intermedia	Intermediate Egret												●				
Ardea ibis	Cattle Egret	**M**	**S3**	**IA**							●		●		●	●	
Ardea sumatrana	Great-billed Heron												●				
Butorides striatus	Striated Heron										●	●				●	
Egretta garzetta	Little Egret										●	●				●	
Egretta sacra	Eastern Reef Egret	**M**	**S3**	**IA**							●	●				●	
Nycticorax caledonicus	Nankeen Night Heron								●							●	
THRESKIORNITHIDAE																	
Plegadis falcinellus	Glossy Ibis	**M**	**S3**	**IA**							●	●	●			●	
Threskiornis molucca	Australian White Ibis										●	●	●			●	

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Threskiornis spinicollis	Straw-necked Ibis				●	●		●			●	●	●			●	●
Platalea regia	Royal Spoonbill					●						●	●			●	
Platalea flavipes	Yellow-billed Spoonbill												●				
ACCIPITRIDAE																	
Pandion cristatus	Eastern Osprey	**M**						●	●		●				●	●	
Elanus axillaris	Black-shouldered Kite							●			●					●	
Lophoictinia isura	Square-tailed Kite						●		●		●					●	●
Hamirostra melanosternon	Black-breasted Buzzard				●								●			●	●
Haliaeetus leucogaster	White-bellied Sea-Eagle	**M**	**S3**	**IA**			●	●	●	●	●		●		●	●	
Haliastur sphenurus	Whistling Kite				●	●		●			●		●			●	●
Haliastur indus	Brahminy Kite						●	●		●	●		●			●	
Milvus migrans	Black Kite				●	●	●	●			●		●			●	●
Accipiter fasciatus	Brown Goshawk				●	●	●	●	●	●	●		●			●	
Accipiter cirrhocephalus	Collared Sparrowhawk					●	●				●		●			●	
Circus assimilis	Spotted Harrier					●					●		●			●	
Circus approximans	Swamp Harrier										●		●			●	
Erythrotriorchis radiatus	Red Goshawk	**VU**	**S1**	**VU**											●		
Aquila audax	Wedge-tailed Eagle				●	●							●			●	●
Hieraaetus morphnoides	Little Eagle						●				●					●	
FALCONIDAE																	
Falco cenchroides	Nankeen Kestrel				●	●	●	●	●		●					●	●
Falco berigora	Brown Falcon				●	●	●	●	●	●	●		●			●	●

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	Birdata	This survey
Falco longipennis	Australian Hobby					●		●					●			●	●
Falco hypoleucos	Grey Falcon		**S1**	**VU**									●			●	
Falco subniger	Black Falcon												●				
Falco peregrinus	Peregrine Falcon		**S4**	**Other**				●	●		●		●	●		●	
GRUIDAE																	
Grus rubicunda	Brolga				●						●	●	●			●	
RALLIDAE																	
Porphyrio porphyrio	Purple Swamphen										●		●			●	
Rallina fasciata	Red-legged Crake										●						
Gallirallus philippensis	Buff-banded Rail										●					●	
Porzana pusilla	Baillon's Crake												●				
Fulica atra	Eurasian Coot					●						●	●			●	
OTIDIDAE																	
Ardeotis australis	Australian Bustard			**P4**	●	●	●				●		●	●		●	●
BURHINIDAE																	
Burhinus grallarius	Bush Stone-curlew				●	●	●		●		●		●	●		●	●
Esacus magnirostris	Beach Stone-curlew							●			●					●	
HAEMATOPODIDAE																	
Haematopus longirostris	Australian Pied Oystercatcher						●	●	●		●	●				●	
Haematopus fuliginosus	Sooty Oystercatcher						●	●			●	●				●	
RECURVIROSTRIDAE																	
Himantopus himantopus	Black-winged Stilt					●					●	●	●			●	

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Recurvirostra novaehollandiae	Red-necked Avocet											●	●			●	
CHARADRIIDAE																	
Pluvialis fulva	Pacific Golden Plover	**M**	**S3**	**IA**							●	●	●			●	
Pluvialis squatarola	Grey Plover	**M**	**S3**	**IA**							●	●	●			●	
Charadrius leschenaultii	Greater Sand Plover	**M**	**S3**	**IA**				●			●	●	●			●	
Charadrius mongolus	Lesser Sand Plover	**M**	**S1, S3**	**EN**				●				●				●	
Charadrius ruficapillus	Red-capped Plover						●				●	●	●			●	
Charadrius veredus	Oriental Plover	**M**	**S3**	**IA**								●	●		●	●	
Elseyornis melanops	Black-fronted Dotterel				●	●		●			●	●	●			●	
Erythrogonys cinctus	Red-kneed Dotterel					●					●	●	●			●	
Vanellus miles	Masked Lapwing				●	●		●			●	●	●			●	
JACANIDAE																	
Irediparra gallinacea	Comb-crested Jacana					●					●		●			●	
ROSTRATULIDAE																	
Rostratula australis	Australian Painted Snipe	**EN,M**	**S1**	**EN**									●	●	●	●	
SCOLOPACIDAE																	
Gallinago megala	Swinhoe's Snipe	**M**	**S3**	**IA**								●	●			●	
Limosa limosa	Black-tailed Godwit	**M**	**S3**	**IA**								●	●			●	
Limosa lapponica	Bar-tailed Godwit	**M**	**S1, S3**	**VU, IA**				●			●	●	●			●	
Numenius minutus	Little Curlew	**M**	**S3**	**IA**								●	●			●	
Numenius phaeopus	Whimbrel	**M**	**S3**	**IA**				●			●	●				●	
Numenius madagascariensis	Eastern Curlew	**CR, M**	**S1, S3**	**VU, IA**				●			●	●				●	

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Xenus cinereus	Terek Sandpiper	**M**	**S3**	**IA**								●				●	
Actitis hypoleucos	Common Sandpiper	**M**	**S3**	**IA**					●		●	●	●			●	
Tringa brevipes	Grey-tailed Tattler	**M**	**S3**	**P4**				●			●	●				●	
Tringa glareola	Wood Sandpiper	**M**	**S3**	**IA**		●		●				●	●			●	
Tringa nebularia	Common Greenshank	**M**	**S3**	**IA**				●			●	●	●			●	●
Tringa stagnatilis	Marsh Sandpiper	**M**	**S3**	**IA**								●				●	
Arenaria interpres	Ruddy Turnstone	**M**	**S3**	**IA**				●			●	●				●	
Limnodromus semipalmatus	Asian Dowitcher	**M**	**S3**	**IA**								●				●	
Calidris tenuirostris	Great Knot	**M**	**S1, S3**	**VU, IA**							●	●				●	
Calidris canutus	Red Knot	**M**	**S1, S3**	**VU, IA**								●				●	
Calidris alba	Sanderling	**M**	**S3**	**IA**				●			●	●				●	
Calidris ruficollis	Red-necked Stint	**M**	**S3**	**IA**				●			●	●	●			●	
Calidris subminuta	Long-toed Stint	**M**	**S3**	**IA**								●	●			●	
Calidris melanotos	Pectoral Sandpiper	**M**	**S3**	**IA**								●				●	
Calidris acuminata	Sharp-tailed Sandpiper	**M**	**S3**	**IA**				●				●	●			●	
Calidris ferruginea	Curlew Sandpiper	**CR, M**	**S1, S3**	**VU, IA**								●	●			●	
Limicola falcinellus	Broad-billed Sandpiper	**M**	**S3**	**IA**								●				●	
Philomachus pugnax	Ruff	**M**	**S3**	**IA**								●	●			●	
TURNICIDAE																	
Turnix maculosus	Red-backed Button-quail									●	●					●	
Turnix castanotus	Chestnut-backed Button-quail			**P4**				●									
Turnix pyrrhothorax	Red-chested Button-quail					●	●	●					●			●	

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Turnix velox	Little Button-quail				●	●	●				●		●			●	
	Button-quail sp.					●											
GLAREOLIDAE																	
Glareola maldivarum	Oriental Pratincole	**M**	**S3**	**IA**								●	●		●	●	
Stiltia isabella	Australian Pratincole										●	●	●			●	
STERCORARIIDAE																	
Stercorarius parasiticus	Arctic Jaeger	**M**	**S3**	**IA**												●	
LARIDAE																	
Sternula albifrons	Little Tern	**M**	**S3**	**IA**				●			●	●				●	
Sternula nereis	Fairy Tern										●					●	
Gelochelidon nilotica	Gull-billed Tern							●			●	●				●	
Hydroprogne caspia	Caspian Tern	**M**	**S3**	**IA**								●				●	
Chlidonias hybrida	Whiskered Tern										●	●				●	
Chlidonia leucopterus	White-winged Black Tern	**M**	**S3**	**IA**							●	●				●	
Sterna dougallii	Roseate Tern	**M**	**S3**	**IA**							●	●				●	
Sterna hirundo	Common Tern	**M**	**S3**	**IA**			●	●				●				●	
Thalasseus bengalensis	Lesser Crested Tern	**M**	**S3**	**IA**			●	●			●	●				●	
Thalasseus bergii	Crested Tern						●	●			●	●				●	
Chroicocephalus novaehollandiae	Silver Gull							●			●	●				●	
CACATUIDAE (PSITTACIDAE)																	
Calyptorhynchus banksii	Red-tailed Black-Cockatoo				●	●	●	●			●		●			●	●
Eolophus roseicapillus	Galah				●	●					●		●			●	●

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Cacatua sanguinea	Little Corella				●	●		●			●		●			●	●
Nymphicus hollandicus	Cockatiel				●	●	●						●			●	●
PSITTACIDAE																	
Trichoglossus haematodus	Rainbow Lorikeet						●		●	●			●			●	
Trichoglossus haematodus rubritorquis	Red-collared Lorikeet				●	●		●			●		●				●
Psitteuteles versicolor	Varied Lorikeet				●	●	●		●		●		●			●	●
Aprosmictus erythropterus	Red-winged Parrot				●	●	●	●	●	●	●		●			●	●
Melopsittacus undulatus	Budgerigar				●	●					●		●			●	●
CUCULIDAE																	
Centropus phasianinus	Pheasant Coucal				●	●	●	●	●	●	●		●			●	
Scythrops novaehollandiae	Channel-billed Cuckoo							●								●	
Chalcites basalis	Horsfield's Bronze-Cuckoo				●	●	●	●	●		●		●			●	
Chalcites osculans	Black-eared Cuckoo							●	●							●	
Chalcites minutillus	Little Bronze-Cuckoo					●	●				●		●			●	
Cacomantis pallidus	Pallid Cuckoo				●	●	●	●			●		●			●	
Cacomantis variolosus	Brush Cuckoo					●	●	●	●		●		●			●	
Cuculus optatus	Oriental Cuckoo							●								●	
STRIGIDAE																	
Ninox connivens	Barking Owl										●					●	
Ninox novaeseelandiae	Southern Boobook				●	●	●				●		●			●	
TYTONIDAE																	

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	Birdata	This survey
Tyto longimembris	Eastern Grass Owl										●					●	
Tyto novaehollandiae kimberli	Masked Owl	**VU**		**P1**										●	●		
HALCYONIDAE																	
Dacelo leachii	Blue-winged Kookaburra				●	●	●	●	●		●		●			●	●
Todiramphus pyrrhopygius	Red-backed Kingfisher					●		●	●		●		●			●	
Todiramphus sanctus	Sacred Kingfisher					●	●	●	●	●	●		●			●	
Todiramphus chloris	Collared Kingfisher										●		●			●	
MEROPIDAE																	
Merops ornatus	Rainbow Bee-eater	**M**	**S3**	**IA**	●	●	●	●	●	●	●		●		●	●	●
CORACIIDAE																	
Eurystomus orientalis	Dollarbird					●	●	●	●				●			●	
CLIMACTERIDAE																	
Climacteris melanura	Black-tailed Treecreeper				●	●	●				●		●			●	●
PTILINORHYNCHIDAE																	
Ptilonorhynchus nuchalis	Great Bowerbird				●	●	●	●	●	●	●		●			●	
MALURIDAE																	
Malurus lamberti	Variegated Fairy-wren					●	●	●	●	●	●		●			●	●
Malurus melanocephalus	Red-backed Fairy-wren				●	●	●	●	●		●		●				●
ACANTHIZIDAE																	
Smicrornis brevirostris	Weebill				●	●	●		●		●		●			●	●
Gerygone levigaster	Mangrove Gerygone							●			●		●			●	
Gerygone fusca	Western Gerygone										●					●	

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	Birdata	This survey
Gerygone tenebrosa	Dusky Gerygone										●					●	
Gerygone albogularis	White-throated Gerygone				●	●	●	●	●	●	●		●			●	●
PARDALOTIDAE																	
Pardalotus rubricatus	Red-browed Pardalote				●	●		●	●		●		●			●	●
Pardalotus striatus	Striated Pardalote				●	●	●		●	●	●		●			●	●
MELIPHAGIDAE																	
Certhionyx variegatus	Pied Honeyeater										●						
Lichenostomus virescens	Singing Honeyeater				●	●	●	●	●	●	●		●			●	●
Lichenostomus unicolor	White-gaped Honeyeater						●	●	●	●	●					●	
Lichenostomus plumulus	Grey-fronted Honeyeater								●								
Lichenostomus flavescens	Yellow-tinted Honeyeater				●	●	●		●		●					●	●
Lichenostomus penicillatus	White-plumed Honeyeater							●	●								
Manorina flavigula	Yellow-throated Miner										●					●	
Ramsayornis fasciatus	Bar-breasted Honeyeater												●				
Conopophila rufogularis	Rufous-throated Honeyeater					●	●	●	●		●		●			●	
Epthianura crocea	Yellow Chat												●				
Epthianura tricolor	Crimson Chat										●						
Sugomel niger	Black Honeyeater				●	●										●	
Myzomela erythrocephala	Red-headed Honeyeater							●			●					●	
Cissomela pectoralis	Banded Honeyeater					●	●						●			●	
Lichmera indistincta	Brown Honeyeater				●	●	●	●	●	●	●		●			●	●
Melithreptus gularis	Black-chinned Honeyeater				●	●	●	●	●	●	●		●			●	●

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	Birdata	This survey
Melithreptus albogularis	White-throated Honeyeater					●	●	●			●		●			●	
Philemon argenticeps	Silver-crowned Friarbird							●			●		●				
Philemon citreogularis	Little Friarbird				●	●	●	●	●	●	●		●			●	
POMATOSTOMIDAE																	
Pomatostomus temporalis	Grey-crowned Babbler				●	●	●	●	●	●	●		●			●	●
NEOSITTIDAE																	
Daphoenositta chrysoptera	Varied Sittella				●	●	●	●	●		●		●			●	●
CAMPEPHAGIDAE																	
Coracina novaehollandiae	Black-faced Cuckoo-shrike				●	●	●	●	●	●	●		●			●	●
Coracina papuensis	White-bellied Cuckoo-shrike												●				●
Lalage sueurii	White-winged Triller				●	●	●	●		●	●		●			●	●
PACHYCEPHALIDAE																	
Pachycephala melanura	Mangrove Golden Whistler										●					●	
Pachycephala rufiventris	Rufous Whistler				●	●	●	●	●	●	●		●			●	●
Pachycephala lanioides	White-breasted Whistler										●					●	
Colluricincla harmonica	Grey Shrike-thrush				●	●	●	●	●	●	●		●			●	●
Oreoica gutturalis	Crested Bellbird										●						
ORIOLIDAE																	
Oriolus sagittatus	Olive-backed Oriole				●	●	●	●			●		●			●	●
ARTAMIDAE																	
Artamus leucorhynchus	White-breasted Woodswallow					●		●	●	●	●		●			●	●

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Artamus personatus	Masked Woodswallow				●	●	●			●	●		●			●	
Artamus superciliosus	White-browed Woodswallow						●				●					●	
Artamus cinereus	Black-faced Woodswallow				●	●	●	●	●	●	●		●			●	●
Artamus minor	Little Woodswallow				●	●	●	●	●	●	●		●			●	●
Cracticus torquatus	Grey Butcherbird								●							●	
Cracticus nigrogularis	Pied Butcherbird				●	●	●	●	●	●	●		●			●	●
Cracticus tibicen	Australian Magpie												●				●
RHIPIDURIDAE (DICRURIDAE)																	
Rhipidura albiscapa	Grey Fantail				●						●		●			●	●
Rhipidura phasiana	Mangrove Grey Fantail										●					●	
Rhipidura rufiventris	Northern Fantail						●	●	●	●	●					●	
Rhipidura leucophrys	Willie Wagtail				●	●	●	●	●		●		●			●	●
CORVIDAE																	
Corvus bennetti	Little Crow						●				●					●	
Corvus orru	Torresian Crow				●	●	●	●	●	●	●		●			●	●
MONARCHIDAE (DICRURIDAE)																	
Myiagra ruficollis	Broad-billed Flycatcher										●					●	
Myiagra rubecula	Leaden Flycatcher						●	●	●							●	
Myiagra nana	Paperbark Flycatcher				●	●	●	●	●	●	●		●			●	●
Grallina cyanoleuca	Magpie-lark				●	●	●	●			●		●			●	●
PETROICIDAE																	
Microeca fascinans	Jacky Winter				●	●	●	●	●		●		●			●	●

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	Birdata	This survey
Microeca flavigaster	Lemon-bellied Flycatcher										●					●	
Melanodryas cucullata	Hooded Robin					●	●				●		●			●	●
Poecilodryas cerviniventris	Buff-sided Robin												●				
ALAUDIDAE																	
Mirafra javanica	Horsfield's Bushlark										●		●			●	
CISTICOLIDAE (SYLVIIDAE)																	
Cisticola exilis	Golden-headed Cisticola								●				●			●	
ACROCEPHALIDAE (SYLVIIDAE)																	
Acrocephalus australis	Australian Reed-Warbler										●		●			●	
MEGALURIDAE (SYLVIIDAE)																	
Megalurus timoriensis	Tawny Grassbird										●		●			●	
Cincloramphus mathewsi	Rufous Songlark				●	●	●			●	●		●			●	
Cincloramphus cruralis	Brown Songlark						●				●		●			●	
TIMALIIDAE (ZOSTEROPIDAE)																	
Zosterops luteus	Yellow White-eye							●		●	●					●	
HIRUNDINIDAE																	
Hirundo rustica	Barn Swallow	**M**	**S3**	**IA**									●		●	●	
Petrochelidon ariel	Fairy Martin				●		●				●					●	
Petrochelidon nigricans	Tree Martin				●	●	●		●	●	●		●			●	●
NECTARINIIDAE (DICAEIDAE)																	
Dicaeum hirundinaceum	Mistletoebird				●	●	●	●		●	●		●			●	●
ESTRILDIDAE																	

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Taeniopygia guttata	Zebra Finch				●	●			●	●	●		●			●	●
Taeniopygia bichenovii	Double-barred Finch						●		●		●		●			●	
Poephila acuticauda	Long-tailed Finch					●	●	●	●		●		●			●	●
Neochmia ruficauda subclarescens	Star Finch (western)			**P4**									●				
Emblema pictum	Painted Finch															●	
Erythrura gouldiae	Gouldian Finch	**EN**		**P4**				●	●	●	●		●	●	●	●	
Lonchura castaneothorax	Chestnut-breasted Mannikin															●	
MOTACILLIDAE																	
Motacilla cinerea	Grey Wagtail	**M**	**S3**	**IA**		●							●				
Motacilla tschutschensis	Eastern Yellow Wagtail	**M**	**S3**	**IA**		●					●	●	●			●	

Reptiles

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	This survey
CROCODYLIDAE															
Crocodylus porosus	Salt-water Crocodile	**M**	**S4**	**Other**							●			●	
DIPLODACTYLIDAE															
Diplodactylus conspicillatus	Fat-tailed Gecko					●	●	●	●	●	●	●			
Lucasium stenodactylum	Sand-plain Gecko					●	●		●	●	●	●			
Oedura rhombifer								●			●				
Rhynchoedura ornata	Beaked Gecko														
Strophurus ciliaris						●	●	●	●	●	●	●			
Strophurus jeanae											●				
Strophurus taeniatus											●				
GEKKONIDAE															
Gehyra australis							●					●			
Gehyra nana						●					●	●			
Gehyra pilbara					●	●	●		●		●	●			
Gehyra punctata									●		●				
Gehyra variegata								●			●				
Heteronotia binoei	Bynoe's Gecko					●	●		●	●	●	●			
**Hemidactylus frenatus*	Asian House Gecko										●				
PYGOPODIDAE															
Delma borea											●				
Delma tincta						●			●		●	●			

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	This survey
Lialis burtonis						●	●	●	●	●	●	●			
Pygopus nigriceps															
Pygopus steelescotti	Northern Hooded Scaly-foot					●			●			●			
AGAMIDAE															
Amphibolurus gilberti	Gilbert's Dragon					●	●	●	●	●	●	●			
Chelosania brunnea	Chameleon Dragon										●				
Chlamydosaurus kingii	Frilled Lizard					●	●	●	●	●	●	●			
Ctenophorus caudicinctus	Ring-tailed Rock Dragon										●				
Ctenophorus isolepis	Military Dragon										●	●			
Ctenophorus nuchalis	Central Netted Dragon										●	●			
Diporiphora magna						●						●			
Diporiphora pindan						●	●	●	●	●	●	●			
Diporiphora sp.							●								
Pogona minor	Dwarf Bearded Dragon				●	●	●	●	●	●	●	●			
EGERNIIDAE															
Tiliqua multifasciata	Central Blue-tongue								●		●	●			
Tiliqua scincoides	Common Blue-tongue					●	●	●	●	●	●	●			
EUGONGYLIDAE															
Carlia munda					●	●	●				●	●			
Carlia rufilatus						●	●		●	●	●	●			
Carlia triacantha							●								
Cryptoblepharus carnabyi							●								

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	This survey
Cryptoblepharus metallicus											●				
Cryptoblepharus ruber	Tawny Snake-eyed Skink				●	●	●		●	●	●	●			
Cryptoblepharus sp.						●									
Menetia greyii										●					
Menetia maini						●						●			
Morethia ruficauda											●				
Morethia storri						●	●		●			●			
Proablepharus tenuis						●			●			●			
SPHENOMORPHIDAE															
Ctenotus colletti						●					●	●			
Ctenotus helenae											●				
Ctenotus inornatus					●	●	●	●	●	●	●	●			●
Ctenotus pantherinus						●	●					●			
Ctenotus robustus						●						●			
Ctenotus serventyi						●	●		●			●			
Eremiascincus isolepis						●	●	●	●	●	●	●			
Eremiascincus richardsonii	Banded Skink										●				
Lerista apoda					●	●	●		●	●		●			
Lerista bipes						●	●		●	●	●				
Lerista greeri						●					●	●			
Lerista griffini							●		●	●					
Lerista labialis											●				

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	This survey
Lerista separanda				P2					●		●				
VARANIDAE															
Varanus acanthurus	Spiny-tailed Monitor					●		●			●	●			
Varanus brevicauda	Short-tailed Pygmy Monitor					●	●		●			●			
Varanus gouldii	Gould's Monitor					●	●	●	●		●	●			●
Varanus panoptes	Yellow-spotted Monitor							●	●						
Varanus scalaris	Spotted Tree Monitor						●								
Varanus sparnus	Dampier Peninsula Goanna					●									
Varanus tristis	Black-headed Monitor					●	●	●	●	●	●	●			
TYPHLOPIDAE															
Ramphotyphlops diversus							●		●	●	●				
Ramphotyphlops sp.						●									
BOIDAE															
Antaresia stimsoni	Stimson's Python					●	●	●	●		●	●			
Aspidites melanocephalus	Black-headed Python						●			●	●				
Liasis olivaceus	Olive Python										●				
COLUBRIDAE															
Dendrelaphis punctulata	Common Tree Snake									●	●				
ELAPIDAE															
Brachyurophis roperi	Northern Shovel-nosed Snake					●	●		●	●		●			
Demansia angusticeps						●	●		●	●		●			
Demansia olivacea	Olive Whipsnake										●				

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	This survey
Demansia psammophis	Yellow-faced Whipsnake										●				
Ephalophis greyae	Mangrove Sea Snake													●	
Furina ornata	Moon Snake					●	●		●	●	●	●			
Pseudechis australis	Mulga Snake					●	●		●	●	●	●			S
Pseudonaja mengdeni	Western Brown Snake					●	●					●			
Pseudonaja nuchalis	Northern Brown Snake								●		●				
Simoselaps anomalus	Desert Banded Snake										●				
Simoselaps minimus	Dampierland Burrowing Snake			**P2**					●		●				
Suta punctata	Spotted Snake					●			●	●	●	●			

Amphibians

Family and Species	Common name	EPBC Act	WC Act	DEC	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	Jmes Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	This survey
HYLIDAE													
Cyclorana australis	Giant Frog				●	●	●		●	●			
Cyclorana cryptotis	Hidden-ear Frog									●			
Cyclorana longipes	Long-footed Frog				●		●			●			
Litoria caerulea	Green Tree Frog				●	●	●		●	●			
Litoria coplandi	Rock Frog								●				
Litoria meiriana	Rockhole Frog								●				
Litoria rothii	Northern Laughing Tree Frog				●				●	●			
Litoria rubella	Little Red Tree Frog				●	●			●	●			
LIMNODYNASTIDAE													
Notaden nichollsi	Desert Spadefoot				●					●			
Platyplectrum ornatum	Ornate Burrowing Frog				●	●	●	●	●	●			
MYOBATRACHIDAE													
Uperoleia mjobergii	West Kimberley Toadlet									●			
Uperoleia talpa	Mole Toadlet				●	●			●	●			

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APPENDIX C GREATER BILBY RECORDS

Evidence	Date	Easting	Northing
Digging	14/05/2015	501261	8069764
Digging	14/05/2015	501261	8069767
Digging	14/05/2015	501259	8069761
Digging	14/05/2015	501258	8069748
Digging	14/05/2015	501227	8069724
Digging	14/05/2015	501219	8069740
Digging	14/05/2015	501216	8069742
Digging	14/05/2015	501203	8069755
Digging	14/05/2015	501128	8069761
Digging	14/05/2015	501129	8069756
Digging	14/05/2015	501114	8069750
Digging	14/05/2015	500956	8069749
Digging	14/05/2015	500934	8069766
Digging	14/05/2015	500926	8069776
Digging	14/05/2015	500933	8069786
Digging	14/05/2015	500934	8069790
Digging	14/05/2015	500621	8069649
Digging	14/05/2015	500649	8069649
Digging	14/05/2015	500647	8069651
Digging	14/05/2015	500642	8069641
Digging	14/05/2015	500638	8069647
Digging	14/05/2015	500620	8069648
Digging	14/05/2015	500629	8069630
Digging	14/05/2015	500624	8069628
Digging	14/05/2015	500617	8069627
Digging	14/05/2015	500594	8069611
Digging	14/05/2015	500592	8069613
Digging	14/05/2015	500581	8069620
Digging	14/05/2015	500568	8069633
Digging	14/05/2015	500584	8069642
Digging	14/05/2015	500584	8069638
Digging	14/05/2015	500594	8069634
Digging	14/05/2015	500594	8069636
Digging	14/05/2015	500600	8069636
Digging	14/05/2015	500468	8069541
Digging	14/05/2015	500536	8069590
Digging	14/05/2015	500540	8069599
Digging	14/05/2015	501499	8070386
Digging	14/05/2015	501496	8070400
Digging	14/05/2015	501502	8070417
Digging	14/05/2015	501497	8070418
Digging	14/05/2015	501511	8070434
Digging	14/05/2015	501529	8070422
Digging	14/05/2015	501544	8070419
Digging	14/05/2015	501552	8070430
Digging	14/05/2015	501565	8070424
Digging	14/05/2015	501575	8070418
Digging	14/05/2015	501577	8070411
Digging	14/05/2015	501488	8070363
Digging	14/05/2015	501478	8070364
Digging	14/05/2015	501471	8070370

Digging	14/05/2015	501474	8070377
Digging	14/05/2015	501452	8070386
Digging	14/05/2015	501460	8070390
Digging	14/05/2015	501452	8070402
Digging	14/05/2015	501444	8070408
Digging	14/05/2015	501440	8070400
Digging	14/05/2015	501428	8070412
Digging	14/05/2015	501426	8070409
Digging	14/05/2015	501406	8070403
Digging	14/05/2015	501389	8070395
Digging	14/05/2015	501374	8070395
Digging	14/05/2015	501406	8070446
Digging	14/05/2015	501415	8070448
Digging	14/05/2015	501783	8069629
Digging	14/05/2015	501781	8069632
Digging	14/05/2015	501733	8069530
Digging	14/05/2015	501740	8069517
Digging	14/05/2015	501758	8069498
Digging	14/05/2015	501777	8069510
Digging	14/05/2015	501213	8069580
Digging	14/05/2015	501097	8069683
Digging	14/05/2015	501087	8069688
Digging	14/05/2015	501096	8069697
Digging	14/05/2015	501099	8069701
Digging	14/05/2015	501096	8069712
Digging	14/05/2015	501049	8069748
Digging	14/05/2015	501037	8069780
Digging	14/05/2015	501044	8069795
Digging	14/05/2015	501048	8069798
Digging	14/05/2015	501048	8069830
Digging	14/05/2015	501024	8069893
Digging	14/05/2015	501006	8069888
Digging	14/05/2015	500980	8069821
Digging	14/05/2015	501006	8069811
Digging	14/05/2015	501013	8069801
Digging	14/05/2015	501000	8069771
Digging	14/05/2015	500960	8069749
Digging	14/05/2015	501369	8070264
Digging	14/05/2015	501350	8070271
Digging	14/05/2015	501347	8070279
Digging	14/05/2015	501334	8070295
Digging	14/05/2015	501330	8070296
Digging	14/05/2015	501327	8070303
Digging	14/05/2015	501323	8070308
Digging	14/05/2015	501290	8070326
Digging	14/05/2015	501263	8070350
Digging	14/05/2015	501321	8070418
Digging	14/05/2015	501372	8070394
Digging	14/05/2015	501396	8070387
Digging	14/05/2015	501416	8070384
Digging	14/05/2015	501424	8070373
Digging	14/05/2015	501438	8070372

Digging	14/05/2015	501438	8070381
Digging	14/05/2015	501446	8070388
Digging	14/05/2015	501445	8070392
Digging	14/05/2015	501508	8070488
Digging	13/05/2015	501462	8070400
Digging	13/05/2015	500977	8069946
Digging	14/05/2015	503165	8066826
Digging	14/05/2015	503071	8066928
Scat	14/05/2015	503748	8066030
Scat	13/05/2015	501573	8070421
Scat	13/05/2015	501449	8070406
Active burrow	13/05/2015	501452	8070397
Active burrow	14/05/2015	501769	8069648
Active burrow	14/05/2015	501734	8069517
Active burrow	14/05/2015	501060	8069737
Active burrow	14/05/2015	501051	8069815
Active burrow	14/05/2015	501011	8069889
Active burrow	15/05/2015	501222	8069733
Active burrow	14/05/2015	500978	8069759
Active burrow	15/05/2015	500606	8069630
Active burrow	14/05/2015	503721	8066163
Active burrow	14/05/2015	503450	8066252
Active burrow	14/05/2015	503322	8066391
Active burrow	14/05/2015	503257	8066429
Active burrow	14/05/2015	503807	8066263
Active burrow	14/05/2015	503872	8066222
Active burrow	14/05/2015	503775	8066033
Active burrow	14/05/2015	502969	8067046
Active burrow	14/05/2015	502980	8067161
Inactive burrow	15/05/2015	499512	8069908

GDA 94 Zone 51

APPENDIX D COASTAL HABITAT RESTRICTED CONSERVATION SIGNIFICANT BIRD SPECIES

Species name	Common name	EPBC Act	WC Act	DPaW	Likelihood of occurrence
Fregata ariel	Lesser Frigatebird	M	S3	IA	**LOW**
Sula leucogaster	Brown Booby	M	S3	IA	**LOW**
Egretta sacra	Eastern Reef Egret	M	S3	IA	**LOW**
Pluvialis squatarola	Grey Plover	M	S3	IA	**LOW**
Charadrius leschenaultii	Greater Sand Plover	M	S3	IA	**LOW**
Charadrius mongolus	Lesser Sand Plover	M	S1, S3	EN, IA	**LOW**
Limosa limosa	Black-tailed Godwit	M	S3	IA	**LOW**
Limosa lapponica	Bar-tailed Godwit	M	S1, S3	VU, IA	**LOW**
Numenius phaeopus	Whimbrel	M	S3	IA	**LOW**
Numenius madagascariensis	Eastern Curlew	CR, M	S1, S3	VU, IA	**LOW**
Xenus cinereus	Terek Sandpiper	M	S3	IA	**LOW**
Actitis hypoleucos	Common Sandpiper	M	S3	IA	**LOW**
Tringa brevipes	Grey-tailed Tattler	M	S3	P4	**LOW**
Tringa stagnatilis	Marsh Sandpiper	M	S3	IA	**LOW**
Arenaria interpres	Ruddy Turnstone	M	S3	IA	**LOW**
Limnodromus semipalmatus	Asian Dowitcher	M	S3	IA	**LOW**
Calidris tenuirostris	Great Knot	M	S1, S3	VU, IA	**LOW**
Calidris canutus	Red Knot	M	S1, S3	VU, IA	**LOW**
Calidris alba	Sanderling	M	S3	IA	**LOW**
Calidris ferruginea	Curlew Sandpiper	CR, M	S1, S3	VU, IA	**LOW**
Limicola falcinellus	Broad-billed Sandpiper	M	S3	IA	**LOW**
Philomachus pugnax	Ruff	M	S3	IA	**LOW**
Stercorarius parasiticus	Arctic Jaeger	M	S3	IA	**LOW**
Sternula albifrons	Little Tern	M	S3	IA	**LOW**
Hydroprogne caspia	Caspian Tern	M	S3	IA	**LOW**
Sterna dougallii	Roseate Tern	M	S3	IA	**LOW**
Sterna hirundo	Common Tern	M	S3	IA	**LOW**
Thalasseus bengalensis	Lesser Crested Tern	M	S3	IA	**LOW**

APPENDIX E FLORA SPECIES LIST

Sheffield Thunderbird Haul Road and Camp Vascular Flora Species List

Family	Taxon	Status
Acanthaceae	*Dicliptera armata*	
Aizoaceae	*Trianthema pilosum*	
Amaranthaceae	*Gomphrena canescens subsp. canescens*	
Amaranthaceae	*Gomphrena flaccida*	
Amaranthaceae	*Gomphrena leptoclada*	
Amaranthaceae	*Ptilotus corymbosus*	
Amaranthaceae	*Ptilotus polystachyus*	
Apocynaceae	*Carissa lanceolata*	
Apocynaceae	*Wrightia saligna*	
Araliaceae	*Trachymene oleracea subsp. oleracea*	
Asteraceae	*Blumea integrifolia*	
Asteraceae	*Pluchea rubelliflora*	
Asteraceae	*Pterocaulon intermedium*	P3
Asteraceae	*Pterocaulon paradoxum*	
Asteraceae	*Pterocaulon serrulatum var. velutinum*	
Asteraceae	*Pterocaulon sp.*	
Asteraceae	*Pterocaulon sphacelatum*	
Asteraceae	*Pterocaulon tricholobum*	
Asteraceae	*Tridax procumbens*	Weed
Bignoniaceae	*Dolichandrone heterophylla*	
Boraginaceae	*Ehretia saligna var. saligna*	
Boraginaceae	*Heliotropium cunninghamii*	
Boraginaceae	*Heliotropium leptaleum*	
Boraginaceae	*Heliotropium sp.*	
Boraginaceae	*Trichodesma zeylanicum var. latisepalum*	
Byblidaceae	*Byblis filifolia*	
Caryophyllaceae	*Polycarpaea corymbosa*	
Caryophyllaceae	*Polycarpaea longiflora*	
Celastraceae	*Denhamia cunninghamii*	
Cleomaceae	*Cleome viscosa*	
Combretaceae	*Terminalia canescens*	
Commelinaceae	*Murdannia graminea*	
Convolvulaceae	*Bonamia linearis*	
Convolvulaceae	*Evolvulus alsinoides var. decumbens*	
Convolvulaceae	*Ipomoea coptica*	
Convolvulaceae	*Polymeria ambigua*	
Cyperaceae	*Abildgaardia schoenoides*	
Cyperaceae	*Bulbostylis barbata*	
Cyperaceae	*Cyperus conicus*	
Cyperaceae	*Cyperus microcephalus subsp. microcephalus*	
Cyperaceae	*Fimbristylis ammobia*	
Cyperaceae	*Fimbristylis caespitosa*	
Cyperaceae	*Fimbristylis neilsonii*	
Cyperaceae	*Fimbristylis oxystachya*	
Cyperaceae	*Fimbristylis schultzii*	
Cyperaceae	*Fimbristylis sp.*	
Droseraceae	*Drosera derbyensis*	
Euphorbiaceae	*Euphorbia hassallii*	
Euphorbiaceae	*Euphorbia trigonosperma*	
Euphorbiaceae	*Microstachys chamelea*	
Fabaceae	*Acacia colei var. colei*	
Fabaceae	*Acacia colei var. ileocarpa*	
Fabaceae	*Acacia drepanocarpa subsp. drepanocarpa*	
Fabaceae	*Acacia hippuroides*	
Fabaceae	*Acacia monticola*	
Fabaceae	*Acacia platycarpa*	
Fabaceae	*Acacia tumida var. tumida*	
Fabaceae	*Bauhinia cunninghamii*	
Fabaceae	*Chamaecrista moorei*	
Fabaceae	*Crotalaria crispata*	
Fabaceae	*Crotalaria medicaginea var. neglecta*	
Fabaceae	*Crotalaria sp.*	
Fabaceae	*Cullen pustulatum*	
Fabaceae	*Desmodium filiforme*	
Fabaceae	*Erythrophleum chlorostachys*	
Fabaceae	*Galactia tenuiflora*	
Fabaceae	*Glycine tomentella*	
Fabaceae	*Indigofera linifolia*	
Fabaceae	*Senna costata*	
Fabaceae	*Senna oligoclada*	
Fabaceae	*Tephrosia crocea*	
Fabaceae	*Tephrosia leptoclada*	
Fabaceae	*Tephrosia remotiflora*	
Fabaceae	*Tephrosia sp. C Kimberley Flora (K.F. Kenneally 5599)*	
Fabaceae	*Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)*	
Fabaceae	*Zornia chaetophora*	
Fabaceae	*Zornia prostrata*	
Fabaceae	*Zornia prostrata var. prostrata*	
Fabaceae	**Stylosanthes hamata*	Weed
Fabaceae	**Stylosanthes scabra*	Weed
Goodeniaceae	*Goodenia armitiana*	
Goodeniaceae	*Goodenia sepalosa var. sepalosa*	
Lamiaceae	*Clerodendrum tomentosum var. tomentosum*	
Lamiaceae	*Cyanostegia cyanocalyx*	
Lauraceae	*Cassytha capillaris*	
Loganiaceae	*Mitrasacme exserta*	
Loganiaceae	*Mitrasacme lutea*	
Loranthaceae	*Amyema sanguinea var. sanguinea*	
Malvaceae	*Brachychiton diversifolius subsp. diversifolius*	
Malvaceae	*Corchorus sidoides*	
Malvaceae	*Corchorus tridens*	
Malvaceae	*Gossypium australe*	
Malvaceae	*Triumfetta albida*	
Malvaceae	*Waltheria indica*	
Malvaceae	**Malvastrum americanum*	Weed
Menispermaceae	*Tinospora smilacina*	
Moraceae	*Ficus aculeata var. indecora*	
Myrtaceae	*Calytrix exstipulata*	
Myrtaceae	*Corymbia flavescens*	
Myrtaceae	*Corymbia greeniana*	
Myrtaceae	*Corymbia zygophylla*	
Myrtaceae	*Eucalyptus zygophylla*	
Myrtaceae	*Melaleuca alsophila*	
Myrtaceae	*Melaleuca viridiflora*	
Orobanchaceae	*Buchnera asperata*	
Orobanchaceae	*Buchnera linearis*	
Orobanchaceae	*Buchnera ramosissima*	
Orobanchaceae	*Buchnera urticifolia*	
Orobanchaceae	*Striga curviflora*	
Orobanchaceae	*Striga squamigera*	
Phyllanthaceae	*Sauropus trachyspermus*	
Plantaginaceae	*Stemodia lythrifolia*	
Poaceae	*Aristida aff. nitidula*	
Poaceae	*Aristida holathera var. holathera*	
Poaceae	*Aristida hygrometrica*	
Poaceae	*Aristida inaequiglumis*	
Poaceae	*Aristida sp.*	
Poaceae	*Bothriochloa sp.*	
Poaceae	*Chloris lobata*	
Poaceae	*Chrysopogon fallax*	
Poaceae	*Chrysopogon pallidus*	
Poaceae	*Digitaria brownii*	
Poaceae	*Ectrosia schultzii var. schultzii*	
Poaceae	*Eragrostis cumingii*	
Poaceae	*Eragrostis eriopoda*	
Poaceae	*Eragrostis sp.*	
Poaceae	*Eriachne ciliata*	
Poaceae	*Eriachne melicacea*	
Poaceae	*Eriachne obtusa*	
Poaceae	*Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)*	
Poaceae	*Heteropogon contortus*	
Poaceae	*Schizachyrium fragile*	
Poaceae	*Setaria surgens*	
Poaceae	*Sorghum plumosum*	
Poaceae	*Sorghum timorense*	
Poaceae	*Sporobolus australasicus*	
Poaceae	*Triodia schinzii* (Broome variant)	
Poaceae	*Triodia caelestialis*	P3
Poaceae	*Urochloa praetervisa*	
Poaceae	*Xerochloa imberbis*	
Poaceae	*Yakirra australiensis var. australiensis*	
Poaceae	*Yakirra australiensis var. intermedia*	
Poaceae	*Yakirra pauciflora*	
Polygalaceae	*Polygala tepperi*	
Portulacaceae	*Calandrinia quadrivalvis*	
Portulacaceae	*Calandrinia strophiolata*	
Portulacaceae	*Calandrinia translucens*	
Proteaceae	*Grevillea pyramidalis subsp. pyramidalis*	
Proteaceae	*Grevillea refracta subsp. refracta*	
Proteaceae	*Grevillea striata*	
Proteaceae	*Hakea arborescens*	
Proteaceae	*Hakea macrocarpa*	
Proteaceae	*Persoonia falcata*	
Pteridaceae	*Cheilanthes brownii*	
Rubiaceae	*Spermacoce occidentalis*	
Sapindaceae	*Atalaya hemiglauca*	
Sapindaceae	*Dodonaea hispidula var. arida*	
Solanaceae	*Solanum cleistogamum*	
Solanaceae	*Solanum cunninghamii*	
Solanaceae	*Solanum dioicum*	
Thymelaeaceae	*Thecanthes punicea*	
Violaceae	*Hybanthus aurantiacus*	

APPENDIX F QUADRAT DATA

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Site:	**1**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0505039 8064598
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange; Brown;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	2%

Taxa:

Acacia monticola
Acacia tumida var. tumida
Aristida sp.
Atalaya hemiglauca
Bauhinia cunninghamii
Brachychiton diversifolius subsp. diversifolius
Buchnera ramosissima
Calandrinia quadrivalvis
Chrysopogon pallidus
Corchorus sidoides
Corymbia flavescens
Crotalaria medicaginea var. neglecta
Denhamia cunninghamii
Dolichandrone heterophylla
Ectrosia schultzii var. schultzii
Eragrostis cumingii
Eriachne melicacea
Eriachne obtusa
Galactia tenuiflora
Gomphrena canescens subsp. canescens
Goodenia sepalosa var. sepalosa
Gossypium australe
Grevillea pyramidalis subsp. pyramidalis
Grevillea refracta subsp. refracta
Heteropogon contortus
Hybanthus aurantiacus
Indigofera linifolia
Malvastrum americanum
Microstachys chamelea
Mitrasacme lutea
Pterocaulon paradoxum
Ptilotus corymbosus
Ptilotus polystachyus
Schizachyrium fragile
Solanum cunninghamii
Tephrosia remotiflora
Terminalia canescens
Trianthema pilosum
Waltheria indica

Site:	**2**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0505634 8064081
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Yellow;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	25%

Taxa:

Acacia colei var. colei
Acacia platycarpa
Bauhinia cunninghamii
Bothriochloa sp.
Brachychiton diversifolius subsp. diversifolius
Buchnera asperata
Chrysopogon pallidus
Corymbia greeniana
Dolichandrone heterophylla
Eriachne obtusa
Erythrophleum chlorostachys
Evolvulus alsinoides var. decumbens
Galactia tenuiflora
Gossypium australe
Grevillea pyramidalis subsp. pyramidalis
Pterocaulon paradoxum
Sauropus trachyspermus
Sorghum timorense
Striga curviflora
Stylosanthes scabra
Terminalia canescens
Trichodesma zeylanicum var. latisepalum

Site:	**3**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0506044 8062635
Habitat:	Rocky Outcrop
Slope:	Gentle; Moderate;
Surface Layer:	Rocky/Stony;
Soil Colour:	Brown;
Soil Texture:	Loam;
Rock Type:	Other/Unsure;
Rock Size:	Stones (can pick up); Boulders (can't pick up); Surface Plates;
Rock Abundance:	Continuous (>70%)
Vegetation Condition:	Excellent (no obvious disturbance)
Disturbance Type:	No Disturbance;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	5%

Taxa:

Acacia tumida var. tumida
Buchnera ramosissima
Calytrix exstipulata
Cassytha capillaris
Cheilanthes brownii
Chrysopogon pallidus
Cleome viscosa
Corchorus tridens
Corymbia flavescens
Cyperus microcephalus subsp. microcephalus
Desmodium filiforme
Dicliptera armata
Eriachne ciliata
Euphorbia trigonosperma
Galactia tenuiflora
Glycine tomentella
Gomphrena leptoclada
Heteropogon contortus
Indigofera linifolia
Persoonia falcata
Polycarpaea longiflora
Ptilotus corymbosus
Striga curviflora
Tephrosia remotiflora
Terminalia canescens
Tinospora smilacina
Triodia schinzii (Broome variant)
Triumfetta albida
Wrightia saligna

Site:	**4**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0506772 8059862
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange;
Soil Texture:	Sand;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	1-2 years;
Leaf Litter Cover:	2%

Taxa:

Acacia platycarpa
Acacia tumida var. tumida
Aristida inaequiglumis
Brachychiton diversifolius subsp. diversifolius
Buchnera asperata
Bulbostylis barbata
Calandrinia quadrivalvis
Chrysopogon pallidus
Corymbia greeniana
Denhamia cunninghamii
Dolichandrone heterophylla
Eragrostis eriopoda
Eriachne obtusa
Erythrophleum chlorostachys
Fimbristylis oxystachya
Galactia tenuiflora
Goodenia sepalosa var. sepalosa
Grevillea refracta subsp. refracta
Heteropogon contortus
Microstachys chamelea
Mitrasacme lutea
Persoonia falcata
Ptilotus polystachyus
Senna oligoclada
Terminalia canescens
Wrightia saligna

Site:	**5**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0508913 8056904
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange;
Soil Texture:	Sand; Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Very Good (slight disturbance)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	1-2 years;
Leaf Litter Cover:	2%

Taxa:

Acacia tumida var. tumida
Aristida inaequiglumis
Bonamia linearis
Brachychiton diversifolius subsp. diversifolius
Chrysopogon pallidus
Corchorus sidoides
Corymbia greeniana
Corymbia zygophylla
Crotalaria crispata
Dodonaea hispidula var. arida
Dolichandrone heterophylla
Ehretia saligna var. saligna
Eragrostis eriopoda
Eriachne obtusa
Erythrophleum chlorostachys
Fimbristylis oxystachya
Galactia tenuiflora
Grevillea refracta subsp. refracta
Heliotropium leptaleum
Microstachys chamelea
Mitrasacme lutea
Polygala tepperi
Pterocaulon intermedium
Pterocaulon sphacelatum
Ptilotus corymbosus
Terminalia canescens
Tinospora smilacina
Trichodesma zeylanicum var. latisepalum
Triodia caelestialis
Waltheria indica

Site:	**6**
Date:	14/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0511410 8054256
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange; Brown;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	5%

Taxa:

Acacia tumida var. tumida
Aristida holathera var. holathera
Atalaya hemiglauca
Bauhinia cunninghamii
Buchnera asperata
Chrysopogon pallidus
Clerodendrum tomentosum var. tomentosum
Corymbia greeniana
Crotalaria crispata
Dolichandrone heterophylla
Eriachne obtusa
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Erythrophleum chlorostachys
Eucalyptus zygophylla
Fimbristylis oxystachya
Galactia tenuiflora
Hakea macrocarpa
Mitrasacme lutea
Sorghum plumosum
Terminalia canescens
Triodia caelestialis
Urochloa praetervisa
Waltheria indica
Wrightia saligna
Yakirra australiensis var. australiensis

Site:	**7**
Date:	14/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0512194 8053067
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	5%

Taxa:

Acacia platycarpa
Acacia tumida var. tumida
Amyema sanguinea var. sanguinea
Aristida holathera var. holathera
Bauhinia cunninghamii
Brachychiton diversifolius subsp. diversifolius
Buchnera asperata
Calandrinia quadrivalvis
Chrysopogon pallidus
Corymbia greeniana
Crotalaria crispata
Dolichandrone heterophylla
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Erythrophleum chlorostachys
Evolvulus alsinoides var. decumbens
Galactia tenuiflora
Grevillea refracta subsp. refracta
Heteropogon contortus
Microstachys chamelea
Persoonia falcata
Polycarpaea corymbosa
Pterocaulon intermedium
Pterocaulon paradoxum
Schizachyrium fragile
Solanum cunninghamii
Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)
Terminalia canescens
Trichodesma zeylanicum var. latisepalum
Triodia caelestialis
Yakirra australiensis var. australiensis

Site:	**8**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0513299 8051669
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange; Brown;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	> 5 years;
Leaf Litter Cover:	2%

Taxa:

Acacia platycarpa
Acacia tumida var. tumida
Aristida holathera var. holathera
Aristida inaequiglumis
Atalaya hemiglauca
Brachychiton diversifolius subsp. diversifolius
Buchnera asperata
Chrysopogon pallidus
Corymbia flavescens
Corymbia greeniana
Crotalaria crispata
Crotalaria sp.
Dolichandrone heterophylla
Drosera derbyensis
Eriachne obtusa
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Fimbristylis sp.
Glycine tomentella
Gomphrena flaccida
Goodenia armitiana
Goodenia sepalosa var. sepalosa
Grevillea pyramidalis subsp. pyramidalis
Heliotropium cunninghamii
Heteropogon contortus
Indigofera linifolia
Polycarpaea corymbosa
Pterocaulon intermedium
Pterocaulon serrulatum var. velutinum
Sorghum plumosum
Stylosanthes hamata
Tephrosia leptoclada
Tephrosia remotiflora
Triodia schinzii (Broome variant)
Waltheria indica
Yakirra pauciflora

Site:	**9**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0513903 8051197
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Loose;
Soil Colour:	Other;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	5%

Taxa:

Acacia colei var. colei
Acacia drepanocarpa subsp. drepanocarpa
Aristida aff. nitidula
Aristida hygrometrica
Aristida inaequiglumis
Bauhinia cunninghamii
Brachychiton diversifolius subsp. diversifolius
Buchnera ramosissima
Corymbia greeniana
Crotalaria crispata
Cyperus microcephalus subsp. microcephalus
Dolichandrone heterophylla
Eragrostis cumingii
Eriachne obtusa
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Erythrophleum chlorostachys
Evolvulus alsinoides var. decumbens
Galactia tenuiflora
Gomphrena canescens subsp. canescens
Hakea macrocarpa
Heteropogon contortus
Indigofera linifolia
Pterocaulon intermedium
Schizachyrium fragile
Solanum dioicum
Sporobolus australasicus
Striga squamigera
Stylosanthes scabra
Tephrosia leptoclada
Triodia schinzii (Broome variant)
Zornia prostrata var. prostrata

Site:	**10**
Date:	11/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0515171 8049722
Habitat:	Floodplain
Slope:	Gentle;
Surface Layer:	Crust;
Soil Colour:	Yellow; White;
Soil Texture:	Sand; Sandy-Clay;
Rock Type:	Other/Unsure;
Rock Size:	Boulders (can't pick up);
Rock Abundance:	Few (<10%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Weeds; Animal Tracks; Grazing; Faeces;
Time Since Fire:	> 5 years;
Leaf Litter Cover:	2%

Taxa:

Acacia colei var. colei
Aristida hygrometrica
Bauhinia cunninghamii
Buchnera ramosissima
Buchnera urticifolia
Bulbostylis barbata
Calandrinia strophiolata
Carissa lanceolata
Chloris lobata
Chrysopogon fallax
Corchorus tridens
Corymbia greeniana
Cyperus conicus
Digitaria brownii
Eragrostis cumingii
Eragrostis eriopoda
Eriachne obtusa
Erythrophleum chlorostachys
Fimbristylis caespitosa
Fimbristylis schultzii
Gomphrena canescens subsp. canescens
Grevillea striata
Ipomoea coptica
Melaleuca alsophila
Pluchea rubelliflora
Polycarpaea corymbosa
Pterocaulon intermedium
Setaria surgens
Solanum dioicum
Sorghum plumosum
Sporobolus australasicus
Stylosanthes hamata
Tridax procumbens
Waltheria indica
Xerochloa imberbis

Site:	**11**
Date:	11/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0515243 8049399
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange; Yellow;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Very Good (slight disturbance)
Disturbance Type:	Faeces;
Time Since Fire:	> 5 years;
Leaf Litter Cover:	2%

Taxa:

Acacia colei var. colei
Acacia drepanocarpa subsp. drepanocarpa
Aristida holathera var. holathera
Bauhinia cunninghamii
Buchnera ramosissima
Chrysopogon pallidus
Corymbia greeniana
Crotalaria crispata
Cyperus conicus
Desmodium filiforme
Dolichandrone heterophylla
Drosera derbyensis
Ehretia saligna var. saligna
Eragrostis eriopoda
Glycine tomentella
Gomphrena canescens subsp. canescens
Goodenia sepalosa var. sepalosa
Hakea macrocarpa
Heliotropium sp.
Heteropogon contortus
Indigofera linifolia
Polygala tepperi
Ptilotus polystachyus
Sorghum plumosum
Stylosanthes hamata
Stylosanthes scabra
Yakirra australiensis var. australiensis

Site:	**12**
Date:	14/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0515924 8048995
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	5%

Taxa:

Acacia tumida var. tumida
Amyema sanguinea var. sanguinea
Aristida holathera var. holathera
Aristida hygrometrica
Aristida inaequiglumis
Bauhinia cunninghamii
Brachychiton diversifolius subsp. diversifolius
Buchnera linearis
Calandrinia quadrivalvis
Calandrinia translucens
Chrysopogon pallidus
Corchorus sidoides
Corymbia greeniana
Corymbia zygophylla
Crotalaria crispata
Dolichandrone heterophylla
Eragrostis eriopoda
Eriachne obtusa
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Erythrophleum chlorostachys
Ficus aculeata var. indecora
Fimbristylis oxystachya
Grevillea pyramidalis subsp. pyramidalis
Polycarpaea corymbosa
Solanum dioicum
Sorghum plumosum
Spermacoce occidentalis
Trianthema pilosum
Yakirra australiensis var. australiensis

Site:	**13**
Date:	15/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0512144 8050058
Habitat:	Undulating Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Brown;
Soil Texture:	Sandy-Clay; Clay-Loam; Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Weeds; Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	2%

Taxa:

Acacia colei var. colei
Acacia colei var. ileocarpa
Acacia tumida var. tumida
Aristida aff. nitidula
Aristida inaequiglumis
Aristida sp.
Bauhinia cunninghamii
Chrysopogon pallidus
Corymbia greeniana
Crotalaria crispata
Cullen pustulatum
Dolichandrone heterophylla
Eragrostis sp.
Eriachne obtusa
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Gomphrena canescens subsp. canescens
Hakea arborescens
Heliotropium cunninghamii
Heliotropium sp.
Heteropogon contortus
Indigofera linifolia
Polycarpaea corymbosa
Pterocaulon paradoxum
Pterocaulon sp.
Spermacoce occidentalis
Stylosanthes hamata
Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)
Tinospora smilacina
Triodia schinzii (Broome variant)
Waltheria indica
Yakirra australiensis var. australiensis
Zornia prostrata

Site:	**16**
Date:	15/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0512281 8047660
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Very Good (slight disturbance)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	> 5 years;
Leaf Litter Cover:	5%

Taxa:

Acacia tumida var. tumida
Aristida aff. nitidula
Aristida holathera var. holathera
Bauhinia cunninghamii
Bonamia linearis
Brachychiton diversifolius subsp. diversifolius
Bulbostylis barbata
Calandrinia quadrivalvis
Chrysopogon pallidus
Corchorus sidoides
Corymbia greeniana
Crotalaria crispata
Dolichandrone heterophylla
Eriachne obtusa
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Erythrophleum chlorostachys
Euphorbia hassallii
Goodenia sepalosa var. sepalosa
Grevillea pyramidalis subsp. pyramidalis
Grevillea refracta subsp. refracta
Heliotropium cunninghamii
Microstachys chamelea
Mitrasacme exserta
Polycarpaea corymbosa
Polygala tepperi
Polymeria ambigua
Senna costata
Solanum cunninghamii
Spermacoce occidentalis
Tephrosia sp. C Kimberley Flora (K.F. Kenneally 5599)
Trichodesma zeylanicum var. latisepalum
Triodia schinzii (Broome variant)
Waltheria indica
Yakirra pauciflora

Site:	**17**
Date:	13/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0501476 8070456
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	Common (10-30%)
Vegetation Condition:	Very Good (slight disturbance)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	< 1 year;
Leaf Litter Cover:	2%

Taxa:

Abildgaardia schoenoides
Acacia tumida var. tumida
Aristida holathera var. holathera
Aristida hygrometrica
Bonamia linearis
Buchnera asperata
Calandrinia quadrivalvis
Chamaecrista moorei
Corchorus sidoides
Crotalaria crispata
Eragrostis eriopoda
Eriachne obtusa
Erythrophleum chlorostachys
Euphorbia hassallii
Fimbristylis ammobia
Fimbristylis neilsonii
Goodenia sepalosa var. sepalosa
Grevillea refracta subsp. refracta
Heteropogon contortus
Microstachys chamelea
Persoonia falcata
Ptilotus polystachyus
Spermacoce occidentalis
Striga squamigera
Tephrosia crocea
Trachymene oleracea subsp. oleracea
Trianthema pilosum
Triodia schinzii (Broome variant)
Zornia chaetophora

Site:	**18**
Date:	14/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0503734 8066043
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Loose;
Soil Colour:	Orange;
Soil Texture:	Sand; Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	10%

Taxa:

Abildgaardia schoenoides
Acacia tumida var. tumida
Aristida inaequiglumis
Bonamia linearis
Buchnera ramosissima
Byblis filifolia
Calandrinia quadrivalvis
Crotalaria crispata
Eragrostis eriopoda
Eriachne obtusa
Erythrophleum chlorostachys
Fimbristylis ammobia
Goodenia sepalosa var. sepalosa
Grevillea refracta subsp. refracta
Heliotropium leptaleum
Heteropogon contortus
Microstachys chamelea
Polygala tepperi
Pterocaulon paradoxum
Schizachyrium fragile
Solanum cleistogamum
Spermacoce occidentalis
Tephrosia crocea
Triodia schinzii (Broome variant)
Waltheria indica
Yakirra australiensis var. intermedia

APPENDIX G SIGNFICANT FLORA AND WEED LOCATIONS

Priority Flora Records

Taxon	Status	Date	Collector	Count	Easting	Northing
Pterocaulon intermedium	P3	15-MAY-15	Matthew Macdonald	1	499972	8069648
Pterocaulon intermedium	P3	15-MAY-15	Matthew Macdonald	1	500041	8069802
Pterocaulon intermedium	P3	15-MAY-15	Matthew Macdonald	1	499540	8069960
Pterocaulon intermedium	P3	15-MAY-15	Matthew Macdonald	1	512043	8053129
Pterocaulon intermedium	P3	14-MAY-15	Matthew Macdonald	1	504309	8065397
Pterocaulon intermedium	P3	11-MAY-15	Matthew Macdonald	1	515172	8049723
Pterocaulon intermedium	P3	12-MAY-15	Matthew Macdonald	1	508905	8056914
Pterocaulon intermedium	P3	13-MAY-15	Matthew Macdonald	1	513902	8051201
Pterocaulon intermedium	P3	14-MAY-15	Matthew Macdonald	1	504489	8065127
Pterocaulon intermedium	P3	14-MAY-15	Matthew Macdonald	1	512185	8053074
Pterocaulon intermedium	P3	14-MAY-15	Matthew Macdonald	1	512185	8053074
Pterocaulon intermedium	P3	13-MAY-15	Matthew Macdonald	1	513285	8051678
Pterocaulon intermedium	P3	14-MAY-15	Matthew Macdonald	1	503365	8066681
Pterocaulon intermedium	P3	13-MAY-15	Matthew Macdonald	1	501697	8069412
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	300	512037	8053110
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	1500	499689	8069847
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	100	501015	8069032
Triodia caelestialis	P3	14-MAY-15	Matthew Macdonald	50	502678	8067418
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	200	512322	8051853
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	1000	512324	8051958
Triodia caelestialis	P3	14-MAY-15	Matthew Macdonald	50	512185	8053074
Triodia caelestialis	P3	12-MAY-15	Matthew Macdonald	1	505982	8062571
Triodia caelestialis	P3	14-MAY-15	Matthew Macdonald	20	511403	8054250
Triodia caelestialis	P3	12-MAY-15	Matthew Macdonald	50	508905	8056914
Triodia caelestialis	P3	14-MAY-15	Matthew Macdonald	100	503921	8066082
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	200	500946	8069120
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	100	500798	8069186
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	100	500656	8069273
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	50	500373	8069441
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	100	500273	8069488
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	100	499926	8069682
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	1000	499834	8069766
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	1000	512216	8052028
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	100	499512	8069908
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	500	499685	8069931
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	1000	499908	8069827
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	500	500036	8069802
Triodia caelestialis	P3	14-MAY-15	Matthew Macdonald	50	502526	8067594
Triodia caelestialis	P3	14-MAY-15	Matthew Macdonald	100	502306	8067938

Introduced Flora Records

Taxon	Status	Date	Collector	Count	Easting	Northing
**Malvastrum americanum*	Weed	12-MAY-15	Matthew Macdonald	1	505038	8064608
**Stylosanthes hamata*	Weed	15-MAY-15	Matthew Macdonald	1	512132	8050056
**Stylosanthes hamata*	Weed	13-MAY-15	Matthew Macdonald	1	513285	8051678
**Stylosanthes hamata*	Weed	11-MAY-15	Matthew Macdonald	20	515244	8049400
**Stylosanthes hamata*	Weed	11-MAY-15	Matthew Macdonald	10	515172	8049723
**Stylosanthes scabra*	Weed	11-MAY-15	Matthew Macdonald	1	515244	8049400
**Stylosanthes scabra*	Weed	12-MAY-15	Matthew Macdonald	1	505637	8064082
**Stylosanthes scabra*	Weed	13-MAY-15	Matthew Macdonald	10	513902	8051201
**Tridax procumbens*	Weed	11-MAY-15	Matthew Macdonald	1	515172	8049723

Datum: GDA 1994 MGA Zone 50

APPENDIX H SHEFFIELD RESOURCES THUNDERBIRD PROJECT *VARANUS SPARNUS* MEMO

LEVEL 8 CARILLON CITY OFFICE TOWER 207 MURRAY ST PERTH 6000 • PH: 6180 4450 • FAX: 6180 4451 •
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www.ecologia.com.au

Thunderbird Project

Sheffield Resources

***Varanus sparnus* Memo**

Attention: Wayne Groeneveld

MEMO

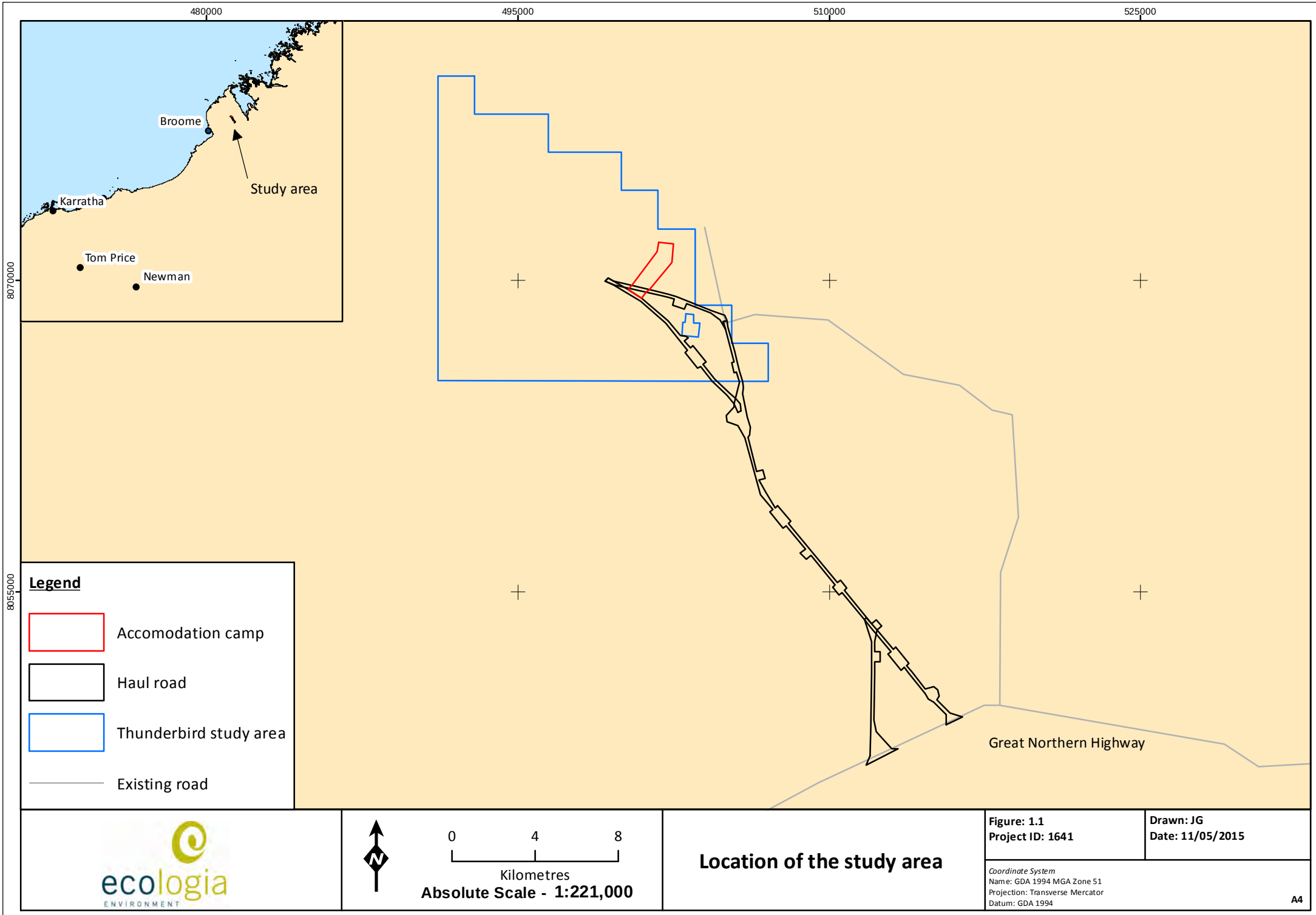
Introduction

Sheffield Resources Limited (Sheffield) is a rapidly emerging mineral sands company with significant additional nickel, talc and iron assets, all located within the state of Western Australia. Sheffield are currently validating extensive historical work and undertaking biological surveys at an early stage to aid their project pathway.

In 2014 Sheffield commissioned *ecologia* Environment (*ecologia*) to undertake a two-phase Level 2 terrestrial (vertebrate and SRE invertebrate) and subterranean fauna survey of its Thunderbird Project (study area), located 70 kilometres west of Derby on the Dampier Peninsula (Figure 1.1). Level 2 assessments were completed in 2014.

Following the completion of the Level 2 assessments, Doughty *et. al.* (2014) identified a new species of Goanna from the Dampier Peninsula; Dampier Peninsula Goanna (*Varanus sparnus*) (Appendix A). One of the individuals used in the morphological and DNA analysis for the new species description was an individual collected during phase 1 of the Level 2 fauna assessment at Thunderbird, which was vouchered at the Western Australian Museum (WAM) at a request of WAM.

Given the interest and potential implications of a newly described species within the study area, this memo has been developed to clarify *Varunus sparnus* occurrence within the Thunderbird study area.


480000
495000
510000
525000
8070000
8055000
Broome
Karratha
Tom Price
Newman
Study area
Great Northern Highway
Legend
Accomodation camp
Haul road
Thunderbird study area
Existing road
N
0
4
8
Kilometres
Absolute Scale - 1:221,000
Location of the study area
Figure: 1.1
Project ID: 1641
Drawn: JG
Date: 11/05/2015
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
A4

***Varanus sparnus* study area records**

The newly described *Varanus sparnus* has been split from the similar looking and widely distributed Short-tailed Pygmy Monitor (*Varanus brevicauda*), on the grounds of both distinct morphological and DNA characteristics (Doughty *et. al.* 2014). However, based on current knowledge, both species occur sympatrically, and could both therefore occur within the study area. As the species was described following the field assessments, the only confirmed record within the study area exists as the vouchered individual, with the remaining individuals potentially being either species.

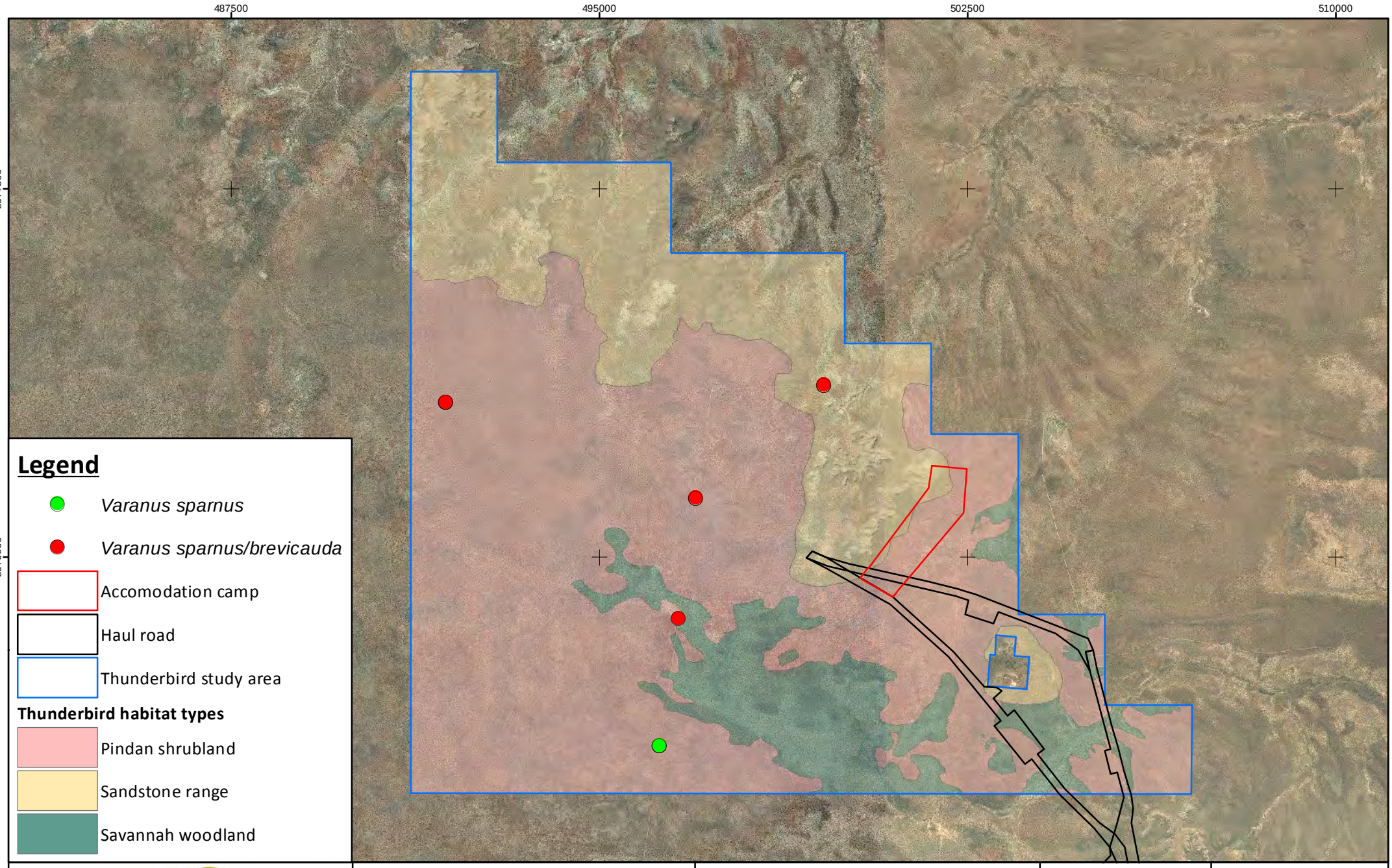
A total of 12 individuals were recorded, including seven during Phase 1 and five during Phase 2 (Table 1.1, Figure 1.3). One individual was vouchered from Phase 1 (WAM voucher number R173115, Figure 1.2), and confirmed as *Varanus sparnus*. Individuals were recorded from a total of five of the seven trapping sites installed. All individuals were trapped from systematic trapping sites in pitfall or funnel traps. Individuals were recorded from all three broad fauna habitat types identified from the study area (Figure 1.3).

Figure 1.2 *Varanus sparnus* WAM vouchered individual from Thunderbird study area

Table 1.1 – *Varanus sparnus/brevicauda* records from the study area.

	Site	Count	Easting	Northing	Date
Phase 1					
Varanus sparnus/brevicauda	TB S4	1	491858	8073144	11/04/2013
Varanus sparnus/brevicauda	TB S4	1	491858	8073144	12/04/2013
Varanus sparnus/brevicauda	TB S5	1	496965	8071200	7/04/2013
Varanus sparnus/brevicauda	TB S6	1	496603	8068741	13/04/2013
Varanus sparnus/brevicauda	TB S7	1	496226	8066143	12/04/2013
Varanus sparnus/brevicauda	TB S7	1	496226	8066143	13/04/2013
*Varanus sparnus**	TB S7	1	496226	8066143	13/04/2013
Phase 2					
Varanus sparnus/brevicauda	TBS1	1	499584	8073492	19/10/2013
Varanus sparnus/brevicauda	TBS1	1	499584	8073492	21/10/2013
Varanus sparnus/brevicauda	TBS4	1	491858	8073144	22/10/2013
Varanus sparnus/brevicauda	TBS4	1	491858	8073144	22/10/2013
Varanus sparnus/brevicauda	TBS5	1	496965	8071200	19/10/2013

GDA94 Zone 51K
*Vouchered individual confirmed as *Varanus sparnus*



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***Varanus sparnus/brevicauda* records**

Figure: 1.3
Project ID: 1641

Drawn: BG
Date: 19/05/15

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID:

A4

Regional context

To date, a total of four individuals have been identified as *Varanus sparnus*, these individuals were those utilised for the description of the species based on morphology and DNA characteristics (Doughty *et. al.* 2014). Details of these individuals are provided in Table 1.2, adapted from Doughty *et. al.* 2014, and shown in Figure 1.4.

Figure 1.4 shows relatively few *Varanus brevicauda/sparnus* records on the Dampier Peninsular, with previous records restricted to the Thunderbird study area, and in the surrounding region of the James Price Point precinct (DPaW 2015). The lack of records is likely attributed to a lack of biological survey work utilising pitfall and funnel trap methods on Dampier Peninsular.

Current habitat associated with *V.sparnus* is broadly described as pindan shrubland (Doughty *et. al.* 2014). Given *Varanus brevicauda* is known to excavate and live in burrows (Wilson and Swan 2013), and observations of *Varanus sparnus* in captivity are that this species also regularly excavates and burrows (Doughty *et. al.* 2014), any soil substrate on the Dampier Peninsular able to be excavated could currently be considered as potential suitable habitat. Presence of spinifex (*Triodia* spp.) is also a likely component of this habitat association.

Given two disjunct location records exist approximately 85 km apart, it is likely *Varanus sparnus* occurs throughout the Dampier Peninsula, wherever suitable sandy substrate habitat exists. There is no conservation status currently assigned to *Varanus sparnus*.

Table 1.2 – Vertebrate fauna species recorded

WAM voucher number	Locality	Sex	Easting	Northing
WAM R168486	Coulomb Point	M	409970	8072930
WAM R168474	Coulomb Point	-	411859	8056795
WAM R168475	Coulomb Point	F	410010	8069268
WAM R173115	Thunderbird Study area	F	496284	8066624

GDA 94 Zone 51K

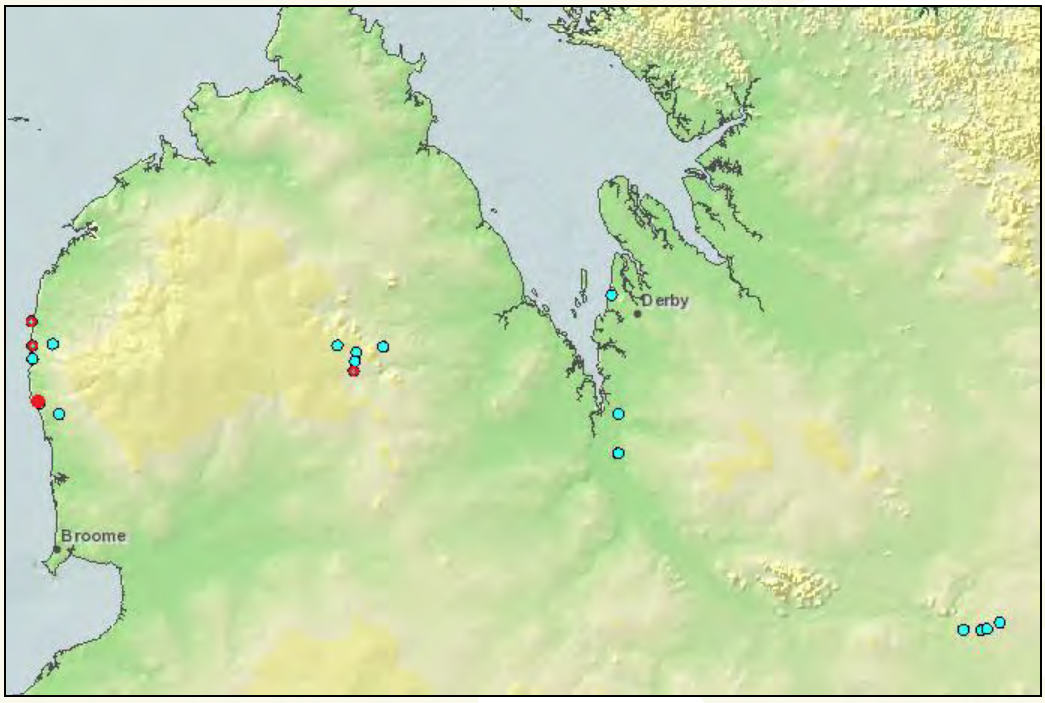

Figure 1.4 – NatureMap *Varanus brevicauda/sparnus* and *Varanus sparnus* (red dots)records

Please feel free to contact myself or Bruce Greatwich to discuss any aspect of this memo.

Best regards,
Shaun Grein
Managing Director

2 June 2015

References

Doughty, P., Kealley, L., Fitch, A. and Donnellan, S., 2014. *A new diminutive species of Varanusfrom the Dampier Peninsula, western Kimberley region, Western Australia*. Records of the Western Australian Museum, **(29)**, Pg 128-140.

Department of Parks and Wildlife, 2015. *NatureMap, Mapping Western Australia's biodiversity*. http://naturemap.dpaw.wa.gov.au/default.aspx (Accessed 27/5/15).

Wilson, S and Swan, G., 2013. *A complete guide to reptiles of Australia*. New Holland Publishers, Sydney.

APPENDIX A – Doughty *et. al.* 2014, A new diminutive species of *Varanus* from the Dampier Peninsula, western Kimberley region, Western Australia

RECORDS OF THE WESTERN AUSTRALIAN MUSEUM 29 128–140 (2014)

A new diminutive species of *Varanus* from the Dampier Peninsula, western Kimberley region, Western Australia

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ABSTRACT – *Varanus* lizards in Australia are moderately diverse and include a radiation of small-bodied species that occur in arid or tropical environments. *Varanus brevicauda* is the smallest species, with an elongate body and short prehensile tail and is associated with spinifex clumps in arid environments. Recently collected unusual specimens at the north-western edge of the range of *V. brevicauda* on the Dampier Peninsula, Western Australia, had an even more elongate body and also co-occurred with typical *V. brevicauda*. This led us to conduct a morphological and molecular genetic systematic appraisal of the two morphotypes. We found that the more elongate specimens were highly divergent genetically from both typical *V. brevicauda* and another related species, *V. eremius*, with the three lineages forming a polytomy. Morphologically, the elongate specimens are most similar to *V. brevicauda*, but possess a more elongate body, less robust head and limbs, distinctive scales on the front of the arms that are large, squarish and lacking surrounding granules and a plainer pattern and colouration. The co-occurrence of both forms on the Dampier Peninsula in combination with the extent and pattern of genetic divergence and presence of key morphologically diagnostic traits unequivocally demonstrates that more elongate form is a new species, which we describe here. The new species may be of conservation concern owing to the small range of the only known specimens and development proposals in the area.

KEYWORDS: Goanna, monitor lizard, *Varanus brevicauda*, *Varanus sparnus* sp. nov.

INTRODUCTION

Lizards of the genus *Varanus* Merrem, 1820, commonly referred to as goannas or monitors, are a moderately diverse group with over 70 species from Australia, south-east Asia, India, the Middle East and Africa. Australia is the most species-rich region with 31 species, including a radiation of small to very small-bodied species within the subgenus *Odatria* Gray, 1838 (Pianka et al. 2004). *Varanus* show strong conservatism in body shape, with most species having long, pointed heads and tails (King and Green 1999). Body proportions, however, can differ substantially among species, with relative head and tail lengths differing widely in association with differences in ecology (Thompson and Withers 1997; Openshaw and Keogh 2014).

Within the small-bodied Australian *Odatria* group there are three widely-distributed arid zone species: *V. brevicauda* Boulenger, 1898, *V. acanthurus* Boulenger, 1885 and *V. eremius* Lucas & Frost, 1895. *Varanus brevicauda* is the smallest species of *Varanus*, with a snout-vent length of around 120 mm and a total length of about 250 mm owing to its short tail (hence the specific name) (Storr et al. 1983; Pianka 2004). It occurs along the west coast and extends eastwards and inland through the sandy deserts as far as the Simpson Desert in western Queensland (Wilson and Swan 2010). This species is an active burrower, with relatively straight claws on the hands, capable of digging their own tunnels and foraging for food among *Triodia* clumps and along sand dunes (Pianka 2004).

Recently, several unusual specimens assignable to *V. brevicauda* have been collected from the extreme north-west of the species' range, from near Coulomb Point on the Dampier Peninsula, north of Broome in the western Kimberley region (Figure 1). This area is characterised by sandy soils and pindan vegetation communities (McKenzie 1983). The specimens have a more elongate and gracile appearance than typical *V. brevicauda* and a more subdued pattern. We carried out

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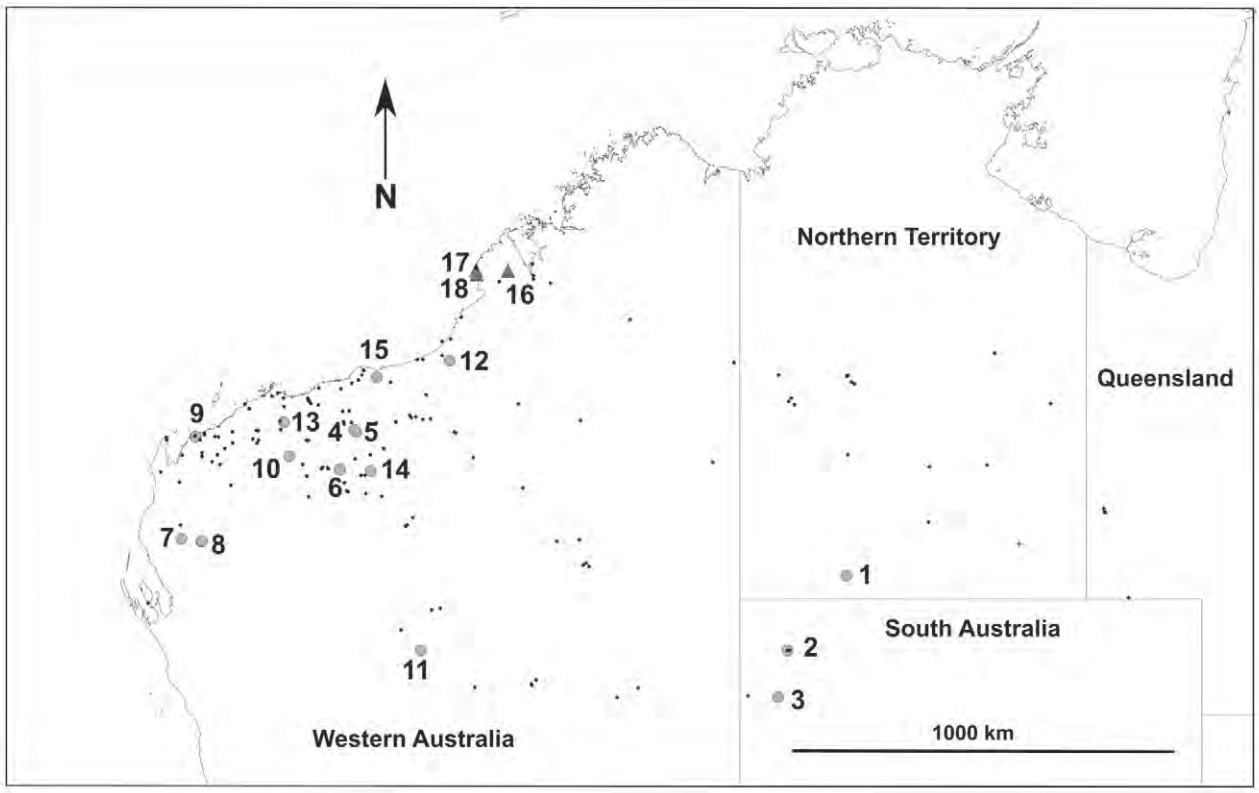

FIGURE 1 Map showing the distribution of *Varanus brevicauda* (dots) and *V. sparnus* sp. nov. (triangles) based on Atlas of Living Australia voucher records (small dots) and locations from which molecular genetic data were obtained (large symbols).

a molecular genetic analysis to assess the distinctiveness of these specimens from 'typical' *V. brevicauda* sampled throughout its range. This genetic evidence indicated that the elongate specimens are equally distant genetically to *V. brevicauda* and *V. eremius*. Examination of specimens also revealed a suite of morphological characters to distinguish the new form. Here we describe this population as a new species of *Varanus*.

METHODS

MORPHOLOGY

Specimens were examined from the collections of the Western Australian Museum (WAM; where new type material is deposited). We examined three preserved specimens of the elongate form, plus one live captive specimen, and compared these with 20 *V. brevicauda* from throughout the rest of its range in Western Australia, including from the Dampier Peninsula (Appendix 1). We compared the two forms qualitatively and measured and counted other characters. Table 1 presents the morphological variables assessed and how they were measured. Measurements were made with electronic callipers to the nearest 0.1 mm, with SVL, TailL and TrunkL to 0.5 mm (broken tails were excluded). Individuals were sexed on the basis of everted hemipenes in males or of conspicuous gravidity in females, or by direct examination of the gonads.

MOLECULAR GENETICS

Frozen or alcohol preserved tissues were available from 31 *Varanus* vouchers (Appendix 1). DNA was extracted from using a Puregene DNA isolation kit (Gentra Systems, Minneapolis, U.S.A.) following the manufacturer's protocol for DNA purification from solid tissue. An ~886 bp fragment of the mitochondrial genome, including the 3′ end of the *NADH dehydrogenase* subunit *4* (*ND4*) gene (710 bp) and the tRNA genes *tRNAHis*, *tRNASer* and the 5′ end of *tRNALeu* (176 bp), hereafter referred to as *ND4*, was amplified and sequenced using the forward primers *ND4*: 5′-TGACTACCAAAAGCTCATGTAGAAGC-3′ or *ND4*: 5′-ACCTATGACTACCAAAAGCTCATGTAGA AGC-3′ with the reverse primer Leu1: 5′-CATTACTTT TTACTTGGATTTGCACCA-3′. Each PCR was carried out in a volume of 25 ml with a final concentration of 1X GeneAmp PCR Gold buffer, 2–4 mM MgCl2, 200 M of each dNTP, 0.2 mM of each primer and 0.5 U of AmpliTaq Gold DNA polymerase (Applied Biosystems, Foster City, CA, U.S.A.). Amplifications consisted of an initial denaturation step of 94°C for 9 min, followed by 34 cycles of PCR with the following temperature profile: denaturation at 94°C for 45 s, annealing at 55°C for 45 s, and extension at 72°C for

TABLE 1 Morphological characters measured.

Character	Description
SVL	Snout-vent length
LegL	Leg length, measured from the knee patella to the tip of the 4th toe including claw
HeadL	Head length, measured obliquely from tip of snout to anterior margin of tympanum
HeadW	Head width, measured at the widest point
HeadD	Head depth, measured level with centre of the tympanum, at the highest point
SupLab	Number of supralabial scales
InfLab	Number of infralabial scales, ending with the last small scale in contact with the posterior margin of the last upper labial
MBSR	Number of midbody scale rows, counted midway between axilla and groin
4TLam	Number of enlarged subdigital lamellae under fourth toe, counted from toe junction to base of claw
PCP	Number of pre-cloacal pores
TailL	Tail length, measured from the base of the cloaca to the tip of the tail
CloSpu	Number of cloacal spurs present
ILL	Inter-limb length, measured between the forelimb and hindlimb
UArmL	Upper arm length, measured from the lower side of the axilla to the outside of the elbow
LArmL	Lower arm length, measured from the outside of the elbow to the inside of the wrist
HandL	Hand length, measured from the inside of the wrist to the tip of the 4th toe, excluding the nail
ULegL	Upper leg length, measured from the lower side of the groin to the outside of the knee
LLegL	Lower leg length, measured from the outside of the knee to the inside of the ankle
FootL	Foot length, measured from the inside of the ankle to the 4th toe, excluding the nail

1 min, with an additional final extension at 72°C for 6 min. The double-stranded amplification products were visualised on 1.5% agarose gels and purified using an UltraClean PCR clean-up DNA purification kit (Mo Bio Laboratories Inc., CA, U.S.A.) before cycle-sequencing using the BigDye Terminator v3.1 cycle-sequencing kit (Applied Biosystems). The cycling protocol consisted of 25 cycles of denaturation at 96°C for 30 s, annealing at 50°C for 15 s, and extension at 60°C for 4 min. All samples were sequenced on an Applied Biosystems 3700 DNA sequencer. These sequences were aligned with previously published *Varanus ND4* sequences, including species from clades related to *V. brevicauda* as identified by Fitch et al. (2006) and Vidal et al. (2012) (Appendix 1) with MAFFT v6.814b (Katoh et al. 2005) implemented in Geneious Pro v5.5.2.

Bayes factors were used to assess all possible alternative partitioning strategies for four data subsets: 1st, 2nd and 3rd codon positions and the tRNA in PartitionFinder v1.0.0 (Lanfear et al. 2012). The Akaike Information Criterion (AIC) and Bayes Information Criterion (BIC) were used to assess the best fit partition strategy and nucleotide substitution model for each data subset in the selected partition strategy. Sequences were analysed phylogenetically using Bayesian and maximum likelihood methods. Bayesian analysis was conducted using MrBayes v3.1.2 (Ronquist and Huelsenbeck 2003). The analysis was run with model parameters unlinked using default priors for two million generations with two independent runs and two chains sampling every 1000 generations. The first 25% of sampled trees were discarded as burn-in and convergence was assessed by examining effective sample sizes (ESS values), split frequencies of clades across runs and likelihood plots through time in TRACER v1.4.1 (Rambaut and Drummond 2007).

Net average sequence divergence between lineages (*dA*) was calculated in MEGA v5 (Tamura et al. 2011) as: $dA = dXY - (dX + dY)/2$, where, dXY is the average distance between groups X and Y, and dX and dY are the within-group means. Net average sequence divergence between taxa was calculated from our data and the data of Fitch et al. (2006), Smith et al. (2007), Smissen et al. (2013), Maryan et al. (2014) and GenBank accessions for *V. komodoensis* Ouwens, 1912 for sister species pairs of *Varanus* where more than one sequence was available for each member of the pair.

RESULTS

MOLECULAR GENETICS

The partioning scheme and models of nucleotide substitution for the *ND4* alignment of 460 bp chosen in Partition Finder were first codon position with HKY+G, second codon position with HKY+G and third codon position with TIM+G. Figure 2 shows a Neighbor-Joining phylogram showing relationship among mitochondrial *ND4* sequences from *V. brevicauda* and near relatives. This topology was also recovered with the Bayesian analysis. Specimens resembling *V. brevicauda* fell into two highly divergent groups: the first is widespread across the arid zone, while the second appears to be geographically restricted to the Dampier Peninsula at the north-western edge of the range of *V. brevicauda sensu lato* (Figures 1, 2). The relationships of these two groups with *V. eremius* are unresolved by our data but net average sequence divergence (*dA*) between the three exceeds that between many other sister species pairs of varanids (Table 2).

MORPHOLOGY

Table 3 presents a summary of the morphological differences between *V. brevicauda* from across its range and the elongate individuals from the Dampier Peninsula (Figure 3). The two taxa had similar dorsal patterning, although *V. brevicauda* tended to have more pronounced ocelli than the elongate specimens, giving it a bolder pattern (Figure 4). Morphologically, the elongate specimens had a more gracile appearance (Figure 4), with longer inter-limb lengths (Table 3). We also found that head depth was shallower in the elongate individuals as well (Figure 5).

FIGURE 2 Neighbour-Joining (NJ) phylogram of relationships among mitochondrial *ND4* sequences of *Varanus brevicauda* and near relatives. Numbers at nodes are NJ bootstrap proportions (left) and Bayesian posterior probabilities (right).

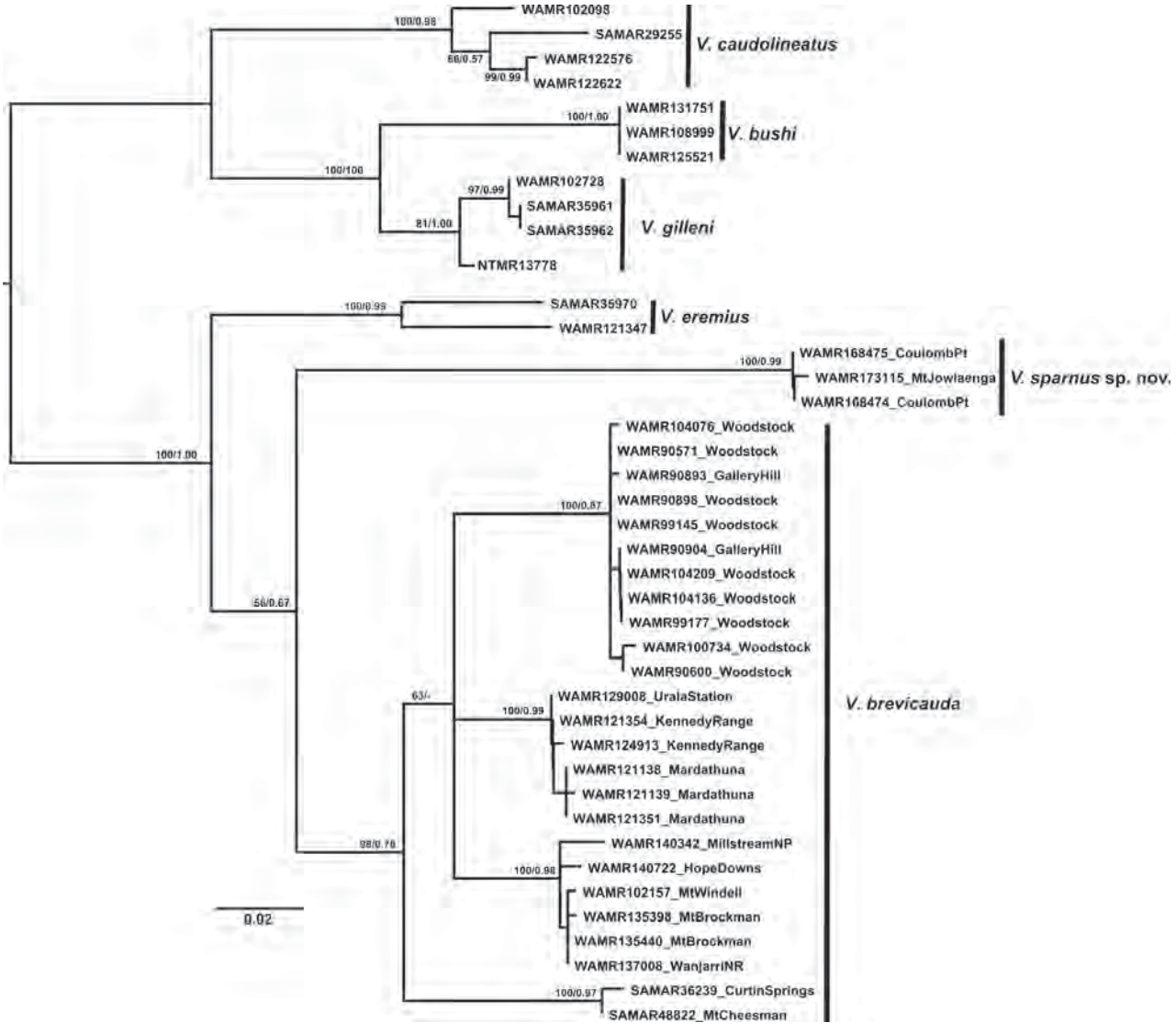

TABLE 2 Net average sequence divergence (*dA*) between sister species pairs of varanids and among *Varanus brevicauda*, *V. sparnus* sp. nov., *V. eremius* and other more distantly-related species pairs.

Sister species pair	*dA*
V. brevicauda-sparnus sp. nov.	0.134
V. eremius-sparnus sp. nov.	0.143
V. brevicauda-eremius	0.085
V. komdoensis-varius	0.125
V. mitchelli-semiremex	0.121
V. gouldii-rosenbergi	0.112
V. bushi-gilleni	0.066
V. pilbarensis-hamersleyensis	0.063
V. acanthurus insulanicus-baritji	0.019

A key difference between the two taxa observed was the appearance of the scales on the front and leading edge of the arms. The scales on the arms of *V. brevicauda senso stricto* are oval in shape and possess a ring of granules around them (Figure 6), similar to scales elsewhere on the body. In contrast, the elongate individuals had large, squarish scales on the front and leading edge of the arms, and the scales lacked small granules at their periphery (Figure 6). A further difference is that, in ventral view, the transition from the large squarish scales on the elongate individuals is quite abrupt, whereas in *V. brevicauda* the scales encircling the arm are similar in appearance with no abrupt transition (Figure 6).

TAXONOMIC CONCLUSIONS

The molecular genetic evidence strongly supported the existence of two independently evolving lineages within *V. brevicauda senso lato* (including the elongate specimens) based on reciprocal monophyly in the mitochondrial nucleotide sequence data and the extent of net average sequence divergence between the lineages relative to other recognised sister species pairs of *Varanus* (Table 2). Furthermore, nuclear gene sequence data from more than 300 loci produced from an anchored enrichment phylogenomic approach (Lemmon and Lemmon 2012) supports the highly divergent nature of the two lineages (Donnellan, Keogh, Lemmon and Lemmon, unpublished data).

The morphological evidence also supports the existence of two species, with the new species more elongate and gracile than *V. brevicauda*, and differences in scalation on the arms. Patterning and colouration differences were less apparent, although there was a trend for specimens of the elongate form to be less well-marked and to be a darker reddish-brown (at least in the two adults). Significantly, the two species are in sympatry on the Dampier Peninsula, where typical *V. brevicauda* specimens (WAM R40273, R40274, R44329) were collected 7 km to the north of the holotype of the new species. There was no evidence of individuals demonstrating intermediate morphological states, indicating a lack of gene flow between the two species.

Taken together, morphology, molecular genetics and the overlapping distributions of the two forms strongly demonstrate that the more elongate Dampier Peninsula specimens represent a new species distinct from *V. brevicauda*, which we describe below.

TAXONOMY

Family Varanidae Merrem, 1820

Genus *Varanus* Merrem, 1820

TYPE SPECIES

Lacerta varia (= *Varanus varius*) White, 1790, by subsequent designation.

***Varanus sparnus* sp. nov.**

Dampier Peninsula Goanna

Figures 3–6

http://www.zoobank.org/urn:lsid:zoobank.org:act:039C783D-5A6C-4B79-9069-94E1C51E77C7

MATERIAL EXAMINED

Holotype

Australia: *Western Australia*: WAM R168486, adult male collected by R.J. Teale and G. Harold on 10 March 2009, from Coloumb Point, Dampier Peninsula (-17.4277ºS, 122.1522ºE).

Paratypes

Australia: *Western Australia*: WAM R168475, adult female from Coloumb Point, Dampier Peninsula, collected on 14 March 2009 (-17.4608ºS, 122.1525ºE); WAM R168474, subadult, from Coloumb Point, Dampier Peninsula (-17.5736ºS, 122.1694ºE).

Additional material

Australia: *Western Australia*: WAM R173115, live subadult female from 9 km south-west of Mt Jowlaenga, Dampier Peninsula (-17.4865ºS, 122.9650ºE).

DIAGNOSIS

A very small *Varanus* (< 120 mm SVL) with short limbs, elongate body, ridged, circular and short prehensile tail (TailL/SVL: 0.92–0.99), and relatively plain reddish-brown dorsum with widely scattered small black spots. Further distinguished from *V. brevicauda* by having a more elongate body, shorter limbs, less robust head, body and tail, and presence of enlarged squarish scales not encircled by granules on front of the arms.

TABLE 3 Summaries of characters and ratios measured for *Varanus brevicauda* and *V. sparnus* sp. nov. Means±S.D and ranges on the second line for each character are presented. See Table 1 for abbreviations. Sample sizes are listed in column headings, unless noted for individual characters below.

	V. brevicauda	*V. sparnus* sp. nov.			
Character:	N = 20 (8♀, 12♂)	R168486 (♂)	R168475 (♀)	R168474 (J)	R173115 (♀)
SVL	102.0±8.2	116.0	116.4	72.1	110.0
	90.5–120.5				
TailL	98.1±10.9	111.5	108.4	69.0	101.0
	79–117				
HeadL	18.2±1.2	20.1	17.9	13.6	15.9
	16.0–20.5				
HeadW	10.8±0.8	10.5	9.5	6.9	9.5
	9.4–12.6				
HeadD	8.1±0.9	7.6	7.0	5.0	7.5
	6.0–9.7				
SupLab	17.5±1.5	16	17	16	18
	15–21				
InfLab	17.1±1.1	16	16	15	18
	15–19				
MBSR	88.4±6.8	79	86	66	
	80–103				
4TLam	16.1±1.6	15	16	14	
	14–19				
PCP	0.4±1.4	0	0	0	0
	0–6				
ILL	58.2±5.7	66.6	74.1	40.2	79.7
	49.2–69.1				
UArmL	8.4±0.8	8.3	8.7	6.2	6.3
	7.0–9.8				
LArmL	6.8±0.7	6.9	7.0	4.9	7.6
	4.7–7.8				
HandL	9.3±0.6	10.1	8.9	6.0	8.4
	8.4–10.3				
ULegL	9.7±0.8	10.0	9.0	6.1	8.0
	7.8–11.0				
LLegL	8.7±1.0	7.6	7.8	5.6	7.3
	6.6–10.2				
FootL	10.5±1.2	9.9	9.6	7.2	8.6
	7.4–12.3				

DESCRIPTION OF HOLOTYPE (WAM R168486)

Head short (HeadL/SVL – 0.173), narrow (HeadW/SVL – 0.091) and shallow (HeadD/SVL – 0.066); snout slightly concave dorsally, narrowing to broadly rounded tip when viewed dorsally; in lateral view, snout gradually narrows to nostrils, then angles downwards to tip of snout; upper jaw protrudes slightly beyond lower jaw; eyes relatively large; nares large and directed posteriorly, posterior edge straight and defined by ridge, narrowing anteriorly; nostril opening small and positioned anteriorly and ventrally within narial opening; external ear opening large (~1.5 times width of eye), ventral portion angled forwards, anterior edge curved slightly and posterior edge straight for uppermost 1/3, then angled anteriorly; line of mouth gradually rising from snout tip to below posterior edge of eye, then straight to ventral edge of ear opening. Longitudinally oriented scales on top of head behind eyes with pronounced, straight keels; scales on top of snout protruding and irregular, lacking keels; scales above eyes with short keels; keels at back of head angled outwards.

Mental two times longer than wide, sides gradually narrowing then angling at 45º to meet at posterior terminal point; first, second and third infralabials enlarged, gradually decreasing in size from mental until the size of surrounding scales. Gular scales near edge of jaw flattened and elongate, gradually rounding towards gular fold; gular fold strong, with underlying granular scales underneath fold.

FIGURE 3 Images in life of *Varanus sparnus* sp. nov. Upper image – WAM R173115 (image by R. Ellis); lower image – holotype WAM R168486 (image by G. Harold).

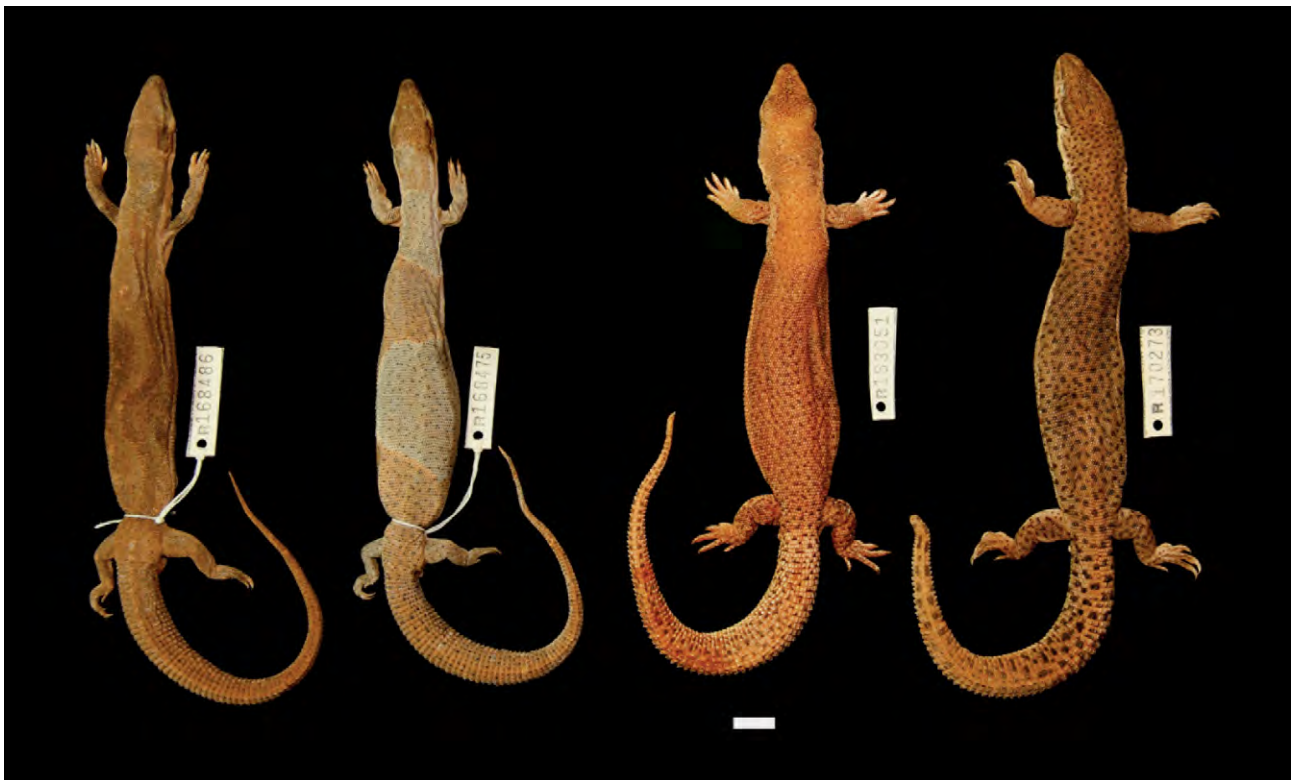

FIGURE 4 Preserved specimens of *Varanus sparnus* sp. nov. (holotype – WAM R168486; paratype – 168475), and *V. brevicauda* (WAM R163051, WAM R170273). Scale bar = 1 cm.

Torso extremely elongate (ILL/SVL – 0.57); covered in rows of small scales; dorsal scales non-overlapping and oblong with low keels bordered by 8–12 small granules (except for anterior edge); scales on sides lack keels and are rounder (less oblong); ventral scales non-overlapping, smooth (i.e. no perforation visible) and rectangular with slightly rounded posterior edge.

Limbs extremely short (UArmL/SVL – 0.072; LArmL/SVL – 0.059; ULegL/SVL – 0.086 LLegL/SVL – 0.066), with relatively large hands (HandL/SVL – 0.087) and feet (FootL/SVL – 0.085); absolute lengths: hand length > lower arm > upper arm, upper leg > foot length > lower leg. Lower arm compressed; scales on dorsal surface of lower and upper arm large, squarish and flattened, lacking surrounding granules; scales on ventral surface small; abrupt transition of scale size at leading edge of lower arm: from rows of large scales of inner lower arm to smaller scales on ventral surfaces. Scales on upper and lower surfaces of legs similar to dorsal scales on body, but smaller; scales on anterior surface enlarged and flattened, lacking surrounding granules; scales on posterior edge very small, almost granular; medial rows of scales on dorsal surfaces of hands and feet enlarged and with tightly grouped non-overlapping flat scales; palmar and plantar surfaces with small rounded scales. Fingers long with long recurved claws; toes moderately long with long recurved claws.

Cloacal spurs to either side of vent, each with 20–25 spurs arranged in 3 or 4 irregular rows; spurs flattened at base and curve upwards to fine point. Tail short and covered in regular rows of scales; dorsal scales strongly keeled and angled dorsally at posterior edge; ventral scales strongly keeled and flat; tail tip gradually tapering to a fine point; tail tip very flexible and prehensile. Measurements of the holotype and all other specimens are presented in Table 3.

Colouration

In life, ground colour of dorsum and lateral surfaces light reddish-brown; freckled with fine black spots (no ocelli present) that occupy a single scale; ventral surfaces dull yellowy-white; head with a dark blackish streak from the eye to the dorsal portion of ear opening; upper labials and scales below eye pale with light grey stippling (Figure 3). In preservative, ground colour darker reddish-brown and lower surfaces dull yellowy-white; otherwise similar to life (Figure 4).

VARIATION

The adult female (WAM R168475) is similar in most respects to the male holotype, however, this specimen has a longer torso and more gracile proportions (including slender head and neck, and thinner tail). The patterning also differs in that 1–4 scales comprise the black spots scattered on the dorsum, giving them a darker appearance. Cloacal spurs in the same position as for the male, but much shorter and without sharp tips. The juvenile (WAM R168474) is more heavily spotted in appearance than the adult female, with the black spots comprised of 4–6 scales. Otherwise, the colouration is similar in most respect to the adults. The live specimen (WAM R173115) is a subadult female, with a very subdued pattern (Figure 3).

FIGURE 5 Comparison of lateral view of heads of *Varanus sparnus* sp. nov. (top two images) and *V. brevicauda* (bottom two images). From top to bottom: WAM R168475, WAM R168486, WAM R163051, WAM R170273. Scale bar = 1 cm.

HABITAT

The three Coloumb Point specimens were collected in areas with alluvial or sandstone deposits, and broadly classed as 'pindan shrubland'. A detailed vegetation assessment for the three type specimens is provided below (M. Maier, Biota Environmental Consultants, pers. comm.). The holotype, WAM R168486, occurred with *Corymbia* sp. low trees over *Acacia monticola, A. colei, A. eriopoda* tall open scrub over mixed open grassland, on pindan soil on plain. The paratype WAM R168474 was associated with *Corymbia dampieri* and *C. polycarpa* scattered low trees over *Acacia*

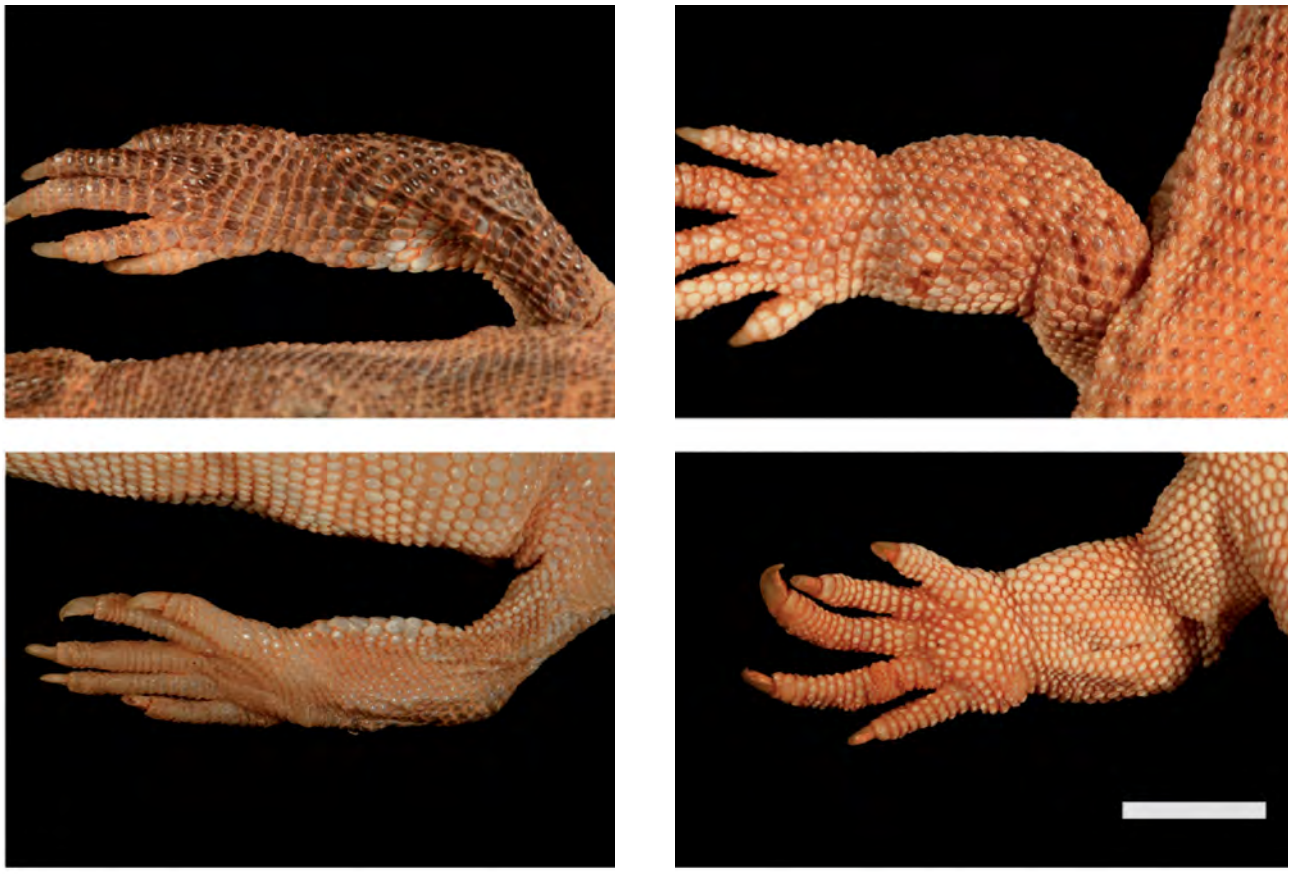

FIGURE 6 Close up comparison of the difference in arm scalation between *Varanus sparnus* sp. nov. (upper left – dorsal view; lower left – ventral view; WAM R168486) and *V. brevicauda* (upper right – dorsal view; lower right – ventral view; WAM R163051). Scale bar = 0.5 cm.

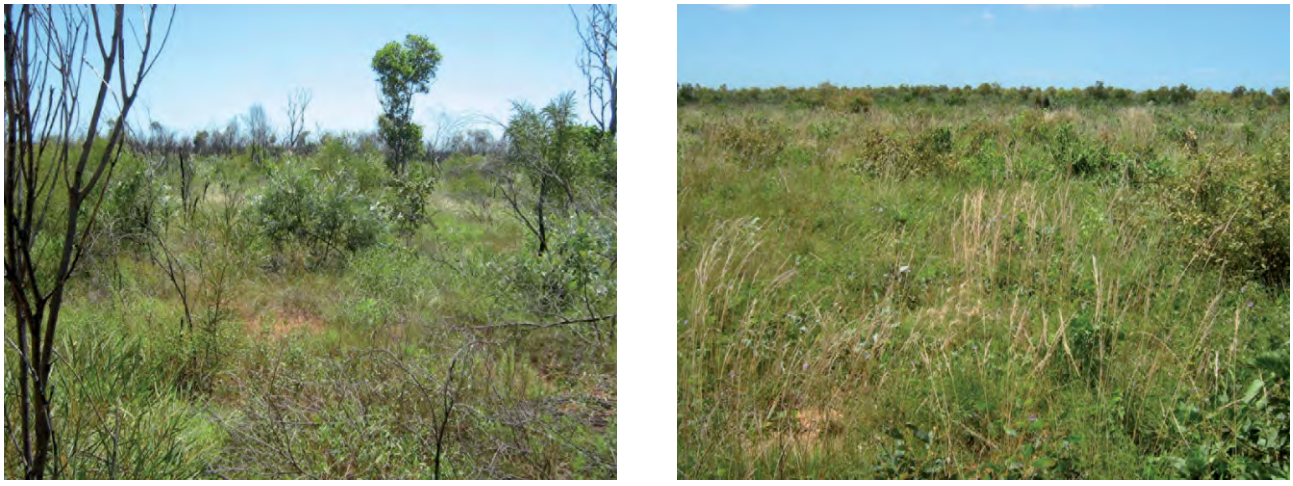

FIGURE 7 Habitat shots from the type series of *Varanus sparnus* sp. nov. from near Coloumb Point, Dampier Peninsula, Western Australia. Collection locations of paratypes WAM R168474 (left) and WAM R168475 (right).

eriopoda open shrubland; on pindan soil on plain. The paratype WAM R168475 was found amongst *Eucalyptus miniata, Terminalia ferdinandiana* low open woodland over *Acacia tumida* var. *kulparn* low closed heath over *Triodia schinzii* very open hummock grassland on exposed coastal fringe; on coastal sand in dune swale (Figure 7). The Mt Jowelaenga individual (WAM R173115) was collected in a funnel trap in pindan woodland with dense shrubs of *Acacia tumida*, scattered *Triodia caelestialis* and *Sorghum timorense* and soil consisting of red-brown sandy loam (N. Jackett, Ecologia Environment, pers. comm.).

BEHAVIOUR

Observations of the captive individual (WAM R173115) indicate that this species is a highly active burrower, excavating underneath all hard structures, such as flat pieces of wood and a heating stone (L. Umbrello, pers. comm.). This specimen readily consumed both live food (*Tenebrio* larvae, crickets) and wet cat food. Attempts to photograph this species in life were difficult, as the animals were constantly moving and rarely paused (G. Harold, R. Ellis, pers. comm.). The tail is highly prehensile, similar to that of *V. brevicauda*, possibly functioning to assist in navigating through *Triodia* clumps and shrubs.

DISTRIBUTION

The four individuals were collected from two locations approximately 90 km apart in the central portion of the Dampier Peninsula in the western Kimberley (Figure 1). This species is likely to be restricted to the peninsula (~15,000 km^2). No specimens from outside of the Dampier Peninsula (i.e. the western deserts and Pilbara region) were detected when sorting through the *V. brevicauda* specimens in the WAM collections.

ETYMOLOGY

sparnos is Greek for ‘rare’ or ‘scarce’, in reference to this species’ isolation and small range on the Dampier Peninsula. Latinised to *sparnus*, and used as an adjective.

REMARKS

Descriptions of new Australian goanna species in the past 10 years have all come from Western Australia: two from the southern Pilbara region (Aplin et al. 2006; Maryan et al. 2014), and now *V. sparnus* from the south-western Kimberley, approximately 700 km to the north. The description of *V. sparnus* further establishes Australia’s status as the most species-rich region for *Varanus* globally, with approximately 32 of 75 species (Uetz 2014).

Varanus sparnus has an apparently extremely restricted distribution, completely confined to the relatively small Dampier Peninsula area. This is in contrast to its two closest relatives, *V. brevicauda* and *V. eremius*, which nearly range across the entire arid zone that comprises the majority of the Australian continent (Pianka et al. 2004). All three species occupy sandy substrates, so other factors would explain the distributional patterns of these taxa. The sandy arid regions of the west coast of Australia has a disproportionately high number of endemics with small ranges (McKenzie et al. 2000; How and Cowan 2006; Doughty et al. 2011). Although most of these species occur further south in the mid-west and Pilbara regions, the same processes (e.g. changes in sea level that affect sand-associated taxa) may affect taxa in the Dampierland region as well. As the distribution of *V. sparnus* appears to be extremely restricted, it would be prudent for wildlife and conservation agencies to consider this species for some kind of protected status until more is known about its true range and biology.

Varanus sparnus is slightly smaller than *V. brevicauda* in maximum body size, making it the smallest known *Varanus*. In contrast, the largest member of the genus, *V. komodoensis*, reaches sizes of over 1.5 m in SVL, 3.0 m in total length and 80 kg (Jessop et al. 2006), compared to *V. sparnus* with an SVL of 116 mm, total length of 227.5 mm and mass of only 16.3 g, a remarkable size difference within a single genus of reptiles (e.g. King and Green 1999; Pianka et al. 2004; Openshaw and Keogh 2014).

ACKNOWLEDGEMENTS

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REFERENCES

Aplin, K.P., Fitch, A.J. and King, D.J. (2006). A new species of *Varanus* Merrem (Squamata: Varanidae) from the Pilbara region of Western Australia, with observations on sexual dimorphism in closely related species. *Zootaxa* **1313**: 1–38.

Boulenger, G.A. (1885). *Catalogue of the lizards in the British Museum (Natural History).* British Museum: London.

Boulenger, G.A. (1898). Third report on additions to the collection of lizards in the British Museum. *Proceedings of the Zoological Society of London* 1898: 912–923.

Doughty, P., Rolfe, J.K., Burbidge, A.H., Pearson, D.J. and Kendrick, P.G. (2011). Herpetologial assemblages of the Pilbara biogeographic region, Western Australia: ecological associations, biogeographic patterns and conservations. *Records of the Western Australian Museum,* Supplement **78**: 315–341.

Fitch, A.J., Goodman, A.E. and Donnellan, S.C. (2006). A molecular phylogeny of the Australian monitor lizards (Squamata: Varanidae), inferred from mitochondrial DNA sequences. *Australian Journal of Zoology* **54**: 253–269.

Gray, J.E. (1838). A catalogue of the slender tongue saurian, with descriptions of many new genera and species. *The Annals and Magazine of Natural History* **1**: 388–394.

How, R.A. and Cowan, M.A. (2006). Collections in space and time: geographical patterning of native frogs, mammals and reptiles through a continental gradient. *Pacific Conservation Biology* **12**: 111–133.

Jessop, T.S., Madsen, T., Sumner, J., Rudiharto, H., Phillips, J.A. and Ciofi, C. (2006). Maximum body size among insular Komodo dragon populations covaries with large prey density. *Oikos* **112**: 422–429.

Katoh, K., Kuma, K., Toh, H. and Miyata, T. (2005). MAFFT version 5: improvement in accuracy of multiple sequence alignment. *Nucleic Acids Research* **33**: 511–518.

King, D. and Green, B. (1999). *Goannas: the biology of varanid lizards*. UNSW Press: New South Wales.

Lanfear, R., Calcott, B., Ho, S.Y.W. and Guindon, S. (2012). PartitionFinder: Combined selection of partitioning schemes and substitution models for phylogenetic analyses. *Molecular Biology and Evolution* **29**: 1695–1701.

Lemmon, A.R. and Lemmon, E.M. (2012). High-throughput identification of informative nuclear loci for shallow-scale phylogenetics and phylogeography. *Systematic Biology* **61**: 745–761.

Lucas, A.H.S. and Frost, C. (1895). Preliminary notice of a certain species of lizard from central Australia. *Proceedings of the Royal Society of Victoria* **7**: 264–269.

Maryan, B., Oliver, P.M., Fitch, A.J. and O'Connell, M. (2014). Molecular and morphological assessment of *Varanus pilbarensis* (Squamata: Varanidae), with a description of a new species from the southern Pilbara, Western Australia. *Zootaxa* **3768**: 139–158.

McKenzie, N.L. (1983). Wildlife of the Dampier Peninsula, south-west Kimberley, Western Australia. *Wildlife Research Bulletin, Western Australia* **11**: 1–83.

McKenzie, N.L., Rolfe, J.K., Aplin, K.P., Cowan, M.A., and Smith, L.A. (2000). Herpetofauna of the southern Carnarvon Basin, Western Australia. *Records of the Western Australian Museum*, Supplement **61**: 335–360.

Merrem, B. (1820). Versuch eines Systems Amphibien. *Tentamen Systematis Amphibiorum*. Krieger: Marburg, Germany.

Openshaw, G.H. and Keogh, J.S. (2014). Head shape evolution in monitor lizards (*Varanus*): interactions between extreme size disparity, phylogeny and ecology. *Journal of Evolutionary Biology* **27**: 363–373.

Ouwens, P.A. (1912). On a large *Varanus* species from the island of Komodo. *Bulletin du Jardin Botanique de Buitenzorg* **6**: 1–3.

Pianka, E.R. (2004). *7.3. Varanus brevicauda*. *In:* Pianka, E.R., King, D. and King, R.A. (eds), *Varanoid lizards of the world*. Indiana University Press: U.S.A.

Pianka, E.R., King, D. and King, R.A. (eds). (2004). *Varanoid lizards of the world*. Indiana University Press: U.S.A.

Rambaut, A. and Drummond, A.J. (2007). Tracer v1.4. http://beast.bio.ed.ac.uk/Tracer.

Ronquist, F. and Huelsenbeck, J.P. (2003). MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics* **19**: 1572–1574.

Smissen, P.J., Melville, J., Sumner, J. and Jessop, T.S. (2013) Mountain barriers and river conduits: phylogeographic structure in a large, mobile lizard (Varanidae: *Varanus varius*) from eastern Australia. *Journal of Biogeography* **40**: 1729–1740.

Smith, W., Scott, I.A.W. and Keogh, J.S. (2007). Molecular phylogeography of Rosenberg's goanna (Reptilia:Varanidae: *Varanus rosenbergi*) and its conservation status in New South Wales. *Systematics and Biodiversity* **5**: 361–369.

Storr, G.M., Smith, L.A. and Johnstone, R.E. (1983). *Lizards of Western Australia. II. Dragons and Monitors*. Western Australia Museum Press: Perth.

Tamura, K., Peterson, D., Peterson, N., Stecher, G., Nei, M. and Kumar, S. (2011). MEGA5: Molecular evolutionary genetics analysis using maximum likelihood, evolutionary distance, and maximum parsimony methods. *Molecular Biology and Evolution* **28**: 2731–2739.

Thompson, G.G. and Withers, P.C. (1997). Comparative morphology of Western Australian varanid lizards (Squamata: Varanidae). *Journal of Morphology* **233**: 127–152.

Uetz, P. (ed). The reptile database, www.reptile-database.org. Accessed 1 October 2014.

Vidal, N., Marin, J., Sassi, J., Donnellan, S.C., Fitch, A., Fry, B.G., Vonk, F.J., de la Vega, R., Couloux, A. and Hedges, S.B. (2012). Molecular evidence for an Asian origin of monitor lizards followed by Tertiary dispersals to Africa and Australasia. *Biology Letters* **8**: 853–855.

White, J. (1790). Journal of a voyage to New South Wales, with sixty five plates of non-descript animals, birds, lizards, serpents, curious cones of trees and other natural productions. Appendix. Debrett: London.

Wilson, S. and Swan, G. (2010). *A complete guide to reptiles of Australia*. 3rd ed. New Holland: Sydney.

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APPENDIX 1 Specimens examined for morphological[M] and molecular genetic analyses. Numbers in bold preceding localities refer localities from which genetic data were obtained (see Figure 1). *Short sequences that we did not include in Figure 2, but fall within the *V. brevicauda* clade (sequences not on GenBank but available from the authors).

Registration Number	Locality	State	Sex	GenBank	Declat	Declong
Varanus brevicauda						
SAMA R36239	**(1)** Curtin Springs	NT		KP076412	-25.392	131.767
SAMA R48822	**(2)** Mt Cheesman	SA		KP076413	-27.337	130.237
SAMA R62377*	**(3)** 166 km SSE Watarru	SA		*	-28.549	129.998
WAM R13837[M]	Derby	WA	♀	-	-17.300	123.617
WAM R20350[M]	32 km S Derby	WA	♂	-	-17.600	123.633
WAM R28029[M]	La Grange	WA	♀	-	-18.683	121.767
WAM R40274[M]	Coloumb Point	WA	♂	-	-17.367	122.150
WAM R44329[M]	Coloumb Point	WA	♂	-	-17.367	122.150
WAM R46168[M]	Anna Plains	WA	♀	-	-19.250	121.483
WAM R90571	**(4)** Woodstock	WA		KP076403	-21.6097	118.9878
WAM R90600[M]	**(4)** Woodstock	WA	♀	KP076409	-21.6116	118.9556
WAM R90893[M]	**(5)** 200 m S Gallery Hill	WA	♂	KP076410	-21.6677	119.0408
WAM R90898[M]	**(4)** Woodstock	WA	♂	DQ525115	-21.6116	118.9556
WAM R90904[M]	**(5)** 200 m S Gallery Hill	WA	♂	KP076411	-21.6677	119.0408
WAM R99145[M]	**(5)** 200 m S Gallery Hill	WA	♀	KP076402	-21.6677	119.0408
WAM R99177	**(5)** 200 m S Gallery Hill	WA		KP076408	-21.6677	119.0408
WAM R100734	**(4)** Woodstock	WA		KP076407	-21.6094	118.9878
WAM R102157	**(6)** Mt Windell	WA		DQ525116	-22.6300	118.6139
WAM R104076	**(4)** Woodstock	WA		KP076404	-21.6166	118.9500
WAM R104136	**(4)** Woodstock	WA		KP076405	-21.6166	118.9500
WAM R104209	**(4)** Woodstock	WA		KP076406	-21.6166	118.9500
WAM R121138[M]	**(7)** 8 km NW Mardathuna Homestead	WA	♂	KP076419	-24.4288	114.5000
WAM R121139[M]	**(7)** 8 km NW Mardathuna Homestead	WA	♂	KP076417	-24.4288	114.5000
WAM R121351[M]	**(7)** 8 km NW Mardathuna Homestead	WA	♀	KP076418	-24.4288	114.5000
WAM R121354[M]	**(8)** Kennedy Range National Park	WA	♂	KP076416	-24.4930	115.0306
WAM R124913	**(8)** Kennedy Range	WA		KP076414	-24.5008	115.0175
WAM R129008	**(9)** Urala Station	WA		KP076420	-21.7836	114.8633
WAM R135398[M]	**(10)** Mt Brockman	WA	♂	KP076399	-22.3000	117.3000
WAM R135440[M]	**(10)** Mt Brockman	WA	♀	KP076398	-22.2919	117.2989
WAM R137008[M]	**(11)** Wanjarri NR	WA	♀	KP076415	-27.3333	120.7167
WAM R139065*	**(12)** Mandora	WA		*	-19.8083	121.4639
WAM R140342[M]	**(13)** Millstream-Chichester	WA	♂	KP076401	-21.4116	117.1561
WAM R140722	**(14)** Hope Downs	WA		KP076400	-22.6736	119.4161
WAM R140985*[M]	**(9)** Urala Station	WA	♂	*	-21.7827	114.8697
WAM R161599*	**(15)** Goldsworthy	WA		*	-20.2419	119.5740

Registration Number	Locality	State	Sex	GenBank	Declat	Declong
Varanus sparnus sp. nov.						
WAM R168486[M]	Coulomb Point	WA	♂		-17.4277	122.1522
WAM R168474[M]	**(18)** Coulomb Point	WA	-	KP076422	-17.5736	122.1694
WAM R168475[M]	**(17)** Coulomb Point	WA	♀	KP076423	-17.4608	122.1525
WAM R173115[M]	**(16)** 9 km SW Mt Jowlaenga	WA	♀	KP076421	-17.4865	122.9650
Varanus eremius						
SAMA R35970	2 km W Purni Bore	SA	-	DQ525114	-26.28	136.08
WAM R121347	30 km S Carnarvon	WA	-	DQ525113	-25.1313	113.7681
Varanus caudolineatus						
SAMA R29255	57 km S Leonara	WA	-	DQ525139	-29.37	121.27
WAM R102098	Wongida, Barlee Range	WA	-	DQ631874	-22.9666	115.8500
WAM R122622	18.5 km SE Wooramel	WA	-	DQ631876	-25.7105	114.5994
WAM R122576	18 km SE Wooramel	WA	-	DQ631875	-25.6805	114.6217
Varanus bushi						
WAM R131751	Hamersley Station	WA	-	DQ631883	-22.4452	117.8797
WAM R125521	North Pilbara	WA	-	DQ631882	-21.5000	117.5000
WAM R129912	West Angelas iron ore mine	WA	-	DQ631877	-23.1858	118.7544
Varanus gilleni						
WAM R102728	Little Sandy Desert	WA	-	DQ631872	-24.5925	120.2631
SAMA R35961	Alka Seltzer Bore	SA	-	DQ525138	-26.33	136.01
NTM R13778	no locality data	-	-	DQ525137	-	-

APPENDIX 5: TARGETED GREATER BILBY ASSESSMENT, ECOLOGIA, 2016

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TABLE OF CONTENTS

1 INTRODUCTION 1
1.1 PROJECT BACKGROUND 1
1.2 LEGISLATIVE FRAMEWORK 1
1.3 GREATER BILBY DESCRIPTION 2
2 METHODOLOGY 5
2.1 GUIDING PRINCIPLES 5
2.2 SURVEY TIMING 5
2.3 STUDY TEAM AND LICENCES 5
2.4 GREATER BILBY SAMPLING METHODS 5
3 RESULTS 10
3.1 GREATER BILBY RECORDS 10
3.2 DNA SCAT ANALYSIS 15
4 DISCUSSION 17
4.1 OCCURRENCE OF GREATER BILBY WITHIN THE STUDY AREA 17
4.2 HABITAT ASSOCIATION 17
4.3 GREATER BILBY OCCURRENCE ON THE DAMPIER PENINSULA 19
4.4 SURVEY LIMITATIONS 20
5 CONCLUSION 21
6 REFERENCES 22

TABLES

Table 2.1 – Study team 5
Table 2.2 – Camera trap locations 6
Table 3.1 – Greater Bilby scat collection locations and DNA analysis results 15

FIGURES

Figure 1.1 – Location of the study area 3
Figure 2.1 – Example of camera trap set on active Greater Bilby burrow 7
Figure 2.2 – Greater Bilby secondary evidence search transect and camera trap locations 9
Figure 3.1 – Example of Greater Bilby digging recorded 10
Figure 3.2 – Example of Greater Bilby scat recorded (BGS9) 11
Figure 3.3 – Example of Greater Bilby active burrow recorded 11
Figure 3.4 –Greater Bilby recorded by camera trap (RC13) 12

Figure 3.5 –Previous and current Greater Bilby records 13
Figure 3.6 –Greater Bilby DNA scat analysis results 16
Figure 4.1 – Example of dense, mature *Acacia tumida* var. *tumida* within pindan shrubland 18
Figure 4.2 – Example of high intensity fire in dense, mature *Acacia tumida* var. *tumida* habitat 18
Figure 4.3 –Example of Witjuti grub (*Endoxyla* spp.) larvae casing from the study area 19
Figure 4.4 – Previous Greater Bilby records on Dampier Peninsula 20

APPENDICES

Appendix A DPaW Greater Bilby scats analysis report 24
Appendix B Greater Bilby records from all Thunderbird Project surveys 25

EXECUTIVE SUMMARY

Sheffield Resources Limited is undertaking biological surveys to support environmental impact assessment and environmental approvals for its Thunderbird Project. The Thunderbird Project study area (study area) is located approximately 70 kilometres west of Derby on the Dampier Peninsula and is approximately 148.8 km^2 in area, of which 17.23 km^2 is proposed disturbance area. Previous Level 1 and 2 vertebrate fauna surveys of the study area recorded the Greater Bilby (*Macrotis lagotis*). In order to gain a more comprehensive understanding of Greater Bilby occurrence, habitat utilisation and estimated size of the resident population within the study area, Sheffield commissioned *ecologia* to conduct a targeted Greater Bilby assessment.

The targeted Greater Bilby assessment was conducted by two zoologists over six days from the 22 to 27 September 2015. Prior to the field survey, secondary evidence search transects were selected to provide spatially representative and systematic coverage within the previously mapped pindan shrubland habitat type. Each transect was traversed by a zoologist, searching for secondary evidence signs of Greater Bilby (diggings, tracks, scats and burrows). Where active burrows were recorded in relatively close proximity to vehicle tracks (facilitating the collection of cameras at conclusion of field survey), motion cameras were established in an attempt obtain Greater Bilby burrow utilisation records. For a greater understanding of actual number of individuals present, DNA extraction and analysis of Greater Bilby scats was completed.

The Greater Bilby was recorded from numerous locations throughout the study area via secondary evidence in the form of diggings, scats, active burrows and motion camera records. A total of 26 scats were collected during the targeted assessment and subsequently underwent DNA extraction and analysis. Of the 26 scats collected, 15 produced viable amounts of DNA with 13 scats able to facilitate individual analysis. This analysis resulted in a total of nine individual Greater Bilbies being identified.

The DNA extrapolation analysis results suggest the study area is likely to be supporting additional individuals (to the nine individuals confirmed through DNA analysis) at the time of surveying. It is estimated the Greater Bilby population within the study area at the time of the targeted survey was approximately 25 individuals, with this population likely to fluctuate according to seasonal and annual variations in rainfall, resource availability, fire history and feral animal populations. When comparing the spatial occurrence of Greater Bilby in relation to location of proposed disturbance areas, it can be demonstrated that the Greater Bilby occurs both inside proposed mine disturbance areas and within close proximity to haul road disturbance areas. Overall, however, more Greater Bilby activity was recorded outside proposed disturbance areas. Using the estimate of 25 individuals, a home range of 3.69 km^2 per individual is calculated within the pindan shrubland habitat type.

The Greater Bilby was almost exclusively recorded from the pindan shrubland habitat type, specifically within the dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat. This micro-habitat appears to be influenced by fire age, with older fire age (>2 years) then surrounding areas. The dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat forms a dense canopy layer but relatively open ground cover, which is in contrast to surrounding areas which appear to have been burnt more frequently and are characterised by dense ground vegetation.

The Greater Bilby population status on Dampier Peninsula is not clear, however it has been suggested it is most likely a scattered population in low densities. Relatively few biological surveys have been completed on Dampier Peninsula, however three recent biological assessments have all recorded Greater Bilby, suggesting the species may be more common on Dampier Peninsula than previously thought. Due to the uncertainties regarding the status of the Dampier Peninsula population, the regional significance of the Greater Bilby population within the study area is difficult to determine. Using the estimated national Greater Bilby population of 10,000, should the study area contain 25 individuals, than the study area would contain 0.25% of the estimated national Greater Bilby population.

1 INTRODUCTION

1.1 PROJECT BACKGROUND

Sheffield Resources Limited (Sheffield) is an emerging Western Australian company, with significant mineral sands, nickel, talc and iron assets, all located within the state of Western Australia. Sheffield is undertaking biological surveys to support environmental approvals for their Thunderbird mineral sand project. The Thunderbird project study area (study area) is approximately 148.8 km^2 in area, of which 17.23 km^2 is proposed disturbance area. The study area located approximately 70 kilometres west of Derby on the Dampier Peninsula (Figure 1.1).

Sheffield has previously commissioned *ecologia* Environment (*ecologia*) to undertake a two-phase Level 2 terrestrial (vertebrate and SRE invertebrate) and subterranean fauna survey of the study area. Level 2 assessments were completed in 2014. An additional Level 1 survey was completed for infrastructure areas including haul road and proposed accommodation camp in May 2015.

Both the initial Level 2 vertebrate fauna survey and the more recent Level 1 survey recorded the Greater Bilby (*Macrotis lagotis*) in the study area. In order to gain a comprehensive understanding of Greater Bilby occurrence, habitat utilisation and resident population estimate within the study area, Sheffield commissioned *ecologia* to conduct a targeted Greater Bilby assessment.

1.2 LEGISLATIVE FRAMEWORK

Commonwealth and State legislation applicable to the conservation of native flora and fauna in Western Australia (WA) includes, but is not limited to, the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the Western Australian *Wildlife Conservation Act 1950* (WC Act) and the *Environment Protection Act 1986* (EP Act). Section 4a of the EP Act requires that developments take into account the following principles applicable to native flora and fauna:

- **The Precautionary Principle:** Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- **The Principles of Intergenerational Equity:** The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations; and
- **The Principle of the Conservation of Biological Diversity and Ecological Integrity:** Conservation of biological diversity and ecological integrity should be a fundamental consideration of development projects.

The EPBC Act was developed to provide for the protection of the environment, particularly those aspects of the environment that are matters of national environmental significance, to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources; and to promote the conservation of biodiversity. The EPBC Act includes provisions to protect native species (in particular to prevent the extinction and promote the recovery of threatened species) and to ensure the conservation of migratory species. In addition to the principles outlined in Section 4a of the EP Act, Section 3a of the EPBC Act includes the principle of ecologically sustainable development; that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations.

The WC Act was developed to provide for the conservation and protection of wildlife in Western Australia. Under the WC Act, all native flora and fauna are protected in WA; however, the Minister may, via a notice published in the Government Gazette, declare a list of flora and fauna identified as likely to become extinct, or as rare, or otherwise in need of special protection. The current listing was gazetted on 2 December 2014.

1.3 GREATER BILBY DESCRIPTION

Conservation status: EPBC Act Vulnerable, WC Act Schedule 1 (Vulnerable), DPaW Vulnerable.

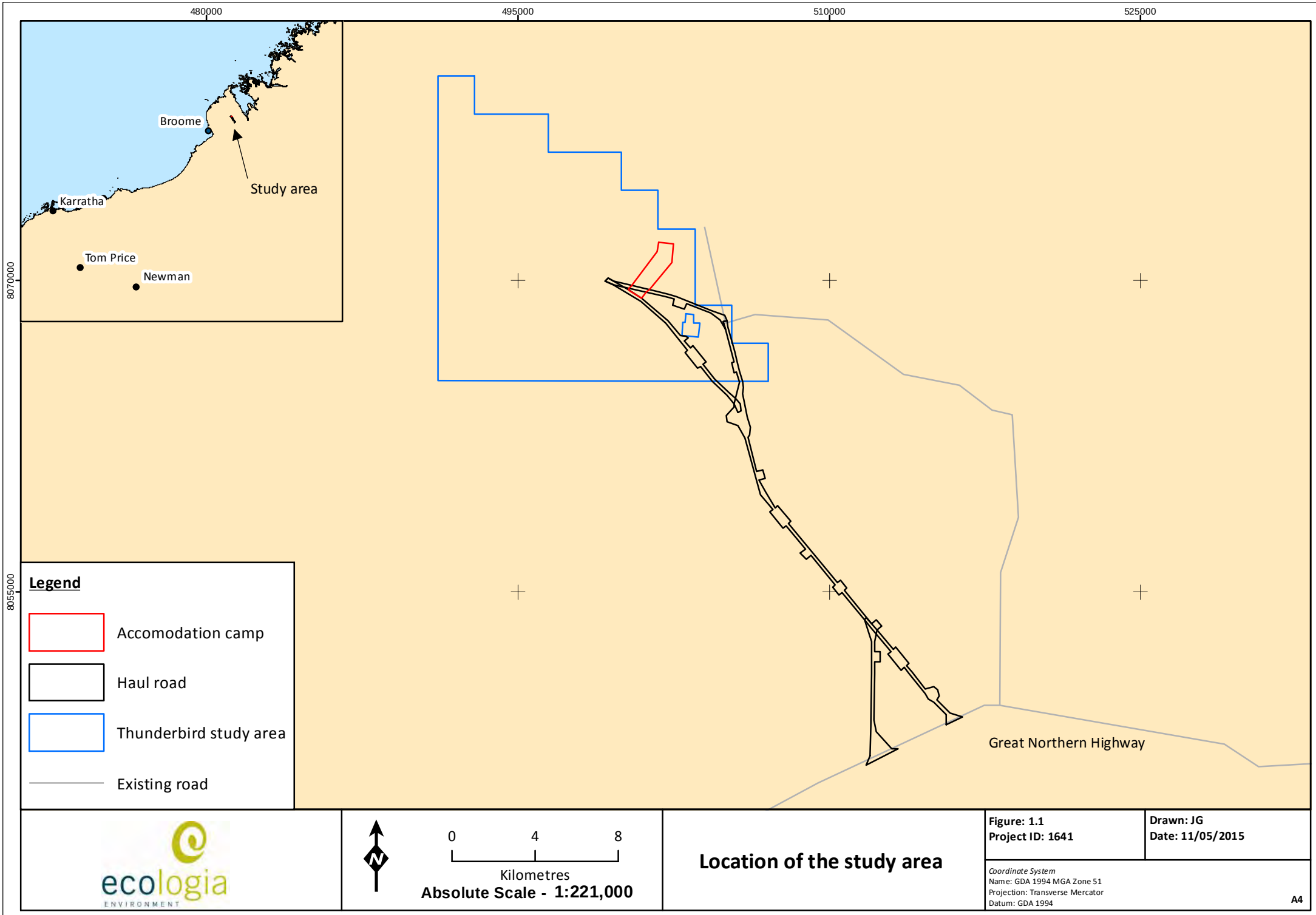
The Greater Bilby (*Macrotis lagotis*) formerly occurred over 70% of mainland Australia's arid and semiarid regions prior to European settlement (ABAS 2002). During the 20th century its range reduced significantly and is now absent from its previous southern and central range and restricted to northern Australia (Tyndale-Biscoe 2005). Woinarski *et al.* (2012) estimate the total Australian population size as 10,000 individuals, and is undergoing continual decline estimated to exceed 10% over the last three generations (12 years), that is likely to continue.

Greater Bilbies are currently patchily distributed through the Tanami, Great Sandy and Gibson Deserts, west to the Pilbara and north to Dampier Peninsula (Maxwell *et al.* 1996). Isolated populations also occur in south-west Queensland and to the north-east of Alice Springs. Greater Bilbies occur in a variety of habitats, including spinifex grassland, acacia shrubland, open woodland, fringes of salt lakes and cracking clays (Maxwell *et al.* 1996; Johnson 2008). Reasons for their population decline include predation by feral predators on both young and adult bilbies, competition from rabbits and livestock, reduced food as a result of changed fire regimes and drought (Maxwell *et al.* 1996; O'Malley 2006; Johnson 2008).

The Greater Bilby is a mainly solitary omnivorous marsupial and is the sole surviving species from the family Thylacomyidae, of which the Lesser Bilby (*Macrotis leucura*) has gone extinct (Tyndale-Biscoe 2005). As with all bandicoot species, the Greater Bilby are generalists in their diet and very effective opportunists, exploiting their environment by their wide choice of food in conjunction with fast growth and rapid reproduction, particularly when conditions are favourable (Tyndale-Biscoe 2005). Their typical diet consists of insects and larvae, seeds, bulbs, fruit and fungi (van Dyck and Strahan 2008).

Unlike other bandicoot species, the Greater Bilby constructs burrows where it shelters during the day. The burrows are up to two meters deep and descend in a spiralling direction with each individual animal utilising up to 12 burrows within its home range (ABAS 2002). Bilbies are strictly nocturnal and have been known to move up to five kilometres each night in search of food (Pavey 2006b). Home ranges are variable and temporary, with individuals responding to changes in food availability (van Dyck and Strahan 2008). Males, females and juveniles may all have overlapping home ranges, where densities in optimum habitat can be 12-16 individuals per km^2, however typically densities are 1-2 individuals per km^2 (Pavey 2006b). Estimates of short-term home ranges are relatively small, varying from 1.1 to 3.16 km^2, however females have been recorded with a home range as little as 0.18 km^2 (Pavey 2006a). Male home ranges and male-female home ranges overlap considerably, however overlap between females has not been recorded (Pavey 2006a).

The breeding season also reflects the opportunistic nature of this species, with Bilbies able to breed throughout the year whenever conditions are suitable (van Dyck and Strahan 2008). They are rapid breeders, with reproduction at faster rates than any other group of marsupials (Tyndale-Biscoe 2005).


480000
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Broome
Karratha
Tom Price
Newman
Study area
Great Northern Highway
Legend
Accomodation camp
Haul road
Thunderbird study area
Existing road
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Kilometres
Absolute Scale - 1:221,000
Location of the study area
Figure: 1.1
Project ID: 1641
Drawn: JG
Date: 11/05/2015
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
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2 METHODOLOGY

2.1 GUIDING PRINCIPLES

This survey was undertaken as part of the Environmental Impact Assessment process in WA and is required to address the following government legislation and guidelines:

- EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2002a);
- EPA Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002b);
- *Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010); and
- Greater Bilby specific survey guidelines within *Survey guidelines for Australia's Threatened Mammals* (DSEWPaC 2011).

2.2 SURVEY TIMING

The targeted Greater Bilby assessment was conducted by two zoologists over six days from the 22 to 27 September 2015.

2.3 STUDY TEAM AND LICENCES

The targeted Greater Bilby assessment was planned, coordinated and executed by those listed in Table 2.1. The assessment was carried out under DPaW issued Regulation 17 License Number SF010517.

Table 2.1 – Study team

Project Staff			
Name	**Qualification**	**Role**	**Project role**
Shaun Grein	B. App. Sc; Grad. Dip. Nat Res.	Managing Director	QA and technical review
Matthew Macdonald	PhD	Principal Ecologist	QA and technical review
Bruce Greatwich	BSc.	Senior Zoologist	Project management, field survey and reporting
Sean White	BSc. (Hons)	Level 2 Zoologist	Field survey

2.4 GREATER BILBY SAMPLING METHODS

Greater Bilby sampling methods align with those recommended in the Commonwealth Department of the Environment guidelines (DSEWPaC 2011). Because traditional trapping methods can be unreliable in capturing Greater Bilbies, survey guidelines for the Greater Bilby focus on methods of determining presence/absence – these include secondary evidence signs (number of diggings, active burrows present) and activity captured on camera traps (DSEWPaC 2011). These methods were therefore used during this survey, and trapping was not conducted.

In the broader region of the study area, the Greater Bilby has been recorded in open woodland and open forest pindan habitats, and has also been recorded in pindan shrubland and other vegetation communities but with a lower degree of preference (Southgate 2012). Previous sampling and Greater Bilby records obtained during previous surveys of the Thunderbird study area, however, indicate that Greater Bilby predominantly occur locally in small, isolated patches of dense, mature *Acacia tumida* within the broader pindan shrubland habitat (*ecologia* 2014, 2015). This habitat was therefore targeted during survey activities, using both systematic and opportunistic methods.

2.4.1 Secondary evidence search transects

It was determined that traversing systematically spaced walking transects through the pindan shrubland habitat type would be the most effective sampling method to identify evidence of Greater Bilby activity. Other habitat types in the study area are not evidenced to be the preferred habitat of the Greater Bilby at Thunderbird (*ecologia* 2014, 2015), although isolated occurrences of the species in other habitats may exist on occasion.

Secondary evidence search transects were selected prior to the commencement of the field survey. Transects were selected to provide representative survey coverage within the previously mapped pindan shrubland habitat type. Each transect was spaced between 0.5-1 km apart and traversed by a zoologist searching for secondary evidence signs of Greater Bilby.

Secondary evidence searched for included diggings, tracks, scats and burrows. Where evidence was encountered, the immediately surrounding area (within 200 m radius) was searched in an attempt to record further evidence. Secondary evidence search transect locations are shown in Figure 2.2.

2.4.2 Camera trapping

Based on the habitats observed during surveying and the secondary evidence identified, motion-sensor camera trapping was also undertaken in order to detect the presence of the Greater Bilby (with capacity to detect other species of conservation significance if present). Camera trapping on active burrows that were located was completed using Reconyx HC500 Hyperfire motion cameras. All cameras are triggered by movement using highly sensitive, passive infra-red motion sensors that function both during the day and at night. Motion cameras were established on the entrance of active burrows that were located within relatively close proximity to vehicle tracks, allowing cameras to be collected at the conclusion of the field survey. Camera trap locations are shown in Table 2.2 and Figure 2.2. An example of camera trapping set up during the current field survey is shown in Figure 2.1.

Table 2.2 – Camera trap locations

Camera name	Easting	Northing	No. nights deployed
RC29	497065	8071777	3
RC16	497458	8071357	3
RC14	501767	8065957	5
RC32	502029	8065980	5
RC13	501663	8068089	4

GDA 94 Zone 51

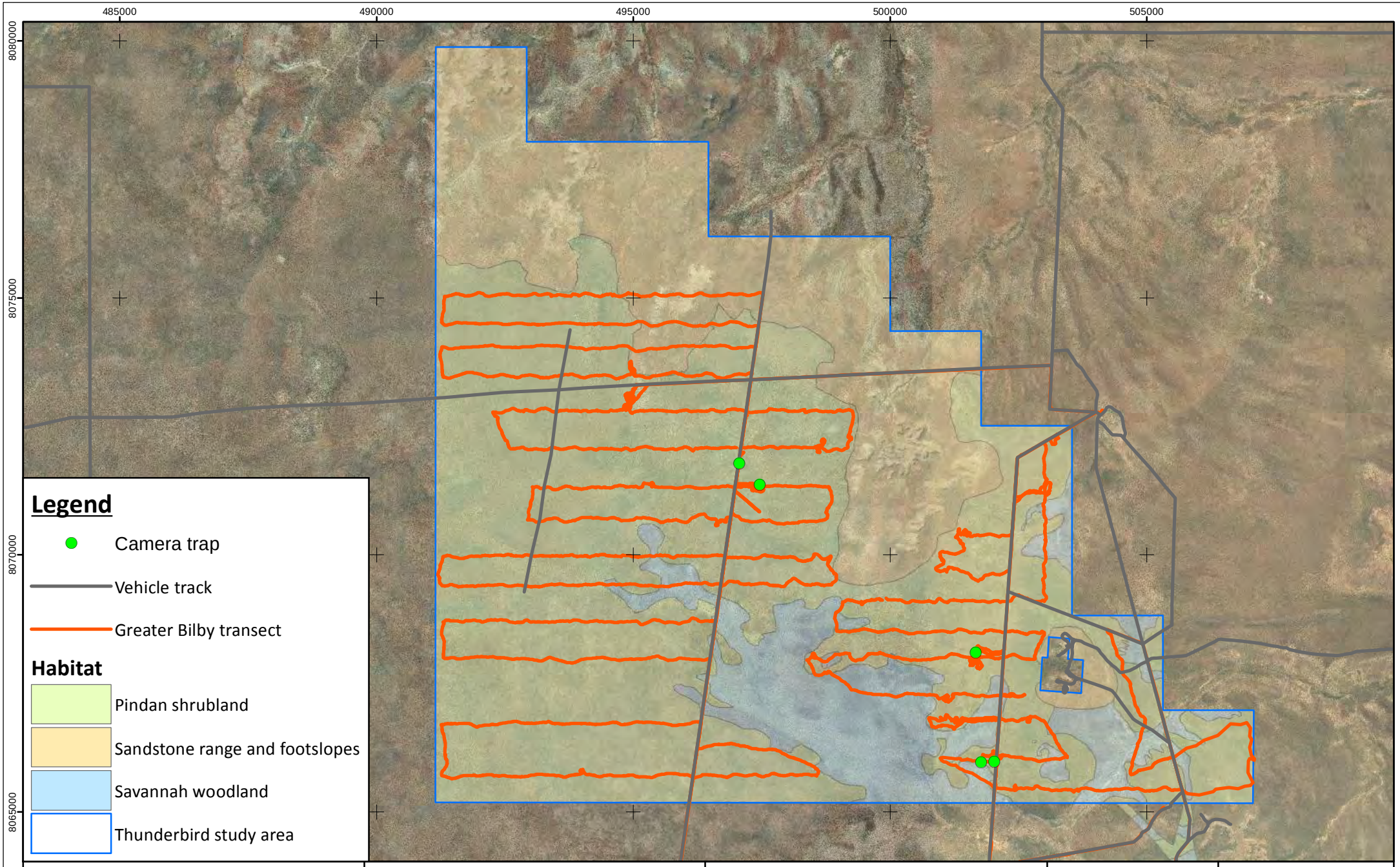
Figure 2.1 – Example of camera trap set on active Greater Bilby burrow

2.4.3 Scat collection and DNA analysis

To more accurately quantify the number of individuals present, DNA extraction and analysis was completed on Greater Bilby scats. This allowed for identification of individual Greater Bilbies.

When Greater Bilby evidence or burrows were encountered during transects, the surrounding area was searched in an attempt to find Greater Bilby scat. All attempts were made to find scat at each location where Greater Bilby evidence was recorded; this included sieving through spoil heap dirt associated with diggings, as scats are often produced in association with diggings. However, a number of sites where Greater Bilby evidence was recorded failed to yield any scat. Where a scat was recorded, the location was marked by GPS, with the scat scooped in to a vial using the lid to avoid contamination. Each vial contained silica gel to absorb moisture within the scat and prevent DNA degradation.

Scats were brought back to Perth, with DNA extraction and analysis completed by the Department of Parks and Wildlife (DPaW). Detailed scat extraction and analysis methodology is provided in the associated DPaW report (Appendix A).



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Greater Bilby secondary evidence search transect and camera trap locations

Figure: 2.2
Project ID: 1657

Drawn: BG
Date: 19/05/15

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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3 RESULTS

3.1 GREATER BILBY RECORDS

The presence of the Greater Bilby in the study area was evidenced by 754 records of secondary evidence. These records comprised:

- diggings – e.g. as per Figure 3.1 – 670 records;
- scats – e.g. as per Figure 3.2 – 25 records/samples;
- active burrows – e.g. as per Figure 3.3 – 17 records; and
- inactive burrows – 42 records.

In addition, two direct records were obtained via the camera traps. In these cases, Bilbies were photographed entering and emerging from the active burrows monitored (two different burrows). The remaining three active burrows did not trigger the camera traps (Table 3.1).

Greater Bilby records from this targeted assessment, in addition to previous records from Level 1 and Level 2 assessments, and the proposed disturbance areas are shown in Figure 3.4 and in Appendix A.

Table 3.1 – Camera trap results

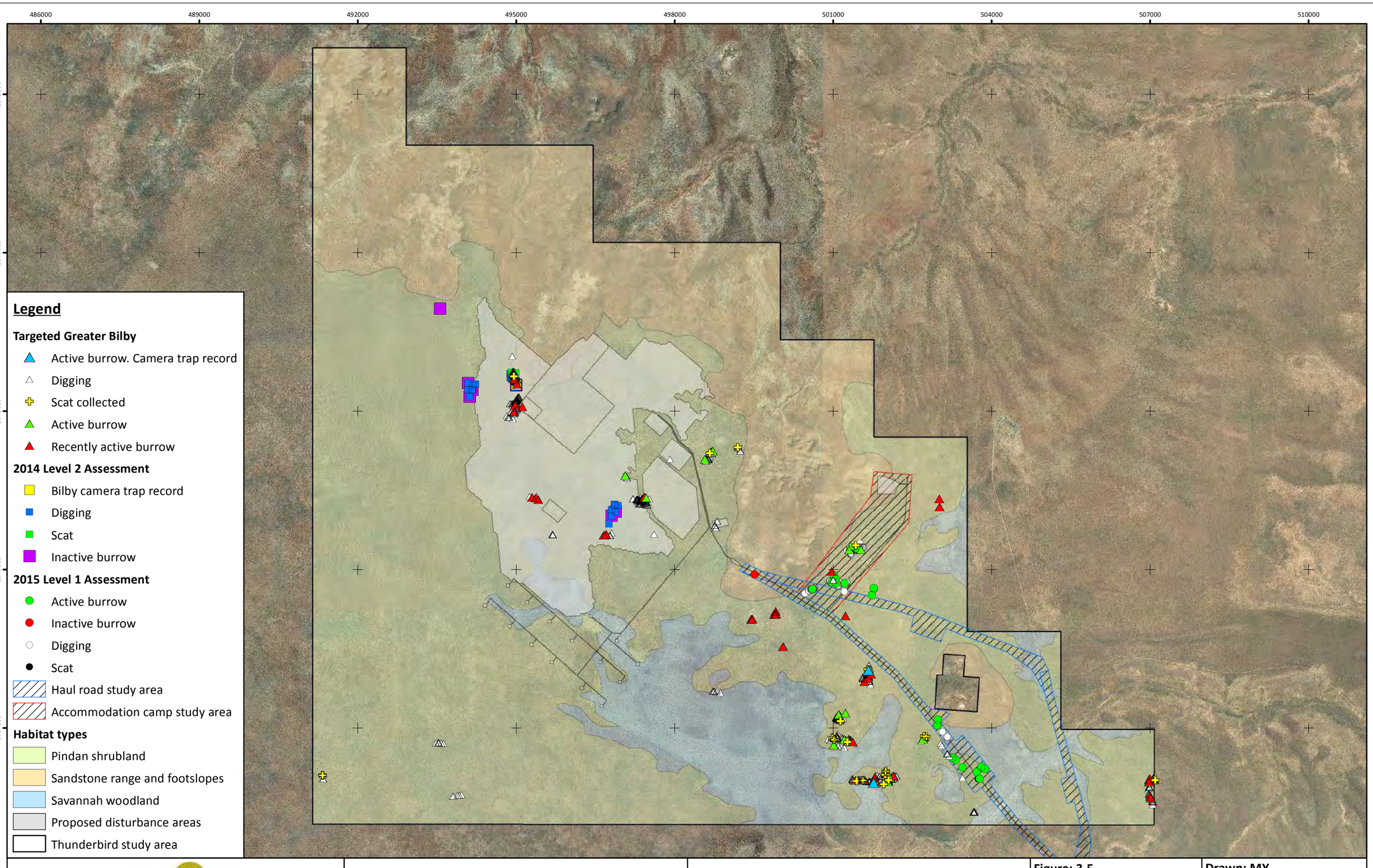
Camera name	Positioned at	Greater Bilby detected
RC29	Active burrow	NO
RC16	Active burrow	NO
RC14	Active burrow	YES
RC32	Active burrow	NO
RC13	Active burrow	YES

Figure 3.1 – A Greater Bilby digging recorded (51K 501090 mE 8067243 mN)

Figure 3.2 – A Greater Bilby scat recorded (51K 501656 mE 8068113 mN / BGS9)

Figure 3.3 – A Greater Bilby active burrow recorded (51K 0501663 mE 8068089 mN / RC13)

Figure 3.4 – A Greater Bilby recorded by camera trap (51K 0501663 mE 8068089 mN / RC13)



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Kilometres

Absolute Scale - 1:65,000

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Previous and current Greater Bilby records

Figure: 3.5
Project ID: 1657

Drawn: MY
Date: 03/06/2016

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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3.2 DNA SCAT ANALYSIS

At each location where Greater Bilby secondary evidence such as diggings was recorded, an attempt was made to locate fresh scat to be able to conduct DNA analysis. Despite these efforts, it was not possible to collect Greater Bilby scats at a number of sites, despite other forms of secondary evidence being present.

A total of 26 scat samples were collected during the targeted survey, which subsequently underwent DNA extraction and analysis (Table 3.2). One was identified as probably being from a macropod and did not respond to analysis (not included hereafter in datasets in this report), but the remaining 25 were identified as being from Greater Bilby (Appendix A).

Of the 25 scats collected, 15 produced viable DNA and 13 of these provided sufficient quantities of DNA to facilitate individual identification. The remaining two amplified successfully, but not at sufficient numbers of loci to allow for individual identification. A study currently being completed by the Department of Parks and Wildlife shows that the age of scats has an effect on amplification success rate (Appendix A); therefore, the scat samples that did not yield enough DNA or did not amplify at enough loci may simply have been too old for analysis.

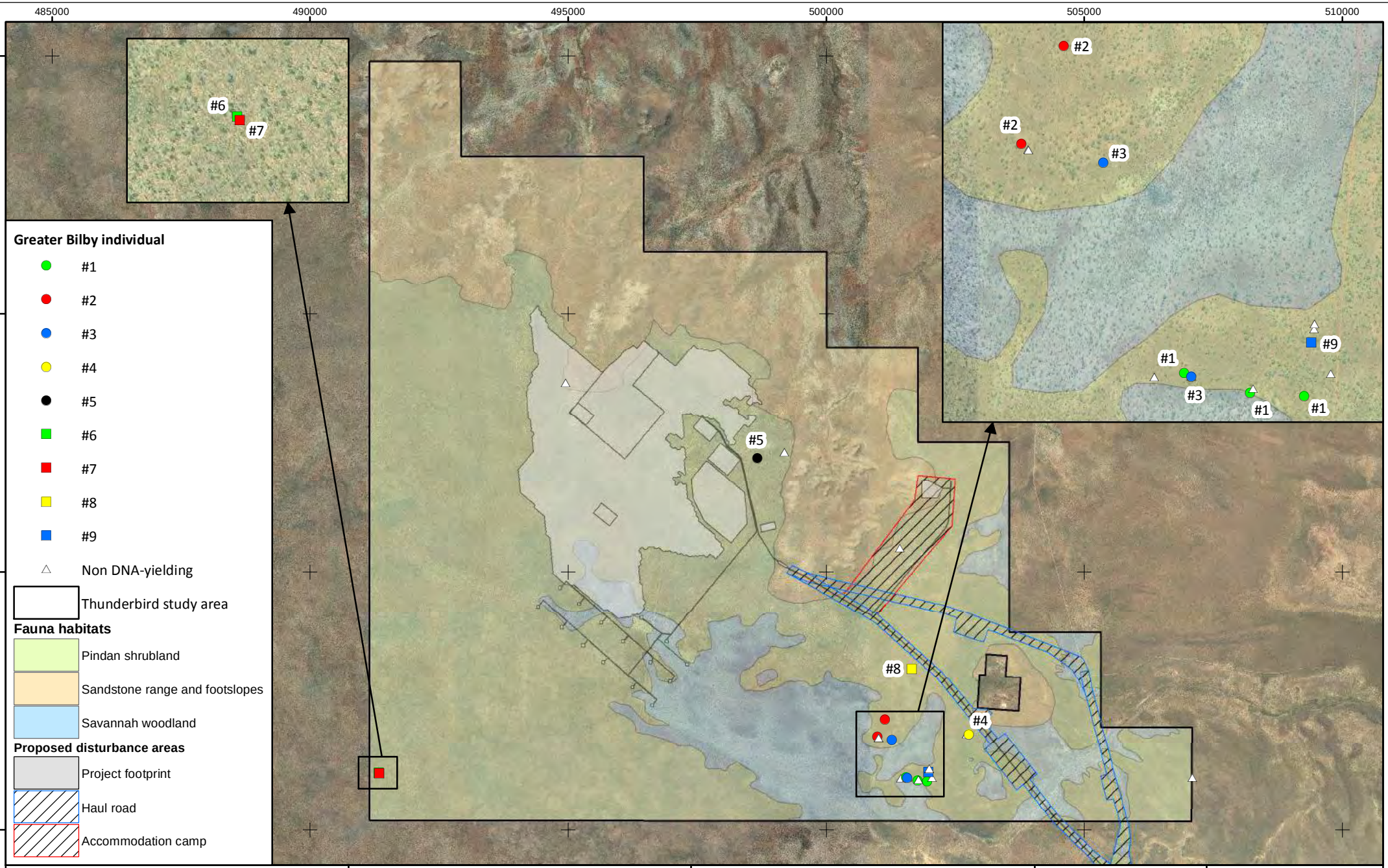
This analysis resulted in a total of nine individual Greater Bilbies being identified as occurring within the study area at the time of surveying (Figure 3.6).

Table 3.2 – Greater Bilby scat collection locations and DNA analysis results

Evidence	Scat ID	Sufficient DNA	Greater Bilby individual	Easting	Northing
Scat	BGS2	No	-	501446	8065999
Scat	BGS3	Yes	#1	501548	8066014
Scat	BGS4	No*	-	501573	8066002
Scat	BGS5	Yes	#3	501572	8066001
Scat	BGS6	Yes	#1	501775	8065945
Scat	BGS7	Yes	#1	501959	8065934
Scat	BGS8	No	-	502049	8066012
Scat	BGS9	Yes	#8	501656	8068113
Scat	BGS10	Yes	#2	501136	8067133
Scat	BGS11	Yes	#3	501271	8066734
Scat	BGS12	Yes	#2	500991	8066798
Scat	BGS13	No	-	501014	8066778
Scat	BGS14	No	-	501015	8066777
Scat	BGS15	No	-	494953	8073657
Scat	BGS16	No	-	501426	8070457
Scat	BGS17	No	-	501784	8065961
Scat	BGS18	Yes	#9	501982	8066117
Scat	BGS19	No	-	501993	8066164
Scat	BGS20	No	-	501995	8066181
Scat	Sws1	No*	-	502724	8066845
Scat	Sws2	Yes	#4	502759	8066841
Scat	Sws3	No	-	499192	8072315
Scat	Sws4	Yes	#5	498667	8072199
Scat	Sws5	Yes	#6	491331	8066102
Scat	Sws6	Yes	#7	491335	8066096

GDA 94 Zone 51

*DNA amplified but not in sufficient quantity to allow for individual identification



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Greater Bilby DNA scat analysis results

Figure: 3.6
Project ID: 1657

Drawn: MY
Date: 10/06/16

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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4 DISCUSSION

4.1 OCCURRENCE OF GREATER BILBY WITHIN THE STUDY AREA

The current targeted Greater Bilby assessment, in conjunction with previous Thunderbird Project fauna assessments (*ecologia* 2014, 2015), has given a good understanding of spatial occurrence and activity levels of Greater Bilby in the study area. The DNA scat analysis has provided quantitative data as to the minimum number of individuals present at the time of the targeted survey.

The DNA analyses suggest the study area was supporting, at the time of surveying, at least nine individuals (unique individual animals confirmed through DNA analysis). The results of this assessment overall generally show that each of these uniquely identified individuals was associated with an isolated, discrete cluster of records of Greater Bilby activity (Figure 3.6).

As noted earlier (Section 2.4.3), efforts to locate scat were made at every area of Greater Bilby activity. However, at many locations where activity was recorded, no scats were available to collect (Figure 3.5). Given that individual clusters of activity were generally associated with unique individual animals in the cases where genetic identifications could be made, it is possible that locations where identifications could not be made are also associated with unique individuals. These would therefore be over and above the nine individuals conclusively identified during this assessment; based on this hypothesis, it is possible that the total number of individuals present in the study area at the time of the assessment was in the vicinity of 25 animals.

It is possible this is an underestimate; transects during this assessment were selected to provide representative coverage of the pindan shrubland habitat type in the study area, and were spaced 0.5-1 km apart (Figure 2.2). As a result of the width of the spaced transects, it is possible that Greater Bilby activity in some areas remained undetected at the time of surveying. Equally this may be an overestimate, due to difficulty in interpreting the age of secondary evidence that is not obviously fresh. The population is also likely to fluctuate according to seasonal and annual variations in rainfall, resource availability, predator presence and fire history (Section 4.2). Only a highly-intensive survey conducted over multiple seasons would produce an absolute, quantitative baseline estimate of the Greater Bilby population size in the study area..

When comparing the spatial occurrence of Greater Bilby in relation to location of proposed disturbance areas, it can be demonstrated that the Greater Bilby occurs both inside proposed mine disturbance areas and within close proximity to haul road disturbance areas (Figure 3.5). Overall, however, more Greater Bilby activity was recorded outside proposed disturbance areas (Figure 3.5). All individuals identified from DNA scat analysis were outside proposed disturbance areas (Figure 3.6), with only a single scat collected from inside the proposed disturbance area (despite numerous locations of secondary evidence), which did not yield DNA.

On the basis of existing habitat mapping and estimated Greater Bilby population number within the study area, an approximate home range of Greater Bilby within the study area can be estimated. Approximately 92.2 km^2 of pindan shrubland habitat type has been calculated to occur within the study area. Applying the estimate of 25 individuals, this equates to a home range of 3.69 km^2 per individual. This home range estimate is likely to be actually slightly lower, given Greater Bilbies preference towards micro-habitat within the study area (Section 4.2). This home range estimate is close to previous calculations of Greater Bilby short-term home ranges of 1.1 to 3.16 km^2 (Pavey 2006a).

4.2 HABITAT ASSOCIATION

As within the previous fauna assessments for the Thunderbird Project (*ecologia* 2014, 2015), the Greater Bilby was recorded predominately within the pindan shrubland habitat type (Figure 3.5), and more specifically within the dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat

(Figure 4.1). This micro-habitat appears to be influenced by fire age, with older fire age (>2 years) then surrounding areas. The dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat forms a dense canopy layer but relatively open ground cover, which is in contrast to surrounding areas which appear to have been burnt more frequently and are characterised by dense ground vegetation.

The intensity of fire also appears to have an important influence on suitability of habitat. A number of areas of dense, mature *Acacia tumida* var. *tumida* woodland were encountered that had been burnt by large scale fire and that result in the loss of *Acacia tumida* var. *tumida* plants (evident by lack of regeneration) (Figure 4.2). Burnt areas included patches where Greater Bilby evidence had been recorded previously. The regeneration process within these areas will consequently take longer and be unsuitable habitat for Greater Bilby in the short to medium term, than if lower intensity fires occurred. The potential benefits of fire to Greater Bilby are not well known, although Southgate and Carthew (2006) determined fire-promoted plant growth contributed significantly to the amount of dietary plant material, concluding spatial and temporal heterogeneity of fire age beneficial to Greater Bilby populations. Fire age and intensity is therefore likely to be an important local factor in determining suitability of habitat for Greater Bilby, with small scale and mosaic fire patterns likely to be of greatest benefit.

Figure 4.1 – Dense, mature *Acacia tumida* var. *tumida* within pindan shrubland

Figure 4.2 – Damage from high-intensity fire in dense, mature *Acacia tumida* var. *tumida* habitat

This assessment identified a strong Greater Bilby feeding association with *Acacia tumida* var. *tumida* plants. It was observed diggings were commonly made at the base of this plant species (Figure 3.1), with extractions of root dwelling larvae made from the roots. Shell casings of Witjuti grub larvae (*Endoxyla* spp.) was observed at the base of *Acacia tumida* var. *tumida* plants (Figure 4.3), suggesting Witjuti grubs as an important food source for the local Greater Bilby population.

Figure 4.3 – Example of Witjuti grub (*Endoxyla* spp.) larvae casing from the study area

4.3 GREATER BILBY OCCURRENCE ON THE DAMPIER PENINSULA

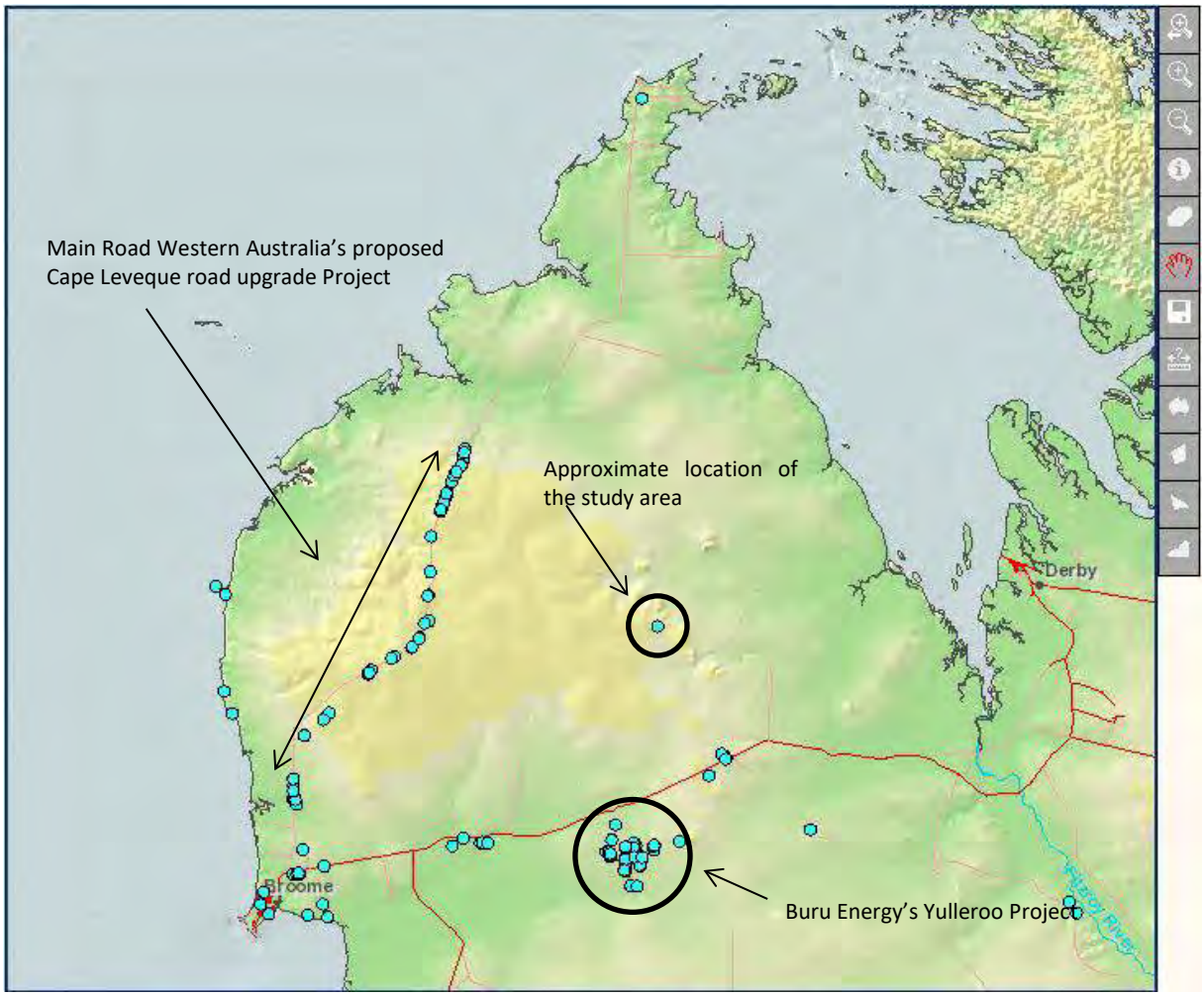
The Dampier Peninsula is a geographic region recognised as supporting a remnant, patchily distributed Greater Bilby population following the range contraction of this species in the early 1900's (Johnson 2008; Woinarski *et al.* 2012). The Greater Bilby population status on Dampier Peninsula is not clear, however Dr. Rick Southgate (GHD 2015) suggests it is most likely a scattered population in low densities. The northern edge of the Greater Bilby distribution (Dampierland and northern edges of the Great Sandy and Tanami Deserts) is thought to be of considerable importance to the conservation of the species, because it represents the only part of its range where populations can persist without the need of intensive management (Southgate 2012).

Relatively few biological surveys have been completed on Dampier Peninsula, however recent biological assessments including James Price Point (*ecologia* 2011), Buru Energy's Yulleroo Project (Ogburn 2013) and Main Road Western Australia's proposed Cape Leveque road upgrade Project (GHD 2013) all recorded Greater Bilby on the Dampier Peninsula. Previous records from NatureMap in relation to the study area are shown in Figure 4.4.

The impacts of development on Greater Bilby populations continue to be studied. Bilbies have been noted to be able to tolerate disturbance; however, it is important that indirect threats are also considered, in addition to the more obvious impacts of habitat removal (Southgate 2012).

Of particular importance in understanding Greater Bilby occupation of Dampier Peninsula are previous records associated with Main Road Western Australia's Cape Leveque road upgrade project (GHD 2013). These records can be seen in Figure 4.4, displayed as the linear collection of records west of the study area. The continued presence of Greater Bilby throughout the Cape Leveque road upgrade project area (approximately 100 km in length) suggests the Greater Bilby may be more common on the Dampier Peninsula then previously considered.

Due to the uncertainties regarding the status of the Dampier Peninsula population, the regional significance of the Greater Bilby population within the study area is difficult to determine. Using the estimated national Greater Bilby population of 10,000 (Woinarski *et al.* 2012), should the study area contain 25 individuals, then it is estimated that it would contain approximately 0.25% of the total national Greater Bilby population.



Source:(DPaW 2015)

Figure 4.4 – Previous Greater Bilby records on Dampier Peninsula

4.4 SURVEY LIMITATIONS

While this Targeted Bilby survey was conducted over a single season in 2015, a comprehensive Level 2, two-season terrestrial (vertebrate and SRE invertebrate) and subterranean fauna assessment was previously conducted for the Thunderbird Project in 2013 (*ecologia*, 2016a). Therefore the single season Targeted survey is no considered a limitation.

There were no major field constraints during the field survey. Survey methodology was conducted in accordance with the Commonwealth Guidelines for Survey for Australia's Threatened Mammals (DSEWPaC, 2011), with a focus on evidence of the presence and absence including secondary evidence of presence (ie scats, burrows and digging) and activity recorded from motion camera's within preferred habitat identified during the 2013 Level 2 survey (ie stands of mature *Acacia tumida* within the broader Pindan shrubland habitat).

5 CONCLUSION

The main conclusions from this targeted Greater Bilby assessment of the Thunderbird study area are:

- The Greater Bilby was recorded in the Thunderbird study area. A total of 754 Greater Bilby records were obtained, comprising secondary evidence in the form of diggings, scats, active burrows and inactive burrows;
- Direct confirmation of the contemporary presence of the Greater Bilby in the study area was obtained, with camera traps detecting the species at two out of the five active burrows that were monitored using this technique.
- Of the 25 scats collected, 15 produced viable DNA with 13 of these providing DNA that amplified at a sufficient number of loci to facilitate individual identification. This analysis resulted in a total of nine individual Greater Bilbies being recognised as occurring within the study area at the time of surveying;
- Extrapolating DNA scat analysis results suggests the study area is likely to be supporting additional individuals at the time of surveying. It is estimated the local Greater Bilby population within the study area at the time of the targeted survey is approximately 25 individuals;
- The size of this population is likely to fluctuate according to environmental factors including, but not limited to, seasonal and annual variations in rainfall, resource availability, fire history and the size of sympatric feral animal populations;
- When comparing the spatial occurrence of Greater Bilby in regards to location of proposed disturbance areas, it can be seen Greater Bilby occurs inside proposed mine disturbance areas, and in close proximity to haul road disturbance areas. However, overall more Greater Bilby activity was recorded outside proposed disturbance areas;
- Using the estimate of 25 individuals, a home range of 3.69 km^2 per individual is calculated within the pindan shrubland habitat type. This home range estimate is likely to be actually slightly lower, given the Greater Bilbies preference towards the micro-habitat recorded within the study area. This home range estimate is close to previous calculations of Greater Bilby short-term home ranges of 1.1 to 3.16 km^2;
- As per previous fauna assessments of the Thunderbird Project, the Greater Bilby was recorded almost exclusively within the pindan shrubland habitat type, and more specifically within the dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat. This micro-habitat appears to be influenced by fire age, with older fire age (>2 years) then surrounding areas;
- The Greater Bilby population status on Dampier Peninsula is not clear, however it has been suggested it is most likely a scattered regional population in low densities. Relatively few biological surveys have been completed on Dampier Peninsula, however three recent biological assessments have all recorded Greater Bilby on the Dampier Peninsula, suggesting the species may be more common on Dampier Peninsula than previously thought; and
- Due to the uncertainties regarding the status of the Dampier Peninsula population, the regional significance of the Greater Bilby population within the study area is difficult to quantify. Using the estimated national Greater Bilby population of 10,000 (Woinarski *et al.* 2012), and the estimated study area population of 25 individuals, then the study area may support up to 0.25% of the estimated total national Greater Bilby population.

6 REFERENCES

ABAS. 2002. Bilby Facts and Figures. The Australian Bilby Appreciation Society.

DPaW. 2015. NatureMap: Mapping Western Australia's Biodiversity. Available at http://naturemap.dpaw.wa.gov.au/. Department of Parks and Wildlife.

DSEWPaC. 2011. Survey guidelines for Australia's Threatened Mammals. Department of Sustainability, Environment, Water, Population and Communities.

ecologia Environment. 2011. James Price Point: Light Industrial Area, Worker's Accommodation Camp and Souther Pipeline. Vertebrate Fauna Assessment. Report prepared for Woodside Energy Limited.

ecologia Environment. 2014. Thunderbird Project Terrestrial and Subterranean Fauna Assessment. Unpublished report for Sheffield Resources Ltd.

ecologia Environment. 2015. Thunderbird Haul Road and Accommodation Camp Flora and Fauna Assessment. Unpublished report for Sheffield Resources Ltd.

EPA. 2002a. Terrestrial Biological Surveys as an Element of Biodiversity Protection *in* Environmental Protection Authority, ed, Perth.

EPA. 2002b. Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3. Environmental Protection Authority, Western Australia.

EPA and DEC. 2010. Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment. Environmental Protection Authority and Department of Environment and Conservation *in* Hyder, B. M., Dell, J., Cowan, M. A., ed. Environmental Protection Authority and Department of Environment and Conservation.

GHD. 2013. Cape Leveque Road Upgrade Targeted Greater Bilby Assessment. Unpublished Report for Main Roads Western Australia.

GHD. 2015. Main Roads Western Australia, Cape Leveque Road Upgrade (SLK 25 - 102.6). Response to comments on the Draft Preliminary Documentation.

Johnson, K. A. 2008. Bilby, *Macrotis lagotis*. pp. 191-193 *in* van Dyck, S., and Strahan, R., eds. The Mammals of Australia. Reed New Holland, Sydney.

Maxwell, S., Burbidge, A. A., and Morris, K. D., eds. 1996. The 1996 Action Plan for Australian Marsupials and Monotremes. Wildlife Australia, Canberra.

O'Malley, C. 2006. Australian Threatened Species, Greater Bilby, *Macrotis lagotis*.

Ogburn, D. 2013. Developing a model for Bilby habitat preference in the Western Sandlands. Buru Energy.

Pavey, C. 2006a. National Recovery Plan for the Greater Bilby *Macrotis lagotis*. Northern Territory Department of Natural Resources, Environment and the Arts.

Pavey, C. 2006b. Threatened Species of the Northern Territory: Greater Bilby *Macrotis lagotis in* Department of Natural Resources Environment and the Arts, ed. Parks and Wildlife Commission - Northern Territory Government.

2012. Peer review of the Browse Bilby Review, a report detailing the consolidated information relating to the occurrence of the Bilby *Macrotis lagotis* near the proposed Browse LNG Precinct (close to James Price Point) and more broadly on the Dampier Peninsula.

Southgate, R. and Carthew, M. 2006. Diet of the bilby (*Macrotis lagotis*) in relation to substrate, fire and rainfall characteristics in the Tanami Desert. Wildlife Research. 33:507-519.

Tyndale-Biscoe, H. 2005. Life of Marsupials. CSIRO Publishing, Melbourne.

van Dyck, S. and Strahan, R. 2008. *The Mammals of Australia*. Reed New Holland, Sydney.

Woinarski, J., Burbidge, A., and Harrison, P. 2012. The Action Plan for Australian Mammals. CSIRO Publishing.

APPENDIX A DPAW GREATER BILBY SCATS ANALYSIS REPORT

Government of Western Australia
Department of Parks and Wildlife
Science and Conservation Division

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Our ref: Bilb002
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Genotyping of bilby scats collected from Dampier Peninsula, Kimberley
Fiona Carpenter and Martin Dziminski

Ecologia provided 26 scat samples for genotyping, of which 25 were confirmed to be greater bilby (*Macrotis lagotis*) scats (Table 1). Sample BGS1 looked like a macropod scat and did not amplify. Samples were stored dry, at room temperature, in 30ml tubes, approximately 1/3-filled with silica gel beads, until DNA extraction was undertaken.

DNA extractions were undertaken on the 21 October 2015. Genomic DNA was extracted from scats using the Qiagen QIAamp Fast DNA Stool Mini Kit with some modifications from Piggott and Taylor (2003) to the recommended procedures included in the kit. DNA was screened using seven highly polymorphic microsatellite markers (Table 2). These were multiplexed into two polymerase chain reactions (PCR) using the Qiagen Multiplex PCR Plus Kit. PCR amplification was performed using cycling conditions modified from the Qiagen Multiplex PCR Plus Kit. The PCR product was then analyzed on an ABI3730XL Sequencer, sized using Genescan-500 LIZ internal size standard, and genotyped using Genemapper software (version 5.0.0).

Of the 25 supplied samples, 15 samples yielded DNA and 13 amplified at enough loci to include in identity analysis (Table 3). Genotyping using the seven loci identified nine distinct individuals present across the survey (Table 4). Overall the average genotyping success rate of 52 % was higher than the expected rate of 20-25 % from initial trials. A study that is currently being completed by Parks and Wildlife shows that age of scats has an effect on amplification success rate. The scats that did not yield DNA or did not amplify at enough loci to be included in identity analysis may have been too old.

Further analyses of these data can reveal the relatedness of individuals within these populations (for example if individuals are full- or half-siblings, or other levels of relatedness). When monitoring is completed at other sites across Western Australia and genetic data is available, population genetic analyses can be completed. These analyses can reveal isolation or connectivity between populations using gene flow and transfer. Furthermore, the data gained from these two monitoring sites can be used in distance analysis techniques to gain accurate measures of the numbers and densities of individuals within monitored populations.

Sincerely,
Dr Martin Dziminski.

References

Moritz, C., A. Heideman, E. Geffen, and P. Mcrae. 1997. Genetic population structure of the Greater Bilby Macrotis lagotis, a marsupial in decline. Mol. Ecol. 6:925–936.

Piggott, M. P., and A. C. Taylor. 2003. Extensive evaluation of faecal preservation and DNA extraction methods in Australian native and introduced species. Aust. J. Zool. 51:341–355.

Smith, S., P. McRae, and J. Hughes. 2009. Faecal DNA analysis enables genetic monitoring of the species recovery program for an arid-dwelling marsupial. Aust. J. Zool. 57:139–148.

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Table 1. Bilby scat samples supplied by Ecologia.

Ecologia ID	DPaW ID	
SWS1	KIM0001	
SWS2	KIM0002	
SWS3	KIM0003	
SWS4	KIM0004	
SWS5	KIM0005	
SWS6	KIM0006	
BGS1	KIM0007	Not bilby.
BGS2	KIM0008	
BGS3	KIM0009	
BGS4	KIM0010	
BGS5	KIM0011	
BGS6	KIM0012	
BGS7	KIM0013	
BGS8	KIM0014	
BGS9	KIM0015	
BGS10	KIM0016	
BGS11	KIM0017	
BGS12	KIM0018	
BGS13	KIM0019	
BGS14	KIM0020	
BGS15	KIM0021	
BGS16	KIM0022	
BGS17	KIM0023	
BGS18	KIM0024	
BGS19	KIM0025	
BGS20	KIM0026	

Table 2. Microsatellite markers used in PCR.

Locus	Primer set	Fluorescent label	Reference
Multiplex 1			
B02	BIL02	6-FAM	Moritz et al. (1997)
B17	Bil17intF	VIC	Moritz et al. (1997) and Smith et al. (2009)
B56	Bil56intF	PET	Moritz et al. (1997) and Smith et al. (2009)
Multiplex 2			
B55	BIL55	6-FAM	Moritz et al. (1997)
B22	BIL22	VIC	Moritz et al. (1997)
B41	BIL41intF	PET	Moritz et al. (1997) and Smith et al. (2009)
B63	BIL63	NED	Moritz et al. (1997)

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Table 3. Bilby scat samples successfully genotyped.	
Scats yielding DNA	Scats with enough loci amplified
KIM0001	KIM0002
KIM0002	KIM0004
KIM0004	KIM0005
KIM0005	KIM0006
KIM0006	KIM0009
KIM0009	KIM0011
KIM0010	KIM0012
KIM0011	KIM0013
KIM0012	KIM0015
KIM0013	KIM0016
KIM0015	KIM0017
KIM0016	KIM0018
KIM0017	KIM0024
KIM0018	
KIM0024	

Table 4. Individuals identified from scat samples.

Individual #	Sample
1	KIM0009
1	KIM0012
1	KIM0013
2	KIM0016
2	KIM0018
3	KIM0011
3	KIM0017
4	KIM0002
5	KIM0004
6	KIM0005
7	KIM0006
8	KIM0015
9	KIM0024

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APPENDIX B GREATER BILBY RECORDS FROM ALL THUNDERBIRD PROJECT SURVEYS

Evidence Type	Easting	Northing	Date
Greater Bilby Targeted Assessment (2015)			
Active burrow	501102	8067252	23/09/2015
Active burrow	500995	8066824	23/09/2015
Active burrow	501211	8066777	23/09/2015
Active burrow	501527	8070381	25/09/2015
Active burrow	501325	8070444	25/09/2015
Active burrow	501307	8070375	25/09/2015
Active burrow	502049	8066093	27/09/2015
Active burrow	501232	8067278	23/09/2015
Active burrow	501012	8066679	23/09/2015
Active burrow	502703	8066787	23/09/2015
Active burrow	498572	8072093	24/09/2015
Active burrow	498722	8072240	24/09/2015
Active burrow	497065	8071777	24/09/2015
Active burrow	497458	8071357	24/09/2015
Active burrow. Camera trap record	501767	8065957	22/09/2015
Active burrow	502029	8065980	22/09/2015
Active burrow. Camera trap record	501663	8068089	23/09/2015
Digging	507060	8066048	22/09/2015
Digging	507060	8066048	22/09/2015
Digging	507061	8066056	22/09/2015
Digging	507067	8066054	22/09/2015
Digging	507072	8066060	22/09/2015
Digging	507086	8066046	22/09/2015
Digging	507085	8066033	22/09/2015
Digging	507087	8066032	22/09/2015
Digging	507085	8066028	22/09/2015
Digging	507084	8066025	22/09/2015
Digging	507101	8066009	22/09/2015
Digging	507093	8066010	22/09/2015
Digging	507090	8066003	22/09/2015
Digging	507079	8066004	22/09/2015
Digging	507049	8066019	22/09/2015
Digging	507037	8066025	22/09/2015
Digging	506984	8066029	22/09/2015
Digging	506981	8066014	22/09/2015
Digging	506984	8065998	22/09/2015
Digging	506976	8065985	22/09/2015
Digging	506979	8065982	22/09/2015
Digging	506977	8065887	22/09/2015
Digging	506981	8065885	22/09/2015
Digging	506983	8065875	22/09/2015
Digging	506986	8065871	22/09/2015
Digging	506991	8065874	22/09/2015
Digging	506987	8065860	22/09/2015
Digging	506969	8065842	22/09/2015
Digging	506976	8065772	22/09/2015
Digging	506977	8065750	22/09/2015
Digging	506979	8065744	22/09/2015
Digging	506989	8065738	22/09/2015
Digging	506991	8065731	22/09/2015
Digging	506997	8065729	22/09/2015
Digging	506996	8065717	22/09/2015
Digging	507006	8065686	22/09/2015
Digging	507040	8065647	22/09/2015
Digging	507043	8065623	22/09/2015
Digging	507045	8065615	22/09/2015
Digging	507037	8065608	22/09/2015
Digging	507042	8065603	22/09/2015

Digging	507049	8065601	22/09/2015
Digging	507052	8065602	22/09/2015
Digging	507061	8065596	22/09/2015
Digging	507050	8065543	22/09/2015
Digging	501359	8066034	22/09/2015
Digging	501361	8066036	22/09/2015
Digging	501369	8066032	22/09/2015
Digging	501368	8066026	22/09/2015
Digging	501374	8066007	22/09/2015
Digging	501378	8066004	22/09/2015
Digging	501380	8066002	22/09/2015
Digging	501379	8065999	22/09/2015
Digging	501416	8066009	22/09/2015
Digging	501429	8066008	22/09/2015
Digging	501428	8066005	22/09/2015
Digging	501437	8066005	22/09/2015
Digging	501443	8065999	22/09/2015
Digging	501450	8065999	22/09/2015
Digging	501464	8066014	22/09/2015
Digging	501476	8066023	22/09/2015
Digging	501480	8066020	22/09/2015
Digging	501496	8066024	22/09/2015
Digging	501509	8066016	22/09/2015
Digging	501532	8066009	22/09/2015
Digging	501549	8066010	22/09/2015
Digging	501560	8066005	22/09/2015
Digging	501565	8066007	22/09/2015
Digging	501585	8066005	22/09/2015
Digging	501585	8066007	22/09/2015
Digging	501600	8066005	22/09/2015
Digging	501604	8065999	22/09/2015
Digging	501604	8065999	22/09/2015
Digging	501612	8065994	22/09/2015
Digging	501622	8065990	22/09/2015
Digging	501630	8065988	22/09/2015
Digging	501676	8065992	22/09/2015
Digging	501679	8065991	22/09/2015
Digging	501682	8065986	22/09/2015
Digging	501688	8065982	22/09/2015
Digging	501688	8065989	22/09/2015
Digging	501696	8065986	22/09/2015
Digging	501704	8065990	22/09/2015
Digging	501730	8065974	22/09/2015
Digging	501729	8065978	22/09/2015
Digging	501742	8065972	22/09/2015
Digging	501757	8065967	22/09/2015
Digging	501758	8065960	22/09/2015
Digging	501758	8065957	22/09/2015
Digging	501773	8065946	22/09/2015
Digging	501776	8065947	22/09/2015
Digging	501789	8065955	22/09/2015
Digging	501807	8065965	22/09/2015
Digging	501806	8065967	22/09/2015
Digging	501815	8065976	22/09/2015
Digging	501814	8065975	22/09/2015
Digging	501821	8065977	22/09/2015
Digging	501822	8065981	22/09/2015
Digging	501830	8065980	22/09/2015
Digging	501864	8065977	22/09/2015
Digging	501888	8065979	22/09/2015

Digging	501930	8065974	22/09/2015
Digging	501945	8065962	22/09/2015
Digging	502007	8065973	22/09/2015
Digging	502019	8065970	22/09/2015
Digging	502022	8065972	22/09/2015
Digging	502038	8065985	22/09/2015
Digging	502039	8065979	22/09/2015
Digging	502040	8065980	22/09/2015
Digging	502041	8065979	22/09/2015
Digging	502045	8065973	22/09/2015
Digging	502047	8065976	22/09/2015
Digging	502040	8065976	22/09/2015
Digging	502049	8065979	22/09/2015
Digging	502055	8065984	22/09/2015
Digging	502056	8065978	22/09/2015
Digging	502057	8066012	22/09/2015
Digging	502052	8066010	22/09/2015
Digging	502048	8066011	22/09/2015
Digging	502053	8066015	22/09/2015
Digging	501670	8068002	23/09/2015
Digging	501671	8068003	23/09/2015
Digging	501676	8067980	23/09/2015
Digging	501681	8067968	23/09/2015
Digging	501672	8067957	23/09/2015
Digging	501655	8067940	23/09/2015
Digging	501657	8067950	23/09/2015
Digging	501656	8067953	23/09/2015
Digging	501645	8067923	23/09/2015
Digging	501596	8067879	23/09/2015
Digging	501596	8067876	23/09/2015
Digging	501639	8067883	23/09/2015
Digging	501604	8067918	23/09/2015
Digging	501604	8067928	23/09/2015
Digging	501596	8067933	23/09/2015
Digging	501594	8067936	23/09/2015
Digging	501562	8067939	23/09/2015
Digging	501561	8067932	23/09/2015
Digging	501558	8067928	23/09/2015
Digging	501548	8067961	23/09/2015
Digging	501566	8067953	23/09/2015
Digging	501591	8067936	23/09/2015
Digging	501632	8067940	23/09/2015
Digging	501663	8067969	23/09/2015
Digging	501682	8067952	23/09/2015
Digging	501670	8067885	23/09/2015
Digging	501676	8067891	23/09/2015
Digging	501680	8067889	23/09/2015
Digging	501685	8067883	23/09/2015
Digging	501688	8067880	23/09/2015
Digging	501706	8067821	23/09/2015
Digging	501707	8068041	23/09/2015
Digging	501689	8068074	23/09/2015
Digging	501676	8068078	23/09/2015
Digging	501674	8068092	23/09/2015
Digging	501701	8068114	23/09/2015
Digging	501700	8068118	23/09/2015
Digging	501687	8068129	23/09/2015
Digging	501661	8068115	23/09/2015
Digging	501660	8068110	23/09/2015
Digging	501657	8068112	23/09/2015

Digging	501654	8068087	23/09/2015
Digging	501666	8068071	23/09/2015
Digging	501669	8068036	23/09/2015
Digging	501667	8068030	23/09/2015
Digging	498720	8067693	23/09/2015
Digging	498726	8067696	23/09/2015
Digging	498743	8067703	23/09/2015
Digging	498749	8067698	23/09/2015
Digging	498782	8067688	23/09/2015
Digging	498797	8067712	23/09/2015
Digging	498861	8067666	23/09/2015
Digging	501070	8067212	23/09/2015
Digging	501065	8067212	23/09/2015
Digging	501076	8067213	23/09/2015
Digging	501090	8067216	23/09/2015
Digging	501102	8067224	23/09/2015
Digging	501124	8067233	23/09/2015
Digging	501123	8067238	23/09/2015
Digging	501123	8067232	23/09/2015
Digging	501125	8067240	23/09/2015
Digging	501124	8067245	23/09/2015
Digging	501122	8067249	23/09/2015
Digging	501096	8067243	23/09/2015
Digging	501090	8067243	23/09/2015
Digging	501110	8067265	23/09/2015
Digging	501098	8067236	23/09/2015
Digging	501094	8067230	23/09/2015
Digging	501056	8067204	23/09/2015
Digging	501059	8067200	23/09/2015
Digging	501056	8067198	23/09/2015
Digging	501055	8067192	23/09/2015
Digging	501056	8067184	23/09/2015
Digging	501063	8067179	23/09/2015
Digging	501062	8067177	23/09/2015
Digging	501069	8067181	23/09/2015
Digging	501077	8067172	23/09/2015
Digging	501077	8067167	23/09/2015
Digging	501082	8067161	23/09/2015
Digging	501081	8067162	23/09/2015
Digging	501090	8067165	23/09/2015
Digging	501078	8067157	23/09/2015
Digging	501070	8067145	23/09/2015
Digging	501108	8067154	23/09/2015
Digging	501105	8067161	23/09/2015
Digging	501103	8067167	23/09/2015
Digging	501095	8067175	23/09/2015
Digging	501091	8067173	23/09/2015
Digging	501087	8067189	23/09/2015
Digging	501071	8067193	23/09/2015
Digging	501128	8067199	23/09/2015
Digging	501127	8067202	23/09/2015
Digging	501128	8067187	23/09/2015
Digging	501130	8067175	23/09/2015
Digging	501140	8067168	23/09/2015
Digging	501139	8067174	23/09/2015
Digging	501138	8067175	23/09/2015
Digging	501148	8067171	23/09/2015
Digging	501138	8067145	23/09/2015
Digging	501130	8067133	23/09/2015
Digging	501136	8067133	23/09/2015

Digging	501157	8067157	23/09/2015
Digging	501187	8067185	23/09/2015
Digging	501243	8067271	23/09/2015
Digging	501329	8066777	23/09/2015
Digging	501328	8066781	23/09/2015
Digging	501301	8066799	23/09/2015
Digging	501299	8066809	23/09/2015
Digging	501300	8066778	23/09/2015
Digging	501303	8066778	23/09/2015
Digging	501310	8066770	23/09/2015
Digging	501326	8066754	23/09/2015
Digging	501347	8066764	23/09/2015
Digging	501374	8066741	23/09/2015
Digging	501375	8066741	23/09/2015
Digging	501369	8066733	23/09/2015
Digging	501310	8066747	23/09/2015
Digging	501306	8066743	23/09/2015
Digging	501269	8066730	23/09/2015
Digging	501255	8066729	23/09/2015
Digging	501260	8066743	23/09/2015
Digging	501238	8066771	23/09/2015
Digging	501244	8066779	23/09/2015
Digging	501219	8066778	23/09/2015
Digging	501205	8066771	23/09/2015
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Digging	501175	8066807	23/09/2015
Digging	501174	8066807	23/09/2015
Digging	501155	8066822	23/09/2015
Digging	501087	8066884	23/09/2015
Digging	501071	8066856	23/09/2015
Digging	501073	8066853	23/09/2015
Digging	501073	8066847	23/09/2015
Digging	501079	8066846	23/09/2015
Digging	501082	8066824	23/09/2015
Digging	501080	8066815	23/09/2015
Digging	501079	8066811	23/09/2015
Digging	501080	8066800	23/09/2015
Digging	501056	8066793	23/09/2015
Digging	501028	8066800	23/09/2015
Digging	501023	8066792	23/09/2015
Digging	501022	8066792	23/09/2015
Digging	501001	8066803	23/09/2015
Digging	500997	8066803	23/09/2015
Digging	500995	8066805	23/09/2015
Digging	500992	8066816	23/09/2015
Digging	500989	8066825	23/09/2015
Digging	500986	8066822	23/09/2015
Digging	500974	8066838	23/09/2015
Digging	500984	8066808	23/09/2015
Digging	501009	8066790	23/09/2015
Digging	500960	8066763	23/09/2015
Digging	500931	8066767	23/09/2015
Digging	500906	8066792	23/09/2015
Digging	501022	8066684	23/09/2015
Digging	501023	8066686	23/09/2015
Digging	501090	8066672	23/09/2015
Digging	501104	8066676	23/09/2015
Digging	501148	8066655	23/09/2015
Digging	501216	8066627	23/09/2015

Digging	502102	8066030	23/09/2015
Digging	502105	8066029	23/09/2015
Digging	502107	8066035	23/09/2015
Digging	502109	8066031	23/09/2015
Digging	502142	8066037	23/09/2015
Digging	502145	8066035	23/09/2015
Digging	502158	8066057	23/09/2015
Digging	502163	8066063	23/09/2015
Digging	502159	8066069	23/09/2015
Digging	502191	8066090	23/09/2015
Digging	502197	8066097	23/09/2015
Digging	502160	8066091	23/09/2015
Digging	502131	8066090	23/09/2015
Digging	502124	8066083	23/09/2015
Digging	502112	8066083	23/09/2015
Digging	502096	8066057	23/09/2015
Digging	502097	8066040	23/09/2015
Digging	494924	8074037	24/09/2015
Digging	495004	8073561	24/09/2015
Digging	495006	8073561	24/09/2015
Digging	495006	8073552	24/09/2015
Digging	494999	8073550	24/09/2015
Digging	494994	8073541	24/09/2015
Digging	494986	8073557	24/09/2015
Digging	494984	8073553	24/09/2015
Digging	494975	8073562	24/09/2015
Digging	494973	8073562	24/09/2015
Digging	494961	8073564	24/09/2015
Digging	494966	8073579	24/09/2015
Digging	494975	8073586	24/09/2015
Digging	494961	8073606	24/09/2015
Digging	494964	8073615	24/09/2015
Digging	494970	8073621	24/09/2015
Digging	494979	8073627	24/09/2015
Digging	494986	8073630	24/09/2015
Digging	494980	8073636	24/09/2015
Digging	494974	8073641	24/09/2015
Digging	494973	8073643	24/09/2015
Digging	494955	8073641	24/09/2015
Digging	494948	8073646	24/09/2015
Digging	494957	8073661	24/09/2015
Digging	494958	8073663	24/09/2015
Digging	494965	8073672	24/09/2015
Digging	494961	8073677	24/09/2015
Digging	494962	8073679	24/09/2015
Digging	494951	8073686	24/09/2015
Digging	494956	8073699	24/09/2015
Digging	494957	8073707	24/09/2015
Digging	494955	8073714	24/09/2015
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Digging	499245	8072279	24/09/2015
Digging	499241	8072245	24/09/2015
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Digging	498703	8072242	24/09/2015
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Digging	494934	8072851	25/09/2015
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Digging	494951	8072978	25/09/2015
Digging	494972	8073012	25/09/2015
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Digging	494932	8073027	25/09/2015
Recently active burrow	506993	8066047	22/09/2015
Recently active burrow	506978	8066018	22/09/2015
Recently active burrow	506975	8065973	22/09/2015
Recently active burrow	507000	8065704	22/09/2015
Recently active burrow	507009	8065672	22/09/2015
Recently active burrow	501418	8066007	22/09/2015
Recently active burrow	501588	8066013	22/09/2015
Recently active burrow	501819	8065968	22/09/2015
Recently active burrow	502040	8065984	22/09/2015
Recently active burrow	495010	8073509	24/09/2015
Recently active burrow	501716	8068019	23/09/2015
Recently active burrow	501593	8067872	23/09/2015
Recently active burrow	502138	8066090	23/09/2015
Recently active burrow	497420	8071371	24/09/2015
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Recently active burrow	495372	8071351	25/09/2015
Recently active burrow	495298	8071369	25/09/2015
Recently active burrow	496663	8070648	25/09/2015
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Recently active burrow	494960	8072987	26/09/2015
Recently active burrow	495114	8073082	26/09/2015
Recently active burrow	501788	8066045	27/09/2015
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Recently active burrow	501995	8066155	27/09/2015
Recently active burrow	500970	8069964	25/09/2015
Recently active burrow	494961	8072990	25/09/2015
Recently active burrow	502728	8066833	23/09/2015
Recently active burrow	494976	8073107	25/09/2015
Recently active burrow	499455	8069061	23/09/2015
Recently active burrow	499898	8069152	23/09/2015
Recently active burrow	494968	8073609	24/09/2015

Recently active burrow	501368	8066727	23/09/2015
Recently active burrow	503007	8071336	23/09/2015
Recently active burrow	503016	8071190	23/09/2015
Recently active burrow	501233	8069124	23/09/2015
Recently active burrow	499918	8069152	23/09/2015
Recently active burrow	499907	8069205	23/09/2015
Recently active burrow	499884	8069146	23/09/2015
Recently active burrow	499468	8069060	23/09/2015
Recently active burrow	500046	8068540	23/09/2015
Recently active burrow	499471	8069057	23/09/2015
Recently active burrow	501661	8067941	23/09/2015
Scat BGS2 Bilby ID – Non DNA yielding	501446	8065999	27/09/2015
Scat BGS3 Bilby ID#1	501548	8066014	22/09/2015
Scat BGS4 Bilby ID – Non DNA yielding	501573	8066002	22/09/2015
Scat BGS5 Bilby ID#3	501572	8066001	22/09/2015
Scat BGS6 Bilby ID#1	501775	8065945	22/09/2015
Scat BGS7 Bilby ID#1	501959	8065934	22/09/2015
Scat BGS8 Bilby ID – Non DNA yielding	502049	8066012	22/09/2015
Scat BGS9 Bilby ID#8	501656	8068113	23/09/2015
Scat BGS10 Bilby ID#2	501136	8067133	23/09/2015
Scat BGS11 Bilby ID#3	501271	8066734	23/09/2015
Scat BGS12 Bilby ID#2	500991	8066798	23/09/2015
Scat BGS13 – Non DNA yielding	501014	8066778	23/09/2015
Scat BGS14 – Non DNA yielding	501015	8066777	23/09/2015
Scat BGS15 – Non DNA yielding	494953	8073657	24/09/2015
Scat BGS16 – Non DNA yielding	501426	8070457	25/09/2015
Scat BGS17 – Non DNA yielding	501784	8065961	27/09/2015
Scat BGS18 Bilby ID#9	501982	8066117	27/09/2015
Scat BGS19 – Non DNA yielding	501993	8066164	27/09/2015
Scat BGS20 – Non DNA yielding	501995	8066181	27/09/2015
Scat Sws1 – Non DNA yielding	502724	8066845	23/09/2015
Scat Sws2 Bilby ID#4	502759	8066841	23/09/2015
Scat Sws3 – Non DNA yielding	499192	8072315	24/09/2015
Scat Sws4 Bilby ID#5	498667	8072199	24/09/2015
Scat Sws5 Bilby ID#6	491331	8066102	27/09/2015
Scat Sws6 Bilby ID#7	491335	8066096	27/09/2015
Haul Road and Accommodation camp Level 1 survey (*ecologia* 2015)			
Scat	501573	8070421	13/05/2015
Scat	501449	8070406	13/05/2015
Active burrow	501452	8070397	13/05/2015
Active burrow	501769	8069648	14/05/2015
Active burrow	501734	8069517	14/05/2015
Active burrow	501060	8069737	14/05/2015
Active burrow	501051	8069815	14/05/2015
Active burrow	501011	8069889	14/05/2015
Active burrow	501222	8069733	15/05/2015
Active burrow	500978	8069759	14/05/2015
Active burrow	500606	8069630	15/05/2015
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Digging	501258	8069748	14/05/2015
Digging	501227	8069724	14/05/2015
Digging	501219	8069740	14/05/2015
Digging	501216	8069742	14/05/2015
Digging	501203	8069755	14/05/2015
Digging	501128	8069761	14/05/2015
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Digging	500568	8069633	14/05/2015
Digging	500584	8069642	14/05/2015
Digging	500584	8069638	14/05/2015
Digging	500594	8069634	14/05/2015
Digging	500594	8069636	14/05/2015
Digging	500600	8069636	14/05/2015
Digging	500468	8069541	14/05/2015
Digging	500536	8069590	14/05/2015
Digging	500540	8069599	14/05/2015
Digging	501499	8070386	14/05/2015
Digging	501496	8070400	14/05/2015
Digging	501502	8070417	14/05/2015
Digging	501497	8070418	14/05/2015
Digging	501511	8070434	14/05/2015
Digging	501529	8070422	14/05/2015
Digging	501544	8070419	14/05/2015
Digging	501552	8070430	14/05/2015
Digging	501565	8070424	14/05/2015
Digging	501575	8070418	14/05/2015
Digging	501577	8070411	14/05/2015
Digging	501488	8070363	14/05/2015
Digging	501478	8070364	14/05/2015
Digging	501471	8070370	14/05/2015
Digging	501474	8070377	14/05/2015
Digging	501452	8070386	14/05/2015
Digging	501460	8070390	14/05/2015
Digging	501452	8070402	14/05/2015
Digging	501444	8070408	14/05/2015
Digging	501440	8070400	14/05/2015
Digging	501428	8070412	14/05/2015
Digging	501426	8070409	14/05/2015
Digging	501406	8070403	14/05/2015
Digging	501389	8070395	14/05/2015
Digging	501374	8070395	14/05/2015
Digging	501406	8070446	14/05/2015
Digging	501415	8070448	14/05/2015
Digging	501783	8069629	14/05/2015
Digging	501781	8069632	14/05/2015
Digging	501733	8069530	14/05/2015
Digging	501740	8069517	14/05/2015
Digging	501758	8069498	14/05/2015
Digging	501777	8069510	14/05/2015
Digging	501213	8069580	14/05/2015

Digging	501097	8069683	14/05/2015
Digging	501087	8069688	14/05/2015
Digging	501096	8069697	14/05/2015
Digging	501099	8069701	14/05/2015
Digging	501096	8069712	14/05/2015
Digging	501049	8069748	14/05/2015
Digging	501037	8069780	14/05/2015
Digging	501044	8069795	14/05/2015
Digging	501048	8069798	14/05/2015
Digging	501048	8069830	14/05/2015
Digging	501024	8069893	14/05/2015
Digging	501006	8069888	14/05/2015
Digging	500980	8069821	14/05/2015
Digging	501006	8069811	14/05/2015
Digging	501013	8069801	14/05/2015
Digging	501000	8069771	14/05/2015
Digging	500960	8069749	14/05/2015
Digging	501369	8070264	14/05/2015
Digging	501350	8070271	14/05/2015
Digging	501347	8070279	14/05/2015
Digging	501334	8070295	14/05/2015
Digging	501330	8070296	14/05/2015
Digging	501327	8070303	14/05/2015
Digging	501323	8070308	14/05/2015
Digging	501290	8070326	14/05/2015
Digging	501263	8070350	14/05/2015
Digging	501321	8070418	14/05/2015
Digging	501372	8070394	14/05/2015
Digging	501396	8070387	14/05/2015
Digging	501416	8070384	14/05/2015
Digging	501424	8070373	14/05/2015
Digging	501438	8070372	14/05/2015
Digging	501438	8070381	14/05/2015
Digging	501446	8070388	14/05/2015
Digging	501445	8070392	14/05/2015
Digging	501508	8070488	14/05/2015
Digging	501462	8070400	13/05/2015
Digging	500977	8069946	13/05/2015
Scat	503748	8066030	14/05/2015
Active burrow	503721	8066163	14/05/2015
Active burrow	503450	8066252	14/05/2015
Active burrow	503322	8066391	14/05/2015
Active burrow	503257	8066429	14/05/2015
Active burrow	503807	8066263	14/05/2015
Active burrow	503872	8066222	14/05/2015
Active burrow	503775	8066033	14/05/2015
Digging	503165	8066826	14/05/2015
Digging	503071	8066928	14/05/2015
Active burrow	502969	8067046	14/05/2015
Active burrow	502980	8067161	14/05/2015
Inactive burrow	499512	8069908	15/05/2015
Level 2 Thunderbird Project Assessment (*ecologia* 2014)			
Digging	495011	8073550	22/10/2013
Digging	495005	8073572	22/10/2013
Digging	494999	8073578	22/10/2013
Digging	494994	8073571	22/10/2013
Digging	494978	8073558	22/10/2013
Digging	494918	8073595	22/10/2013
Digging	494891	8073627	22/10/2013

Digging	494889	8073642	22/10/2013
Digging	494885	8073708	22/10/2013
Digging	495002	8073513	22/10/2013
Digging	494992	8073488	22/10/2013
Digging	494985	8073445	22/10/2013
Digging	496862	8071229	22/10/2013
Digging	496862	8071232	22/10/2013
Digging	494999	8073486	22/10/2013
Digging	496881	8071087	22/10/2013
Digging	494116	8073268	22/10/2013
Digging	494166	8073394	22/10/2013
Digging	494085	8073523	22/10/2013
Digging	495000	8073487	22/10/2013
Digging	494169	8073407	22/10/2013
Digging	494180	8073485	22/10/2013
Digging	494230	8073512	22/10/2013
Digging	494086	8073400	22/10/2013
Digging	496756	8070856	22/10/2013
Digging	496804	8071125	22/10/2013
Digging	496807	8071018	22/10/2013
Scat	495015	8073510	19/10/2013
Scat	494911	8073733	19/10/2013
Scat	494996	8073723	20/10/2013
Digging	496928	8071212	22/10/2013
Digging	495019	8073532	22/10/2013
Active burrow. Camera rap record.	495001	8073488	22/10/2013
Inactive burrow	496881	8071087	19/10/2013
Inactive burrow	494116	8073268	10/04/2013
Inactive burrow	494166	8073394	10/04/2013
Inactive burrow	496807	8071018	20/10/2013
Inactive burrow	494085	8073523	20/10/2013
Inactive burrow	495000	8073488	20/10/2013
Inactive burrow	494116	8073268	20/10/2013
Inactive burrow	494166	8073394	20/10/2013
Inactive burrow	493555	8074935	11/04/2013