



# Balmoral South Environmental Impact Assessment Flora and Fauna Survey

Balmoral South

International Minerals

November 2006

MAUNSELL | AECOM

# Flora and Fauna Survey

Prepared for

**International Minerals**

Prepared by

**Maunsell Australia Pty Ltd**

Level 1, 629 Newcastle Street, PO Box 81, Leederville 6902, Western Australia  
T +61 8 9281 6100 F +61 8 9281 6295 www.maunsell.com

ABN 20 093 846 925

November 2006

60020130

© Maunsell Australia Pty Ltd 2007

The information contained in this document produced by Maunsell Australia Pty Ltd is solely for the use of the Client identified on the cover sheet for the purpose for which it has been prepared and Maunsell Australia Pty Ltd undertakes no duty to or accepts any responsibility to any third party who may rely upon this document.


All rights reserved. No section or element of this document may be removed from this document, reproduced, electronically stored or transmitted in any form without the written permission of Maunsell Australia Pty Ltd.

## Quality Information

Document Flora and Fauna Survey  
Ref 60020130  
Date November 2006  
Prepared by Gaby Martinez and Andrew Batty  
Reviewed by Kellie Gibbs

### For Information

### Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	23/11/2006	Internal Review	Jamie Shaw Senior Environmental Scientist	
B	19/01/2007	Incorporating client comments	Jamie Shaw Senior Environmental Scientist	
C	17/04/2007	Incorporation of additional client comments	Jamie Shaw Senior Environmental Scientist	

# Table of Contents

Executive Summary		i
1.0	Introduction	1
1.1	Background	1
1.2	Location	2
1.3	Climate	2
1.4	IBRA Bioregion	2
1.5	Existing Environment	2
1.5.1	Soils	2
1.5.2	Land System Units	2
1.5.3	Flora and Vegetation	5
1.5.4	Fauna	5
1.6	Biological Factors of Environmental Significance	6
1.6.1	Flora	6
1.6.2	Vegetation	8
1.6.3	Fauna	9
2.0	Objectives	11
3.0	Methodology	12
3.1	Terrestrial Flora and Vegetation Survey	12
3.1.1	Desktop Studies	12
3.1.2	Field Survey	12
3.1.3	Data Processing	15
3.2	Vertebrate Fauna Survey	15
3.2.1	Desktop Studies	15
3.2.2	Field Survey	16
3.2.3	Data Processing	20
4.0	Survey Limitations	21
4.1	Flora and Vegetation	21
4.2	Fauna	21
5.0	Results	22
5.1	Flora	22
5.2	Vegetation Communities	25
5.2.1	Additional Infrastructure Corridor Vegetation Communities	33
5.2.2	Assessment of Vegetation Significance	34
5.3	Vegetation Condition	38
5.4	PATN Analysis	38
5.5	Fauna	41
5.5.1	Desktop Surveys	41
5.5.2	Infrastructure Corridor Fauna	42
	Fauna Habitats	42
	Fauna Species of Significance	43
5.5.3	Field Survey	43
6.0	Discussion	53
6.1	Flora and Vegetation	53
6.1.1	Flora	53

6.1.2	Vegetation Communities	53
6.1.3	Vegetation Condition	54
6.2	Infrastructure Corridor	54
6.2.1	Impacts on Mangrove Communities	54
6.3	Fauna	55
6.4	Statutory Obligations	57
6.4.1	Priority Flora and Fauna	57
6.4.2	Significant Vegetation Communities	57
6.4.3	Declared Plants (Pest Weeds)	57
6.4.4	Migratory Birds	57
7.0	References	58
Appendix A:	PATN Analysis Report	a
Appendix B:	Individual Quadrat data used for PATN Analysis	b
Appendix C:	Summary of Vascular Flora Species Recorded within Each Vegetation Community within the Balmoral South Project Area, July 2006	c
Appendix D:	Summary of Vascular Flora Species Recorded within Each Quadrat, Balmoral South Project Area, July 2006	d
Appendix E:	Summary of Vascular Flora recorded within Each Vegetation Community Represented by Quadrats, Balmoral South Project Area, for the Auststeel Project HGM, 2000)	e
Appendix F:	Species of Reptiles and Amphibians Captured or Observed at Each Transect Site and During Spotlighting Exercises	f
Appendix G:	Species of Birds Identified in the Study Area	g
Appendix H:	Species of Mammals Recorded During Field Survey	h
Appendix I:	Recommended Weed Control Methods	i
Appendix J:	Balmoral South Iron Ore Project Fauna Survey	j
Appendix K:	Additional Threatened Fauna Enquires	k

### List of Tables

Table 1	Vegetation Communities Affected by Project Infrastructure	4
Table 2	Definition of Rare and Priority Flora Species (Department of Conservation and Land Management, 2005)	7
Table 3	Categories of Threatened Flora Species ( <i>Environment Protection and Biodiversity Conservation Act, 1999</i> )	7
Table 4	Western Australian <i>Wildlife Conservation Act, 1950</i> Codes for Threatened Fauna	9
Table 5	Explanation of Priority Codes Observed by DEC	9
Table 6	Categories of Threatened Fauna Species ( <i>Environment Protection and Biodiversity Conservation Act, 1999</i> )	10
Table 7	Bushland Condition Ratings (adapted from Keighery, 1994 and the Braun-Blanquet Scale of Cover Abundance (from Mueller-Dombois and Ellenberg, 1974))	14
Table 8	Recorded Significant Fauna Species occurring within the Project Area	16
Table 9	Summary of Trapping Effort	17

## Executive Summary

International Minerals (IM) are preparing to begin magnetite mining operations at the Balmoral South deposit located south of Cape Preston, near Karratha. IM commissioned Maunsell Australia Pty Ltd (Maunsell) to conduct Seasonal Flora and Fauna (Biological) surveys of the mining leases and surrounding areas proposed for development for mining purposes.

The Biological Surveys of the proposed mine development specifically dealt with:

- flora;
- vegetation communities;
- vegetation condition;
- observed fauna;
- evidence of fauna activity;
- trapped fauna records
- potentially present fauna; and
- inferred fauna habitats.

During 2000, Maunsell (then Halpern Glick Maunsell (HGM)) conducted a large scale Biological Survey of the area for the Austeel (Mineralogy) project. This survey assessed all of the mining leases (M08/118 to M08/130) covering the Balmoral Deposit held by Mineralogy, including the Balmoral South deposit. Additional areas proposed for impact fall outside this previously surveyed area to the north-east, west and south-west of the Austeel project area. The 2006 surveys involved detailed studies in the previously unsurveyed areas and a review of results gathered during the 2000 survey in the overlapping areas. This review determined that the 2000 survey had been conducted to a stringent level of detail and that even several years later, the results are considered current and credible. Few updates and supplementary additions could be made.

This report presents the findings of the Maunsell biological survey for the proposed mine and associated infrastructure locations, including new survey results from 2006 and conclusions and a review of information gathered as part of the previous study conducted in 2000.

None of the Threatened Flora species identified by the database enquiries for the project area were recorded during the 2000 HGM survey. The 2000 survey recorded two Priority Flora species, *Hibiscus brachysiphonius* (P3) and *Phyllanthus aridus* (P3). The 2006 survey recorded one Priority 3 species, *Goodenia pasqua*.

No species listed as Declared Rare Flora (DRF) by the Department of Environment and Conservation (DEC), under the *Wildlife Conservation Act, 1950*, or as Threatened under the *Environment Protection and Biodiversity Conservation (EPBC) Act, 1999* were recorded within the survey area.

None of the species recorded were found to be exhibiting a range extension from recorded occurrences, as documented by the WA State Herbarium (DEC, 2006).

A total of nine weed species were recorded. Two of these, *\*Prosopis pallida* (Mesquite) and *\*Datura leichhardtii* (Native Thornapple) are listed as Declared Plants by the Department of Agriculture, pursuant to the *Agriculture and Related Resources Protection Act, 1976*. Under the Act, landholders are obliged to carry out recommended control measures. Buffel Grass (*\*Cenchrus ciliaris*) was recorded across most of the project area and is also a significant weed within the region. Weed control measures will be implemented within the project area as specified within the *Agriculture and Related Resources Protection Act, 1976*.

A number of vegetation communities recorded during both the 2000 and 2006 surveys were determined to be of local or regional significance. The significance is due to either communities supporting significant flora, being limited to specific landforms, or both.

The condition of the vegetation within the project area ranges from Completely Degraded to Very Good. The majority of the vegetation is in Good condition, however weed invasion is relatively high throughout the project area.

During the 2000 and 2006 field fauna surveys, no Threatened species of either State (Scheduled under the WA *Wildlife Conservation Act, 1950*) or Commonwealth (under the *EPBC Act, 1999*) significance were recorded.

The 2000 fauna survey did not record any Schedule fauna, but recorded a total of three Priority Fauna species within the Balmoral South Project area. These species were:

- Western Pebble-mound Mouse (*Pseudomys chapmani*);
- Lakeland Downs Mouse (*Leggadina lakedownensis*);
- Eastern Curlew (*Numenius madagascariensis*);
- Little Western Freetail Bat (*Mormopterus loriae cobourgensis*);
- Bush Stonecurlew (*Burhinus grallarius*);
- Beach Stonecurlew (*Esacus neglectus*); and
- Green Turtle (*Chelonia mydas*).

Additional to these Priority species, one undescribed species of rodent (*Pseudomys* sp. "Hamersley") and two undescribed skinks (*Ctenotus* aff. *robustus* and *Ctenotus* sp. nov.) of possible conservation significance were recorded.

During the 2006 survey, only one Priority Fauna species, *Ardeotis australis* (Australian Bustard) was recorded at four separate locations. The Australian Bustard is classified as a Priority 4 species by DEC.

The undescribed species of skink, *Ctenotus* aff. *robustus* was also recorded during the 2006 survey and two species listed under the JAMBA/CAMBA International Agreements for the protection of Migratory bird species were recorded. The Bee Eater (*Merops ornatus*) was recorded regularly throughout the survey area and the White Bellied Sea Eagle (*Haliaeetus leucogaster*) was sighted once.

In general, it has been determined over the course of the 2000 and the 2006 field surveys that the fauna habitats within the project area are all regarded as well represented in the region and none are regraded as regionally significant or unique. Many years of livestock grazing has reduced the quality of available fauna habitat.

The factors of biological significance determined to be present within the Balmoral South project area are:

- Priority 3 Flora species, *Hibiscus brachysiphonius* and *Phyllanthus aridus* were recorded during 2000;
- Priority 3 Flora species, *Goodenia pasqua* was recorded during 2006;
- Declared Plants \**Prosopis pallida* (Mesquite) and \**Datura leichhardtii* (Native Thornapple) recorded throughout the area;
- a range of communities are considered locally or regionally significant due to supporting significant flora or being limited to specific landforms;

- Priority fauna species, Western Pebble Mound Mouse, Lakeland Downs Mouse and Far Eastern Curlew were recorded during 2000;
- Priority fauna species, the Australian Bustard was recorded during 2006;
- two undescribed rodent species were recorded during 2000 and one of these also during 2006; and
- JAMBA/CAMBA Migratory Bird species, the Bee Eater and the White Bellied Sea Eagle were recorded during 2006.

The statutory obligations arising as a result of the flora and fauna surveys are:

- liaison with DEC regarding priority flora and fauna recorded;
- liaison with DEC regarding significant vegetation communities;
- control of Declared Plants as per recommended control measures of the Department of Agriculture and Food; and
- liaison with the DEH regarding migratory bird species.

# 1.0 Introduction

## 1.1 Background

Mineralogy Pty Ltd (Mineralogy) is in the process of finalising environmental approvals for the proposed Cape Preston Iron Ore development located approximately 80km south-west of Karratha. When operational the project will produce up to 19.6 million tonnes per annum of export product utilising part of the estimated 15 - 20 billion tonne ore resource over which mining rights are held by Mineralogy Pty Ltd.

The project will include the development of an open pit, waste dumps, tailings storage facility, product stockpiles and additional infrastructure including access roads, haul roads, construction camps, village, power station, power distribution network and desalinated water plant. Full details of the development and environmental studies undertaken to date are summarised in the Public Environmental Review (PER) and Supplementary Environmental Review (SER) (HGM 2000 and 2002, respectively).

The Balmoral South site is located immediately south of the Mineralogy project within an area reputed to be the world's largest undeveloped magnetite deposit. The proposed project involves the mining of magnetite ore at the Southern Block of the Balmoral magnetite resource located in the Cape Preston area. International Minerals (IM) has entered into an exclusive due diligence and negotiation agreement for mining rights with the vendor, Mineralogy Pty Ltd.

The proposed Balmoral South project includes iron ore mining, ore concentration, ore pelletisation and production of DRI/HBI. Associated site infrastructure include a waste rock dump, tailings pond, transportation and utilities corridors, pre-mining construction facilities and workforce accommodation. The central block of the extensive Balmoral magnetite deposits (Preston Iron Project) includes substantial port and related facilities at Cape Preston. Existing agreements allow access to these facilities. Mineralogy are also seeking permission to develop a borefield west of the Balmoral South deposit, production from which will be available to the Balmoral South project.

International Minerals commissioned Maunsell Australia Pty Ltd (Maunsell) to conduct Seasonal Flora and Fauna (Biological) Surveys of the abovementioned mining and other leases, including some areas already surveyed (HGM, 2000). This report presents the findings of the surveys conducted during 2006.

The Biological Surveys of the proposed mine development specifically dealt with:

- flora;
- vegetation communities;
- vegetation condition;
- observed fauna;
- evidence of fauna activity;
- trapped fauna records
- potentially present fauna; and
- inferred fauna habitats.

## 1.2 Location

The Balmoral South site is located approximately 90km WSW of Karratha and 30km from Cape Preston, within the mining leases 08/126 to 08/130 (Figure 1.1). The study area is comprised of two sections, based on previous recent surveys. Section A refers to areas within the previous project area surveyed by Maunsell (then Halpern Glick Maunsell (HGM)) in 2000 and Section B (referred to as the study area herein) refers to areas outside the previous project area and newly surveyed by Maunsell in 2006. All of the area previously surveyed by Maunsell (2000) that falls within the current study area was also reviewed via a reconnaissance survey with additional quadrat sampling.

## 1.3 Climate

Rainfall is relatively low throughout the general region of the project area. Except in the far south, almost all rain comes from scattered summer thunderstorms and the occasional Tropical Cyclone.

The coast from Port Hedland to Exmouth Gulf is one of the most cyclone prone in Australia with several severe Tropical Cyclones crossing this section of coastline this century. The general rainfall range is 250 - 450mm per annum. In many cases several years may pass without significant rainfall followed by sudden and substantial downpours from Tropical Cyclone activity. In the south where tropical activity is lower, Bureau of Meteorology data (2006) shows lower rainfall totals.

This Pilbara region supports a number of Australia's consistently hottest townships. The normal inland Summer range is 37 - 42°C and the coast such as Port Hedland is 2 - 3 °C cooler, but often with higher humidity. Winter temperatures are warm, winter is a short 6 - 8 week period with temperatures in the 23 - 27°C range.

## 1.4 IBRA Bioregion

The Interim Biogeographic Regionalisation for Australia (IBRA) recognises 85 bioregions. Western Australia supports 53 biogeographical subregions (DEH, 2002). The study area is located in the Pilbara Bioregion which has four subregions; the Chichester, Fortescue Plains, Hamersley and Roebourne. The Pilbara Bioregion is listed as a high priority for funding for land purchase under the national Reserves System Co-operative Program due to the limited representation of the area in conservation reserves.

## 1.5 Existing Environment

### 1.5.1 Soils

The project area falls within the Pilbara Region which lies on a complex mixture of soils. The Balmoral South project area includes the weakly gilgaied cracking clay plains of the Horseflats, rugged basalt or jaspilite plateaus and ridges shifting to stony plains and active floodplains of deltaic deposits flanking major rivers and creeks (HGM, 2001).

### 1.5.2 Land System Units

The study area lies within a region for which the Land Systems have been mapped as part of the rangeland assessment programme (Department of Agriculture, 2004). Digital data was obtained from the current custodian, the Department of Land Information (DLI).

The survey area included portions of eight land systems, described as follows:

**Horseflats** Extensive, weakly gilgaied clay plains with tussock grasslands; prominent in the north west and central portions of the study area;

**Littoral** Coastal fringe consistin of areas of mangal on the seaward fringe, samphire shrublands on mudflats, *Acacia coriacea* shrublands over spinifex or tussock grasses on coastal dunes and *Triodia angusta* hummock grasslands on broad sandy plains.

**Newman** Rugged jaspilite plateaux and ridges with hard Spinifex grassland; prominent in the Northern, central and western sections of the study area.

**Rocklea** Rugged Basalt hills and plateau remnants with hard Spinifex grasslands; prominent in the northern portion of the survey area;

**Paraburdoo** Stony plains derived from basalt, supporting snakewood Shrublands and Spinifex grasslands; occurred around hills of the Newman LS;

**Boolgeeda** Stony lower slopes and plains found below hill systems, supporting hard Spinifex grasslands; occurred as a single patch in the 2000 already surveyed study area);

**River** Active floodplains and terraces flanking major rivers and creeks, supporting riverine woodlands and tussock and hummock grasslands; associated with the Fortescue River system;

**Yamerina** Floodplains and deltaic deposits supporting tussock grasslands with chenopod low shrubs and soft Spinifex grasslands; occurred in the western portions of the study area.

Table 1 presents the distribution of the Vegetation Communities and the seven Land Systems within the areas of the project area proposed for clearing for infrastructure and other development. Spatial distribution of the Land Systems within the study area is presented in Figure 1.2.

**Table 1 Vegetation Communities Affected by Project Infrastructure**

<b>Land System</b>	<b>Vegetation Type</b>	<b>Total Area Proposed for Clearing (ha)</b>
Boolgeeda	Bx1	94.22
Horseflats	Hp	412.6.47
Littoral	Ld2	48.5
	Ld3	9.1
	Ld4	0.72
	Lm	2.69
	Lp1	5.49
	Ls1	16.58
	Ls2	3.39
Newman	Nc	50.99
	Nh	242.66
	Nh2	46.9
	Nh3	12.5825.1
	Nr3	0.16
Paraburdoo	Pc	34.38
	Pc2	5.2
	Pc3	1.7
	Pf1	0.41
	Pp1	55.2
	Pp2	38.64
	Px1	483.4
	Px2	254.0
Rocklea	Rc1	8.77
	Rc2	0.14
	Rc3	10.79
	Rc4	17.85
	ROc2	8.69
	ROc3	0.44
	ROc5	0.32
	ROpl	5.96
Riverland	Rf1	258.86
	Rf2	144.64
	ROh1b	45.8
	ROh2	43.7
	ROr	0.1
		<b>2383.4</b>

### 1.5.3 Flora and Vegetation

The Cape Preston area falls within the northern limit of the Onslow Coastal Plain, a sub-unit of the Fortescue Botanical District as described by Beard (1975) and on the boundary of the Carnarvon and Pilbara IBRA regions.

The Department of Agriculture WA has mapped the Land Systems (and sub-units of these) of the region from 1:50 000 aerial photography and this mapping provides the largest scale interpretation of vegetation units available for the project area (Van Vreeswyk *et al.*, 2004). The Land System Mapping describes sixty four terrestrial vegetation units, comprising nine land systems for the study area.

In general terms, the vegetation of the project area comprises various *Acacia* Shrublands over *Triodia* Hummock Grasslands on the more rugged, shallow soiled habitats and *Eragrostis xerophila* Tussock Grasslands dominating the heavy clay soils. Drainage lines are dominated by *Eucalyptus* species over *Melaleuca* and *Acacia* Shrublands. These areas also tend to be heavily infested with \**Cenchrus ciliaris* (Buffel Grass), a highly invasive weed introduced by pastoralists for its high grazing value.

Beard's (1975) 1:1,000,000 scale mapping of the Pilbara region identified the following broad terrestrial vegetation types occurring in the study area:

T <sub>1</sub> Hi	<i>Triodia pungens</i> steppe (hummock grassland);
A <sub>2</sub> Sr,t <sub>1</sub> Hi	Shrub-steppe of <i>Acacia pyrifolia</i> over <i>Triodia pungens</i> ;
xGc/t <sub>1</sub> Hi	Mosaics of grass savannah with Spinifex <i>Triodia pungens</i> ;
e <sub>40</sub> Lr.xGc	<i>Eucalyptus</i> sp. aff. <i>aspersa</i> sparse tree savannah over short grassland;
a <sub>11</sub> Sb.xGc/a <sub>2</sub> Sr.t <sub>1</sub> Hi	Shrub savannah of <i>Acacia xiphophylla</i> over short grassland and shrub-steppe of <i>Acacia pyrifolia</i> .

Beard's mapping is at a broad scale which requires amalgamation of minor vegetation types and a bias towards large and commonly distributed units. In addition, due to limited sampling, Beard's units often contain inaccuracies.

### 1.5.4 Fauna

As for most of the Pilbara region, the general area of the proposed mining development is relatively poorly surveyed for both flora and especially fauna (HGM, 2000). Recent mining booms in the Pilbara have resulted in the need for a rapid increase in the number of biological surveys conducted.

Typically, adequate fauna trapping and sampling in climates such as the Pilbara is difficult, due to the climate. During higher temperature, there are significant timing limitations as traps must be cleared well before the onset of the heat of the day. Conversely low levels of reptile and small mammal activity are encountered during cooler months. It is therefore considered that at any given time of the year, fauna surveys are unrepresentative of faunal composition of the region.

From what surveys have been carried out, the fauna of the project area has been found to be dominated by avifauna (birds) and reptiles (HGM, 2000; Biota 2005). Several species of mammal are also common, predominantly consisting of small species such as native mice. Several species of conservation significance are known to occur in the area, including the Northern Quoll, Night Parrot, Pilbara Olive Python and the migratory Peregrine Falcon (Biota, 2005). None of these species were identified to occur within the project area.

## 1.6 Biological Factors of Environmental Significance

### 1.6.1 Flora

Species of flora are defined as Declared Rare or Priority conservation status where their populations are restricted geographically or threatened by local processes. The Department of Environment and Conservation (DEC) recognises these threats of extinction and consequently applies regulations towards population and species protection.

Rare Flora species are gazetted under subsection 2 of section 23F of the *Wildlife Conservation Act, 1950*. It is an offence to “take” or damage Rare Flora without Ministerial approval. Section 23F of the *Wildlife Conservation Act, 1950* defines “to take” as “... to gather, pick, cut, pull up, destroy, dig up, remove or injure the flora or to cause or permit the same to be done by any means.”

Species designated as Priority Flora are under consideration for declaration as ‘Rare Flora’ and are in urgent need of further survey (Priority One to Three) or require monitoring every 5-10 years (Priority Four). Table 2 presents the definitions of Declared Rare and the four Priority ratings under the *Wildlife Conservation Act, 1950* as extracted from Department of Conservation and Land Management (2005).

Table 2 Definition of Rare and Priority Flora Species (Department of Conservation and Land Management, 2005)

Conservation Code	Category
DRF	<b>Declared Rare Flora – Extant Taxa</b> “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. ”
P1	<b>Priority One – Poorly Known Taxa</b> “Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat. Such taxa are under consideration for declaration as ‘rare flora’, but are in urgent need of further survey. ”
P2	<b>Priority Two – Poorly Known Taxa</b> “Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (not currently endangered). Such taxa are under consideration for declaration as ‘rare flora’, but urgently need further survey. ”
P3	<b>Priority Three – Poorly Known Taxa</b> “Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (ie. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as ‘rare flora’ but need further survey. ”
P4	<b>Priority Four – Rare Taxa</b> “Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years. ”

Threats of extinction of species are also recognised at a Commonwealth level and are categorised according to the *Environment Protection and Biodiversity Conservation (EPBC) Act, 1999*. Categories of Commonwealth listed threatened species are summarised in Table 3.

Table 3 Categories of Threatened Flora Species (*Environment Protection and Biodiversity Conservation Act, 1999*)

Conservation Code	Category
Ex	<b>Extinct</b> 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	<b>Extinct in the Wild</b> 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.

Conservation Code	Category
CE	<b>Critically Endangered</b> 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	<b>Endangered</b> 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	<b>Vulnerable</b> 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	<b>Conservation Dependent</b> 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.

## 1.6.2 Vegetation

### Threatened Ecological Communities

Communities are described as 'Threatened Ecological Communities' (TECs) if they have been defined by the Western Australian Threatened Ecological Communities Scientific Advisory Committee (DEC) and found to be Presumed Destroyed (PD), Critically Endangered (CR), Endangered (EN) or Vulnerable (VU). For definitions of TEC categories and criteria refer to English and Blyth (1997). CALM maintains a database of state listed TECs which is available for online searches via their website ([www.calm.wa.gov.au](http://www.calm.wa.gov.au)).

Selected plant communities have also been listed as 'Threatened Ecological Communities' under the Commonwealth *EPBC Act, 1999*. The TECs on the commonwealth register are also available online via the Department of Environment and Heritage (DEH) website ([www.deh.gov.au](http://www.deh.gov.au)).

### Locally and Regionally Significant Communities

Vegetation communities are referred to as Locally Significant where they:

- support populations of Priority Flora species;
- extend the geographic range of particular taxa from previously recorded locations;
- are restricted to only one or a few locations;
- occur as small isolated communities; or
- exhibit unusually high structural and species diversity (Dr. E. Matiske, *pers. comm.*).

Vegetation communities are referred to as 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 Declared Rare Flora (Dr. E. Matiske, *pers. comm.*).

### 1.6.3 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. The Department of Conservation and Land Management recognises these threats of extinction and consequently applies regulations towards population and species protection.

Threatened fauna species are protected under Section 16 of the *Wildlife Conservation Act, 1950*. It is an offence to “take, destroy or possess” threatened fauna without Ministerial approval. Species of fauna listed under Schedule 1 to 4 of the *Wildlife Conservation Act, 1950* are summarised in Table 4.

**Table 4 Western Australian *Wildlife Conservation Act, 1950* Codes for Threatened Fauna**

Conservation Code	Category
<b>Schedule 1</b>	Fauna that is rare or likely to become extinct, are declared to be fauna that is in need of special protection.
<b>Schedule 2</b>	Fauna that is presumed to be extinct, are declared to be fauna that is in need of special protection.
<b>Schedule 3</b>	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.
<b>Schedule 4</b>	Fauna that is in need of special protection, otherwise than for the reasons mentioned [in Schedule 1 – 3].

Priority fauna not listed as Threatened (Scheduled) under the *Wildlife Conservation Act, 1950*, but poorly known or poorly represented in the conservation estate are regarded as Priority and attention is given to their conservation, primarily through improving available information, by DEC. The four classifications of priority fauna are listed in Table 5.

**Table 5 Explanation of Priority Codes Observed by DEC**

Category	Code	Description
Priority 1	P1	Taxa with few, poorly known populations on threatened lands
Priority 2	P2	Taxa with few, poorly known populations on conservation lands.
Priority 3	P3	Taxa with several, poorly known populations, some on conservation lands.
Priority 4	P4	Taxa in need of monitoring – considered to have been adequately surveyed
Priority 5	P5	Taxa in need of monitoring – not considered threatened

Threats of extinction of fauna species are also recognised at a Commonwealth level and are categorised according to the *EPBC Act, 1999*. Categories of threatened species are summarised in Table 6.

**Table 6 Categories of Threatened Fauna Species (*Environment Protection and Biodiversity Conservation Act, 1999*)**

<b>Conservation Code</b>	<b>Category</b>
<b>Ex</b>	<b>Extinct</b> Taxa not definitely located in the wild during the past 50 years
<b>ExW</b>	<b>Extinct in the Wild</b> Taxa known to survive only in captivity
<b>CE</b>	<b>Critically Endangered</b> Taxa facing an extremely high risk of extinction in the wild in the immediate future
<b>E</b>	<b>Endangered</b> Taxa facing a very high risk of extinction in the wild in the near future
<b>V</b>	<b>Vulnerable</b> Taxa facing a high risk of extinction in the wild in the medium-term
<b>NT</b>	<b>Near Threatened</b> Taxa that risk becoming Vulnerable in the wild
<b>CD</b>	<b>Conservation Dependent</b> Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened.
<b>DD</b>	<b>Data Deficient (Insufficiently Know)</b> Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

## 2.0 Objectives

The overall objective for the flora and fauna biological assessment of the Balmoral South project area was to identify biological issues that may trigger formal assessment requirements, and to provide advice regarding ecological constraints on the development of the project area.

The specific objectives for the assessment of flora and vegetation values are to:

- review available information on terrestrial flora and vegetation of the study area and surrounds;
- review the conservation status of potential threatened flora and vegetation occurring within the project area;
- conduct a 'Level 2' detailed vegetation and flora survey (EPA 2004a);
- interpret and report on survey results, including a summary of the consequences of these results on environmental approvals;
- identify the potential impacts of the project; and
- provide management recommendations to reduce or eliminate any potential impacts on flora and vegetation.

The specific objectives for the assessment of fauna values are to:

- review available information on terrestrial vertebrate fauna of the study area and surrounds;
- review the conservation status of potential threatened vertebrate fauna occurring within the project area;
- conduct a 'Level 2' detailed fauna survey (EPA 2004a);
- interpret and report on survey results, including a summary of the consequences of these results on environmental approvals;
- identify the potential impacts of the project; and
- provide management recommendations to reduce or eliminate any potential impacts on flora and vegetation.

## 3.0 Methodology

The seasonal surveys of the area proposed for development assessed a range of factors during the field investigations, including:

- *flora*, with the focus on significant flora and threatened species;
- *vegetation communities*, with the focus on threatened ecological communities and local and regional significance;
- *vegetation condition*;
- *fauna*, with the focus on threatened fauna; and
- *fauna habitats*, based on vegetation

### 3.1 Terrestrial Flora and Vegetation Survey

The flora and vegetation field assessment of the Balmoral South study area was conducted in accordance with the EPA Guidance Statement No. 51, *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004) for Level 2 Surveys, encompassing:

- desktop studies;
- field survey, encompassing:
  - review field survey; and
  - detailed field survey (including establishment of permanent study plots).

#### 3.1.1 Desktop Studies

A literature review of limited available information documenting the flora and vegetation of the project area and the Pilbara region was conducted prior to the commencement of field investigations. This review concentrated primarily on the original Biological Survey of the Austeel project area (HGM, 2000).

As part of the desktop studies, a search of the Department of Environment and Conservation's (DECs) Declared Rare and Priority Flora database was undertaken to identify significant flora that could potentially occur in the study area. The search co-ordinates used were 21<sup>0</sup> 00' - 21<sup>0</sup> 19' S and 115<sup>0</sup> 56' - 116<sup>0</sup> 17' E. This investigation encompassed a review of the following databases:

- DEC 'Threatened (Declared Rare) Flora' database; and
- DEC 'Declared Rare and Priority Flora List'

The results of both database searches are presented in the Results section of this report.

A current search of the DEC Threatened Ecological Communities (TEC) database was also conducted for the entire 2006 study area prior to undertaking the field assessment. This search identified that there are no known occurrences of threatened ecological communities within the study area.

#### 3.1.2 Field Survey

The study area occurs in the Northern Province (tropical and semi tropical) which is characterised by summer rainfall events. The study area received significant amount of rainfall in April and May 2006 (Bureau of Meteorology, 2006) therefore the Department of Environment and Conservation (DEC)

agreed that the timing of the survey (July, 2006) was considered optimal for the flowering and presence of annual and ephemeral species potentially occurring within the study area.

The survey was conducted by two botanists and an environmental scientist between the 3<sup>rd</sup> and the 9<sup>th</sup> July 2006, during conditions favourable for accurately identifying the maximum number of species occurring within the study area. This survey was conducted to supplement previous surveys of adjoining areas conducted by Halpern Glick Maunsell during April 2000.

The field investigations were conducted within two sub-sections of the project area; within the Austeel project area, surveyed during 2000 (HGM), as a reconnaissance review and confirmation of existing results and also within the previously unsurveyed sections of the project area, to the north east and south west, studied in more detail.

Assessment of flora and vegetation included:

- broad scale vegetation mapping; and
- detailed permanent plot studies.

The broad scale mapping involved defining vegetation community types by recording accurate information at various locations, based on changes in floristic structure and species composition. Where marked changes in species composition occurred, all flora species encountered were identified and recorded. These proportions were then used to describe the vegetation communities, which could then be plotted onto aerial photography for extrapolation of distribution. The broad scale vegetation mapping described was carried out both within the unsurveyed project area and within the previously surveyed Austeel project area (HGM, 2000) in order to ground truth and review existing results.

Detailed assessment of the flora and vegetation was carried out within permanent vegetation quadrats established in a range of locations and within a range of vegetation communities, representative of the floral composition of the project area. Quadrats of 50m x 50m were established, based on the recommended dimensions for Pilbara vegetation which has relatively low diversity and also to replicate methods used during the 2000 assessment (HGM).

Creekline vegetation was sampled using 2m wide transects, rather than quadrats, in order to capture only the targeted vegetation type. Transect lengths varied based on the width of the riparian vegetation and the entire width was usually captured. In the event that transects encountered more than one distinct vegetation type, data was separated to permit accurate analysis without misleading results.

A total of 34 quadrats were established and recorded across the site, within previously unsurveyed areas. The locations of the detailed recording sites were chosen to represent the major vegetation types occurring within the study area. Due to time limitations, sites were concentrated in areas proposed for development, whilst still sampling a representative suite of vegetation types. Additionally, the DEC had previously identified cracking clay communities of the Horseflat Land System as a likely habitat for threatened flora species. Accordingly, particular attention was paid to sampling in this habitat via quadrats and numerous foot traverses.

Each of the quadrats was permanently pegged with one wooden peg in the north-west corner. Temporary pegs were placed in the remaining three corners during sampling and measuring tapes used to construct the quadrats were kept in place to clearly indicate quadrat boundaries.

Information was collected systematically using standardised data sheets, ensuring accurate and consistent data records. The following records were made at each location:

- quadrat number;
- vegetation community or quadrat location, based on broad scale mapping;
- GPS co-ordinates of the north-west corner peg;
- all flora species,
- dominance of each species;
- average height of each species;
- soil type and colour;
- outcropping rocks and their type;
- topography;
- percentage litter cover;
- percentage bare ground;
- degree of disturbance/weed invasion; and
- type of disturbance, if other than weed invasion (e.g. cattle, erosion, etc.).

Species unidentifiable in the field were systematically collected, pressed, dried and fumigated in accordance with the requirements of the West Australian Herbarium. The plant species were identified and then compared with pressed specimens housed at the West Australian Herbarium. Where appropriate, plant taxonomists with specialist skills were consulted. Nomenclature of the species recorded follows protocols of the West Australian Herbarium (CALM, 2005).

Vegetation condition was determined within each quadrat and at a range of additional locations, based primarily on the ratio of introduced (weed) species to native species. Where marked changes in vegetation condition were noted, detailed recordings were made and the level and nature of disturbance such as grazing or erosion were also considered. The categories used to determine vegetation condition consisted of a combination of methods developed by Keighery (1994) and the Braun-Blanquet Scale (Mueller-Dombois and Ellenberg, 1974) for cover abundance, as summarised in Table 7.

**Table 7 Bushland Condition Ratings (adapted from Keighery, 1994 and the Braun-Blanquet Scale of Cover Abundance (from Mueller-Dombois and Ellenberg, 1974))**

<b>Descriptor</b>	<b>Explanation</b>
Pristine	Pristine or nearly so, no obvious signs of disturbance. <i>0% weed cover</i>
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species. <i>1 – 5% weed cover</i>
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. <i>5 – 25% weed cover</i>
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. <i>25 – 50% weed cover</i>

Descriptor	Explanation
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance of vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing. <i>50 – 75% weed cover</i>
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. <i>75 – 100% weed cover</i>

### 3.1.3 Data Processing

All raw site data was submitted for analysis to Mr Ted Griffin. Data was entered into an Access database containing the entire suite of the Western Australian Flora. The database permits corrections to spelling mistakes and other nomenclature and then accurate data is statistically analysed using PATN (Belbein, 1987) Analysis. The PATN Analysis was used to determine which quadrats (and therefore vegetation communities) are floristically similar. The comparisons were run twice, using both presence / absence data and percentage cover / dominance data. The presence/absence data was found to be most appropriate for assessing the regional nature of the variation in site composition of quadrat data in earlier analysis of the Pilbara bioregion (Ted Griffin *pers. comm.*).

Several modules of the numerical classification package PATN (Belbein 1987) were used for the analysis. The Griffin (2006) report explains these methods and discusses some of the results of the analysis (Appendix A). The quadrat data used for the PATN analysis is included as Appendix B. The qualitative results of PATN analysis were used to refine the classification and distribution of vegetation communities identified in the field.

## 3.2 Vertebrate Fauna Survey

The fauna field assessment of the South Balmoral study area was conducted in accordance with the EPA Guidance Statement No. 56, *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2003) for Level 2 Surveys, encompassing:

- desktop studies;
- field survey, encompassing:
  - opportunistic sightings and sampling; and
  - a targeted trapping program.

### 3.2.1 Desktop Studies

Maunsell conducted a literature review of limited available information documenting the fauna of the project area and the Pilbara region prior to the commencement of field investigations. This review concentrated primarily on the original Biological Survey of the Austeel project area (HGM, 2000).

As part of the desktop studies, a search of the DEC Rare Fauna database was undertaken to identify significant fauna that could potentially occur in the study area. The search co-ordinates used were 4707°S 115.882° E / 20.8749°S 116.415°E (Mardie Station plus 15 km buffer).

The results of the database search are presented below in Table 8.

**Table 8** Recorded Significant Fauna Species occurring within the Project Area

Species	Common Name	Conservation Status	Habitat	Record
<i>Leggadina lakedownensis</i>	Lakeland Downs Mouse	Priority 4	A secretive species is known to occur in the Pilbara and Kimberley. Populations rise and fall dramatically, likely in response to climate and seed availability.	Trapped
<i>Pseudomys chapmani</i>	Western Pebble-mound Mouse	Priority 4	This species is well-known for the characteristic pebble-mounds which it constructs over underground burrow systems. These mounds are most common on spurs and lower slopes of rocky hills.	Definite evidence
<i>Ardeotis australis</i>	Australian Bustard	Priority 4	This species is uncommon and may occur in open or lightly wooded grasslands.	Suspected
<i>Burhinus grallarius</i>	Bush Stonecurlew	Priority 4	A well camouflaged, ground nesting bird which prefers to freeze (fright) rather than fly when disturbed. It inhabits lightly timbered open woodlands.	Sighted

Vegetation mapping and aerial photography of the project area were reviewed prior to the field survey in an effort to locate potential fauna trapping sites. Nominated areas were inspected on site and assessed for suitability and accessibility. Four transect sites were identified, representing a large proportion of the project area. These areas were defined based on the habitat requirements of a range of vertebrate species, including reptiles, mammals and birds and were partially dependant on the level of livestock activity in the immediate area.

### 3.2.2 Field Survey

The fauna field survey was conducted during October in accordance with advice from DEC that this timing would record optimum fauna records. This was predicted as animals feeding on abundant annuals and a range of flowering plants will be most active at this time, following rains and the onset of warmer weather, typical of what occurred during October. In addition, temperatures in the Pilbara region are increasing at this time, and reptiles and other cold blooded animals are regarded as far more active. The field survey took place between the dates of 21<sup>st</sup> and 29<sup>th</sup> of October 2006.

The fauna survey was conducted by an experienced Zoologist assisted by an experienced Environmental Scientist. Sampling for the survey was conducted under DEC Regulation 17 "Licence to Take for Scientific Purposes" No SF005496.

The field survey within the project area specifically included;

- habitat definition, based on vegetation mapping;
- targeted searches along defined transects recording detailed field observations including;
  - evidence of fauna activity such as scats, tracks and fur; and
  - turning over rocks and searching micro-habitats;
- targeted trapping for frogs, reptiles and mammals over a series of consecutive nights, in a range of representative habitats;
- visual avifauna (bird) surveys;

- night time spotlighting for nocturnal species.

Some of the abovementioned sampling activities are described in more detail in the following sections.

## Trapping

Methods employed for the sampling of vertebrate species via trapping included the use of pitfall, funnel and small box (Elliott) traps within the project area. Traps were deployed along four transects with the aim of sampling differing vegetation communities and soil types. Table 9 summarises the trapping effort made during the survey.

**Table 9** Summary of Trapping Effort

Site	Location	Date Set-up	Date Closed	Nights Open	Pit Traps	Elliott Traps	Funnel Traps	Pit Trap Effort	Elliott Trap Effort	Funnel Trap Effort	Total Trap Effort
1		21/10/06	27/10/06	5	10	10	10	50	50	50	150
2		22/10/06	27/10/06	5	10	10	10	50	50	50	150
3		23/10/06	28/10/06	5	10	10	10	50	50	50	150
4		24/10/06	29/10/06	5	10	10	10	50	50	50	150
								200	200	200	600

Each transect line comprised 10 pitfall traps, each placed at an interval of approximately of 25 - 30m, with Elliott traps placed adjacent to every pitfall, (10 Elliott traps per transect). Pitfall traps were made up of 40L PVC buckets with a 25 cm high flywire drift fence extending perpendicular to the transect, for approximately 2.5m either side of the pitfall.

Each pitfall fence was linked to a 15 cm wide and 60 cm long funnel trap. Funnel traps were set up at the end of each drift fence with the funnel's 5cm entrance bisected by the fence. Each funnel trap was covered with shade cloth and where possible positioned under the cover of vegetation to provide shade and cooler conditions for trapped fauna. Elliott traps were baited with a mixture of rolled oats, peanut butter and sardines.

Due to the hot conditions during the survey, trap clearing commenced at first light and was completed by 8am each day. Elliott traps were closed each morning and then re-opened during the late afternoon. Funnel traps were left unzipped during the heat of the day and then re-set in the late afternoon. The procedure for closing and opening traps, whilst time consuming, was necessary to help reduce the chances of fauna mortality under the hot conditions.

Each transect was operated for a total of five consecutive nights, equating to a total of 200 pitfall, 200 Elliott and 200 funnel trap nights.

The placement of traps and site selection was hampered by two key factors.

1. the number of livestock traversing the survey areas; and
2. reduced vegetation (fauna habitat) due to grazing pressure,

The rationale behind spacing the pitfall traps at 25 – 30 m intervals was to help reduce damage to the trap sites caused by grazing livestock. The utilisation of a 100m transect with all pitfall traps linked continuously was abandoned as interference by cattle may have reduced effectiveness of all traps. By spacing the traps it was considered that interference by cattle may have been reduced, as all the trap effort was not confined to a single location.

Further to trap interference, the survey areas were heavily grazed and locating suitable trapping sites that represented all vegetation communities was difficult. Spacing the pitfalls allowed a degree of flexibility in placement and helped capture varying soil types over short distances.

The location of trap transects were determined based on a range of factors, but largely governed by the need to capture a range of vegetation and soil types. The sample sites and information regarding their soil types is presented below.

**(1) Site 1 – North - Western section of the proposed borefield**

**Location:** E 402683.63, N 7655308.79 to E 402937.18, N 7654982.24 (GDA 95 Zone 50).

Soil association generally heavy clay with occasional sandy rises. Encompassing transitions between vegetation systems SG, LAGS and RF2.



**(2) Transect 2 – Southern section of proposed bore field**

**Location:** E 404900.30, N7654171.64 to E 404508.44, N 7654513.55 (GDA 94 Zone 50)

Soil association generally heavy clay with occasional stony and sandy rises. Encompassing vegetation system Rf1.



**(3) Transect 3 – North western end of proposed tailings dam**

**Location:** E 413651.26, N 7666543.71 to E 413271.74, N 7666696.26 (GDA 94 Zone 50)

Soil associations clay and cracking clays, encompassing vegetation systems Hp and Px2.



**(4) Transect 4 –Proposed eastern tailings dam at Du Boulay Creek**

**Location:** E 411368, N 7661768 to E 411274.75 N, 7662132.55 (GDA 94, Zone 50).

Vegetation system Pc, creek lines open to sparse dominated by tree species.



**Avifauna Surveys**

Bird sampling was conducted in conjunction with checking traps and whilst the trap transects were approximately 300m in length, bird surveying was extended to approximately 500 m past the last trap. Birds that were seen or heard at these locations were recorded. Targeted surveys were also conducted along the Fortescue River, De Boulay Creek and areas proposed for tailings dams and the borefield. Opportunistic observations were also recorded whilst driving around site and when spotlighting.

**Spotlighting**

Spotlighting was conducted on five nights commencing at approximately 1900 hrs and concluding at approximately 2200 hrs. Spotlighting was conducted from a vehicle over all access tracks within the survey area, and portions of the creek lines within the proposed tailings dam area were traversed on foot.

### 3.2.3 Data Processing

The taxonomy and nomenclature used for the fauna assessment are based on:

- **Reptiles:** Storr *et al.* (1999), Cogger (2000).
- **Birds:** Johnston (2000), Flegg (2002) and Simpson and Day (2000).
- **Frogs:** Tyler *et al.* (2000).
- **Mammals:** How *et al.* (2001), Menkhorst and Knight (2004).

The taxonomic orders presented in this report are generally based on the Western Australian Museum. Where a discrepancy exists between references, taxonomy follows that used by the Western Australian Museum.

## 4.0 Survey Limitations

### 4.1 Flora and Vegetation

Limitations experienced during the July 2006 flora and vegetation survey included:

- poor accessibility to some areas;
- time limitations to traverse such a large project area with few vehicular access tracks;
- relatively short days in terms of the hours of sunlight, limiting the effective duration of survey days;
- difficulty in placement of pegs for quadrats in compacted clays or rocky soils; and
- a lack of good quality aerial photography, which was not made available until after field investigations, due to a period of high demand and delays at the Department of Land Information (DLI).

Note: none of these limitations affect the quality of survey works conducted.

### 4.2 Fauna

Limitations experienced during the October 2006 fauna survey included:

- difficulty in selecting suitable trapping sites due to the extent of cattle grazing resulting in an absence of ground cover in many areas;
- continual interference with trap lines by grazing live stock, particularly at sites 1 and 2; and
- hot conditions placing pressure on opening/closing traps before temperatures became dangerous for trapped fauna.

## 5.0 Results

### 5.1 Flora

The results of DEC database enquiry for Threatened Flora previously recorded within the project area are presented in Table 10.

**Table 10** Threatened Flora Species Recorded Within the Project Area (DEC, 2006)

Species	Conservation Status	Preferred Habitat	Flowering Period
<i>Acacia glaucocoesia</i>	P3	Hard red loam on plains	Fl. Jul-Sep. Red loam, sandy loam, clay flood plains
<i>Goodenia nuda</i>	P3	Plain. Dry, red sand. Mesquite scrub	Fl. Apr-Aug.
<i>Goodenia pasqua</i>	P3	In red soil. Annual grassland	Fl. May-Aug. Red sandy soils, basaltic plains
<i>Gunnopsis</i> sp. Fortescue (M.E. Trudgen 11019)	P1	N/A	N/A
<i>Owenia acidula</i>	P3	Near creeks. Shrub steppe	N/A

None of the species listed in Table 10 were recorded during the 2000 HGM survey, suggesting that all recorded occurrences of the listed species are from outside the existing Austeel project area.

The 2000 (HGM) survey identified two additional species of Priority Flora within the boundary of the composite current study area (comprising new and old survey areas). A further four species of Priority Flora were recorded during the 2001 survey north of the current project area, towards Cape Preston. These species occur further north, towards Cape Preston. The two species recorded in 2001 within the current survey area are:

- *Hibiscus brachysiphonius* (P3) @ 21° 08' 02.0" S, 116° 07' 08.2" E, within Vegetation Community Bx1; and
- *Phyllanthus aridus* (P3) @ 21° 06' 37.4" S, 116° 07' 58.5"E., within Vegetation Community Rf1.

These species were not recorded during the 2006 survey either at their previously recorded locations, within the previously surveyed area or within the new survey area.

One other Priority 3 species (*Goodenia pasqua*, P3) was recorded within the 2006 survey area at Transect 6. This low herb was collected only once from the Hp community. *Goodenia pasqua* is more typical of Basaltic plains and is known from relatively few populations in Port Headland and the Roebourne area (DEC, 2006).

No species listed as Declared Rare Flora (DRF) by the Department of Environment and Conservation (DEC), under the *Wildlife Conservation Act, 1950*, or as Threatened under the *Environment Protection and Biodiversity Conservation (EPBC) Act, 1999* were recorded within the new survey area.

Within the previously unsurveyed area (outside the overlap of the 2000 (HGM) Austeel project area), a total of 162 vascular flora species, from 94 genera and 36 families were recorded. This total includes 153 (94%) native species and ten (6%) introduced (weed) or non-endemic species. The full list of the vascular plant species recorded in this section of the project area during 2006 is presented in Appendix C. Species represented in quadrats are presented in Appendix D, which also details which quadrat each species was recorded in. Families with the highest representation were Poaceae (Grass family – 26 native taxa; 2 introduced taxa); Papilionaceae (Pea family – 16 native taxa); and the Amaranthaceae (Amaranth Family – 5 native taxa).

Two weed species that were recorded within the study area are listed as Declared Plants by the Department of Agriculture, pursuant to the *Agriculture and Related Resources Protection Act, 1976*. These species are *\*Prosopis pallida* (Mesquite) and *\*Datura leichhardtii* (Native Thornapple) (Department of Agriculture, 2006). Buffel Grass (*\*Cenchrus ciliaris*) is also an important weed recorded as occurring prolifically throughout most of the project area. These three significant weed species are discussed in further detail below.

***\*Prosopis pallida* (Mesquite)**

Several species of *\*Prosopis*, collectively known as Mesquite, were introduced to parts of the State as ornamental plants. The original stock lacked thorns, however this quickly reverted to the heavily spined and highly invasive wild type. All species of *Prosopis* are listed as Declared Plants (noxious weeds) in Western Australia. Mesquite was recorded within 19 of the total 75 quadrats sampled during 2000 and 2006 plus within other areas throughout the study area. Mature plants were largely associated with tributaries and Floodplains of the Fortescue River system and were also commonly growing along vehicle access tracks. The Mesquite hybrid high shrubland (Rf2) and the Mr5 Community represent the most significant stands of this species within the study area.

***\*Datura leichhardtii* (Native Thornapple)**

Native Thornapple (*\*Datura leichhardtii*) was mistakenly thought to be a native plant for many years, although it is actually of Mexican origin. This species is naturalised in the Australian tropics and was recorded from a single location within the study area in community Rf1.

***\*Cenchrus ciliaris* (Buffel Grass)**

Buffel Grass was introduced as a fodder species by pastoralists. While this highly invasive species has demonstrated alleopathic capacities (whereby they release chemicals that inhibit the growth of other species), it is not listed as a Declared Plant due to its importance to the pastoral industry. Dense grasslands of Buffel Grass were prevalent along creek lines and on floodplains within the study area. Carpets of *\*Cenchrus ciliaris* were recorded in scattered locations across the majority of the project area.

Detailed plot surveys within the 2000 (HGM) surveyed area encompassed 11 of the 19 Vegetation Communities recorded. Only data from the plots within these communities is included in results for this report as results outside the current survey area may be considered irrelevant with regard to flora (extrapolation of Vegetation Communities is considered more relevant than for flora, due to potential subtle differences in site conditions that may be present).

The detailed plot surveys within the 2000 (HGM) survey area recorded a total of 38 families from 88 genera and 171 taxa, including a total of 6 introduced (weed) species. The full list of the vascular plant species recorded within these areas during 2000 is presented in Appendix E. Families with the highest representation were Poaceae and Amaranthaceae.

One of the weed species recorded during the 2000 survey is listed as a Declared Plant (Department of Agriculture, 2006). As previously discussed, *Prosopis pallida*, commonly referred to as Mesquite, has infested a range of locations in the entire project area. The significance of this weed is also discussed above.

None of the species recorded during either the 2000 or 2006 surveys were found to be exhibiting a range extension from recorded occurrences, as documented by the WA State Herbarium (DEC, 2006).

## 5.2 Vegetation Communities

The DEC database search for Threatened Ecological Communities (TECs) within the project area did not return any results.

In addition to distinct vegetation communities, described and mapped within the project area during 2000, two of the vegetation types each recorded four separate sub-units and one recorded three sub-units. These sub-units were considered distinct enough to separate in data collection as they differed in species composition and proportions, but were considered too visually similar both on the ground and on aerial photography to be mapped as distinctly different vegetation communities.

The previously surveyed area recorded a total of 19 separate vegetation communities, or 27 communities including unmappable sub-units. Detailed study plots within the Balmoral South project area represent eleven of the 19 vegetation communities recorded during 2000. Seven of the communities recorded are common to both the 2000 and 2006 surveys. The new survey area assessed during 2006 recorded a total of 11 vegetation communities (or 17 including unmappable sub-units). The two combined project areas therefore recorded a total of 23 vegetation communities (or 31 including unmappable sub-units) across the 2001 and 2006 surveys.

The species composition of the vegetation communities recorded during 2006 is provided in Appendix C. The species composition of the 11 vegetation communities represented within quadrats in the Balmoral South area is presented as Appendix D. The spatial distribution of the vegetation communities (both represented within quadrats or otherwise) within areas proposed for clearing for development is presented in Figures 2 to 7. Similarly, the spatial distribution of vegetation communities within the entire project area is presented in Figure 8. A description of each of the vegetation communities recorded during both surveys is provided below, grouped under the Land System in which they occur.

### **Horseflats Land System**

The following vegetation types occurred on clayey plains within the Horseflats Land System. The grasslands and low Shrublands typically occurred as a mosaic (Hp); hence some sites contained portions of more than one sub-unit of the vegetation type. However, these sub-units are not distinct enough to be mapped separately.

#### **Hpg1 *Eragrostis xerophila* open tussock grassland**

Broad areas of red-brown cracking clay plain supported *Eragrostis xerophila* tussock grassland. These were characterised by an open grassland which was strongly dominated by *E. xerophila*, with occasional other grasses such as *Dichanthium sericeum* subsp. *humilius* and *Xerochloa imberbis*. Scattered herbs included *Corchorus tridens*, *Lotus australis*, *Phyllanthus maderaspatensis* var. *angustifolius*, *Rhynchosia* aff. *minima* and *Stemodia kingii*. The cracking clays largely preclude growth of larger shrub species, however occasional small shrubs were recorded including *Indigofera trita*, *Neptunia dimorphantha* and forms of *Sida* aff. *fibulifera*. This vegetation type was generally in very good condition, despite being subject to grazing. The cracking clay substrate prevents substantial invasion by Buffel grass *\*Cenchrus ciliaris*, which is a pervasive weed on sandier soils within the survey area.

#### **Hpg2 *Eriachne benthamii* tussock grassland**

Localised wetter areas within the clay plains supported *Eriachne benthamii* tussock grasslands. The *Eriachne benthamii* grasslands were typically more dense than the *Eragrostis xerophila* grasslands. Apart from the obvious difference in the dominant grass species, the two grasslands supported quite similar species mixes. However, a number of species which are typical of wet areas were only

recorded from the *E. benthamii* grasslands, including *Cyperus iria*, *C. squarrosus* and *Marsilea hirsuta*. Like the previous vegetation type, the *E. benthamii* grasslands were generally in very good condition, with little invasion by Buffel grass (*\*Cenchrus ciliaris*) and no obvious grazing effects.

### **Hpg3 *Xerochloa imberbis* grassland**

Small patches of grassland dominated by *Xerochloa imberbis* were recorded on clay plains within the survey area. These occurred principally within the Horseflats and Paraburdoo Land System. The vegetation at this site was characterised by a moderately dense, very low (~10cm tall) grassland of *X. imberbis*, with very occasional individuals of *\*Cenchrus ciliaris*. The very sparse cover of herbs was dominated by *Ptilotus murrayi* var. *murrayi*; other species present included *Portulaca oleracea*, *P. pilosa*, *Rhynchosia* cf. *minima* and *Trianthema triquetra*. Very occasional low shrubs were recorded, including species typical of clay plains (eg. *Neptunia dimorphantha* and *Sida* aff. *fibulifera* 'var. L') and species characteristic of saline soils (*Atriplex bunburyana* and *Trianthema turgidifolia*). This vegetation type was in very good condition, with occasional weeds representing the primary disturbance.

### **Hps1 *Sida* aff. *fibulifera* low shrubland over very open herbland**

Patches of low shrubland were observed within the clayey plains in the survey area. These were dominated by *Sida* aff. *fibulifera*, with occasional individuals of *Neptunia dimorphantha*. Scattered grasses included *Aristida contorta*, *\*Cenchrus ciliaris*, *Dichanthium sericeum* subsp. *humilius*, *Enneapogon caeruleus* and *Sporobolus australasicus*. *Streptoglossa liatroides* were the most abundant herb species; others present were *Phyllanthus maderaspatensis* var. *angustifolius*, *Rhynchosia* cf. *minima* and *Sclerolaena costata*. This vegetation type was in very good condition, with occasional weeds representing the primary disturbance.

## **Newman Land System**

The hills were dominated by hummock grasslands of the Newman Land System. These were separated on the basis of differing overstorey layers, which ranged from virtually absent to an open shrubland dominated by some combination of *Acacia* and/or *Senna* species. These grasslands were difficult to map separately as they tended to occur as a mosaic, and also because the different units had a similar photo pattern.

### **Nh1 *Triodia wiseana* hummock grassland**

Areas of hillslopes with very shallow soil in both the Newman and Rocklea Land System supported a moderately dense hummock grassland of *Triodia wiseana* with negligible overstorey. Very occasional low shrubs included *Solanum horridum*, *S. lasiophyllum*, *Tephrosia supina* and *Triumfetta clementii*. *Paspalidium clementii* was the only regularly recorded grass species (other than spinifex), while very scattered sedges included *Bulbostylis barbata* and *Fimbristylis dichotoma*. The very sparse herb stratum included *Crotalaria medicaginea*, *Evolvulus alsinoides* var. *villosicalyx*, *Gomphrena cunninghamii*, *Trachymene oleracea* and *Trichodesma zeylanicum*. This vegetation ranged from very good to excellent condition, with very few weeds recorded. Buffel grass *\*Cenchrus ciliaris* was conspicuously absent.

### **Nh2 *Acacia bivenosa*, *A ancistrocarpa* open shrubland over *Triodia wiseana* hummock grassland**

Hillslopes within the Newman Land System supported an open shrubland dominated by *Acacia bivenosa*, with lesser amounts of *Acacia ancistrocarpa*, over a moderately dense hummock grassland of *Triodia wiseana*. Other tall shrubs frequently recorded included *Acacia coriacea* subsp. *coriacea*, *A. pyrifolia* and *Senna glutinosa* subsp. *pruinosa*. Scattered low shrubs included *Corchorus laniflorus*, *Indigofera monophylla*, *Solanum lasiophyllum* and *Triumfetta clementii*. Grasses such as *Cymbopogon ambiguus*, *Digitaria brownii* and *Paspalidium clementii* provided a very sparse cover, while scattered herbs included *\*Bidens bipinnata*, *Bonamia media* var. *villosa*,

*Cassytha capillaris*, *Evolvulus alsinoides* var. *villosicalyx*, *Hybanthus aurantiacus*, *Polygala* aff. *isingii*, *Ptilotus aervoides*, *Trachymene oleracea* and *Trichodesma zeylanicum*. This vegetation type was generally in very good to excellent condition, with few obvious signs of disturbance.

### **Nh3 *Acacia bivenosa* open shrubland over *Triodia wiseana* hummock grassland**

This vegetation type was similar to the previous, differing primarily in the general lack of *Acacia ancistrocarpa* and *A. pyrifolia* in the tall shrub stratum. Other notable differences included the absence of *Hybanthus aurantiacus* and *Ptilotus aervoides* and the presence of *Tephrosia supina* within this vegetation. The differences in species composition would appear to indicate a lower water availability in this (Nh3) vegetation type. This vegetation was mostly in very good condition, with few signs of disturbance apart from occasional weeds. Mesquite *\*Prosopis pallida* hybrid seedlings were recorded at some of the sites within this vegetation type, but did not appear to survive to maturity.

A number of distinct vegetation types associated with minor flowlines within the Newman Land System were observed, however these were impossible to map separately due to their extreme variability.

### **Nc1 *Corymbia hamersleyana* scattered low trees over *Acacia ancistrocarpa*, *A. tumida*, *Petalostylis labicheoides* open scrub over *Triodia pungens* hummock grassland**

Narrow flowlines within the rocky hills of the Newman Land System often supported scattered low trees of *Corymbia hamersleyana* over a tall shrubland which was dominated by a mixture of *Acacia ancistrocarpa*, *A. tumida* and *Petalostylis labicheoides*, usually with lesser amounts of *Acacia bivenosa*. Low shrubs generally provided a sparse cover and were dominated by *Indigofera monophylla*. Other species recorded included *Abutilon lepidum*, *Corchorus laniflorus*, *Isotropis atropurpurea*, *Solanum gabrielae*, *S. lasiophyllum*, *Triumfetta clementii* and *Waltheria indica*. Soft spinifex *Triodia pungens* provided an open cover, usually with some *Triodia wiseana* from the surrounding hummock grasslands. Other grasses recorded included *Digitaria brownii*, *Eriachne mucronata* and *Paspalidium clementii*. A large variety of herbs were recorded, including *\*Bidens bipinnata*, *Goodenia stobbsiana*, *Hybanthus aurantiacus*, *\*Malvastrum americanum*, *Pterocaulon sphacelatum* and *Trichodesma zeylanicum*. The lianes *Cassytha capillaris* and *Porana commixta* were also often present. This vegetation type was generally in very good condition, with minor weed invasion being the primary disturbance noted.

### **Nc2 *Acacia monticola* dominated open scrub over *Triodia wiseana* hummock grassland**

Other sections of narrow flowlines supported a tall shrubland dominated by *Acacia monticola*, usually with lesser amounts of *Acacia ancistrocarpa*, *A. bivenosa*, *A. coriacea* subsp. *pendens*, *A. pyrifolia*, and sometimes with significant amounts of *Petalostylis labicheoides*. The cover of low trees of *Corymbia hamersleyana* ranged from negligible to open. The sparse cover of low shrubs was again dominated by *Indigofera monophylla*, and also included *Corchorus laniflorus*, *Solanum horridum* and *Triumfetta clementii*. The moderately dense spinifex layer was dominated by *Triodia wiseana*, with small amounts of *T. epactia*. Other grasses noted included *Cymbopogon ambiguus* and *Digitaria brownii*. A variety of herbs were recorded, including *\*Bidens bipinnata*, *Bonamia media* var. *villosa*, *Hybanthus aurantiacus*, *Evolvulus alsinoides*, *Trachymene oleracea* and *Trichodesma zeylanicum*. The taxa *Cassytha capillaris* and *Porana commixta* were also recorded. This vegetation type was generally in very good condition, with minor weed invasion.

### **Nc3 *Acacia coriacea* high shrubland over *Triodia wiseana* hummock grassland**

Some minor flowlines on Cape Preston supported sparse to open tall shrublands dominated by *Acacia coriacea* subsp. *pendens*, frequently over *A. bivenosa*. Other tall shrubs recorded included *Acacia elachantha*, *A. pyrifolia*, *A. tumida* and *Scaevola spinescens*. The sparse cover of low shrubs included *Achyranthes aspera*, *Indigofera monophylla*, *Melhania oblongifolia*, *Solanum lasiophyllum* and *Triumfetta clementii*. The cover of spinifex *Triodia wiseana* ranged from sparse to moderately

dense. The sparse cover of other grasses included *\*Cenchrus ciliaris*, *Cymbopogon ambiguus*, *C. obtectus* and *Paspalidium clementii*. The very sparse cover of herbs included *Alternanthera nana*, *Bonamia media*, *Evolvulus* species, *Hybanthus aurantiacus*, *\*Malvastrum americanum*, *Phyllanthus maderaspatensis* var. *angustifolius*, *Portulaca pilosa*, *Trachymene oleracea* and *Trichodesma zeylanicum*. This vegetation type was generally in very good condition, with only minor invasion by weeds.

#### **Nc4 *Acacia coriacea* high shrubland over *Eriachne benthamii*, *\*Cenchrus ciliaris* tussock grassland**

Located between a ridge of Newman Land System and a plain of Yamerina Land System, this flowline supported a tall shrubland of *Acacia coriacea* subsp. *pendens*, with occasional individuals of *Acacia bivenosa*, *A. elachantha*, *A. farnesiana* and *Ehretia saligna*. Scattered low shrubs included *Achyranthes aspera*, *Indigofera* species, *\*Melochia pyramidata*, *Sida* aff. *fibulifera* (MET Site 1346), *Sida rohlenae*, *Solanum lasiophyllum* and *Triumfetta clementii*. The moderately dense cover of tussock grasses was dominated by *Eriachne benthamii*, with lesser amounts of *\*Cenchrus ciliaris*. A variety of other grasses was recorded including *Bothriochloa ewartiana*, *Chrysopogon fallax* and *Eragrostis* species. Very occasional spinifex hummocks were recorded, particularly of *Triodia angusta*. Scattered sedges included *Bulbostylis barbata*, *Cyperus iria* and *Fimbristylis depauperata*. The sparse but diverse array of herbs included *\*Bidens bipinnata*, *Corchorus tridens*, *Evolvulus alsinoides*, *Hybanthus aurantiacus*, *Ipomoea muelleri*, *\*Malvastrum americanum*, *Marsilea hirsuta*, *Phyllanthus maderaspatensis* var. *angustifolius* and *Rostellularia adscendens* var. *clementii*. This vegetation type was in good condition, with invasion by Buffel grass representing the major disturbance.

#### **Rocklea Land System**

Similar to the Newman Land System, hummock grasslands of the low hills of the Rocklea Land System frequently occurred as a mosaic and hence could not be mapped separately. These were separated on the basis of differing overstoreys, which ranged from virtually absent, to low open shrublands of the pea *Indigofera monophylla*, to sparse or open shrublands of mixed *Acacia* species.

#### **ROh1b *Indigofera monophylla* low open shrubland over *Triodia wiseana* hummock grassland**

Stony hillslopes in the northern section of the survey area, typically supported a low shrubland dominated by *Indigofera monophylla*, often with *Corchorus walcottii*, over a moderately dense hummock grassland of *Triodia wiseana*. Other low shrub species recorded included *Crotalaria novae-hollandiae*, *Hibiscus* aff. *platyklamys*, *Melhania oblongifolia*, *Scaevola spinescens*, *Solanum diversiflorum*, *S. lasiophyllum*, *Tephrosia supina* and *Triumfetta clementii*. Tall shrubs were occasional only and included *Acacia bivenosa*, *A. coriacea* subsp. *coriacea* and *A. pyriformis*. The very sparse cover of grasses other than spinifex included *\*Cenchrus ciliaris*, *Cymbopogon ambiguus* and *Paspalidium clementii*. The variety of herbs which contributed a very sparse cover was often dominated by *Euphorbia schultzei*, and also included *Boerhavia gardneri*, *Bonamia media* var. *villosa*, *Evolvulus alsinoides* var. *villosicalyx*, *Gomphrena cunninghamii*, *Hybanthus aurantiacus*, *Phyllanthus maderaspatensis* var. *angustifolius*, *Polycarpha longiflora* (pale form), *Pterocaulon sphacelatum*, *Rhynchosia* cf. *minima*, *Trachymene oleracea* and *Trichodesma zeylanicum*. This vegetation type was typically in very good condition, with only scattered weeds (primarily Buffel grass).

#### **Paraburdoo Land System**

Snakewood (*Acacia xiphophylla*) shrublands characterise the Paraburdoo Land System, and a number of distinct Snakewood types were recognised for it, based primarily on the composition of the understorey. These shrublands frequently occurred in a mosaic with annual herblands on cracking clay and with the grasslands described for the Horseflats Land System. Snakewood shrublands also dominated the section of Boolgeeda Land System within the study area and occurred occasionally within the Rocklea Land System.

**Px1 *Acacia xiphophylla* open shrubland over patches of *Triodia wiseana* hummock grassland**

This represented the most common of the Snakewood vegetation types, occurring generally on the stony plains of the Paraburdoo Land System. It consisted of a sparse to open (typically ~5-10 % cover) tall shrubland of *Acacia xiphophylla* over patches of moderately dense *Triodia wiseana* hummock grassland. Other shrubs were infrequent, however the low shrubs *Enchylaena tomentosa* and *Maireana planifolia* were commonly present. Grasses other than spinifex generally contributed a very sparse cover but included a variety of species (e.g. *Aristida contorta*, *\*Cenchrus ciliaris*, *\*C. setigerus*, *Enneapogon caerulescens*, *Eragrostis xerophila*, *Eriachne pulchella* subsp. *dominii*, *Iseilema dolichotrichum*, *Paspalidium clementii*, *Sporobolus australasicus* and *Tragus australianus*). Very sparse herbs included *Evolvulus alsinoides* var. *villosicalyx*, *Leptopus decaisnei*, *Portulaca oleracea* and *Sclerolaena eriakantha*. This vegetation was generally in very good condition, with only scattered weeds at most sites.

**Px2 *Acacia xiphophylla* open shrubland over patches of *Eragrostis xerophila* tussock grassland**

Areas of clayey plain within the Paraburdoo Land System, particularly near boundaries with the Horseflats Land System, supported open shrublands of *Acacia xiphophylla* over occasional low shrubs such as *Enchylaena tomentosa* and *Neptunia dimorphantha*. The patches of moderately dense tussock grasses were typically dominated by *Eragrostis xerophila*, sometimes with significant amounts of *\*Cenchrus ciliaris* and/or *Eriachne benthamii*. Other species recorded included *Enneapogon caerulescens*, *Enteropogon acicularis*, *Sporobolus australasicus* and *Xerochloa imberbis*. Herbs were very sparse but included *Cleome viscosa*, *Heliotropium heteranthum*, *Hibiscus brachysiphonius* (Priority 3), *\*Malvastrum americanum*, *Portulaca oleracea* and *Streptoglossa liatroides*. This vegetation type was generally in very good condition, with only minor invasion by weed species.

The Paraburdoo System was also found to support *Eucalypt* communities that dominate the creeklines. The Pc vegetation type typically occurred as a mosaic and some areas mapped as PC may therefore contain more than one sub-unit, however, these sub-units are not distinct enough to be mapped separately.

**Pc1 *Eucalyptus victrix*, *E. camaldulensis* woodland over *Acacia coriacea*, Mesquite high shrubland over open herbland**

This vegetation type was recorded within the bed of a major creekline. It consisted of a woodland of *Eucalyptus victrix* and *E. camaldulensis* over a high shrubland dominated by *Acacia coriacea* subsp. *pendens*, with significant invasion by Mesquite (*\*Prosopis pallida* hybrid). Other tall shrubs recorded included *Acacia pyrifolia*, *A. trachycarpa*, *Ehretia saligna*, *Eremophila longifolia*, *Melaleuca glomerata* and *Santalum lanceolatum*. Scattered low shrubs included *Achyranthes aspera*, *Plumbago zeylanicum*, *Sesbania cannabina* and *Triumfetta clementii*. Grasses such as *\*Cenchrus ciliaris*, *\*C. setigerus*, *Eragrostis tenellula* and *Eriachne benthamii* provided a very sparse to sparse cover. The sparse to open herb stratum was dominated by *Alternanthera nana*, with lesser amounts of *Vigna lanceolata* var. *lanceolata*. A variety of other species was recorded including *Cleome viscosa*, *Hybanthus aurantiacus*, *Ipomoea muelleri*, *\*Malvastrum americanum*, *\*Melochia pyramidata*, the Priority 3 species *Phyllanthus aridus*, *Phyllanthus maderaspatensis* var. *angustifolius*, *Pterocaulon sphacelatum*, *Rostellularia adscendens* var. *clementii*, *Trichodesma zeylanicum* and the lianes *\*Cucumis melo* subsp. *agrestis*, *Ipomoea muelleri* and *\*Passiflora foetida*. Occasional sedges included *Cyperus bifax* and *C. vaginatus*. This vegetation type was in moderate condition with the invasion by Mesquite being the major disturbance. (Site 59).

**Pc2 *Eucalyptus victrix* open woodland over *Acacia coriacea* high shrubland over *\*Cenchrus* species tussock grassland**

This vegetation type occurred along minor creeklines within the Paraburdoo LS. It consisted of trees of *Eucalyptus victrix*, ranging in cover from scattered to an open woodland, over a high shrubland dominated by *Acacia coriacea* subsp. *pendens*. Other tall shrub species recorded included *Acacia farnesiana* and *A. pyrifolia*, while scattered low shrubs included *Achyranthes aspera*, *Sesbania cannabina* and *Triumfetta clementii*. The moderately dense to dense grassland was dominated by \**Cenchrus ciliaris* and \**C. setigerus*. Other grasses recorded included *Dactyloctenium radulans*, the Priority 3 species *Eriachne tenuiculmis* (only at Site M006), and spinifex (*Triodia angusta* or *T. pungens*). While the spinifex usually occurred only as scattered individuals, the cover of *T. angusta* at Site M043 was as high as 10%. A variety of herbs contributed a very sparse cover, including *Alternanthera nana*, *Amaranthus pallidiflorus*, \**Bidens bipinnata*, *Cleome viscosa*, *Hybanthus aurantiacus*, *Leptopus decaisnei*, \**Malvastrum americanum*, *Operculina aequisejala*, *Phyllanthus maderaspatensis* var. *angustifolius* and *Rostellularia adscendens* var. *clementii*. This vegetation was generally in good to moderate condition, with invasion by Buffel Grass being the major disturbance factor noted. (Sites M006, M025, M043 & M066).

### **Pc3 *Eucalyptus victrix* open woodland over *Acacia coriacea* high open shrubland over *Triodia epactia* open curly spinifex grassland and \**Cenchrus ciliaris* open tussock grassland**

This vegetation type was recorded within a single small creekline. It had an open woodland of *Eucalyptus victrix* over a high open shrubland of *Acacia coriacea* subsp. *pendens*, with occasional other species such as *Acacia bivenosa*, *A. pyrifolia* and *Eremophila longifolia*. Scattered low shrubs included *Achyranthes aspera*, *Isotropis atropurpurea*, *Solanum horridum*, *S. lasiophyllum*, *Triumfetta clementii* and *Waltheria indica*. *Triodia epactia* contributed ~12 % cover, while the moderate cover of other grasses was dominated by \**Cenchrus ciliaris*, and also included small amounts of *Cymbopogon ambiguus*, *Digitaria brownii*, *D. ctenantha* and *Themeda triandra*. A variety of herbs was recorded, including *Alternanthera nana*, *Amaranthus pallidiflorus*, *Cassytha capillaris*, *Glycine canescens*, *Ipomoea muelleri*, \**Malvastrum americanum*, various species with affinities to *Mukia maderaspatana*, *Polymeria ambigua* and *Vigna lanceolata* var. *lanceolata*. This vegetation type was in very good condition, with minor invasion by weeds being the major disturbance. (Site M029).

### **Yamerina Land System**

The Yamerina Land System occurred as broad plains in the western section of the study area.

### **Pp2 *Triodia angusta* hummock grassland with patches of open herbland**

This vegetation occurred broadly on stony plains in the south-western section of the survey area. It consisted of a moderately dense to dense hummock grassland of *Triodia angusta*, with a very sparse to sparse overstorey of low shrubs, principally *Atriplex bunburyana*, *Indigofera trita* and *Sclerolaena hostilis*. Very occasional grasses included \**Cenchrus ciliaris*, *Dactyloctenium radulans* and *Dichanthium sericeum* subsp. *humilius*, while occasional sedges (*Fimbristylis dichotoma*) were also present. Herbs were very sparse within the general hummock grassland and included *Cassytha capillaris*, *Corchorus tridens*, *Crotalaria medicaginea*, *Evolvulus alsinoides* var. *villosicalyx*, *Phyllanthus maderaspatensis* var. *angustifolius*, *Polycarpaea corymbosa* and *Portulaca pilosa*. Small patches of open herblands in the area supported greater densities of these species, together with others such as *Trianthema turgidifolia* and *Sclerolaena ericantha*. This vegetation community was in very good condition, with occasional weeds being the main disturbance noted.

### **Boolgeeda Land System**

#### **Bx1 *Acacia xiphophylla* open shrubland over *Triodia epactia* hummock grassland**

The single site located on the area of Boolgeeda Land System west of the Southern Ore Body comprised an open shrubland of *Acacia xiphophylla* over a moderately dense *Triodia epactia* hummock grassland. *Triodia wiseana* was present only as very occasional hummocks. Other species noted were relatively similar to those recorded for the more broadly distributed Snakewood shrublands over *Triodia wiseana* (see Px1). Scattered low shrubs included *Enchylaena tomentosa*, *Indigastrium parviflorum*, *Solanum horridum*, *S. lasiophyllum* and *Triumfetta clementii*. Occasional grasses again included \**Cenchrus ciliaris*, *Enneapogon caeruleus*, *Eriachne pulchella* subsp. *dominii*, *Paspalidium clementii* and *Sporobolus australasicus*. The very sparse herb stratum was not

particularly diverse but included *Evolvulus alsinoides* var. *villosicalyx*, the Priority 3 *Hibiscus brachysiphonius* and *Leptopus decaisnei*. This vegetation type was in very good condition, with only scattered weeds.

### **River Land System**

#### **Rc1 Scattered riverine trees and shrubs**

Areas of scoured creekbed occurred within major creeklines associated with the Fortescue River system. These consisted primarily of bare gravels, with occasional trees and tall shrubs of species occurring on the creek banks (eg. *Eucalyptus camaldulensis* and *Melaleuca glomerata*). Herbs and grasses were sometimes abundant on islands within the creek beds.

#### **Rc2 Cadjeput *Melaleuca argentea*, River Redgum *Eucalyptus camaldulensis* open forest over patches of *Acacia coriacea* high shrubland over \**Cenchrus* species tussock grassland**

Only one location supporting Cadjeputs was observed during the field survey (although it should be noted that the entire river system was not traversed). Site M126 (from the 2000 assessment) was located on a permanent pool which supported an open forest (12-15 m tall) of *Melaleuca argentea* and *Eucalyptus camaldulensis*. Patches of tall shrubs were dominated by *Acacia coriacea* subsp. *pendens*, and also included scattered *Acacia trachycarpa*, *Erythrina vespertilio* and a single Mesquite (\**Prosopis pallida* hybrid). \**Cenchrus ciliaris* and \**C. setigerus* dominated the moderately dense cover of grasses, while small patches of sedges included *Bulbostylis barbata*, *Cyperus bifax*, *C. squarrosus* and *C. vaginatus*. A variety of herbs was recorded, including *Alternanthera nodiflora*, *Ipomoea muelleri*, \**Malvastrum americanum*, *Marsilea hirsuta*, \**Melochia pyramidata* and *Rostellularia adscendens* var. *clementii*. This vegetation was in good condition, with invasion by introduced grasses being the only obvious disturbance.

#### **Rc3 *Eucalyptus camaldulensis* woodland over patches of *Melaleuca glomerata* high shrubland over patches of *Cyperus vaginatus* sedgeland**

This riverine vegetation was recorded only within major tributaries of the Fortescue River system. It consisted of a woodland of *Eucalyptus camaldulensis*, with occasional individuals of *E. victrix*, over patches of tall shrubs dominated by *Melaleuca glomerata*. Other tall shrubs recorded included *Acacia coriacea* subsp. *pendens* and very occasional Mesquite \**Prosopis pallida* hybrid. The sparse cover of low shrubs included *Achyranthes aspera* and *Sesbania cannabina*. Patches of sedges were dominated by *Cyperus vaginatus*. Other species noted included *Cyperus squarrosus* and *Typha domingensis*. Sparse grasses were typically dominated by \**Cenchrus ciliaris*. The sparse herb stratum contained a variety of species including *Amaranthus pallidiflorus*, \**Argemone ochroleuca* (only at Site M124 from the 2000 assessment), *Basilicum polystachyon*, *Datura leichhardtii*, \**Melochia pyramidata*, *Mimulus gracilis*, *Rostellularia adscendens* var. *clementii*, and the lianes \**Cucumis melo* subsp. *agrestis*, *Operculina aequisejala* and \**Passiflora foetida*. This vegetation type was in good condition, with the major disturbance being invasion by weeds.

#### **Rc4 *Eucalyptus victrix*, *E. camaldulensis* woodland over patches of *Melaleuca glomerata* high shrubland over \**Cenchrus* species tussock grassland**

This vegetation type occurred in tributaries of the Fortescue River System and in Eramurra Creek. It consisted of a woodland of *Eucalyptus victrix* with lesser amounts of *E. camaldulensis* over patches of tall shrubs dominated by *Melaleuca glomerata*, frequently with small amounts of *Acacia ampliceps*. Other tall shrub species included *Acacia coriacea* subsp. *pendens* and scattered Mesquite \**Prosopis pallida* hybrid, recorded from Site M101 only (from the 2000 assessment). Low shrubs such as *Sesbania cannabina* provided a very sparse cover. The moderately dense cover of grasses was dominated by \**Cenchrus ciliaris* and \**C. setigerus*, with occasional individuals of other species such as *Dactyloctenium radulans* and \**Setaria verticillata*. Scattered patches of sedges included the species *Cyperus bifax*, *C. bulbosus*, *C. squarrosus*, *C. vaginatus* and *Schoenoplectus litoralis*. Herbs provided a very sparse to sparse cover and included *Amaranthus pallidiflorus*, *Corchorus tridens*, *Ipomoea muelleri*, *Nicotiana rosulata* subsp. *rosulata*, *Phyllanthus maderaspatensis* var. *angustifolius*, *Pluchea rubelliflora* and *Stemodia grossa*. This vegetation was considered to be in moderate condition, with the heavy infestations of introduced grasses being the major disturbance.

#### **Rf1 *Eucalyptus victrix* open woodland over \**Cenchrus* species tussock grassland**

This vegetation type occurred on floodplains associated with the Fortescue River system. It consisted of scattered tall trees of *Eucalyptus victrix* with occasional low trees of *Erythrina vespertilio* over a moderately dense grassland dominated by \**Cenchrus ciliaris* and \**C. setigerus*. Very occasional tall shrubs included *Melaleuca glomerata*, which had been killed by a fire. A variety of herbs contributed a very sparse cover, including species such as *Alternanthera nodiflora*, *Amaranthus pallidiflorus*, *Ammannia baccifera*, Mexican poppy \**Argemone ochroleuca*, *Basilicum polystachyon*, *Datura leichhardtii*, *Glinus lotoides*, *Rostellularia adscendens* var. *clementii*, *Stemodia grossa*, and the lianes *Ipomoea muelleri*, *Operculina aequisejala* and \**Passiflora foetida*. This vegetation was in moderate condition, with heavy invasion by introduced grasses representing the major disturbance.

#### **Rf2 Mesquite \**Prosopis pallida* hybrid high shrubland to open scrub**

Moderately dense, tall shrublands (>2m in height) of the Declared Weed Mesquite (a hybrid form of \**Prosopis pallida*) occurred in the south of the survey area on dense clayey plains associated with the Fortescue River system. These shrublands tended to occur over patches of Birdwood grass (\**Cenchrus setigerus*) and Buffel grass (\**C. ciliaris*). The few other species present included occasional low shrubs (eg. *Sida* aff. *fibulifera* 'var. L') and herbs such as *Euphorbia tannensis* subsp. *eremophila*, *Ptilotus aervoides*, *Salsola tragus* and *Trianthema triquetra*. These shrublands were completely degraded, being heavily infested by Mesquite.

### **Macroy Land System**

#### **#Mr3 Low Shrubland of *Acacia* spp. over a \**Cenchrus ciliaris* and *Brachyachne convergens* Grassland**

This vegetation type consists of a Low Shrubland of *Acacia* spp. including *Acacia inaequilatera*, *Acacia sclerosperma* subsp. *sclerosperma*, *Acacia coriacea* var. *coriacea* and *Acacia victoriae* over a mid-dense Grassland of \**Cenchrus ciliaris* and *Brachyachne convergens*. Occasional other grasses include *Eriachne* aff. *helmsii* and *Themeda triandra*.

#### **#Mr4 Low Shrubland dominated by *Ptilotus aervoides* and *Sida rohlenae* over a Mid Dense Hummock Grassland of *Triodia wiseana* and *Enneapogon caerulecens***

This Low Shrubland is dominated by low shrubs including *Ptilotus aervoides* and *Sida rohlenae* with scattered *Triumfetta clementii* and typically occurred over a mid-dense Hummock Grassland usually consisting of little more than *Triodia wiseana* and *Enneapogon caerulecens*. Occasional other grasses include *Aristida contorta* and \**Cenchrus ciliaris*. This vegetation community was found to have low disturbance.

#### **#Mr5 Very Open Mixed Herbland with infestation of Mesquite (\**Prosopis pallida*)**

This highly disturbed association was dominated by large quantities of the Declared Weed, Mesquite (also known as Mesquite). A range of other herbaceous species were recorded as seasonally occurring, including *Ptilotus aervoides*, *\*Malvastrum americanum* and *Ptilotus exaltatus* var. *exaltatus* occurring over perennial grasses including *\*Cenchrus ciliaris*, *Sporobolus australasicus* and *Enneapogon caerulescens*.

#### **#Mr6 Closed Tussock Grassland dominated by *Enneapogon caerulescens*, *Aristida contorta* and *Eriachne benthamii***

A Closed Tussock Grassland of *Enneapogon caerulescens*, *Aristida contorta* and *Eriachne benthamii* with very little overstorey characterised the Mr6 community type. This classification of vegetation was generally in Good condition with scattered Mesquite (*\*Prosopis pallida*, Mesquite). Other species of grass are sometimes present, including *Eragrostis tenellula* and *Eriachne* aff. *Helmsii*, whilst *Eremophila maculata* was also recorded consistently.

### **5.2.1 Additional Infrastructure Corridor Vegetation Communities**

The following additional vegetation communities have been identified to occur within the infrastructure corridor.

#### **Littoral Land System**

##### **#Ld2 *Acacia coriacea*, *A. bivenosa* open shrubland to shrubland over scattered grasses**

This vegetation type occurred on the coarse brown sands of the gently undulating dunes which border Cape Preston. It consisted of an open to sparse tall shrubland that was dominated by *Acacia coriacea* subsp. *coriacea*, with lesser amounts of *A. bivenosa*. Occasional other shrubs included *Rhagodia preissii* subsp. *obovata*, *Scaevola spinescens* and *Threlkeldia diffusa*. The grass cover ranged from a scattered to sometimes open cover of *\*Cenchrus ciliaris*, with occasional other species such as *Enneapogon caerulescens* and *Triraphis mollis*. Very sparse herbs included *Amaranthus pallidiflorus*, *Cleome viscosa*, *Euphorbia schultzii*, *E. tannensis* subsp. *eremophila*, *Ptilotus exaltatus*, *Salsola tragus* and *Tribulus occidentalis*. This vegetation type ranged from very good to good condition, with invasion by Buffel grass the major factor reducing condition

##### **#Ld3 *Acacia coriacea*, *A. bivenosa* open shrubland over *Triodia epactia* curly spinifex grassland**

Areas of backing dunes supported an open tall shrubland of *Acacia coriacea* subsp. *coriacea*, with lesser amounts of *Acacia bivenosa* and *Rhagodia preissii* subsp. *obovata*, over a curly spinifex (ie. not hummock forming) grassland of *Triodia epactia*. Other tall shrubs recorded included *Adriana tomentosa* and *Santalum lanceolatum*, while occasional low shrubs included *\*Aerva javanica*, *Corchorus walcottii*, *Melhanja oblongifolia*, *Sida* aff. *fibulifera* and *Threlkeldia diffusa*. Grasses other than spinifex were dominated by scattered patches of *Eragrostis eriopoda*, with occasional *\*Cenchrus ciliaris* and *Triraphis mollis*. The very sparse herb stratum included *Amaranthus pallidiflorus*, *Cleome viscosa*, *Cuscuta victoriana*, *Euphorbia species*, *Salsola tragus* and *Swainsona formosa*. This vegetation was in very good condition, with only scattered weeds recorded.

##### **#Ld4 *Acacia coriacea* scattered shrubs over mixed low shrubland and *Triodia pungens*, *\*Cenchrus ciliaris* curly spinifex / tussock grassland**

This vegetation occurred on a low, narrow dune and on a broad sandbank in the southwestern portion of Cape Preston. The sandbank supports a broader range of species given its location between more intact and more variable vegetation. The vegetation consisted of very scattered tall shrubs of *Acacia coriacea* subsp. *Coriacea* over sparse to occasional low shrubs of species such as *Adriana tomentosa*, *Atriplex bunburyana*, *Corchorus walcottii*, *Indigofera trita*, *Melhanja oblongifolia*, *Solanum lasiophyllum*, *Trianthema turgidifolia* and *Waltheria indica*. The open to moderately dense curly spinifex grassland of *Triodia pungens* showed some invasion by *\*Cenchrus ciliaris*. Scattered other grasses included *Aristida holathera*, *Eragrostis cumingii*, *E. eriopoda*, *Eriachne mucronata* and

*Panicum decompositum*, while very occasional sedges included *Bulbostylis barbata* and *Cyperus bulbosus*. Very sparse herbs included *Cleome viscosa*, *Indigofera colutea*, *Portulaca pilosa*, *Pterocaulon sphacelatum* and *Rhynchosia cf. minima*. This vegetation type was rated as being in very good (Site M069) to good condition (M063) depending on the extent of invasion by Buffel grass.

#### #Lm Mangals

Belts of mangroves occurred in the intertidal zone, particularly around tidal creeks such as Preston Creek. See section 6.2.1

#### #Lp1 *Triodia angusta* hummock grassland on sandy plain

This vegetation type occurred over a plain of pale brown silty loam on the lower section of Cape Preston. It consisted of a moderately dense hummock grassland of *Triodia angusta*, with considerable invasion by Buffel grass \**Cenchrus ciliaris*. Occasional other grasses included *Eragrostis falcata* and *Panicum decompositum*. Scattered low shrubs included *Indigofera trita*, *Melhania oblongifolia*, *Neobassia astrocarpa* and *Trianthema turgidifolia*. Occasional herbs included *Portulaca oleracea* and *Trianthema triquetra*. This vegetation was considered to only be in moderate condition, given the extent of invasion by Buffel grass.

#### #Ls1 *Halosarcia* spp. scattered low shrubs

Broad areas of tidal mudflat with only scattered low samphires occurred in the northern section of the project area. Species present included the samphires *Halosarcia halocnemoides* subsp. *tenuis* and *H. indica* subsp. *leiostachya*. This vegetation was in excellent condition, with no obvious signs of disturbance.

#### #Ls2 *Halosarcia halocnemoides* subsp. *tenuis* low open shrubland to low open heath

Areas of samphire occurred in the northern section of the study area on mudflats fringing the coast and tidal inlets. These consisted of an open to moderately dense low shrubland (typically ~30 cm tall) dominated by salt tolerant plants, principally samphires. The dominant species was *Halosarcia halocnemoides* subsp. *tenuis*, which occurred with lesser amounts of *Frankenia ambita*, *Halosarcia indica* subsp. *leiostachya*, *Hemichroa diandra*, *Muellerolimon salicorniaceum*, *Neobassia astrocarpa* and *Trianthema turgidifolia*. Occasional seedlings of the mangrove species *Avicennia marina* were also recorded. A small number of grasses was noted, with species of *Eragrostis* and *Sporobolus virginicus* providing a very sparse cover towards the landward edge of this vegetation type. Herbs were occasional only but included *Dysphania plantaginella*. This vegetation was generally in very good to excellent condition, with few obvious signs of disturbance.

### 5.2.2 Assessment of Vegetation Significance

A range of factors, including isolation, supporting significant flora or fauna and landform type, determines the significance of native vegetation communities. However, the most important factor in consideration of community significance is the degree of representation in the local and regional area. That is, vegetation communities are considered significant if they are poorly represented elsewhere. The following sections discuss representation of the vegetation of the project area at a range of scales and by a range of studies.

#### Assessment at the Level of Beard's (1975) Mapping of the Pilbara

The vegetation types mapped by Beard (1975) in the project area are:

- *Triodia pungens* steppe (hummock grassland);
- Shrub-steppe of *Acacia pyrifolia* over *Triodia pungens*;
- Mosaics of grass savanna with Spinifex *Triodia pungens*;
- *Eucalyptus* sp aff. *aspersa* sparse tree savanna over short Grassland; and
- Shrub savanna of *Acacia xiphophylla* over short Grassland and Shrub-steppe of *Acacia pyrifolia*

Beard's mapping shows all of these vegetation units as being relatively widespread and of fairly extensive occurrence. However, inside the project area, each of these units contains substantial variation, as recorded during the surveys. For this reason it is not possible to realistically determine the extent of representation of the vegetation at this broad level.

### Assessment at Land System Level

Of the seven Land Systems occurring within the study area, the Horseflats, Yamerina, Newman, Rocklea and Paraburdoo are widespread according to Department of Agriculture Land System Mapping. The vegetation types occurring as part of these Land Systems in the project area are therefore also likely to be well represented and not significant elsewhere in the region.

The River Land System is widely distributed in the region, but is not very abundant as it covers only a small proportion of the land surface, occurring in association with river systems. This vegetation type is significant due to this limited shape and particularly as it provides connectivity along a vast area of the landscape. In the event that such areas are severed for development clearing, this connectivity will be lost. The areas of this System in the project area (as for the land system as a whole) tend to be highly degraded by grazing and subsequent erosion and weed invasion. The degree of degradation is highly variable, with more stony areas resisting erosion and invasion by weeds and the more sandy and loamy areas being more degraded and often severely infested with \**Cenchrus ciliaris* (Buffel grass). The areas of this Land System within the project area that are in good condition have significant conservation value for vegetation due to the degree of degradation of the System as a whole and the limited area of its occurrence of Good quality representation.

The Boolgeeda Land System occurs as a single thin swathe in the study area and is associated with the stony lower slopes and plains found below hill systems. There are significant areas of this Land System to the north-east and south-west of the study area and while the portion of it within the study area is considered locally significant due to being a locally limited type, these values are considered well represented outside of the study area.

### Assessment at Recorded Community Level

The extent of each of the vegetation communities within the study area is given in Table 11. There is no available mapping of the region, including the study area, at this scale and level of vegetation description and there is no systematic listing of plant communities or vegetation associations for the Fortescue Botanical District giving areas of distributions. It is therefore not possible to provide an objective assessment of the degree of representation and therefore significance of each of the vegetation communities.

However, based on field experience it is possible to give an opinion of the conservation significance of the communities based on extent of that community within the study area. Vegetation communities with moderate – high or high conservation values should be given priority to be conserved to retain conservation values of the area.

Table 11 provides such an opinion for the vegetation communities recorded within the areas proposed for clearing for infrastructure development within the study area, including other comments for each community. Based on the areas presented in Table 11, the suite of PP1, Nc and Bx1 Communities and particularly the Nr Communities are considered to be locally significant. Each of these communities only comprise a small proportion of the entire survey area. These small percentages are indicative of the presence of these communities at a local scale and the potential for these communities to be of local and regional significance.

**Table 11** Significance of Vegetation Communities within Balmoral South Project Area

Vegetation Community	Conservation Significance	Features	Area Mapped (ha)	Percentage of Total Area
Hpg1, Hpg2, Hpg3, Hps1	Moderate to High	Red cracking clay habitat quite widespread and typical flora also relatively widespread and common. Vegetation in Good Condition and supports some Priority flora ( <i>Goodenia pasqua</i> P3). Cracking clays susceptible to weed invasion and erosion following physical disturbance.	Mapped as a mosaic of HP, combined area = 2570.43ha	13.16%
Nh, Nh1, Nh2, Nh3	Moderate	Flora widespread and common. Hummock grasslands dominate, however the HGM study in 2000 found that this vegetation communities could possibly be restricted in the region, given their occurrence on the most coastal part of the Newman land System.	Combined area = 2246.48ha	11.5%
Nc1, Nc2, Nc3, Nc4	Moderate to High	Minor creeklines and have a small representation in the landscape. Where influenced by underlying geology, vegetation communities of these creeklines are possibly restricted in the region.	Combined area = 305.42ha	1.53%
ROh1b, ROh1, ROh2b	Low to Moderate	Flora largely common and widespread. Hummock grassland likely to be broadly distributed given its extensive occurrence in the Rocklea Land System.	Combined area = 2089.19ha	10.69%
Px1, Px2	Moderate	Typical flora is common and widespread and suitable habitat is broadly distributed in the region within the Paraburdoo Land System. Vegetation community is therefore unlikely to be restricted in the region. Habitat is susceptible to weed invasion (Buffel grass)	Combined area = 4042.57ha	20.69%
PP1, PP2	Moderate	Flora generally common and widespread. Suitable habitat is likely to exist elsewhere in the Yamerina Land System.	Combined area = 124.09ha	0.64%
Bx1	Moderate to High	Represented by a small proportion of the landscape. Floral composition is of common species.	Combined area = 197.50ha	1.01%
Rc1, Rc2, Rc3, Rc4	High	Riverine vegetation has a high species richness and supports a range of habitat specific flora. Flora relatively widespread and typical of such habitats. The River Land is widely distributed in region and vegetation communities are therefore unlikely to be restricted. However river systems make up a small portion of the land surface, and riverine forests with Cadjeputs is likely to have a particular limited distribution in the region. Vegetation susceptible to weed invasion. Occurs in the Fortescue River and its tributaries, which represent the major drainage system for the area.	Combined area = 1045.56ha	5.35%
Rf1	Moderate	Flora largely common and widespread (HGM, 2001). Vegetation would occur elsewhere in region on floodplains of the River Land System. Floodplains are an important component of drainage systems. Susceptible to weed invasion.	Combined area = 2983.69ha	15.27%
Rf2	None/ Very Low	Degraded; infested with Mesquite	Combined area = 1197.11ha	6.13%

Vegetation Community	Conservation Significance	Features	Area Mapped (ha)	Percentage of Total Area
Mr3, Mr4, Mr5, Mr6	Moderate	Flora relatively common and widespread. Macrocy LS relatively widely distributed in region, therefore vegetation type unlikely to be restricted. Vegetation in very good to excellent condition with little weed invasion.	Combined area = 1993.50ha	10.20%
Pc, Pc2	High	Creeklines have high species richness and support various habitat-specific flora, including Priority flora in some areas ( <i>Eriachne tenuiculmis</i> , <i>Phyllanthus aridus</i> ). Make up small proportion of landscape. Vegetation very variable, but unlikely to be restricted in region given extensive occurrence of Paraburdoo LS. Susceptible to weed invasion (Buffel grass and Mesquite).	Combined area = 575.65ha	2.95%
ROc2, ROc3, ROc5	Moderate	Minor creeklines relatively species rich and have a small representation in the landscape. Vegetation types unlikely to be restricted in the region, given the broad distribution of the Rocklea LS. Some areas support Priority flora ( <i>Abutilon trudgenii</i> ms.)	Combined area = 70.84ha	0.36%
ROpl	Low to Moderate	Vegetation type associated with calcretisation caused by seepage; occurs elsewhere along the coast in similar habitat (eg. where rocky slopes abut beaches on the Burrup; M. Trudgen, pers. obs.). Some areas support restricted species.	5.96 ha	0.03%
Nr, Nr3	Low to Moderate	Rockpiles within the survey area commonly occurring on the Newman LS and supports a combination of the tall shrubs <i>Acacia coriacea</i> and <i>Ficus</i> species over an understorey of grasses.	Combined area = 1.85ha	0.009%
Ld2, Ld3	High	Coastal dune habitat relatively widespread but has a limited area. Similar habitat and vegetation occurs to the east at Cape Lambert (M. Maier, pers. obs.) and Karratha (Dames & Moore, 1995). Dunes susceptible to invasion by Buffel grass and erosion following physical disturbance.	Combined area = 57.51ha	0.29%
Ld4	High	High species richness. Habitat likely to be poorly distributed along coast.	Combined area = 0.72ha	0.004%
Lm	High	Mangrove communities provide a range of significant ecological functions, including physical stabilisation of shorelines and provision of terrestrial and marine fauna and inputs of nutrients to coastal ecosystems	Combined area = 2.69ha	0.014%
Lp1	Moderate	Flora quite widespread and common. Sandy plain habitat likely to be poorly distributed along coast.	Combined area = 5.49ha	0.028%
Ls1, Ls2	Moderate	Saline flats are abundant along the coast. Communities likely to be relatively similar in floristic composition. Susceptible to physical disturbance such as vehicle trafficking.	Combined area = 19.97ha	0.10%

## Assessment at Recorded Species Level

Vegetation communities are considered regionally significant where they support populations of Priority Flora. For this reason, Vegetation Communities Bx1, Rf1 and Hp may be considered significant due to the species *Hibiscus brachysiphonius* (P3), *Phyllanthus aridus* (P3) and *Goodenia pascua* (P3) being recorded within them, respectively.

### 5.3 Vegetation Condition

The condition of the vegetation within the entire Balmoral South project area ranges from Completely Degraded to Very Good. The majority of the vegetation is in Good condition with relatively high weed invasion, especially on the grassy flats, dominated by \**Cenchrus ciliaris* (Buffel Grass). A high degree of erosion is also present throughout much of the survey area as a result of cattle activity. This erosion is often particularly evident along streamlines and riverbanks, where cattle congregate to drink or obtain shelter.

Areas of better quality vegetation with significantly less weed invasion and higher species richness and native foliage cover were found to occur on the rocky hills and particularly in the area of the main orebody. The spatial extent of the varying vegetation condition is presented in Figure 8.

### 5.4 PATN Analysis

PATN is a statistical analysis software program that generates estimates of association (resemblance, affinity, distance) between any set of objects or data described by a suite of variables or attributes (such as species). PATN then classifies the data into groups (or vegetation communities), condenses the information into three dimensions and displays the patterns graphically ([www.patn.com.au](http://www.patn.com.au)).

The data collected during the 2006 field survey was submitted by local PATN expert Mr Ted Griffin for analysis. The results of the PATN analysis are presented in Figure 10. The objective of the analysis was to provide a classification of sites that are a strong representation of the floristic composition of the sampled communities.

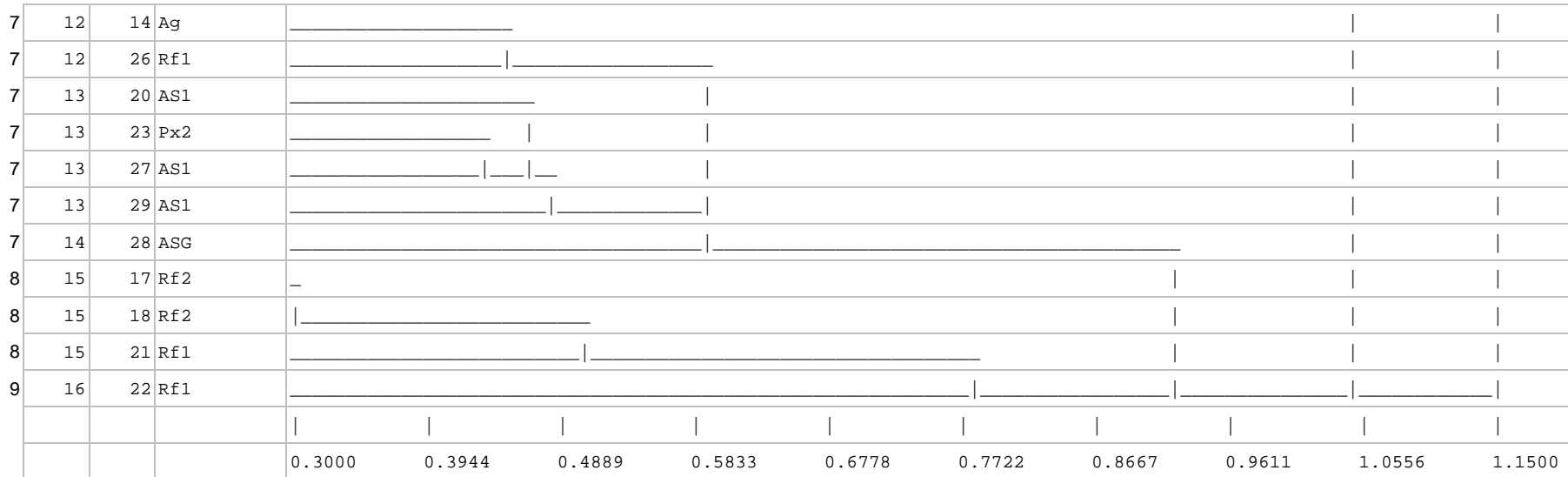
As mentioned previously, the data was analysed as two datasets; one with species being considered as either present or absent from each site and the other as a transformation cover. The analysis indicated that whilst there are differences in the classification using the cover compared to using presence or absence data, there was also significant concurrence. That is, it was possible to determine that all field classifications of vegetation communities were consistent with results from the PATN analysis.

From the results presented in Figure 10, it is possible to infer that a number of differing vegetation communities show similarities in species composition and Projected Foliage Cover (PFC). Branches within the dendrogram link vegetation communities with similar appendages. Nine separate groups were identified to occur in the project area.

**Figure 10** Dendogram Arising From PATN Analysis, Showing Relationships Between Quadrat Data, 2006 Data

GP9	GP16	site	Community	data
				11/24/06 05:43:35.45 dend Maunsell cover Nov 2006
				0.3000 0.3944 0.4889 0.5833 0.6778 0.7722 0.8667 0.9611 1.0556 1.1500
1	1	1 Nh		_____
1	1	2 Px1		_____   _____
1	2	5 Roh1b		_____
1	2	8 Roh1b		_____   _____
1	2	25 Nh2		_____   _____   _____
1	2	11 Roh1b		_____   _____
1	3	32 Nh2		_____   _____
1	3	34 Roh1		_____   _____   _____   _____
2	4	7 Bg		_____
2	5	13 PP2		_____   _____
2	5	19 Nh		_____   _____   _____
2	6	15 Sg		_____   _____
3	7	10 Tt		_____   _____
4	8	16 LH		_____   _____
5	9	33 Px1		_____   _____   _____
6	10	9 HP		_____   _____
6	10	12 HP		_____   _____
6	11	30 HP		_____   _____
6	11	31 Px2		_____   _____   _____

**Figure 10 (cont.)** Dendrogram Arising From PATN Analysis, Showing Relationships Between Quadrat Data, 2006 Data



## 5.5 Fauna

### 5.5.1 Desktop Surveys

The DEC database enquiry for Threatened Fauna previously recorded within the project area was conducted for the area 21.4707°S, 115.882° E to 20.8749°S, 116.415°E (Mardie Station plus 15 km buffer). The search identified one threatened species, Schedule 1, *Pezoporus occidentalis* (Night Parrot) and seven Priority species were identified in the database search. Additional enquires also identified the Schedule 1 species *Dasycercus cristicauda* (Mulgara), to occur in the region (Appendix K).

Summary of the Threatened and Priority Fauna database search are provided below

**Table 12: Threatened Fauna Species Potentially present within the Balmoral Project Area**

Species	Common Name	WA Conservation Category	EPBC Conservation Category	IUCN Threatened Species Category
<i>Dasycercus cristicauda</i>	Mulgara or Minyiminyi	Schedule 1	Vulnerable	Vulnerable
<i>Pezoporus occidentalis</i>	Night Parrot	Schedule 1	Critically Endangered	Critically Endangered
<i>Mormopterus loriae cobourgiana</i>	Little North-Western Mastiff Bat	Priority 1	N/A	N/A
<i>Lagorchestes conspicillatus leichardti</i>	Spectacle Hair Wallaby	Priority 3	N/A	N/A
<i>Leggadina lakedownensis</i>	Lakeland Downs Mouse or Kerakenga	Priority 4	N/A	Near Threatened
<i>Pseudomys chapmani</i>	Western Pebble Mound Mouse	Priority 4	N/A	Least Concern
<i>Ardeotis australis</i>	Bustard	Priority 4	N/A	Near Threatened
<i>Burhinus grallarius</i>	Bush Stone-Curlew	Priority 4	N/A	Near Threatened
<i>Numenius madagascariensis</i>	Far Eastern Curlew	Priority 4	N/A	Least Concern

#### Schedule 1

- *Pezoporus occidentalis* (Night Parrot). This species was not recorded during the field survey. It has been recorded approximately 12km south of the project area, where it inhabits areas dominated by *Triodia spp.*
- *Dasycercus cristicauda* (Mulgara). This species was not recorded during the field survey. It has been recorded to occur in the Pilbara region approximately 300km east of the project area throughout sandy arid regions.

#### Priority 1

- *Mormopterus loriae cobourgiana* (Little North-Western Mastiff Bat). This species was not recorded during the field survey. This species occurs along the north west coast and is known to roost in mangroves. It was recorded in 2000 in the mangrove vegetation community at Cape Preston, north of the survey area. They are restricted to mangrove forests and adjacent areas (Churchill 1998).

### Priority 3

- *Lagorchestes conspicillatus leichardti* (Spectacle Hair Wallaby). This species was not recorded during the field survey. It is known to have declined from many parts of its home range. This species is susceptible to predation by introduced carnivores.

### Priority 4

- *Leggadina lakedownensis* (Lakeland Downs Mouse, Kerakenga). This species was not recorded during the field trip. It has been recorded on Mardie station, with three individuals captured or trapped in 2000. Prior surveys (HGM 2001) suggest that the preferred habitat of this species may be cracking clay, as cracking clays are wide-spread throughout the project area. It is expected that this species will occur in the project area.
- *Pseudomys chapmani* (Western Pebble Mound Mouse). This species was not recorded during this field trip. It is known to inhabit low slopes and rocky hills. A single active mound was observed at Mardie in the 2000 survey; however, despite searching the small area of potentially suitable habitat (stony slopes and rises), no evidence of this species was encountered in the project area.
- *Ardeotis australis* (Bustard). This species was recorded at four locations in the survey area, including sites two, three, four and along the Fortescue River. It was also observed outside of the survey area in the general location of the Balmoral shearing shed.
- *Burhinus grallarius* (Bush Stone Curlew). This species was not recorded during this field trip; it was recorded along the North West Coastal Highway in 2000.
- *Numenius madagascariensis* (Far Eastern Curlew). This species was not recorded during this field survey. It has been recorded along the mud flats adjacent to mangroves west of the Project Area.

### 5.5.2 Infrastructure Corridor Fauna

A desktop review has been carried out to determine the presence of significant fauna within the Infrastructure Corridor, based on information sourced for the 2001 survey (desktop and field survey).

#### Fauna Habitats

The 2000 survey divided the project area into habitat types in order to record fauna results. The habitat types were:

1. Beach
2. Mangrove Flats
3. Coastal sand Dunes
4. Samphire
5. Stony Plains
6. Low Stony Hills
7. Rocky Hills and Outcrops
8. Cracking Clays
9. Creeklines

The Land System Units that relate to these habitat types, spatially represented within the 200m wide proposed infrastructure corridor are:

- Boolgeeda
- Horseflats
- Littoral
- Newman
- Rocklea
- Yamerina

The Land Systems and fauna habitats represented within the proposed infrastructure corridor and the desalination plant site include all nine habitat types defined for the 2000 survey. Therefore, the corridor does or has the potential to support all of the fauna values identified from the 2000 study.

### Fauna Species of Significance

No Threatened fauna species of either State (Scheduled under the *WA Wildlife Conservation Act, 1950*) or Commonwealth (under the *EPBC Act, 1999*) significance were recorded within the area proposed for the infrastructure corridor.

Desktop assessments subsequent to database enquiries conducted initially suggest the potential for the following species of national significance, listed under the *EPBC Act, 1999* to occur within the proposed corridor alignment (Appendix K):

- *Dasyercus cristicauda* (Mulgara) – Schedule 1, Vulnerable. Occurs within drainage lines near sandy plains and dunes;
- *Rhinonictis aurantius* (*Pilbara form*) (Pilbara Leaf-Nosed Bat) – Vulnerable. Occurs within caves and abandoned mines; and
- *Morelia olivacea barroni* (Olive Python) – Vulnerable. Occurs within drainage lines of the Fortescue River System.

The Mangrove flats on the northern coast at Cape Preston support the mangal habitat which constitutes an important habitat for the mastiff Bat (*Mormopterus loriae*). This species' wider distribution encompasses the West Australian coastal areas from Derby to Exmouth Gulf. And individuals are recorded to roost in small sports and crevices in dead upper branches of the Mangrove *Avicennia marina*, restricted to mangrove forests and adjacent areas (Churchill, 1998).

The beach habitat at Cape Preston is likely to provide nesting habitat for marine turtles, although the extent of these areas for this purpose is not fully known. The beach and mudflat habitats of the project area do not appear to be internationally significant as providing habitat for migratory wader species, protected under JAMBA/CAMBA. One of the objectives of future fauna surveys will be to clarify the significance of the area to marine turtles and waders.

#### 5.5.3 Field Survey

The field survey was conducted with attention to the results of the database enquiry and targeted surveys were conducted for some of the abovementioned species. Only one Priority 4 species was identified during the 2006 field survey.

The majority of fauna survey results for the 2000 Austeel project area survey are not regarded as relevant to the Balmoral South project due to the significantly larger size of the former project area and the majority of fauna records, particularly birds, being from the northern coastal areas around Cape Preston. This area is regarded as particularly rich with fauna. In general the location recordings or most of the faunal data is not specific enough to permit separation into only the current Balmoral South project area.

The 2000 fauna survey of the area of the Austeel project area that overlaps with the Balmoral South project area did not record any Schedule fauna, but recorded seven Priority Fauna species. These species were:

- Western Pebble Mound Mouse (*Pseudomys chapmani*);
- Lakeland Downs Mouse (*Leggadina lakedownensis*); and
- Far Eastern Curlew (*Numenius madagascariensis*).
- Little Western Freetail Bat (*Mormopterus loriae cobourgensis*);
- Bush Stonecurlew (*Burhinus grallarius*);

- Beach Stonecurlew (*Esacus neglectus*);and
- Green Turtle (*Chelonia mydas*).

Additional to these Priority species, one undescribed species of rodent (*Pseudomys* sp. "Hamersley") and two undescribed skinks (*Ctenotus* aff. *robustus* and *Ctenotus* sp. nov.) of possible conservation significance were recorded. The majority of these species have been recorded from other sites in the Pilbara, but their regional conservation status remains unclear.

The fauna habitats defined during the 2000 survey are all regarded as well represented in the region and none are regraded as regionally significant or unique. Of some importance are the habitats of the cracking clays (Hp vegetation type), due to the presence of *Leggadina lakedownensis*, *Ctenotus* aff. *robustus* and *Ctenotus* sp. nov., and the major drainage lines, which represent the most fauna rich habitat in the area.

The full comprehensive report presenting the results of the fauna field survey conducted during 2006 is presented as Appendix J. The October 2006 field survey recorded a total of 105 vertebrate species and a total of 114 individuals were captured, identified at site and released. The faunal groups represented during the survey are summarised in Table 13.

**Table 13 Summary of fauna Species Recorded During the 2006 Field Survey**

Faunal Group	No. of Individual Species Recorded
Native Mammals	6
Introduced Mammals	3
Avifauna	57
Reptiles	38
Amphibians	1
<b>Total</b>	<b>105</b>

The groups represented in the survey area are discussed below.

## Reptiles

A total of 38 reptile and one amphibian species were recorded during the October 2006 field survey. The 38 species were represented by 86 individual captures, 39.5% of which were attributed to the Scincidae (Skinks), 28% Gekkonidae (Geckoes) and 20.2% Agamidae (Dragons). The Boidae (Pythons), Elapidae (Front Fanged Snakes), Pygopodidae (Legless Lizards), Typhlopidae (Blind Snakes) and Varanidae (Monitors) all contributed < 10% of total captures. Appendix F summarises data recorded for all reptile species recorded. Each species is discussed in the following annotation.

### Agamidae

- *Ctenophorus caudicinctus caudicinctus*. Uncommon. One individual was captured at Site 3 (T23) on a stony rise over clay.
- *Ctenophorus isolepis isolepis*. Uncommon. It was recorded from Site 2 at Traps 11 and 13 and at Site 4, Traps 36 and 40. *Triodia* spp. was the dominant vegetation in all areas in which this species was found.
- *Ctenophorus nuchalis*. Uncommon. This species was recorded from Site 2 at Traps 14 and 15 and from Site 4 at Trap 40. All sites were dominated by *Triodia* spp.

- *Lophognathus longirostris*. Common. This species was regularly observed at Site 4 along the creek, and it was trapped at Site 4 in Traps 35 and 38. It was also recorded from vegetated areas along Fortescue River and associated feeder creeks.
- *Tympanocryptis cephalus*. This species is uncommon, with only four individuals trapped at Site 3. All four were captured at Trap 23 on a small rise of stony ground over heavy clay. Individuals ranged in size, indicating that the same individual was not re-captured.
- *Pogona mitchelli*. Individuals captured at Site 2 from Trap 18 where the vegetation was dominated by grasses and *Triodia* spp.; from Site 3, Traps 23 & 29 on unvegetated areas of stones over clay; and from Site 4 Trap 31, which consisted of coarse sand dominated by *Triodia* spp..

#### Boidae

- *Antaresia perthensis*. Only one individual was observed during a spotlighting transect of the northern end of the tailings dam area. This individual was recorded near a rocky ridge on the edge of the lease area.

#### Elapidae

- *Pseudonaja nuchalis*. One individual was observed dead on a road adjacent to Site 3.
- *Pseudechis australis*. Only one individual was sighted near Trap 10 at Site 1. An individual was also recorded dead on the North west Highway; however, this individual was outside of the survey area.
- *Acanthophis wellsii*. One individual was observed during a spotlighting excursion at the northern end of the tailings dam area. This individual was recorded near a rocky ridge on the edge of the lease area.

#### Gekkonidae

- *Diplodactylus conspicillatus*. This species is considered relatively common, with individuals captured over a variety of soil and vegetation types at Sites 1, 2, 3, and 4.
- *Diplodactylus savagei*. Only one individual was captured at Site 3 in an area of cracking clays at Trap 30. No other sightings of this species were recorded.
- *Gehyra pilbara*. Two individuals were captured at Sites 2 in cracking clay and at Site 4 along the creek bank in coarse sandy soil.
- *Gehyra variegata*. This is the most common gecko species captured. Individuals were recorded across a range of soil types at Sites 2, 3, and 4.
- *Nephrurus levis occidentalis*. Two individuals were captured: one at Site 4, Trap 40 and one at northern section of the bore field lease.
- *Heteronotia binoei*. Three individuals were captured at Site 4 at Traps 34 & 37 and one individual was captured whilst spotlighting the northern section of the bore field lease.

#### Pygopodidae

- *Lialis burtonis*. One individual was captured on crackling clays at Site three, Trap 26.
- *Pygopus nigriceps*. Two individuals were captured: one at Site 2 on sandy loam dominated by *Triodia* spp. and one at Site 3 on an area of crackling clay with little ground cover.

#### Scincidae

- *Ctenotus schomburgkii*. Individuals were captured over a range of soil types including coarse sand, gravel and cracking clays. Captures included: one at Site 1, three at Site 2, one at Site 3 and two at Site 4.
- *Ctenotus duricola*. Two individuals were captured, one at Site 1 in a well grassed area and one at Site three on cracking clays.

- *Ctenotus aff. helenae*. Individuals were captured at Sites 1, 2 and 4. With the exception of Site 1, this species was typically captured from areas of stone and gravel substrate dominated by *Triodia* spp. The majority of individuals were captured at Site 4 along Du Boulay Creek.
- *Ctenotus pantherinus ocellifer*. One individual was captured in Trap 32 at Site 4. The soil type at this location was gravel to coarse sand dominated by *Triodia* spp.
- *Ctenotus rufescens*. One individual was captured on a stony rise over clay at Trap 28, Site 3.
- *Ctenotus aff. robustus*. One individual was recorded at Site three. This species has not yet been classified by the Museum of Western Australia; however, its presence has previously been recorded in the Pilbara. Photographs of this individual were presented to the Museum, and its identity was confirmed.
- *Ctenotus saxatilis*. Two individuals were captured from Traps 35 & 38 at Site 4.
- *Glaphyromorphus isolepis*. There was only one record of this species from Trap 38 along Du Boulay Creek.
- *Lerista bipes*. This species was commonly trapped in the sandy substrates at Site 2, and it was also recorded from Site 1.
- *Lerista muelleri*. Three individuals were captured: one at Site 1 and two from Site 4.
- *Menetia greyii*. Four individuals were captured at Site 1, in areas of grass on clay; two individuals were captured at an area of grass on clay at Site 2; and one individual was captured from a sandy substrate at Site 4.
- *Morethia ruficauda exquisite*. Three individuals were captured among *Triodia* spp. in Trap 15 at Site 2.
- *Notoscincus ornatus ornatus*. One individual was captured at Site 4 in River bank vegetation.

#### Typhlopidae

- *Ramphotyphlops grypus*. One individual was captured in a grassed area over clay at Site 1.

#### Varanidae

- *Varanus acanthurus*. Two captured individuals were at Site 1: one in funnel Trap 9 and one in Elliott Trap 10.
- *Varanus brevicauda*. One individual was captured at Site 2 in Trap 12 and another was observed at Trap 14 Site 2.
- *Varanus gigantus*. One individual was recorded as road kill at the northern end of the tailings dam lease.
- *Varanus panoptes*. One individual was captured on the access track through the tailings dam lease.
- *Varanus gouldii*. One individual was observed at Site 2 basking at the base of an Acacia tree.

#### Amphibians

- *Cyclorana maini* (Mains Frog). One individual was recorded whilst spotlighting adjacent to the tailings dam lease area.

#### **Birds**

A total of 57 bird species were recorded during the survey of the project area, representing 31 families. The 57 species were represented by approximately 1845 records, 40% of which were attributed to one family group, Cacatuidae, with Galas, Little Corellas and Cockatiels observed in large groups (Appendix G). The family Passeridae was well represented by *Taeniopygia guttata* (Zebra Finch) accounting for 18% of total sightings and the family Columbidae, represented by *Geophaps plumifera* (Spinifex Pigeon) and *Ocyphaps lophotes* (Crested Pigeon) accounting for 11.3% of sightings. A total of 41 species were represented by less than 30 sightings, with 5 species represented by between 30 - 40 individuals, and they include: *Coturnix ypsilophora* (Brown Quail), *Phalacrocorax sulcirostris* (Little

Black Cormorant), *Pelecanus conspicillatus* (Australian Pelican), *Vanellus tricolour* (Banded Lapwing) and *Merops ornatus* (Bee Eater).

Of particular interest was the recording of two species listed as migratory species under the *Environmental Protection and Biodiversity (EPBC) Act 1999* and the JAMBA/CAMBA Agreements:

- *Merops ornatus* Bee Eater (recorded regularly throughout the survey area), and
- *Haliaeetus leucogaster* White Bellied Sea Eagle (one sighting recorded).

Records of breeding behaviour were made for only one species, *Dromaius novaehollandiae* (Emu). Two adult males were observed on different occasions, one with four chicks and the other with two chicks. Appendix G summarises data recorded for bird species present. Each species is discussed in the following annotation.

#### Casuariidae

- *Dromaius novaehollandiae* (Emu). Common. This species was recorded on five occasions, from Sites 1, 4, the River, BDT2 and BDT3. Adult birds with chicks were observed on two occasions, at the River and at BDT2.

#### Phasianidae

- *Coturnix ypsilophora* (Brown Quail). Common. This species was recorded on five occasions from Sites 1, 2, 4, River and BDT2 in small groups. Individuals were recorded from grasses on each occasion.

#### Anatidae

- *Anas superciliosa* (Black Duck). Uncommon. Individuals were recorded on three occasions from water holes along the River and Du Boulay Creek.
- *Anas gracilis* (Grey Teal). Uncommon. This species was recorded on one occasion at the River.

#### Phalacrocoracidae

- *Phalacrocorax sulcirostris* (Little Black Cormorant). Uncommon. Recorded on two occasions: one flock of 30 individuals was observed on the River and five individuals were observed at Du Boulay Creek.

#### Pelecanidae

- *Pelecanus conspicillatus* (Australian Pelican). Uncommon. One flock of 33 individuals was observed on the River late in the afternoon.

#### Ardeidae

- *Ardea pacifica* (White-Necked Heron). Uncommon. This species was recorded at three locations: Site 4, at the River and at BDT3. Individuals were regularly observed at the same water bodies each day, indicating the same birds were regularly seen.
- *Egretta garzetta* (Little Egret). Uncommon. Individuals were recorded from three locations: Site 4, the River and BDT3. Individuals were sighted daily at the same locations.
- *Egretta novaehollandiae* (White-Faced Heron). Uncommon. Individuals were recorded from three locations: Site 4, the River and BDT3. Individuals were sighted daily at the same locations.

#### Threskiornidae

- *Threskiornis spinicollis* (Straw Necked Ibis). Uncommon. Individuals were recorded on three occasions from Site 4, the River and BDT3; at each time they were observed foraging adjacent to remaining water bodies.

### Accipitridae

- *Accipiter fasciatus* (Brown Goshawk). Uncommon. This species was recorded on three occasions from Sites 3, 4 and the River. Two individuals were observed whilst flying and the third individual was observed while perched on a dead trees.
- *Aquila audax* (Wedge Tailed Eagle). Uncommon. This species was recorded on six occasions from Sites 1, 2, 3, 4, the River and BDT1. These same individuals may have been observed more than once.
- *Milvus migrans affinis* (Black Kite). Scarce. A single bird was observed on three occasions at Sites 3, the River and BDT2.
- *Hieraaetus morphnoides* (Little Eagle). Single individuals were observed on different days at three locations: Sites 2, 4 and the River. These sightings were possibly the same individuals.
- *Haliastur sphenurus* (Whistling Kite). A single bird was recorded on different days at Sites 3, 4, the River and BDT2. Three sightings at the River transect possibly reflect observation of the same individual.
- *Haliaeetus leucogaster* (White Bellied Sea Eagle). There was a single sighting of this species at the River. The individual was observed moving along the River between two large water bodies.

### Falconidae

- *Falco berigora* (Brown Falcon). This species was observed on only two occasions: once at Site 3 and once at the River.
- *Falco cenchroides cenchroides* (Nankeen Kestrel). Individuals were recorded at three locations: Sites 2, 4 and the River.

### Gruidae

- *Grus rubicunda* (Brolga). Three individuals were recorded daily at the same large body of water along the River.

### Otididae

- *Ardeotis australis* (Australian Bustard). This Priority 4 species was recorded once each at four locations: Sites 2, 3, 4 and the River. It was also observed on Balmoral adjacent to the shearing shed and on the road linking Northwest Highway. Both sites are outside of the Project Area.

### Turnicidae

- *Turnix velox* (Little Button Quail). Uncommon. This species was recorded at two locations: Site 1 and at the River. On both occasions it was observed in pairs.

### Charadriidae

- *Elsayornis melanops* (Black Fronted Dotterel). Four pairs were recorded regularly at the same large body of water along the River.
- *Vanellus tricolour* (Banded Lapwing). Common. This species was recorded at seven locations: Sites 1, 2, 3, 4, the River, BDT1 and BDT3. As many as twelve individuals were observed at one time. This species was observed at livestock watering points throughout the greater area.

### Laridae

- *Sterna caspia* (Caspian Tern). Uncommon. A single individual was recorded at two locations: Site 4 and the River. Individuals were observed flying low over water bodies, circling, and then landing at the water's edge.

### Columbidae

- *Ocyphaps lophotes* (Crested Pigeon). Common. This species was recorded at seven sites in large groups. Large flocks were observed at water bodies and stock troughs. In addition, this species was observed as individuals or pairs throughout the greater area.
- *Geophaps plumifera* (Spinifex Pigeon). Common. This species was recorded at all locations. Large flocks were observed along the River and stony creek lines. It was often observed at stock watering points and along access tracks throughout the site.
- *Geopelia cuneata* (Diamond Dove). A single pair was recorded from Site 4 adjacent to a creek line, and a group of six individuals were recorded at the River.
- *Geopelia striata placida* (Peaceful Dove). This species was recorded at three locations, each time adjacent to the River or creek lines. The largest group recorded comprised of four individuals drinking at the River.

#### Cacatuidae

- *Nymphicus hollandicus* (Cockatiel). Common. This species was observed in flocks of up to 30 at Sites 1, 2, 3, 4, the River and BDT3. It was regularly seen throughout survey area, particularly during the early morning along the River.
- *Cacatua roseicapilla* (Galah). Common. This species was observed in large flocks at all sites except for Site BDT1. It was observed in large numbers around water holes and stock troughs.
- *Cacatua sanguinea* (Little Corella). Common. This species was observed in large flocks at Sites 1, 2, 4, the River and BDT2. It was observed in large numbers around water holes and stock troughs.

#### Psittacidae

- *Melopsittacus undulatus* (Budgerigar). Uncommon. One flock of approximately 20 individuals was recorded from Site 1 late in the afternoon.

#### Cuculidae

- *Cuculus pallidus* (Pallid Cuckoo). Uncommon. Individuals were recorded from Sites 4 and the River. Both individuals were observed in *Eucalyptus* sp. adjacent to a water body.

#### Podargidae

- *Podargus strigoides* (Tawney Frogmouth). Uncommon. A single individual was recorded whilst spotlighting along the River.

#### Caprimulgidae

- *Eurostopodus argus* (Spotted Nightjar). Uncommon. A single individual was observed whilst spotlighting on the main access track adjacent to the River.

#### Halcyonidae

- *Dacelo leachii leachii* (Blue Winged Kookaburra). Uncommon. A single individual was recorded on one occasion from the River. The individual was recorded drinking from a water body early in the morning.
- *Todiramphus sanctus* (Sacred Kingfisher). Uncommon. Individuals were recorded at Sites 4, the River and BDT3. Each individual was recorded adjacent to water bodies.

#### Meropidae

- *Merops ornatus* (Bee Eater). Common. Recorded from Sites, 2, 3, 4, river, BDT2 and BDT3. Often observed along the banks of water courses in small groups and feeding as singles or in pairs above survey areas.

#### Maluridae

- *Malurus lamberti* (Variegated Fairy Wren). This species was recorded from five locations: Sites 1, 2, 4, the River and BDT1. This species was generally observed in association with small shrubs.
- *Malurus leucopterus* (White Winged Fairy wren). Uncommon. This species was observed at Site 2 and one sighting at the River. It was often heard at Site 2 but only visually recorded twice, and both observations may have been the same individual.

#### Pardalotidae

- *Gerygone tenebrosa* (Dusky Gerygone) Uncommon. Individuals were recorded at Sites 2, 4 and the River. Individuals were observed in the crowns of large eucalyptus trees.

#### Meliphagidae

- *Lichmera indistincta indistincta* (Brown Honeyeater). Uncommon. This species was recorded at Sites 4, the River, BDT2 and BDT3, and it was seen as individuals or pairs. It was only recorded once from each site.
- *Lichenostomus virescens* (Singing Honeyeater). This species was recorded at Sites 1, 2, 3, 4 and the River. However, only single birds or pairs were observed. It was also observed outside of the project area closer to the coast.
- *Manorina flavigula* (Yellow Throated Miner). Moderately common. This species was recorded at sites 1, 2, 4, the River, BDT2 and BDT3 with greater numbers observed along the River and creek line of Site 4.

#### Dicruridae

- *Grallina cyanoleuca* (Magpie Lark). Moderately common. This species was observed at Sites 3, 4, the River and BDT1, with larger numbers recorded from along the creek at Site 4 and the River.
- *Rhipidura leucophrys* (Wagtails). Moderately common. This species was recorded at all sites with the exception of Site BDT2. It was recorded as individuals at all sites.

#### Campephagidae

- *Coracina novaehollandiae* (Black Faced Cuckoo Shrike). Common. This species was recorded from all sites as individuals or in pairs. Greater numbers were observed along the creek at Site 4 and the River.

#### Artamidae

- *Artamus cinereus* (Black Faced Woodswallow). Uncommon. This species was recorded from at sites, 1, 2, 3, 4, and river. Recorded as individuals or in pairs.
- *Artamus minor* (Little Woodswallow). Uncommon. One pair was recorded at Sites 1 and individuals were observed at Sites 3 and 4.
- *Cracticus nigrogularis* (Pied Butcherbird). Uncommon. This species was recorded along the creek at Site 4 and the River. Repeated sightings at Site 4 indicate that it may have been the same individual.
- *Artamus personatus* (Masked Woodswallow). Uncommon. Pairs were observed at Sites 3, the River and BDT2. Individuals were recorded at Site 4.
- *Gymnorhina tibicen* (Magpie). Uncommon. An individual was recorded from the creek line at Site 4 and one individual was observed drinking at the River.

#### Corvidae

- *Corvus orru* (Torresian Crow). Uncommon. This species was recorded on six occasions from Sites 1, 2, 3, 4, the River and BDT2, and they were mostly observed in pairs.

#### Motacillidae

- *Anthus novaeseelandiae* (Richards Pipit). Uncommon. Individuals were recorded at Sites 2, 4 and the River.

#### Passeridae

- *Taeniopygia guttata* (Zebra Finch). Common. This species was observed in large numbers at all occasions, particularly from around water bodies and stock troughs.

#### Hirundinidae

- *Hirundo neoxena* (Welcome Swallow). Uncommon. Two individuals were recorded at the River. Another possible sighting was at the Fortescue River Bridge, outside of the survey area.
- *Hirundo nigricans* (Tree Martins). Uncommon. This species was seen in pairs or individuals along the River on numerous occasions.

### **Native Mammals**

A total of nine mammal species were recorded during the field survey, including six native species and three introduced species. The most commonly recorded native species was *Macropus robustus erubescens* (Euro) and *Macropus rufus* (Red Kangaroo). Moderate numbers of both these species were recorded early in the mornings and during spotlighting events, often with young at foot.

Whilst searching the remains of the old shearer's quarters on Balmoral station, approximately ten bats were recorded roosting in old cupboards. Three individuals were captured and identified as belonging to the family *Vespertilionidae*. Positive identification of these individuals beyond the family group was not achieved. Although these bats were not located within the lease area, they would be expected to feed around water bodies, such as the Fortescue River and so were included in the results.

The species *Sminthopsis macroura* (Striped Faced Dunnart) and *Pseudomys hermannsburgensis* (Inland Sandy Mouse) were also recorded during the field survey. Scats of *Tachyglossus aculeatus* (Echidna) were also observed. Appendix H summarises mammal species recorded, and each species is discussed in the following annotation.

#### Tachyglossidae

- *Tachyglossus aculeatus* (Echidna). Scats of this species were observed on a rocky out-crop at the northern end of the tailings dam area. Prior to the October fauna field survey, one individual was recorded during the July botanical survey, to the west of the proposed tailings dam area.

#### Dasyuridae

- *Sminthopsis macroura* (Stripe Faced Dunnart). Four individuals were captured: two from a sparse area of *Triodia* spp. at Traps 13 and 12 at Site 2 and two at Site 4, Trap 40, an area dominated by *Triodia* spp.

#### Macropodidae

- *Macropus robustus erubescens* (Euro). Common. The Euro was commonly sighted during the day along creek lines at Sites 4, the River and BDT3. This particular species was recorded in abundance on spotlighting excursions through out the survey area, particularly on grassy plains.
- *Macropus rufus* (Red Kangaroo). Common. This species was recorded at all sites with the exception of Site 2. It was commonly sighted early in the morning and on spotlighting excursions throughout the study areas and beyond.

#### Muridae

- *Pseudomys hermannsburgensis* (Inland Sandy Mouse). Two individuals were captured at Site 2 in Traps 11 and 12.

### Vespertilionidae

- Vespertilionidae spp. Approximately ten individuals were observed in old cupboards in the Balmoral shearing quarters adjacent to the survey area.

### **Introduced Mammals**

A number of introduced mammals were observed at the project site.

### Muridae

- *Mus musculus* (House Mouse). Four individuals were captured at Site 2, three of which were captured from Trap 19 on different days. This suggests that the same animal may have been captured repetitively.

### Canidae

- *Canis lupus dingo* (Dingo). A single set of large dog tracks was observed on the track that bisects Site 4 at Du Boulay Creek.

### Felidae

- *Felis catus* (Feral Cat). A single individual was recorded during a spotlighting excursion at the northern section of the bore field location.

## 6.0 Discussion

### 6.1 Flora and Vegetation

#### 6.1.1 Flora

Flora species richness is generally poor in the Pilbara region compared to other areas of Western Australia, and the diversity of the project area was found to be relatively low, even in this context. Most of the species diversity is represented in areas of better quality vegetation, concentrated around the ore body and other stony rises.

The totals of 162 and 171 taxa recorded during the 2000 and 2006 surveys of the project area, respectively represent relatively poor species diversity for such a large project area with relatively diverse vegetation composition. Most of the species diversity is represented in areas of better quality vegetation, concentrated around the ore body and other stony rises.

None of the Threatened Flora species resulting from the database enquiries for the project area were recorded during the 2000 HGM survey. The 2000 survey did record two occurrences of two separate Priority species within the current Balmoral South project area, *Hibiscus brachysiphonius* (P3) within vegetation community Bx1 and *Phyllanthus aridus* (P3) within vegetation community Rf1. During the 2006 survey one Priority 3 species (*Goodenia pascua*, P3) was recorded once within the 2006 survey area at Transect 6, in Vegetation Community Hp. The communities that these species have been recorded as occurring in are regarded as significant, due to supporting these flora populations.

No species listed as Declared Rare Flora (DRF) by the Department of Environment and Conservation (DEC), under the *Wildlife Conservation Act, 1950*, or as Threatened under the *Environment Protection and Biodiversity Conservation (EPBC) Act, 1999* were recorded within the survey area. None of the species recorded were found to be exhibiting a range extension from recorded occurrences, as documented by the WA State Herbarium (DEC, 2006).

Throughout the entire project area, two of the total 9 weed species recorded are listed as Declared Plants by the Department of Agriculture, pursuant to the *Agriculture and Related Resources Protection Act, 1976*. These species are *\*Prosopis pallida* (Mesquite) and *\*Datura leichhardtii* (Native Thornapple) (Department of Agriculture, 2006). Under the Act, landholders are obliged to carry out recommended control measures. The recommendations for each species are detailed in Appendix I. Additional to the recorded Declared Plants, Buffel Grass (*\*Cenchrus ciliaris*) is also a significant weed recorded prolifically throughout most of the project area.

#### 6.1.2 Vegetation Communities

A total of 23 vegetation communities (or 31 if unmappable sub-units are also included) were recorded within the entire Balmoral South project area, combining 2000 and 2006 survey results. The Land Systems represented by these vegetation communities are the Horseflats, Newman, Rocklea, Paraburdoo, Yamerina, Boolgeeda, Riverland and Macroy Land Systems. Vegetation units of the Paraburdoo System dominate representation within the project area. These areas and particularly areas of the Newman Land System were found to be in better condition than most of the grassy flats due to lower occurrence of cattle grazing.

Vegetation communities of the Riverland System (Rc1, Rc2, Rc3, Rc4, Rf1 and Rf2) are regarded as significant due being limited to specific landforms, being creek lines and rivers and furthermore, due to their spatial distribution, being represented by long narrow occurrence along waterways. This spatial distribution makes the vegetation vulnerable to continual decline in the event of disturbances, particularly clearing, as connectivity relies on continual occurrence across the landscape. Such areas are also important for faunal movement.

The Boolgeeda Land System vegetation, represented by only vegetation community Bx1 is locally significant as it occurs only as a single thin swathe in the project area. However, there are significant areas of this Land System (but potentially not this specific vegetation type) to the north-east and south-west of the project area.

The suite of Bx1, Rc and Nc Communities will have the highest proportion of their surveyed area cleared for infrastructure and mine development. This high proportion is attributed to the relatively small area of the communities identified within the project area.

### 6.1.3 Vegetation Condition

The condition of the vegetation within the project area ranges from Completely Degraded to Very Good with those areas of Very Good condition vegetation concentrated around the ore body. The pit area exhibits the best quality vegetation due to the rugged and inhospitable terrain not ideal for cattle grazing. In this regard it is recommended that clearing of good vegetation be minimised as far as practicable.

The majority of the vegetation is in Good condition and weed invasion is relatively high throughout both the project area and the region, due to intensive pastoral activity for a number of years. The grassy plains are often dominated by the pastoral grass *Cenchrus ciliaris* (Buffel Grass) and this species is often found to be dominant along waterways and drainage lines in the region. A high degree of erosion is also present throughout much of the survey area, particularly along waterways as a result of cattle activity.

Clearing of good vegetation will have a greater impact than in comparison to clearing of highly degraded vegetation.

## 6.2 Infrastructure Corridor

The 2001 Austeel project area included survey of the area proposed for the northern infrastructure corridor, however, the 2006 field survey did not include a field reconnaissance of this location. A review of the known flora and fauna values within the proposed corridor alignment has been requested. Due to the results of the original 2001 Austeel field investigations potentially being considered out of date (in consideration of potential changes during this time, primarily due to pastoral and mining exploration activities in the area), it was not regarded as appropriate to include results for this area with main body of the report. Rather, a desktop review has been carried out, based on information sourced for the 2001 survey (desktop and field survey).

Vegetation communities and significant flora and fauna arising from this review are provided in the following sections.

### 6.2.1 Impacts on Mangrove Communities

The coastal mangroves at Cape Preston are classified as a Type 'A' conservation area. The site has been identified as the most southern occurrence of true ria shore mangrove formation in the Pilbara (Semeniuk, 1997).

The Environmental Protection Authority (EPA) Guidance Statement No. 1 – *Guidance Statement for the protection of tropical arid zone mangroves along the Pilbara coastline* (2001) includes the Cape Preston mangroves as one of several populations that occur within areas that have been 'designated for industrial development, associated ports or related uses. Within this context, the Cape Preston populations are considered to be "Mangrove areas of very high conservation value (designated *regionally significant*)" and are classified under Guideline 3 as outlined in the Guidance Statement. The EPA's operational objective for Guideline 3 areas is that no development should take place that would

significantly reduce the mangrove habitat or ecological function of the mangroves in these areas. In this regard, liaison with relevant stakeholders will need to take place prior to any further consideration of developments that have the potential to impact, either directly or indirectly.

Specifically, in accordance with the objectives of Guideline 3, the outcomes in terms of managing impacts on the Cape Preston Mangrove populations would include:

- mangroves should not decline because of altered water flow or salinity (no significant alteration of tidal flow to mangroves with the key objective being to maintain existing tidal patterns);
- water quality in undisturbed mangrove areas adjacent to the development should meet the ANZECC Water Quality Guidelines, unless there is ecological justification for it not doing so;
- existing groundwater flow, freshwater inflows and quality should be maintained in undisturbed mangrove areas;
- mangrove decline should not occur through secondary effects such as shading or dust settlement; and
- sedimentation patterns should be maintained so that erosion and deposition within mangrove habitats is within natural variations.

### 6.3 Fauna

During the 2000 and 2006 field fauna surveys, no Threatened species listed on either the State (Scheduled under the *WA Wildlife Conservation Act, 1950*) or Commonwealth (under the *EPBC Act, 1999*) registers were recorded.

The 2000 fauna survey did not record any Schedule fauna within the Balmoral South project area, but recorded a total of seven Priority Fauna species. These species were:

- Western Pebble Mound Mouse (*Pseudomys chapmani*);
- Lakeland Downs Mouse (*Leggadina lakedownensis*);
- Little Western Freetail Bat (*Mormopterus loriae cobourgensis*);
- Bush Stonecurlew (*Burhinus grallarius*);
- Beach Stonecurlew (*Esacus neglectus*);
- Far Eastern Curlew (*Numenius madagascariensis*); and
- Green Turtle (*Chelonia mydas*).

Additional to these Priority species, one undescribed species of rodent (*Pseudomys* sp. Hamersley) and two undescribed skinks (*Ctenotus* aff. *robustus* and *Ctenotus* sp. nov.) of possible conservation significance were recorded. The majority of these species have been recorded from other sites in the Pilbara, but their regional conservation status remains unclear.

The October 2006 field survey recorded a total of 104 vertebrate species and a total of 114 individuals were captured, identified at site and released.

During the 2006 survey, only one Priority Fauna species, *Ardeotis australis* (Australian Bustard) was recorded at four separate locations. The Australian Bustard is classified as a Priority 4 species by DEC.

The October 2006 survey confirmed that the project area supports a diverse reptilian assemblage with 37 species recorded. The diversity of species recorded can partly be attributed to the range of

habitats sampled, with creek lines and cracking clays dominated by *Triodia* spp. yielding the highest number of species. Many of the expected reptile species prefer rocky habitats, which comprise only a very small proportion of the Balmoral South survey area.

The undescribed species of skink, *Ctenotus* aff. *robustus* was also recorded during the 2006 survey. Although the WA Museum has yet to formally describe this species, positive identification was made using photographs housed at the Museum.

The majority of bird species recorded during 2006 were identified along the Fortescue River and relatively well vegetated creek lines. Most of the species observed in these areas were recorded near ephemeral pools.

Simpson and Day (1999) describe the habitat of the White Bellied Sea Eagle as being large rivers, lakes coastal seas and islands. This species is considered widespread but erratic in distribution, rarely common (Flegg, 2002).

The Rainbow Bee Eater was observed on numerous occasions particularly along the river and creek lines. They are widespread in distribution preferring to excavate burrows for the purpose of breeding, often utilizing the banks of rivers and streams. This species is described as quite common in Flegg (2002).

The Australian Bustard has declined in numbers as a result of disturbances, such as the introduction of predators, land clearing, livestock grazing and illegal hunting. This nomadic species prefers habitat types including open grassland, light scrub, open woodland and occasionally crops (Flegg, 2002). This species is regarded as wide spread, but generally scarce.

Two species listed under the JAMBA/CAMBA International Agreements for the protection of Migratory bird species were recorded. The Bee Eater (*Merops ornatus*) was recorded regularly throughout the survey area and The White Bellied Sea Eagle (*Haliaeetus leucogaster*) was sighted once.

A targeted search of low stony rises failed to identify any signs of the priority mammal species *Pseudomys chapmani* (Western Pebble Mound Mouse) and targeted trapping of cracking clays failed to record *Leggadina lakedownensis* (Lakeland Downs Mouse). This may have been due to unsuitable habitat and prolonged livestock grazing.

In general, it has been determined over the course of the 2000 and the 2006 field surveys that the fauna habitats within the project area are all regarded as well represented in the region and none are regraded as regionally significant or unique. Many years of livestock grazing has reduced the quality of available fauna habitat. Of some importance are the habitats of the cracking clays (Hp vegetation type), due to the potential presence of *Leggadina lakedownensis*, *Ctenotus* aff. *robustus* and *Ctenotus* sp. nov and the major drainage lines as they represent the most fauna rich habitats in the area.

Impacts on fauna in the project area will largely occur due to habitat loss or modification. Minimal impacts on fauna are likely to result from operational activities such as dust and noise. The majority of potential faunal impacts identified are likely to have no adverse long term impact on the environment and can be managed through the implementation of routine management procedures and safeguards.

## 6.4 Statutory Obligations

### 6.4.1 Priority Flora and Fauna

Priority flora and fauna species have been recorded within the Balmoral South project area. Priority flora and fauna lists are administered by the DEC and while listed species do not have the same legal status as the DRF and Scheduled Fauna, they are considered in approvals processes pursuant to the *Environmental Protection Act (1986)* (Department of Industry and Resources, 2006). Priority flora and fauna are listed as such for a range of reasons that include being considered for addition to the DRF or Fauna Schedule list or if there is insufficient information to determine accurate conservation status. It is advisable that the DEC be consulted where developments propose to impact on Priority species, in order to add to information available for such species and progress towards accurate evaluation of conservation status.

### 6.4.2 Significant Vegetation Communities

The significance of communities is determined by a range of factors, including because they support populations of priority flora or being limited to specific landform types. The two mentioned factors both contribute to a suite of communities in the project area being regarded as significant. There is no legislative protection for significant communities, particularly in the Pilbara Region however, again, it is advisable that the DEC be consulted regarding the proposed impacts to areas containing such communities in order to evaluate the appropriate measures in which to proceed.

### 6.4.3 Declared Plants (Pest Weeds)

Certain weed species that are considered noxious or pest weeds and particularly where they pose threats to agriculture of the natural environment are listed as Declared Plants by the Department of Agriculture. These listings are pursuant to the *Agriculture and Related Resources Protection Act, 1976*. The Balmoral project area supports populations of the Declared Plant species *\*Prosopis pallida* (Mesquite) and *\*Datura leichhardtii* (Native Thornapple) (Department of Agriculture, 2006). Under the Act, landholders are obliged to carry out recommended control measures, each specific to the species.

### 6.4.4 Migratory Birds

The Australia has entered into agreements with Japan and China to protect migratory birds and birds in danger of extinction and their environment (JAMBA and CAMBA agreements). Under these agreements, there is an obligation for developments to ensure protection for the listed migratory bird species and their habitats. In this instance, the Balmoral project has the potential to impact on two species of migratory birds covered by the agreements and therefore the proposal must be referred to the Department of Environment and Heritage. It is unlikely, however, that any impact will be significant.

## 7.0 References

- Beard, J. S. (1981) *Vegetation Survey of Western Australia 1:1000000 Vegetation Series* University of Western Australia Press
- Bureau of Meteorology (2006). *Climate averages for specific sites*. Publicly available data prepared by the Bureau of Meteorology, Commonwealth of Australia
- Churchill, S.K. (1998). *Australian Bats*. Reed New Holland: Frenchs Forest, NSW
- Department of Agriculture (2006) *Declared Plant List*. Publicly available list prepared by the Department of Agriculture, Western Australia.
- Department of Environment and Conservation (2006) *Declared Rare and Priority Flora List*. Publicly available list prepared by Department of Environment and Conservation, Western Australia.
- Department of Environment and Conservation (2006) *Florabase*. The Flora of Western Australia Online (from pressed specimens housed at the WA Herbarium). [www.florabase.calm.wa.gov.au](http://www.florabase.calm.wa.gov.au)
- Department of Environment and Heritage (2002). *Interim Biogeographic Regionalisation for Australia Version 6.1*.
- Environmental Protection Authority (EPA) (2003) *Guidance Statement 56, Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia*
- Environmental Protection Authority (EPA) (2004) *Guidance Statement 51, Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia*
- Flegg, J. 2002. *Birds of Australia*. - Australian Museum, Reed New Holland Publishing.
- Halpern Glick Maunsell (2000) *Iron Ore Mine and Downstream Processing, Cape Preston, Western Australia, Public Environmental Review*. Prepared for Austeel Pty Ltd.
- Halpern Glick Maunsell (2001) *Austeel Biological Survey Phase I*. Unpublished report prepared for Austeel Pty Ltd.
- Halpern Glick Maunsell (2002) *Iron Ore Mine and Downstream Processing, Cape Preston, Western Australia, Supplementary Environmental Review*. Prepared for Austeel Pty Ltd
- Hassell (2001). *Shorebird Survey of Cape Preston 23<sup>rd</sup> - 26<sup>th</sup> February 2001*. Prepared for HGM.
- Hassell (2002). *Shorebird Survey of Cape Preston 8<sup>th</sup> - 13<sup>th</sup> October 2002*. Prepared for HGM.
- IUCN 2006. *2006 IUCN Red List of Threatened Species*. <[www.iucnredlist.org](http://www.iucnredlist.org)>. Downloaded on **15 April 2007**.
- Keighery, B.J. (1994) *Bushland Plant Survey - A Guide to Plant Community Survey for the Community Wildflower Society of WA (inc) Nedlands WA*

Mueller-Dombois, D. & Ellenberg, H. (1974) *Aims and Methods of Vegetation Ecology* John Wiley and Sons, New York, 547 pp.

Maunsell (2003). *Cape Preston Iron Ore Development. Seasonal Biological Survey – Threatened Flora*. Prepared for Austeel Pty Ltd.

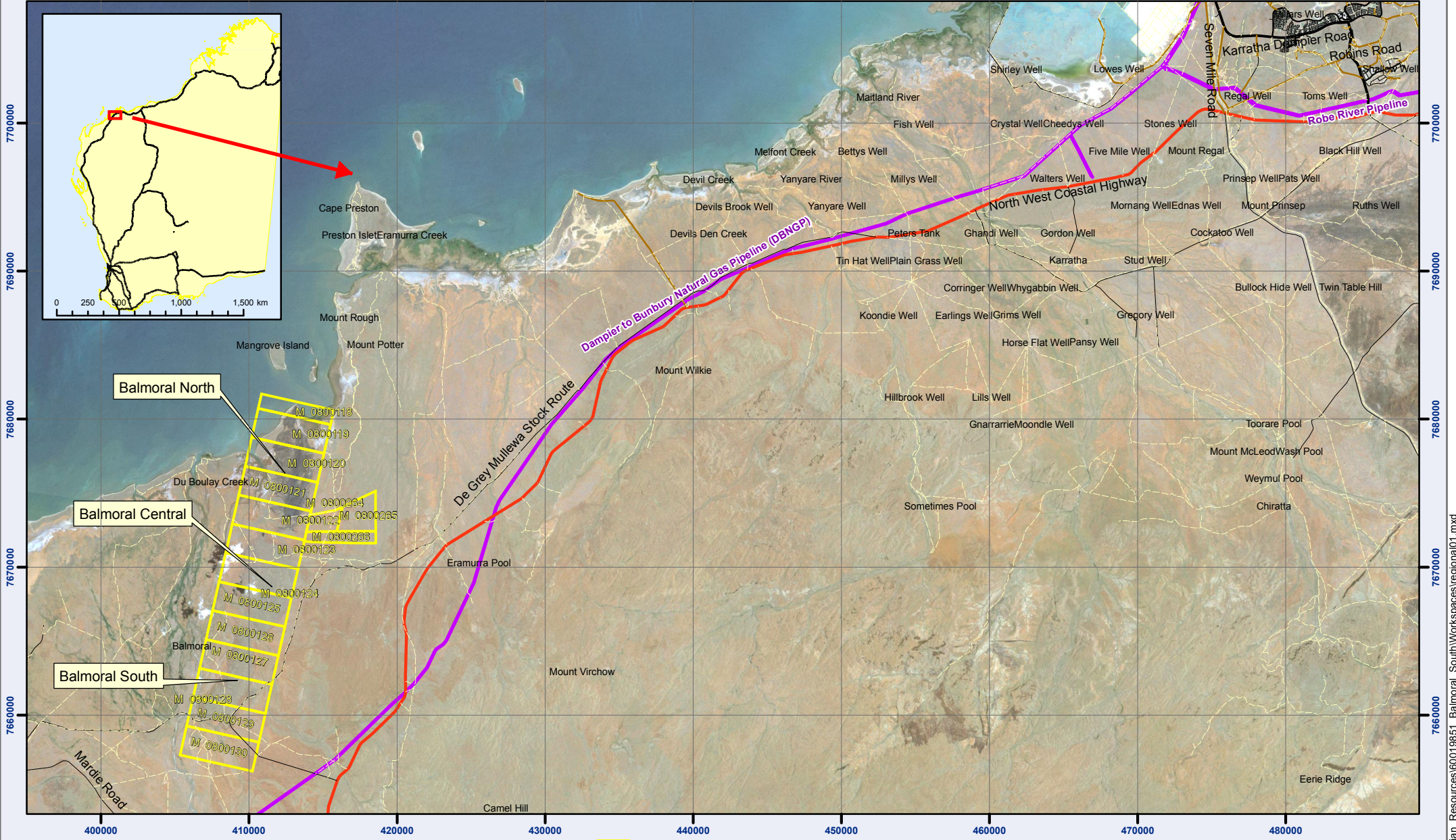
Mueller-Dombois, D. & Ellenberg, H. (1974) *Aims and Methods of Vegetation Ecology*. John Wiley and Sons, New York, 547pp.

Payne, A.L. & P.J. Tille (1992). *An inventory and condition survey of the Roeburne Plains and Surrounds*. Western Australian Department of Agriculture, Technical Bulletin No.83

Simpson, K. and Day, N. 1999. *The Claremont Field Guide to the Birds of Australia*. Penguin Books Australia.

Van Vreeswyk, A., Payne, A., Leighton, K. and Hennig, P. (2004). *An inventory and condition survey of the Pilbara region, Western Australia*. Western Australian Department of Agriculture, *Technical Bulletin No. 92*

**Balmoral South**



**Figure 1.1**

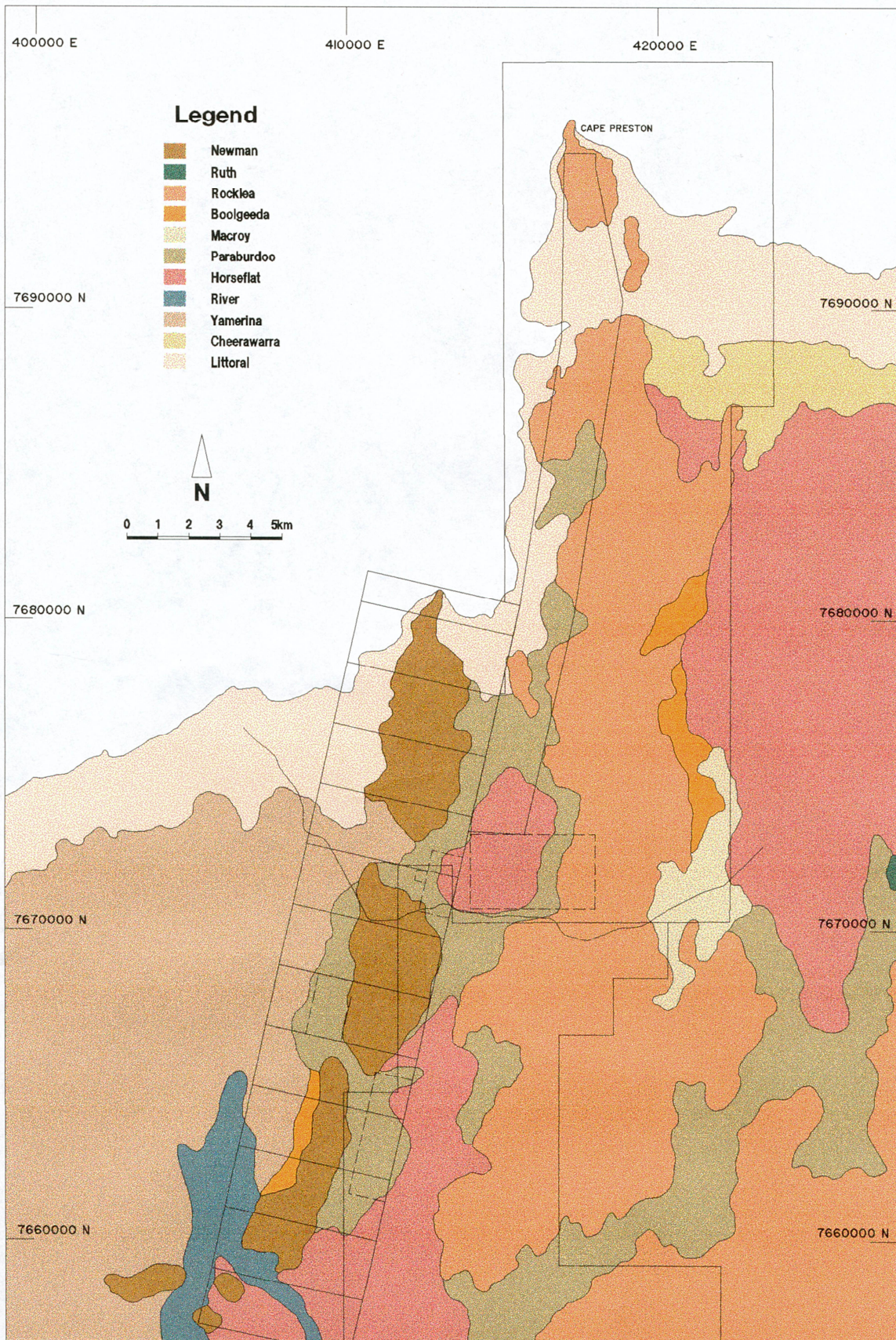
- |                         |                 |                          |
|-------------------------|-----------------|--------------------------|
| WAPlacenames_font_point | Sealed Road     | Mineralogy Mining Leases |
| Highway                 | Unsealed Road   |                          |
| Main Road               | Restricted Road |                          |
| Secondary Road          | Vehicular Track |                          |
|                         | Gas Pipeline    |                          |



**Regional Overview**



**MAUNSELL | AECOM**



**Figure 1.2**

**Land Systems of the Cape Preston Region**

Balmoral South

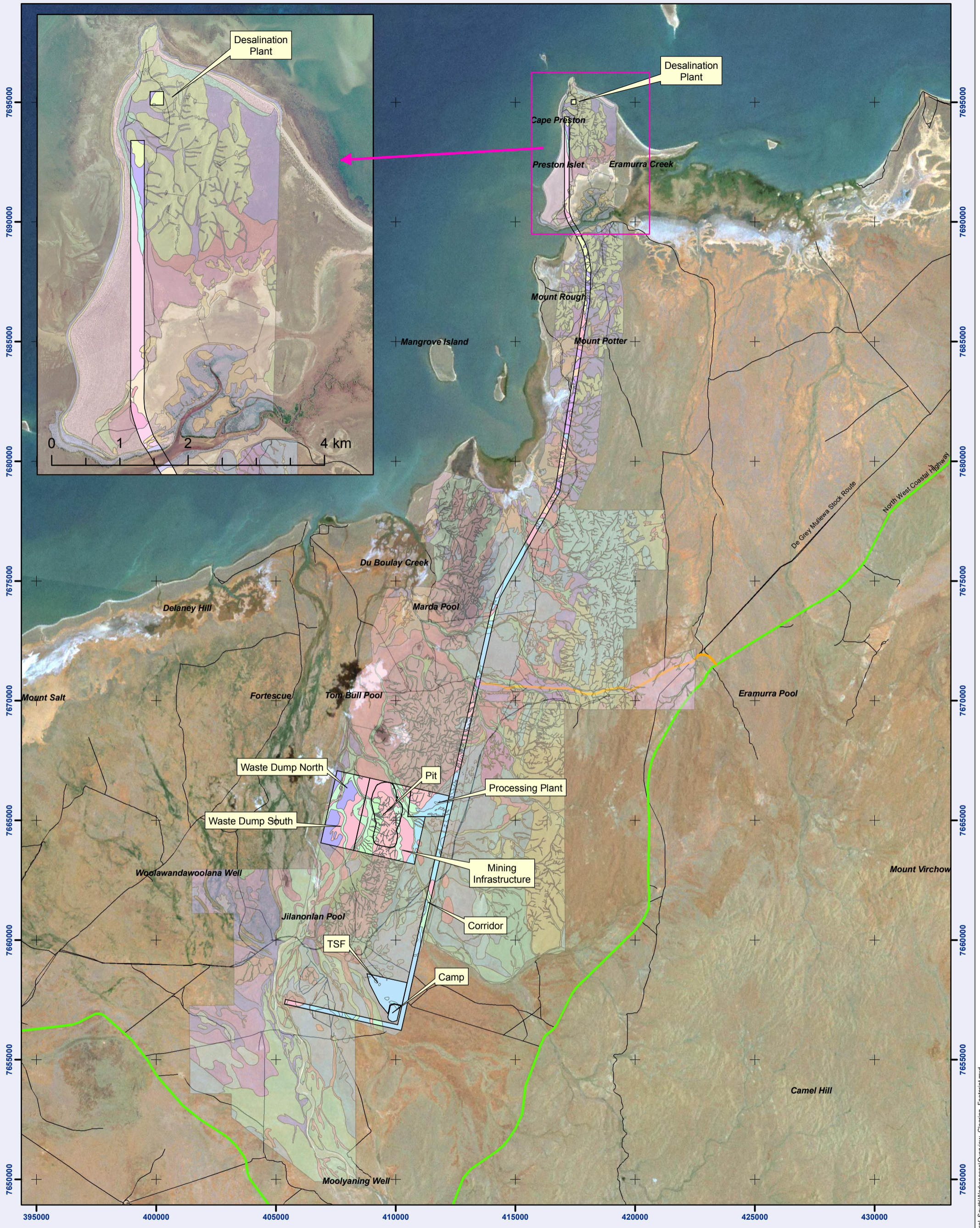


Figure 2

Overview of Clearing Footprint



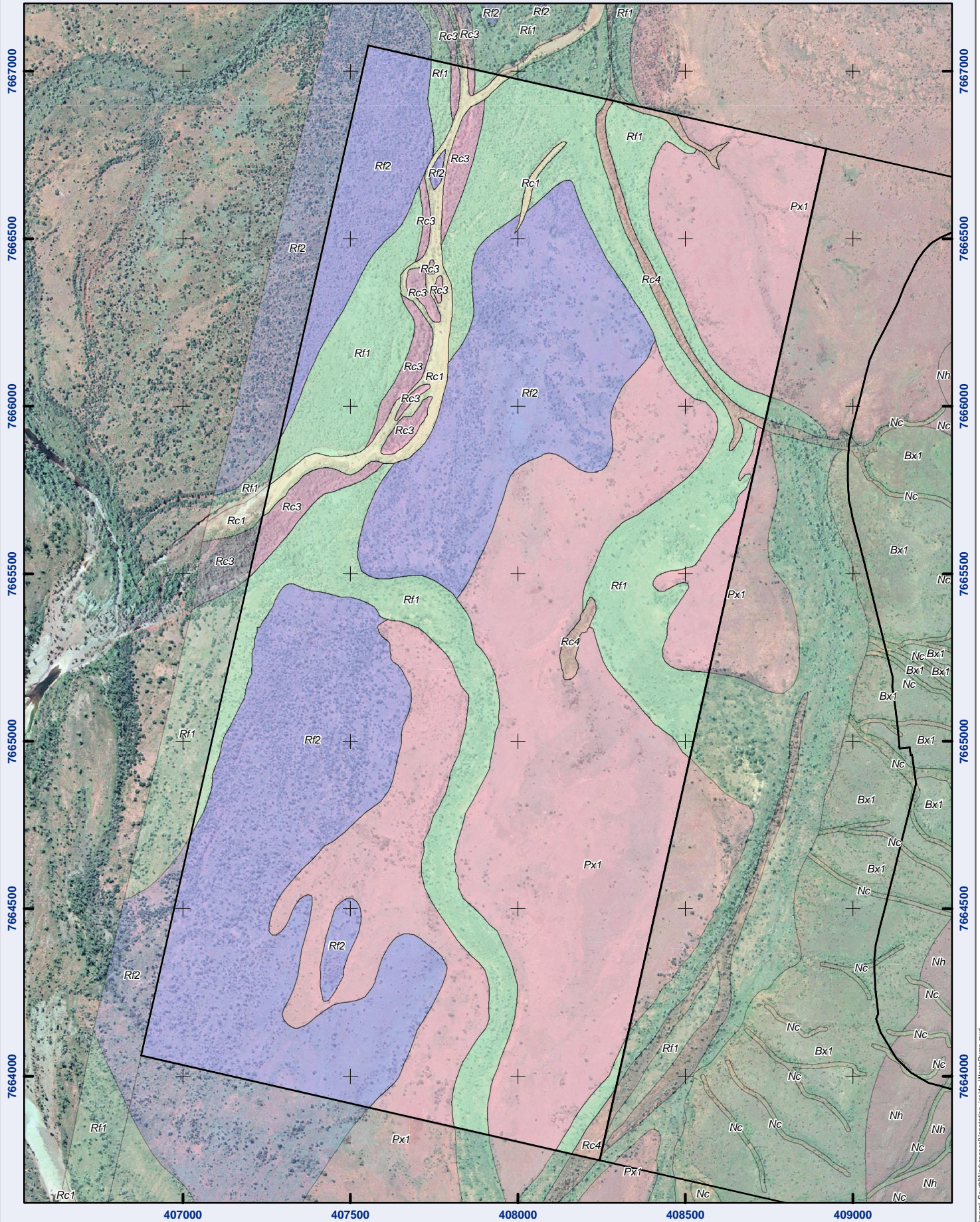
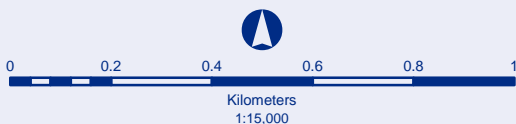


Figure 3

Vegetation Within Proposed Waste Dump Areas



Balmoral South

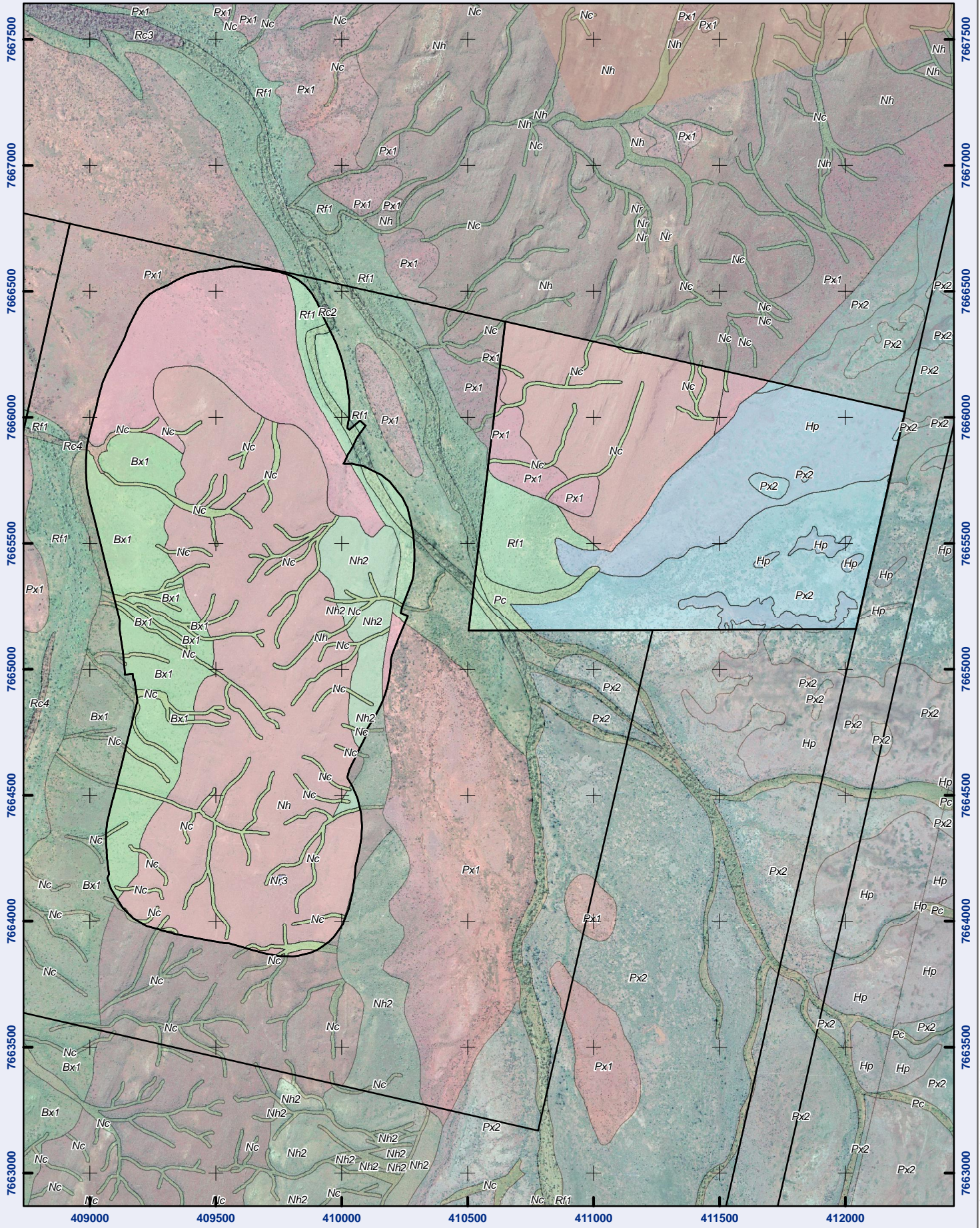


Figure 4

Vegetation Within Proposed Pit & Processing Plant Area



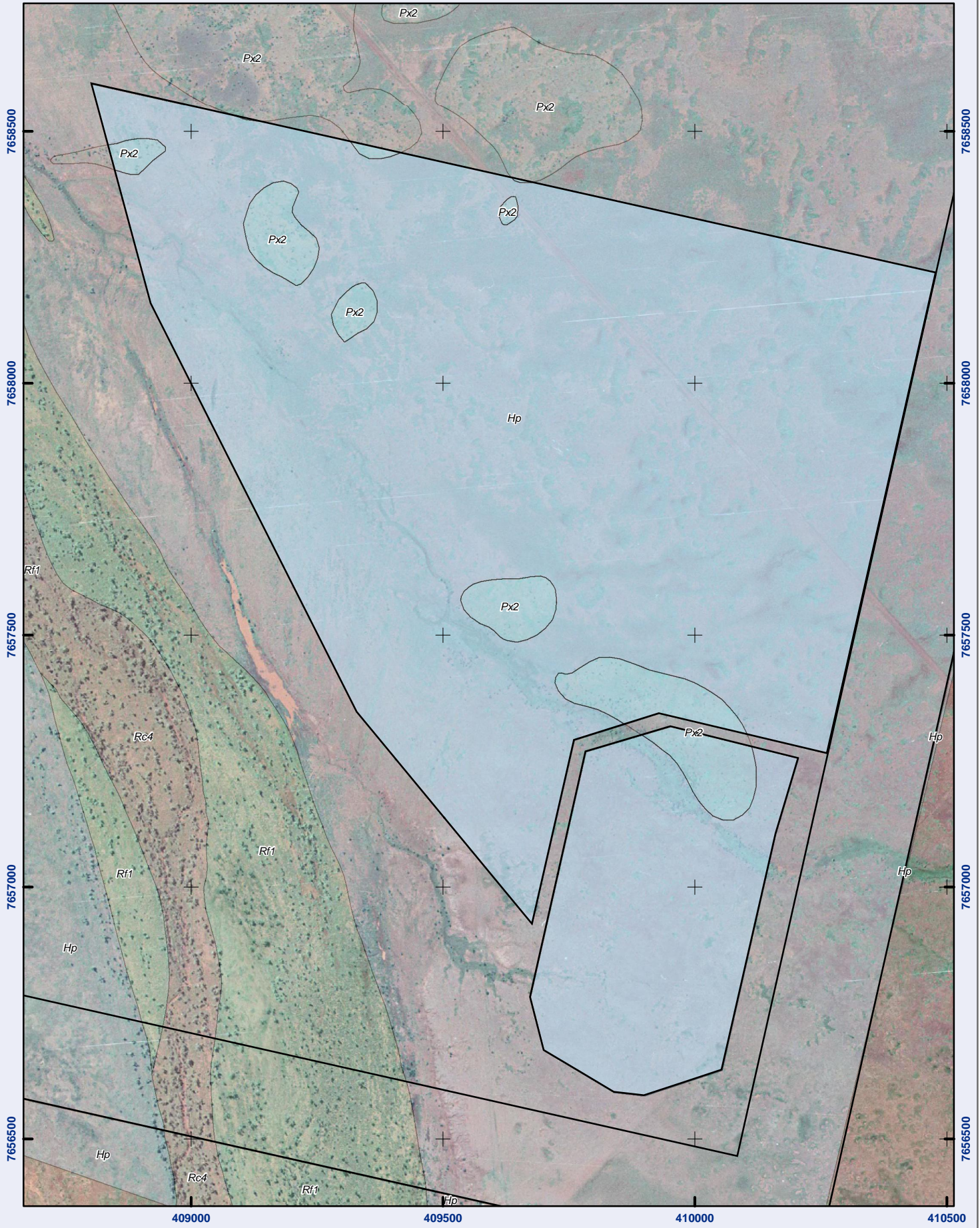
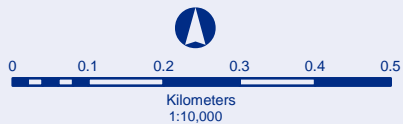


Figure 5

**Vegetation Within Proposed Accommodation Area and Tailings Dam**



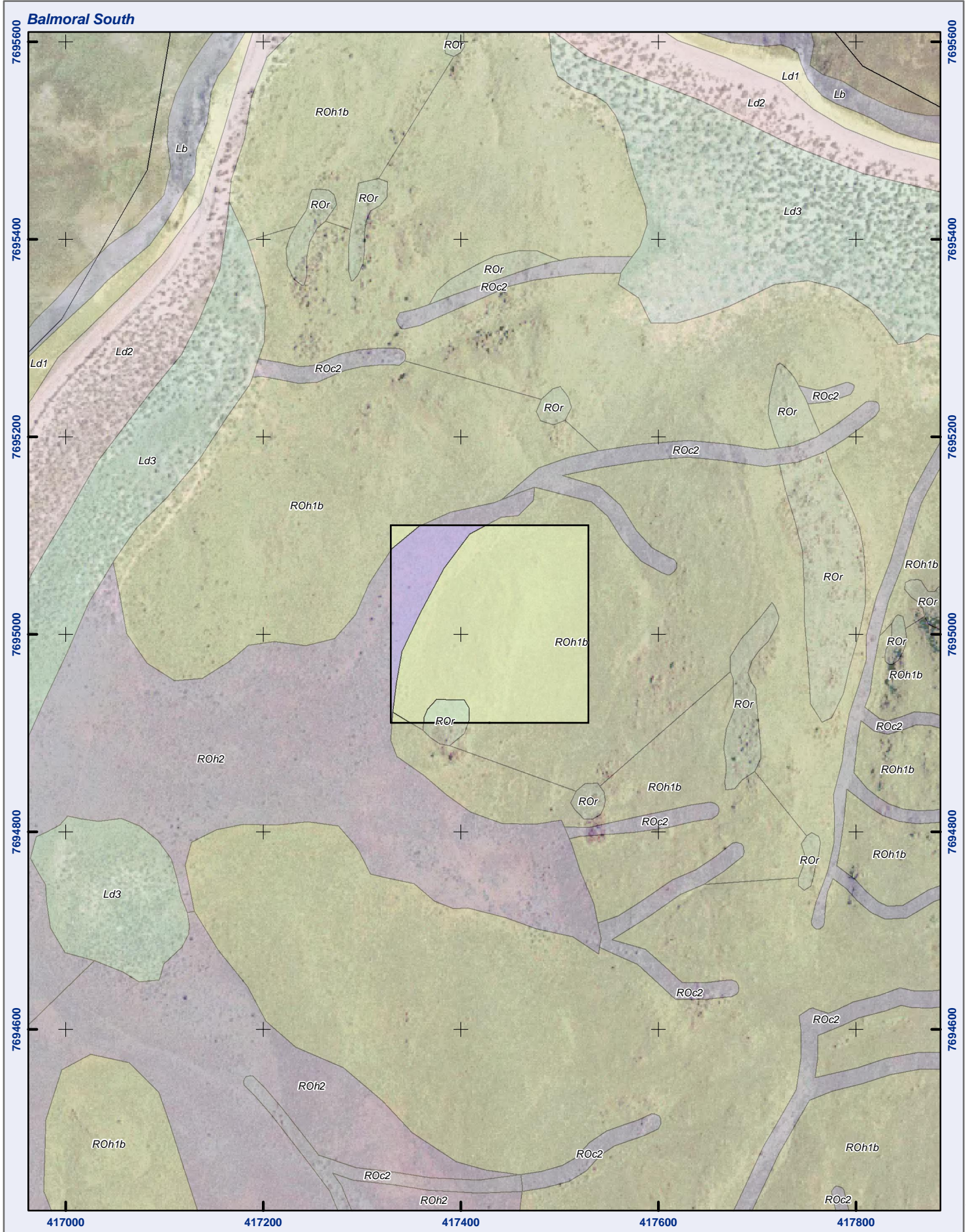
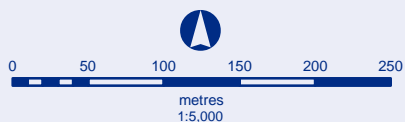


Figure 6

Vegetation Within Proposed Desalination Plant

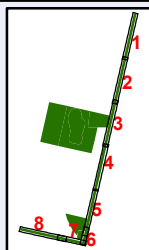
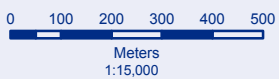


**Balmoral South**



**Figure 7**

**Vegetation Within Proposed Infrastructure Corridor**



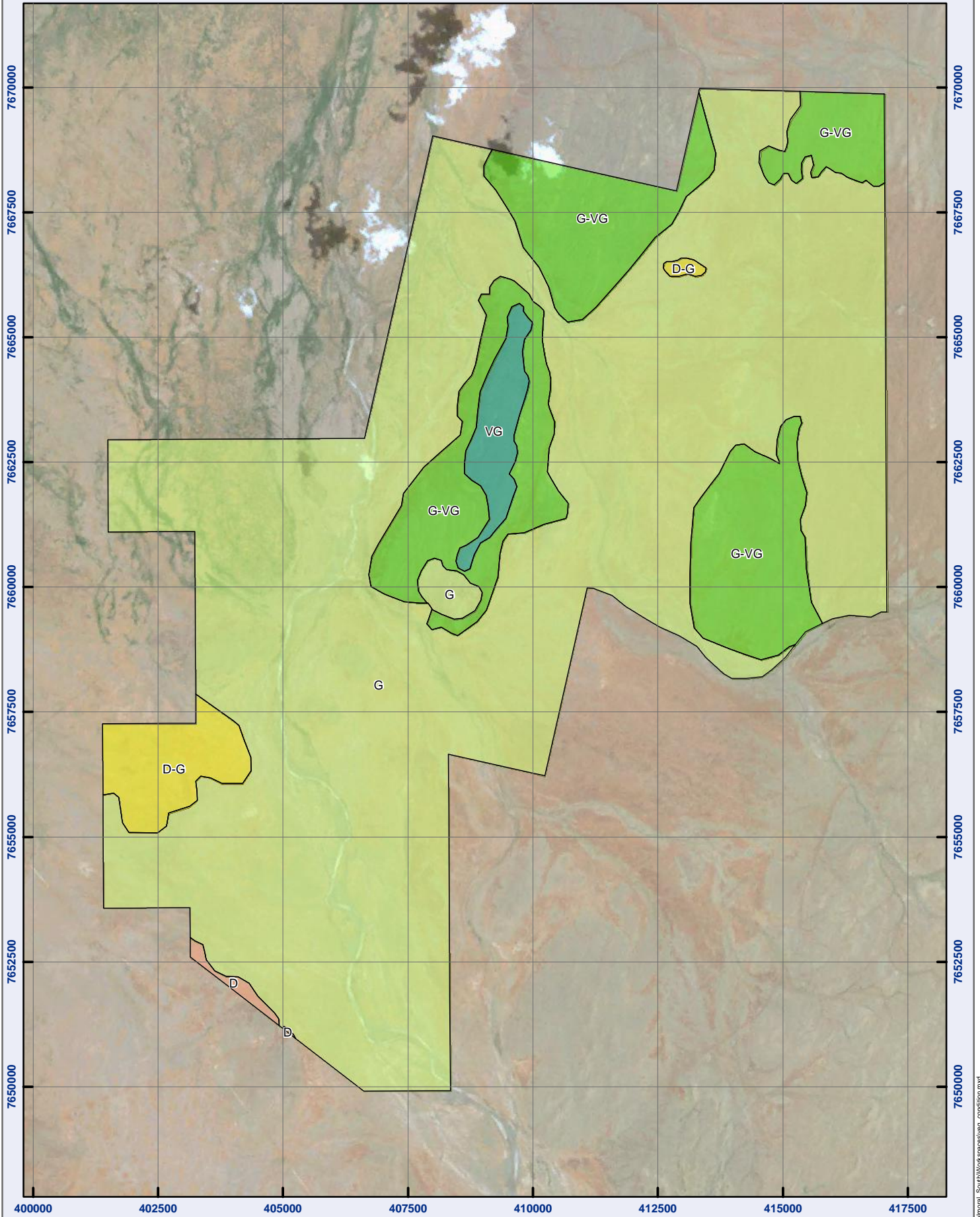
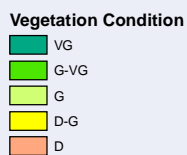


Figure 8

Vegetation Condition



Balmoral South

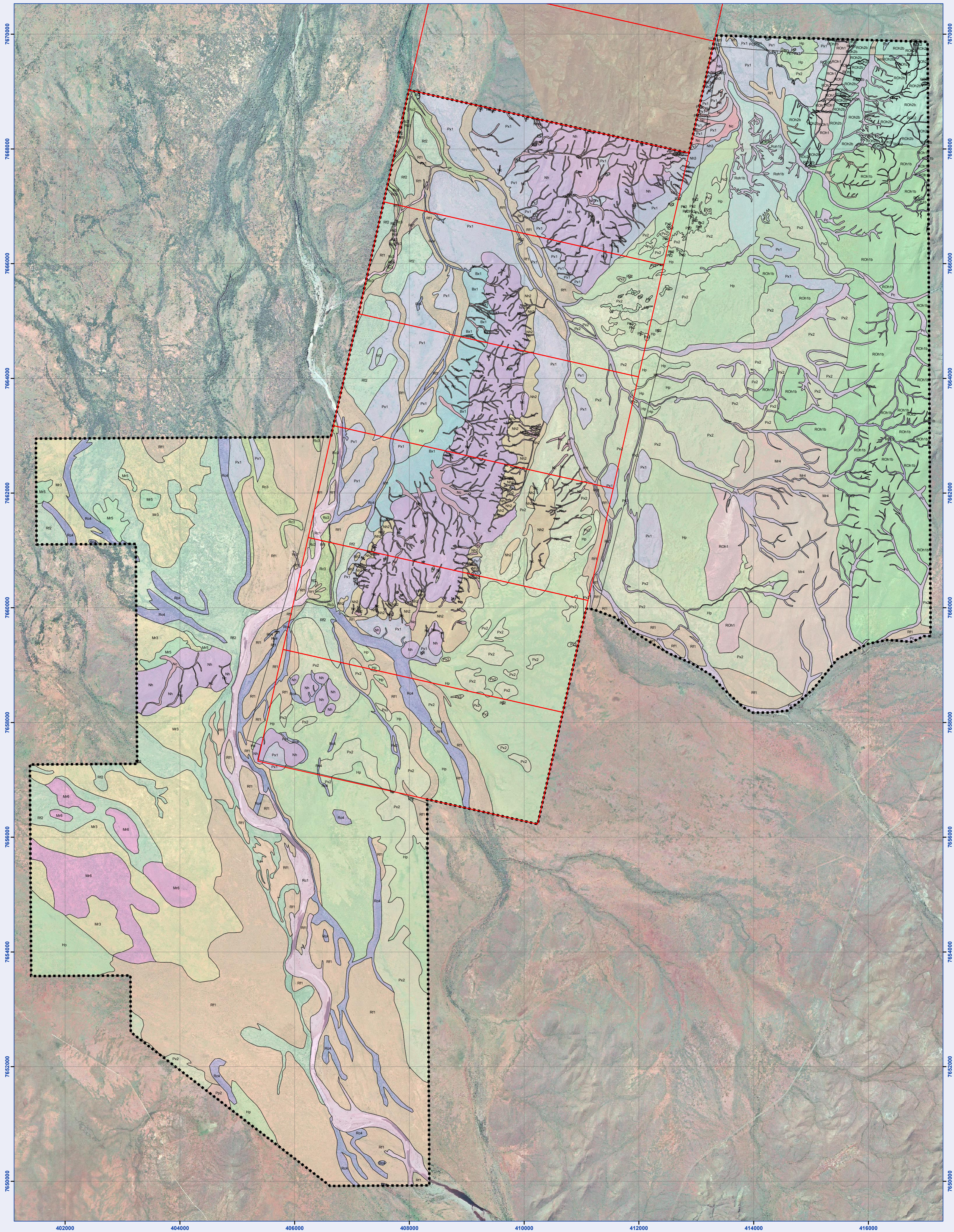


Figure 9

Vegetation Communities

**Legend**

Bx1	Mr6	Nr	Pp2	ROh1b	Rc4
Hp	Nc	Nr3	Px1	ROh2b	Rf1
Mr3	Nh	Pc	Px2	Rc1	Rf2
Mr4	Nh2	Pc2	ROc2	Rc2	ROh1b
Mr5	Nh3	Pp1	ROh1	Rc3	Mineralogy Mining Leases

1:30,000 @ A1



MAUNSELL | AECOM

# Appendix A: PATN Analysis Report

## **1.0 INTRODUCTION**

### **1.1 Purpose of this report**

This report presents the results and brief presentation of floristic analyses carried out to provide classification to assist recognition of plant communities in study my Maunsell in the Pilbara.

### **1.2 Levels of classification provided**

While a classification of the site data was a fundamental part of the analysis, that prepared requires field knowledge for corroboration.

That provided is based in intuition based on experience of how the nature of the clustering.

### **1.2 Location**

The data used in the analyses are from survey areas roughly in the Pilbara.

### **1.3 Data provided by Maunsell**

The data were provided in a spreadsheet as abundance. Each site had co-ordinates and had been allocated to a vegetation community. A limited number of sites had descriptions of soil and landforms.

The area sampled at each site was not disclosed.

Data provided included observations outside of quadrats. Several of the samples were from transects and these were not used.

## **2.0 METHODS**

### **2.1 Data Preparation**

The data was imported into the Microsoft Access database (“Maunsell.mdb”). All relevant data used for preparing the analysis and the products of the PATN analyses were incorporated into that database. The queries used to carry out the analysis are also incorporated into this database. At some quadrats, several records of the same taxon were provided and these were reconciled to one per quadrat and cover adjusted. One site (#4) had no species recorded as being in a quadrat and was excluded.

## **2.2 Comparisons made**

The data assembled were run as two dataset; one with the species being considered as either presence or absent from a site and the other a transformation of cover.

(Experience has shown that results using the absolute cover values tended to be “overly” influenced by the species with large cover. The transformation is the Domin Kranjina scale which is roughly the square root of cover.)

Presence absence has been proven appropriate for assessing the regional nature of the variation in site composition of quadrat data in earlier analyses of Pilbara bioregion data. Data including the cover of species at sites tends to be more useful when analysing datasets from smaller areas.

Only data from species present in quadrats were included in the analysis.

## **2.3 PATN analyses carried out**

Several modules of the numerical classification package PATN (Belbin 1987) were used for the analyses. The default parameter settings were used. A brief account of some of the methods used in PATN is provided in Appendix 1.

The PATN modules used were ASO (calculation of similarity matrix), FUSE (classification), DEND (representation of classification) and SSH (a form of ordination to display relationship of sites to the whole dataset). The results of the analyses were imported into a database so that site characteristics could be joined with the groups formed in the analysis.

For each dataset the modules were run twice;

- first with the sites as the classified objects (ie the species as the attributes), and
- then with the species as the classified objects (ie the sites as the attributes).

In this way both site and species groups were generated. The whole data matrix can then be presented with the rows being ordered by the species groupings and the columns ordered by the site groupings. This provides a way of inspecting how well the data conform with the classifications. Most of the interpretation is made from the

classification of sites. The species groups are used to support the interpretations more than to identify species that may be expected to occur in similar habitats.

The dendrogram represents the way the classified rows (sites or species in the respective data sets) fuse. This can be used to construct groups of rows by “cutting” at a particular value or cutting to obtain a particular number of groups. For the purpose of this study, two “cuts” were made for each of the sites to form “9 group”, and “16 group” classifications and for the species to form “20 group”, and “40 group” classifications. While these are arbitrary, they provide an opportunity to make interpretations of the nature of the classification.

In addition to the classifications described above, an ordination of the site and species data was carried out using the SSH (semi-strong hybrid multi-dimensional scaling) module of the PATN package (Belbin 1987). This was performed to diagrammatically present some of the relationships between sites. (But the results are not presented here.) Commonly, there is too much variation in the datasets to allow useful interpretations to be made using this technique. Interpretation from the preliminary analysis suggested that in this case it is to some degree useful.

## **2.4 Summaries made**

The PATN results were imported into the Access database where it was joined and summarised with Access queries. Key portions were exported to Excel in which the two-way table was formatted for easier visualisation and charts of geographic distribution were constructed.

## **3.0 LIMITATIONS**

The results are a presentation of a view of the data structure.

The classifications have been prepared to provide a basis for interpreting variation in site floristic composition. The absolute composition of groups defined by these analyses should not be interpreted as real communities. A process of review and refinement aided by field knowledge is required. This has not been done.

**4.0 RESULTS**

The objective of the analysis is to provide a classification of sites that are a robust representation of the floristic composition of the sampled plant communities.

The analysis showed that while there were differences in the classification using the cover compared to that using presence absence data, there was significant accord (Table 1).

Table 1 Comparison between site classification using cover vs presence absence data.

		Presence absence classification														
	GP9à	1	2	2	2	3	3	3	4	5	5	6	7	8	8	9
	GP15à	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
GP9	GP16															
1	1	2														
1	2		3	1												
1	3				2											
2	4					1										
2	5					1	1									
2	6					1										
3	7							1								
4	8											1				
5	9								1							
6	10											1	1			
6	11												2			
7	12									2						
7	13									4						
7	14										1					
8	15													2	1	
9	16															1

Because of the accord, and because most vegetation units are at least based on abundance of taxa, it was decided to continue the interpretation based on the cover data.

Figure 1 is the dendrogram from the classification of sites using cover data. While the 9 and 16 groups defined are to a degree arbitrary, they appear to represent a classification moderately similar to the vegetation classification (Table 2)

PATN Analysis Maunsell Sites  
Figure 1

E.A. Griffin & Associates December 2006

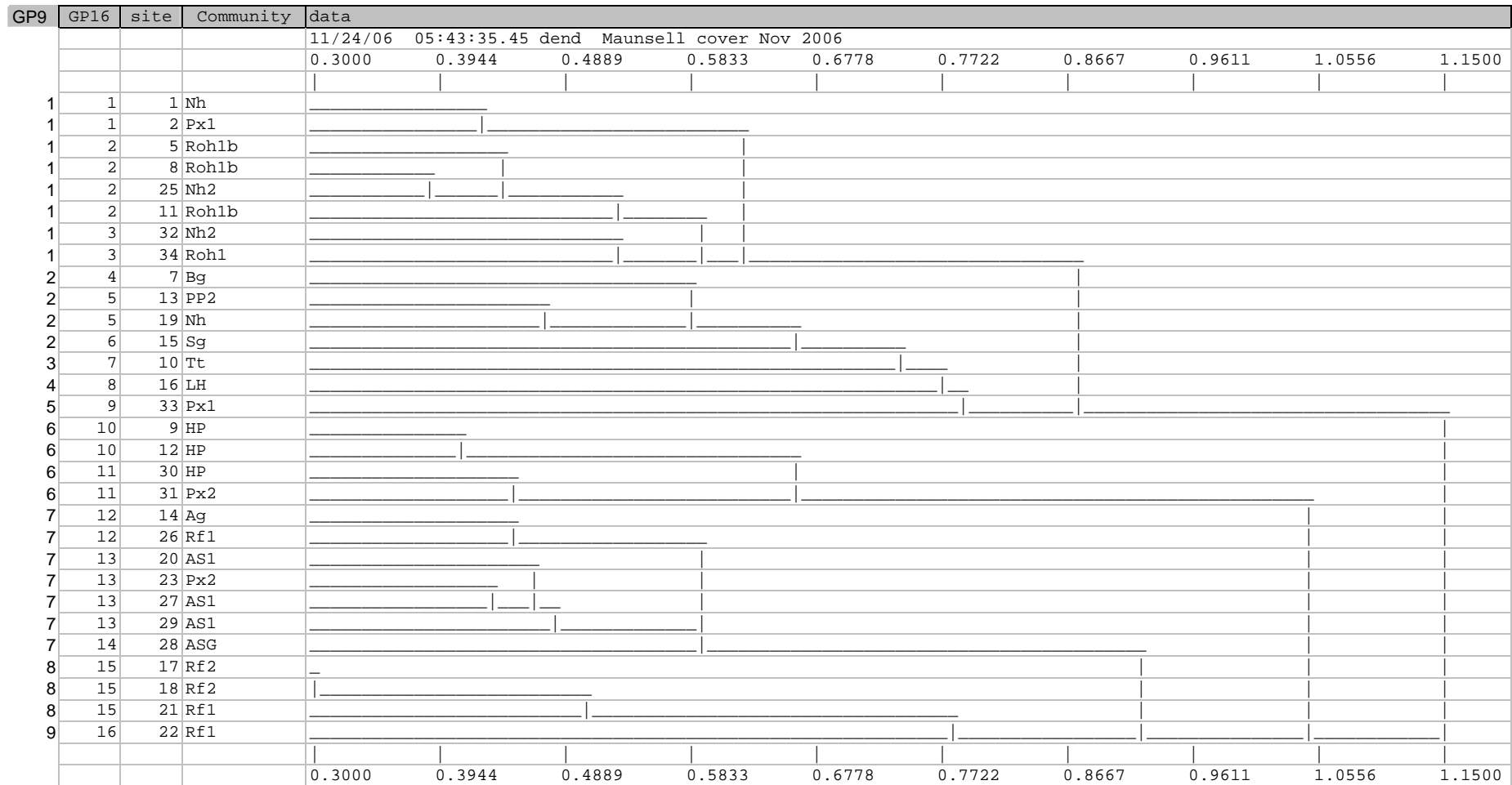


Table 2 Comparison of classification using cover data with the Veg communities defined. (Communities ordered to emphasise the accord between the two methods.)

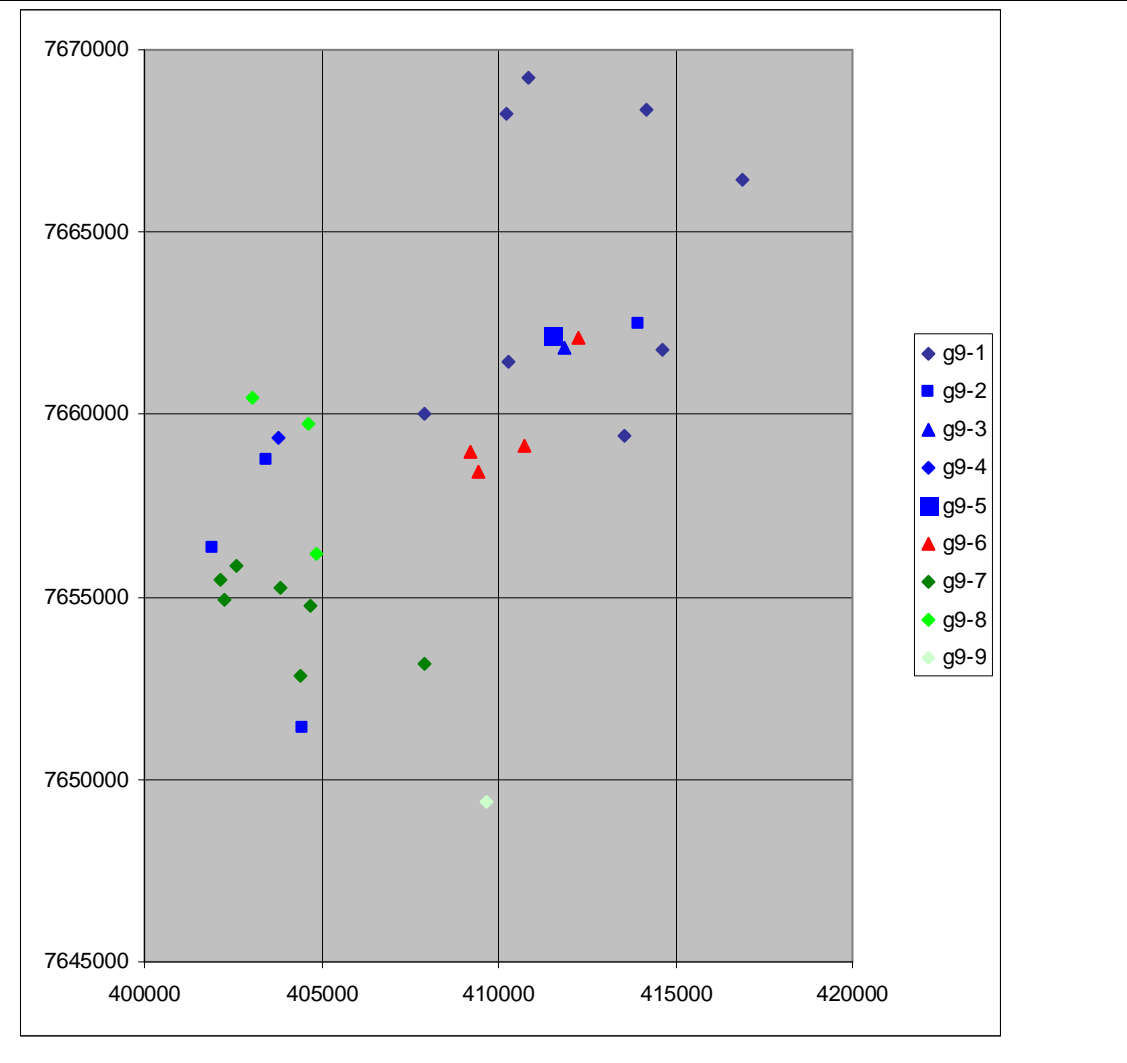
GP9	GP16	Vegetation Communities																	
		Nh	Px1	Roh1b	Nh2	Roh1	Bg	PP2	Sg	Tt	LH	HP	Px2	Ag	AS1	ASG	Rf2	Rf1	
1	1	1	1																
1	2			3	1														
1	3				1	1													
2	4						1												
2	5	1						1											
2	6								1										
3	7									1									
4	8										1								
5	9		1																
6	10											2							
6	11											1	1						
7	12													1					1
7	13												1		3				
7	14															1			
8	15																	2	1
9	16																		1

The classification of species when combined with the site classification enables a closer examination of the differences in composition between the groups defined. This is presented in “cover species by sites” sheet in the Maunsell\_output.xls file. No attempt is made to review or refine the classification. However, it can be seen that there is modest fidelity for species for different groups of sites.

The queries MC\_9\_species site\_freq and MC\_16\_species site\_freq provide lists of species present in each of the 9 and 16 groups respectively. Those that occurred in the greatest proportion of sites in a group are listed first for each group. Thus it is possible to construct a list of most frequently present species for each site group.

The distribution of groups appears to have a modest geographic basis (Figure 2). The classification using presence absence data was also geographically based.

Figure 2 distribution of Group 9 groups from classification of sites using cover data.



### 5.0 DISCUSSION

The accord between the classification of the sites using either presence absence or cover data suggests that the definition of communities by these methods is robust. This is reinforced by the degree of accord between these classifications and the vegetation communities defined by traditional means.

The moderate geographical base to the distribution of these communities is consistent with other studies in the Pilbara. On the face of it this is probably related to the geographic variation of parent material and landforms of the area.

## **6.0 REFERENCES**

Belbin, L. (1987). PATN Reference Manual (313p), Users Guide (79p), Command Manual (47p), and Example Manual (108p). CSIRO Division of Wildlife and Ecology, Lynham, ACT.

## **APPENDIX 1: Brief Account of Some of PATN Functions**

A package of computer routines commonly referred to as PATN provide a suite of useful techniques has been developed over a number of years (Belbin 1987). These have involved state of the art development with significant investigations of the robustness of techniques and appropriateness of use (eg Faith et al 1987). This package is a PC based menu driven interface to a DOS operating system.

The options available in this package are wide. However, there is a commonly used set which, through the extensive research of the developers of PATN, are recognised to be reasonably robust. These were used by Gibson et.al. (1994), Weston et al (1992) and Griffin (1994). Partly because of the desire to follow the same methodology, they were used in this analysis.

### **Classification**

Many mathematical methods have been developed to group (classify) abstract (floristic) units. Some attempt to identify discriminating attributes (species) that might be used as if in a key to define progressively (and hierarchically) more and more homogeneous (floristic) units. Typically these are called divisive classifications and may use one (monothetic) or a number (polythetic) of attributes (species) in each division. This tends to not be favoured for species rich vegetation with low dominance.

Other classifications tend to start from the object (site) and aggregate these with most similar object. Fundamental to the technique is the association matrix that describes how similar each (object) (site) is to each other (object). Similarity between pairs of objects is a function of the attributes (species) they share and the attributes (species) they do not share. It may also include or ignore abundance measures (cover, biomass, frequency scores for species). Different formulas have been found to emphasise different characteristics of the data and might, therefore, be useful in different situations. It is implicit that the formula should generate a similarity coefficient that reflects "ecological" distances. Detailed studies of robustness and suitability of these are numerous (eg Faith et al 1987).

The association matrix (or at least an association coefficient) is just the first step in agglomerative techniques. There are as many methods of agglomerating as there are methods for calculating similarity coefficients. Two basic systems are used; hierarchical and non-hierarchical.

Hierarchical agglomeration techniques progressively create fewer and fewer abstract groups of objects until all are grouped into one. The groups take on the “combined” attributes of the objects. These new groups by definition become more and more heterogeneous as new objects are joined. Once an object joins a group, it remains with it until there is just one group of all sites.

Non-hierarchical methods attempt to divide up ecological space by identifying nodes or areas of concentrations of objects; effectively by a series of “cookie cutters”. One such technique involves many iterations to “place” the “cookie cutters” in a way to achieve an “optimal solution”. Different size “cookie cutters” implies different degrees of similarity. While there might be an expectation that objects grouped together at a certain similarity will stay together when the similarity is widened (to include objects that are less similar). This need not be the case, hence it being described non-hierarchical.

### **Ordination**

Implicit in any ordination technique, and there are many, is that a coefficient can be calculated to represent the ecological distance between objects. The variation between objects can be represented in multi-dimensional space. This abstract space is defined to have  $n-1$  axes where  $n$  is the number of objects. Also implicit is that the distribution of objects in this space is not random and therefore, optimum solutions can be computed which shows the much of the differences can be represented on just a few axes.

This technique is particularly useful in attempting to describe the influence of environmental variables. It, however, has difficulty in representing relationships between data sets that contain objects that have little or nothing in common.

### **Main Programs**

For each data set, ASO created a symmetric association matrix made up of pair-wise calculations of similarity “distance”. The “distance” was 1 minus the Czekanowski coefficient that is the number of species in common divided by the average number of species in the two sites being compared. The more similar are the sites the smaller the distance. This can therefore vary from 0 for absolutely identical to 1 for absolutely different. The latter is a very common occurrence but former is very rare except in very simple communities with just a few species. In moderately rich shrub communities, sites from the same stand have a value of about 0.25 to 0.4.

Using each of these matrices, the routine FUSE classified the sites using the “unweighted pair-group mean average” fusion method. This hierarchical, agglomerative classification “fuses” the most similar sites first in such a way that all sites (by definition) are eventually fused together. FUSE both determines the fusion order and calculates a measure of the distance between the sites (or groups of sites). Since the group “average” calculation is influenced by its contributing sites, it needs to be appreciated that the addition or subtraction of sites from the data set will change the overall fusion. Some of the fusion strategies tend to create groups of odd sites (ones with little in common), especially if there are many similar sites in other groups.

DEND provides a one dimensional, graphic (dendritic or tree) representation of the fusions. Within a “branch”, the site sequence is arbitrary, and sites can be swapped and branches can be rotated so long as no branches cross. The greater the distance (along a branch) between junctions, the more distinct the fusing components are from each other. Belonging to a branch implies a relative affinity. However, care must be taken in assigning meaning to higher order branches for experience has shown that these fusions can often be arbitrary. This is particularly the case where the data set is highly heterogeneous and these branches (groups of sites) may have almost nothing in common.

A number of summary routines were used to assist in the interpretation. GDF provides group membership from the output of FUSE for a user-defined number of groups. NNB provides from the association matrix a list of n nearest neighbours for each site.

SSH is a general purpose multi-dimensional scaling algorithm. This groups of techniques is believed to be the most robust form of ordination available and the algorithm available in PATN has been shown to be superior to a wide range of other ordination methods such as principal components/co-ordinates, reciprocal averaging and detrended correspondence analysis.

Just as the sites can be grouped according to the similarity of their species composition, so too the species can be grouped according to the number of sites in which they occur. To do so, the data matrix was transposed so that the species were the rows and the sites were the columns. A big difference in classifying species is how to calculate a sensible similarity coefficient between a species that for example occurs at very few sites and one that occurs at most. This stretches the meaning of “average” number of species that is used in the numerator of the Czekanowski coefficient. TWOSTEP is an alternate method that attempts to generate a more

“sensible” measure of similarity. This was used in the current analysis as it was in Gibson et.al. (1994).

Once the association matrix was generated, the same routines used above for the sites were performed.

#### TWINSpan

This was not used because of experience with this kind of classification and the analysis of others. Eg Belbin states in the help file for PATN

“What can I say? It is included because I had to make it compatible with PATN to test its properties. It is a divisive-polythetic algorithm that some ecologists like. Tests suggest that flexible UPGMA (FUSE) and ALOC are generally significantly better.”

**APPENDIX 2:** List of Sheets in “Maunsell Output.xls”

**Cover** Dendrogram of sites using species coded cover value community code name, Group 9 and Group 16 numbers, coordinates and some site attributes.

**cover\_distn** scatter plot of GP9 classification on eastings and northings

**cover species by sites** Matrix of all species (rows) by All sites with the species and sites ordered by the respective dendrograms. The classifications are emphasised by highlighting.

**pres\_abs** Dendrogram of sites using species presence or absence with community code, Group 9 and Group 15 numbers, coordinates and some site attributes.

**pres\_abs\_distn** scatter plot of GP9 classification on eastings and northings

## Appendix B: Individual Quadrat data used for PATN Analysis

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Eastings	Northings				
410871	76669236	1	Nh	<i>Acacia bivenosa</i>	3
		1	Nh	<i>Acacia monticola</i>	1
		1	Nh	<i>Corchorus laniflorus</i>	<1
		1	Nh	<i>Erodium</i> sp.	<1
		1	Nh	<i>Glycine ?tomentella</i>	<1
		1	Nh	<i>Glycine ?tomentella</i>	<1
		1	Nh	<i>Goodenia stobbsiana</i>	<1
		1	Nh	<i>Paspalidium ?tabulatum</i>	1.5
		1	Nh	<i>Ptilotus ?auriculifolius/macrocephalus</i>	2
		1	Nh	<i>Ptilotus clementii</i>	<1
		1	Nh	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	4
		1	Nh	<i>Ptilotus villosiflorus</i>	4
		1	Nh	<i>Senna ?notabilis</i>	1
		1	Nh	<i>Senna glutinosa</i> ssp <i>pruinosa</i>	7
		1	Nh	<i>Sida cardiophylla</i>	<1
		1	Nh	<i>Solanum horridum</i>	1
		1	Nh	<i>Triodia wiseana</i>	60
410252	7668255	2	Px1	<i>Acacia bivenosa</i>	2
		2	Px1	<i>Acacia xiphophylla</i>	5
		2	Px1	<i>Corchorus laniflorus</i>	<1
		2	Px1	<i>Glycine ?tomentella</i>	2
		2	Px1	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	<1
		2	Px1	<i>Ptilotus ?auriculifolius/macrocephalus</i>	<1
		2	Px1	<i>Ptilotus clementii</i>	<1
		2	Px1	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	40
		2	Px1	<i>Ptilotus villosiflorus</i>	<1
		2	Px1	<i>Salsola tragus</i> subsp. <i>ragus</i>	0.5
		2	Px1	<i>Sclerolaena uniflora</i>	<1
		2	Px1	<i>Senna glutinosa</i> ssp <i>pruinosa</i>	2
		2	Px1	<i>Senna glutinosa</i> subsp. <i>glutinosa</i>	<1
		2	Px1	<i>Senna glutinosa</i> subsp. <i>x luerssenii</i>	1
		2	Px1	<i>Triodia wiseana</i>	40
409817	7666886	T3	Nc	* <i>Cenchrus ciliaris</i>	1.5
		T3	Nc	* <i>Prosopis pallida</i>	1
		T3	Rf1	<i>Acacia bivenosa</i>	4
		T3	Nc	<i>Acacia coriaceae</i> subsp. <i>pendens</i>	1
		T3	Nc	<i>Alternanthera nodiflora</i>	0.5
		T3	Nc	<i>Ammannia multiflora</i>	3
		T3	Rf1	<i>Cassipourea capillaris</i>	<0.5
		T3	Rf1	<i>Corchorus laniflorus</i>	0.5
		T3	Nc	<i>Cyperus bifax</i>	0.5
		T3	Nc	<i>Eucalyptus victrix</i>	8
		T3	Rf1	<i>Glycine ?tomentella</i>	2
		T3	Nc	<i>Goodenia lamprosperma</i>	0.5
		T3	Nc	<i>Goodenia stobbsiana</i>	<1
		T3	Nc	* <i>Malvastrum americanum</i>	1
		T3	Nc	<i>Mulius gracilis</i>	1.5

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Eastings	Northings				
		T3	Nc	* <i>Passiflora foetida</i>	1.5
		T3	Rf1	<i>Petalostylis labicheoides</i>	40
		T3	Nc	<i>Rostellularia adscendens</i> subsp. <i>clementii</i>	0.5
		T3	Rf1	<i>Senna glutinosa</i> subsp. <i>x luerssenii</i>	0.5
		T3	Nc	<i>Sida rohlenae</i>	<1
		T3	Nc	<i>Stemodia grossa</i>	<1
		T3	Rf1	<i>Triodia wiseana</i>	60
413475	7667899	4	Hp	<i>Dichanthium serium</i> subsp. <i>humilis</i>	na
		4	Hp	<i>Enneapogon caerulescens</i>	na
		4	Hp	<i>Eragrostis setifolia</i>	na
		4	Hp	<i>Eragrostis tenellula</i>	na
		4	Hp	<i>Eragrostis xerophila</i>	na
		4	Hp	<i>Eriachne aff. mucronata</i>	na
		4	Hp	<i>Indigofera linifolia</i>	na
		4	Hp	<i>Indigofera trita</i>	na
		4	Hp	* <i>Malvastrum americanum</i>	na
		4	Hp	<i>Ptilotus aevroides</i>	na
		4	Hp	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	na
		4	Hp	<i>Ptilotus gomprenooides</i> subsp. <i>gomphrenoides</i>	na
		4	Hp	<i>Rynchosia minima</i>	na
		4	Hp	<i>Sida rohlenae</i>	na
		4	Hp	<i>Sporobolus australasicus</i>	na
		4	Hp	<i>Stemodia kingii</i>	na
		4	Hp	<i>Streptoglossa liatroides</i>	na
		4	Hp	<i>Tephrosia clementii</i>	na
		4	Hp	<i>Themeda triandra</i>	na
414164	7668363	5	Roh1b	<i>Corchorus laniflorus</i>	6
		5	Roh1b	<i>Crotalaria medicaginea</i>	<0.5
		5	Roh1b	<i>Dichanthium sericeum</i> subsp. <i>humilius</i>	2
		5	Roh1b	<i>Eremophila maculata</i>	<0.5
		5	Roh1b	<i>Euphorbia coghlanii</i>	<0.5
		5	Roh1b	<i>Glycine ?tomentella</i>	2
		5	Roh1b	<i>Glycine ?tomentella</i>	<0.5
		5	Roh1b	<i>Glycine ?tomentella</i>	<0.5
		5	Roh1b	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	<0.5
		5	Roh1b	<i>Goodenia microptera</i>	<0.5
		5	Roh1b	<i>Indigofera linifolia</i>	<0.5
		5	Roh1b	<i>Indigofera trita</i>	<0.5
		5	Roh1b	<i>Polycarpea holtzei</i>	<0.5
		5	Roh1b	<i>Polycarpea longiflora</i>	<0.5
		5	Roh1b	<i>Pterocaulon sphaeranthoides</i>	<0.5
		5	Roh1b	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	<0.5
		5	Roh1b	<i>Ptilotus helipteroides</i>	<0.5
		5	Roh1b	<i>Rynchosia minima</i>	<0.5
		5	Roh1b	<i>Trichodesma zeylanicum</i> var. <i>grandiflorum</i>	<0.5
		5	Roh1b	<i>Triodia wiseana</i>	50
		5	Roh1b	<i>Triumfetta clementii</i>	1

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Eastings	Northings				
416067	7665584	T6	Rc1	* <i>Cenchrus ciliaris</i>	3
		T6	Rc1	* <i>Cenchrus ciliaris</i>	4
		T6	Rc1	<i>Acacia bivenosa</i>	<1
		T6	Rc1	<i>Acacia coriacea</i> var. <i>coriacea</i>	5
		T6	Rc1	<i>Acacia inaequilatera</i>	<1
		T6	Rc1	<i>Acacia inaequilatera</i>	0.5
		T6	Rc1	<i>Adriana urticoides</i> var. <i>hookeri</i>	<1
		T6	Rc1	<i>Corchus walcottii</i>	<1
		T6	Rc1	<i>Crotalaria novae - hollandiae</i> subsp. <i>crassipes</i>	<1
		T6	Rc1	<i>Cyperus vaginatus</i>	10
		T6	Rc1	<i>Cyperus vaginatus</i>	2
		T6	Rc1	<i>Eragrostis tenellula</i>	<1
		T6	Rc1	<i>Eucalyptus victrix</i>	10
		T6	Rc1	<i>Glycine ?tomentella</i>	1
		T6	Rc1	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	<1
		T6	Rc1	<i>Haloragis gossei</i>	<1
		T6	Rc1	<i>Hibiscus austrinus</i>	0.5
		T6	Rc1	<i>Hybanthus auranticus</i>	<1
		T6	Rc1	* <i>Malvastrum americanum</i>	<1
		T6	Rc1	* <i>Malvastrum americanum</i>	<0.5
		T6	Rc1	<i>Melaleuca linophylla</i>	20
		T6	Rc1	<i>Melaleuca linophylla</i>	50
		T6	Rc1	<i>Nicotiana rosulata</i> subsp. <i>rostulata</i>	<1
		T6	Rc1	<i>Operculina aequisejala</i>	<1
		T6	Rc1	<i>Pterocaulon sphacelatum</i>	0.5
		T6	Rc1	<i>Sesbania cannabina</i>	1
		T6	Rc1	<i>Sesbania cannabina</i>	5
		T6	Rc1	<i>Sida fibulifera</i>	<1
		T6	Rc1	<i>Triodia</i> aff. <i>epactia</i>	3
		T6	Rc1	<i>Triodia</i> aff. <i>epactia</i>	4
413941	7662471	7	Mr4	* <i>Cenchrus ciliaris</i>	<0.5
		7	Mr4	* <i>Prosopis pallida</i>	<0.5
		7	Mr4	<i>Acacia bivenosa</i>	0.5
		7	Mr4	<i>Aristida contorta</i>	2.5
		7	Mr4	<i>Crotalaria medicaginea</i>	<0.5
		7	Mr4	<i>Enneapogon caeruleus</i>	5
		7	Mr4	<i>Eremophila maculata</i>	<0.5
		7	Mr4	<i>Euphorbia coghlanii</i>	<0.5
		7	Mr4	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	2
		7	Mr4	<i>Gomphrena cunninghamii</i>	<0.5
		7	Mr4	<i>Indigofera colutea</i>	1
		7	Mr4	<i>Indigofera linifolia</i>	0.5
		7	Mr4	<i>Ptilotus aevroides</i>	5
		7	Mr4	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	<0.5

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Easting	Northing				
		7	Mr4	<i>Ptilotus helipteroides</i>	<0.5
		7	Mr4	<i>Rynchosia minima</i>	1.5
		7	Mr4	<i>Sida rohlenae</i>	6
		7	Mr4	<i>Sporobolus australasicus</i>	0.5
		7	Mr4	<i>Themeda triandra</i>	<0.5
		7	Mr4	<i>Triodia wiseana</i>	60
414648	7661787	8	Roh1b	<i>Aristida contorta</i>	1
		8	Roh1b	<i>Corchorus laniflorus</i>	4
		8	Roh1b	<i>Glycine ?tomentella</i>	1
		8	Roh1b	<i>Gomprena cunninghamii</i>	1
		8	Roh1b	<i>Goodenia microptera</i>	0.5
		8	Roh1b	<i>Polycarpea longiflora</i>	<0.5
		8	Roh1b	<i>Ptilotus ?auriculifolius/macrocephalus</i>	1
		8	Roh1b	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	2
		8	Roh1b	<i>Rynchosia minima</i>	<0.5
		8	Roh1b	<i>Solanum diversiflorum</i>	<0.5
		8	Roh1b	<i>Solanum horridum</i>	1.5
		8	Roh1b	<i>Tephrosia supina</i>	<0.5
		8	Roh1b	<i>Themeda triandra</i>	<0.5
		8	Roh1b	<i>Triodia wiseana</i>	70
		8	Roh1b	<i>Triumfetta clementii</i>	1
412242	7662112	9	Hp	* <i>Prosopis pallida</i>	1
		9	Hp	<i>Dichanthium sericeum</i> subsp. <i>humilius</i>	35
		9	Hp	<i>Enneapogon caerulescens</i>	1
		9	Hp	<i>Eragrostis xerophila</i>	55
		9	Hp	<i>Eremophila maculata</i>	<0.5
		9	Hp	<i>Goodenia pasqua</i> (P3)	<0.5
		9	Hp	* <i>Malvastrum americanum</i>	<0.5
		9	Hp	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	<0.5
		9	Hp	<i>Sesbania cannabina</i>	<0.5
		9	Hp	<i>Sida rohlenae</i>	5
		9	Hp	<i>Sporobolus australasicus</i>	10
		9	Hp	<i>Stemodia kingii</i>	0.5
411863	7661829	10	Mr6	* <i>Cenchrus ciliaris</i>	3
		10	Mr6	* <i>Prosopis pallida</i>	1
		10	Mr6	<i>Acacia bivenosa</i>	6
		10	Mr6	<i>Acacia inaequilatera</i>	1
		10	Mr6	<i>Alternanthera nodiflora</i>	<0.5
		10	Mr6	<i>Amaranthus pallidiflorus</i>	<0.5
		10	Mr6	<i>Dichanthium sericeum</i> subsp. <i>humilius</i>	15
		10	Mr6	<i>Dichanthium sericeum</i> subsp. <i>humilius</i>	0.5

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Eastings	Northing				
		10	Mr6	<i>Eragrostis tenellula</i>	7
		10	Mr6	<i>Eriachne aff. mucronata</i>	10
		10	Mr6	<i>Erodium sp.</i>	<0.5
		10	Mr6	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	<0.5
		10	Mr6	<i>Goodenia forrestii</i>	<0.5
		10	Mr6	<i>Grevillea pyramidalis</i>	0.5
		10	Mr6	<i>Hybanthus auranticus</i>	<0.5
		10	Mr6	<i>Indigofera colutea</i>	<0.5
		10	Mr6	<i>Indigofera linifolia</i>	0.5
		10	Mr6	<i>Indigofera trita</i>	<0.5
		10	Mr6	<i>Ipomoea muellerii</i>	0.5
		10	Mr6	<i>Marselia drummondii</i>	<0.5
		10	Mr6	<i>Pterocaulon sphacelatum</i>	<0.5
		10	Mr6	<i>Rynchosia minima</i>	0.5
		10	Mr6	<i>Sida rohlenae</i>	1
		10	Mr6	<i>Solanum horridum</i>	<0.5
		10	Mr6	<i>Sporobolus australasicus</i>	1
		10	Mr6	<i>Trichodesma zeylanicum</i> var. <i>grandiflorum</i>	<0.5
		10	Mr6	<i>Triodia aff. epactia</i>	50
		10	Mr6	<i>Triodia pungens</i>	2
		10	Mr6	<i>Triodia wiseana</i>	6
		10	Mr6	<i>Triumfetta clementii</i>	0.5
416894	766415	11	Roh1b	<i>Acacia ancistrocarpa</i>	0.5
		11	Roh1b	<i>Acacia bivenosa</i>	<0.5
		11	Roh1b	<i>Alternanthera nodiflora</i>	<0.5
		11	Roh1b	<i>Aristida holathera</i>	5
		11	Roh1b	<i>Corchorus laniflorus</i>	1
		11	Roh1b	<i>Cymbopogon procerus</i>	3
		11	Roh1b	<i>Glycine ?tomentella</i>	5
		11	Roh1b	<i>Glycine ?tomentella</i>	<0.5
		11	Roh1b	<i>Indigofera linifolia</i>	<0.5
		11	Roh1b	<i>Mukia maderaspatana</i>	0.5
		11	Roh1b	<i>Polycarpea longiflora</i>	0.5
		11	Roh1b	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	<0.5
		11	Roh1b	<i>Rynchosia minima</i>	<0.5
		11	Roh1b	<i>Senna glutinosa</i> subsp. <i>pruinosa</i>	2
		11	Roh1b	<i>Senna glutinosa</i> subsp. <i>glutinosa</i>	<0.5
		11	Roh1b	<i>Solanum horridum</i>	0.5
		11	Roh1b	<i>Stemodia grossa</i>	<0.5
		11	Roh1b	<i>Templetonia aff. hookeri</i>	<0.5
		11	Roh1b	<i>Tribulus suberosus</i>	0.5
		11	Roh1b	<i>Trichodesma zeylanicum</i> var. <i>grandiflorum</i>	<0.5
		11	Roh1b	<i>Triodia wiseana</i>	60
		11	Roh1b	<i>Triumfetta clementii</i>	<0.5

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Easting	Northing				
410742	7659121	12	Hp	<i>Dichanthium fecundum</i>	1
		12	Hp	<i>Dichanthium sericeum</i> subsp. <i>humilius</i>	45
		12	Hp	<i>Eragrostis xerophila</i>	50
		12	Hp	<i>Goodenia forrestii</i>	0.5
		12	Hp	<i>Indigofera colutea</i>	<0.5
		12	Hp	<i>Indigofera linifolia</i>	<0.5
		12	Hp	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	<0.5
		12	Hp	<i>Ptilotus gomphrenoides</i> var. <i>conglomeratus</i>	<0.5
		12	Hp	<i>Rynchosia minima</i>	<0.5
		12	Hp	<i>Scleroleana bicornis</i>	0.5
		12	Hp	<i>Sporobolus australasicus</i>	<0.5
		12	Hp	<i>Stemodia kingii</i>	<0.5
		12	Hp	<i>Streptoglossa liatroides</i>	1
		12	Hp	<i>Themeda triandra</i>	10
404481	7651400	13	Pp2	* <i>Cenchrus ciliaris</i>	1
		13	Pp2	* <i>Prosopis pallida</i>	1
		13	Pp2	<i>Acacia bivenosa</i>	0.5
		13	Pp2	<i>Acaia inaequilatera</i>	0.5
		13	Pp2	<i>Boerhavia paludosa</i>	<0.5
		13	Pp2	<i>Corchorus laniflorus</i>	<0.5
		13	Pp2	<i>Dichanthium sericeum</i> subsp. <i>humilius</i>	0.5
		13	Pp2	<i>Eremophila maculata</i>	<0.5
		13	Pp2	<i>Eriachne benthamii</i>	1
		13	Pp2	<i>Eucalyptus</i> sp.	1
		13	Pp2	<i>Euphorbia australis</i>	0.5
		13	Pp2	<i>Glycine ?tomentella</i>	<0.5
		13	Pp2	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	<0.5
		13	Pp2	<i>Heliptropium chrysocarpum</i>	<0.5
		13	Pp2	<i>Indigofera linifolia</i>	<0.5
		13	Pp2	<i>Mukia maderaspatana</i>	<0.5
		13	Pp2	<i>Pterocaulon sphaeranthoides</i>	<0.5
		13	Pp2	<i>Ptilotus aevroides</i>	<0.5
		13	Pp2	<i>Scleroleana costata</i>	<0.5
		13	Pp2	<i>Senna glutinosa</i> subsp. <i>x luerssenii</i>	1
13	Pp2	<i>Sida rohlenae</i>	<0.5		
13	Pp2	<i>Solanum horridum</i>	<0.5		
13	Pp2	<i>Sporobolus australasicus</i>	<0.5		
13	Pp2	<i>Themeda triandra</i>	<0.5		
13	Pp2	<i>Triodia wiseana</i>	20		
13	Pp2	<i>Triumfetta clementii</i>	1		

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Easting	Northing				
402140	7655455	14	Mr6	* <i>Cenchrus ciliaris</i>	60
		14	Mr6	* <i>Prosopis pallida</i>	5
		14	Mr6	<i>Acacia inaequilatera</i>	1
		14	Mr6	<i>Acacia sclerosperma</i> subsp. <i>sclerosperma</i>	<0.5
		14	Mr6	<i>Acacia synchronicia</i>	<0.5
		14	Mr6	<i>Acaia inaequilatera</i>	2
		14	Mr6	* <i>Aerva javanica</i>	1
		14	Mr6	<i>Aristida contorta</i>	1
		14	Mr6	<i>Brachyachne convergens</i>	<0.5
		14	Mr6	* <i>Citrullus lanatus</i>	<0.5
		14	Mr6	<i>Corchorus laniflorus</i>	0.5
		14	Mr6	<i>Desmodium filiforme</i>	<0.5
		14	Mr6	<i>Dichanthium fecundum</i>	5
		14	Mr6	<i>Dichanthium sericeum</i> subsp. <i>humilius</i>	5
		14	Mr6	<i>Eragrostis xerophila</i>	5
		14	Mr6	<i>Eremophila maculata</i>	<0.5
		14	Mr6	<i>Euphorbia coghlanii</i>	<0.5
		14	Mr6	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	1
		14	Mr6	<i>Goodenia forrestii</i>	<0.5
		14	Mr6	<i>Indigofera colutea</i>	<0.5
		14	Mr6	<i>Indigofera linifolia</i>	<0.5
		14	Mr6	<i>Ipomoea muellerii</i>	<0.5
		14	Mr6	* <i>Malvastrum americanum</i>	<0.5
		14	Mr6	<i>Mukia maderaspatana</i>	<0.5
		14	Mr6	<i>Polygala aff. Isingii</i>	<0.5
		14	Mr6	<i>Polymeria ambigua</i>	<0.5
		14	Mr6	<i>Pterocaulon sphaeranthoides</i>	<0.5
		14	Mr6	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	1
		14	Mr6	<i>Ptilotus helipteroides</i> var. <i>helipteroides</i>	<0.5
		14	Mr6	<i>Rynchosia minima</i>	<0.5
		14	Mr6	<i>Solanum horridum</i>	1
		14	Mr6	<i>Sporobolus australasicus</i>	2
		14	Mr6	<i>Tephrosia supina</i>	1
		14	Mr6	<i>Themeda triandra</i>	2
		14	Mr6	<i>Triumfetta clementii</i>	<0.5

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Easting	Northing				
401935	7656352	15	Mr6	* <i>Cenchrus ciliaris</i>	1
		15	Mr6	* <i>Prosopis pallida</i>	2
		15	Mr6	<i>Acacia xiphophylla</i>	1
		15	Mr6	<i>Acaia inaequilatera</i>	<0.5
		15	Mr6	<i>Aristida contorta</i>	45
		15	Mr6	<i>Enneapogon caeruleus</i>	30
		15	Mr6	<i>Eragrostis tenellula</i>	1
		15	Mr6	<i>Eremophila maculata</i>	<0.5
		15	Mr6	<i>Eriachne aff. helmsii</i>	<0.5
		15	Mr6	<i>Eriachne benthamii</i>	25
		15	Mr6	<i>Eriachne benthamii</i>	<0.5
		15	Mr6	<i>Glycine ?tomentella</i>	<0.5
		15	Mr6	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	<0.5
		15	Mr6	<i>Indigofera linifolia</i>	<0.5
		15	Mr6	<i>Pterocaulon sphaeranthoides</i>	<0.5
		15	Mr6	<i>Ptilotus aevoides</i>	<0.5
		15	Mr6	<i>Rynchosia minima</i>	<0.5
		15	Mr6	<i>Solanum horridum</i>	<0.5
		15	Mr6	<i>Themeda triandra</i>	5
		15	Mr6	<i>Triodia wiseana</i>	<0.5
		15	Mr6	<i>Triumfetta clementii</i>	2
403771	7659346	16	Mr5	* <i>Cenchrus ciliaris</i>	1
		16	Mr5	* <i>Prosopis pallida</i>	30
		16	Mr5	<i>Abutilon lepidum</i>	<0.5
		16	Mr5	<i>Alectryon oleifolius</i>	<0.5
		16	Mr5	<i>Boerhavia repleta</i>	<0.5
		16	Mr5	<i>Enneapogon caeruleus</i>	5
		16	Mr5	<i>Eragrostis xerophila</i>	<0.5
		16	Mr5	<i>Heliptropium heteranthum</i>	<0.5
		16	Mr5	* <i>Malvastrum americanum</i>	<0.5
		16	Mr5	<i>Ptilotus aevoides</i>	5
		16	Mr5	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	<0.5
		16	Mr5	<i>Ptilotus gomphrenoides</i> var. <i>conglomeratus</i>	20
		16	Mr5	<i>Scleroleana costata</i>	<0.5
		16	Mr5	<i>Sesbania cannabina</i>	<0.5
		16	Mr5	<i>Sida rohlenae</i>	<0.5
		16	Mr5	<i>Solanum horridum</i>	<0.5
		16	Mr5	<i>Sporobolus australasicus</i>	5
		16	Mr5	<i>Triumfetta clementii</i>	<0.5

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Eastings	Northings				
404609	7659765	17	Rf2	* <i>Cenchrus ciliaris</i>	25
		17	Rf2	* <i>Prosopis pallida</i>	50
		17	Rf2	* <i>Aerva javanica</i>	1
		17	Rf2	<i>Corchorus laniflorus</i>	0.5
		17	Rf2	<i>Desmodium filiforme</i>	<0.5
		17	Rf2	<i>Eucalyptus victrix</i>	1
		17	Rf2	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	<0.5
		17	Rf2	<i>Indigofera colutea</i>	<0.5
		17	Rf2	<i>Mukia maderaspatana</i>	<0.5
		17	Rf2	<i>Solanum horridum</i>	<0.5
		17	Rf2	<i>Triumfetta clementii</i>	<0.5
403068	7660439	18	Rf2	* <i>Cenchrus ciliaris</i>	80
		18	Rf2	* <i>Prosopis pallida</i>	60
		18	Rf2	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	<0.5
		18	Rf2	<i>Indigofera colutea</i>	<0.5
		18	Rf2	<i>Polygala aff. Isingii</i>	<0.5
		18	Rf2	<i>Scleroleana costata</i>	<0.5
403473	7658783	19	Nh	* <i>Cenchrus ciliaris</i>	<0.5
		19	Nh	<i>Acacia bivenosa</i>	<0.5
		19	Nh	<i>Aristida contorta</i>	<0.5
		19	Nh	<i>Aristida contorta</i>	<0.5
		19	Nh	<i>Autilon cryptopetalum</i>	2
		19	Nh	<i>Corchorus laniflorus</i>	1.5
		19	Nh	<i>Eriachne benthamii</i>	<0.5
		19	Nh	<i>Eriachne pulchella</i> subsp. <i>dominii</i>	<0.5
		19	Nh	<i>Euphorbia boophthona</i>	<0.5
		19	Nh	<i>Evolvulus alsinoides</i> var. <i>villosicalyx</i>	<0.5
		19	Nh	<i>Glycine ?tomentella</i>	<0.5
		19	Nh	<i>Glycine ?tomentella</i>	<0.5
		19	Nh	<i>Glycine ?tomentella</i>	<0.5
		19	Nh	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	<0.5
		19	Nh	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	<0.5
		19	Nh	<i>Gomphrena cunninghamii</i>	<0.5
		19	Nh	<i>Goodenia forrestii</i>	<0.5
		19	Nh	<i>Haloragis gossei</i>	<0.5
		19	Nh	<i>Heliptropium heteranthum</i>	<0.5
		19	Nh	* <i>Malvastrum americanum</i>	<0.5

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Easting	Northing				
		19	Nh	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	1
		19	Nh	<i>Scleroleana costata</i>	<0.5
		19	Nh	<i>Senna artemisioides</i> subsp. <i>oligophylla</i>	1
		19	Nh	<i>Sida rohlenae</i>	<0.5
		19	Nh	<i>Solanum horridum</i>	<0.5
		19	Nh	<i>Sporobolus australasicus</i>	<0.5
		19	Nh	<i>Themeda triandra</i>	<0.5
		19	Nh	<i>Tribulus hirtus</i>	<0.5
		19	Nh	<i>Triodia wiseana</i>	30
		19	Nh	<i>Triumfetta clementii</i>	<0.5
402623	7655852	20	Mr3	* <i>Cenchrus ciliaris</i>	20
		20	Mr3	<i>Acacia coriacea</i> var. <i>coriacea</i>	3
		20	Mr3	<i>Acacia sclerosperma</i> subsp. <i>sclerosperma</i>	5
		20	Mr3	<i>Acacia victoriae</i>	3
		20	Mr3	<i>Acacia inaequilatera</i>	20
		20	Mr3	<i>Aristida contorta</i>	<0.5
		20	Mr3	<i>Boerhavia coccinea</i>	<0.5
		20	Mr3	<i>Brachyachne convergens</i>	20
		20	Mr3	<i>Chrysopogon fallax</i>	<0.5
		20	Mr3	<i>Corchorus laniflorus</i>	0.5
		20	Mr3	<i>Dichanthium fecundum</i>	1
		20	Mr3	<i>Dichanthium sericeum</i> subsp. <i>humilius</i>	1
		20	Mr3	<i>Eremophila longiflora</i>	<0.5
		20	Mr3	<i>Eremophila maculata</i>	<0.5
		20	Mr3	<i>Eriachne aff. helmsii</i>	<0.5
		20	Mr3	<i>Euphorbia coghlanii</i>	<0.5
		20	Mr3	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	<0.5
		20	Mr3	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	<0.5
		20	Mr3	<i>Indigofera linifolia</i>	<0.5
		20	Mr3	<i>Ipomoea muellerii</i>	0.5
		20	Mr3	<i>Ptilotus gomphrenoides</i> var. <i>conglomeratus</i>	10
		20	Mr3	<i>Rynchosia minima</i>	<0.5
		20	Mr3	<i>Sida rohlenae</i>	0.5
		20	Mr3	<i>Solanum horridum</i>	<0.5
		20	Mr3	<i>Sporobolus australasicus</i>	0.5
		20	Mr3	<i>Themeda triandra</i>	<0.5
		20	Mr3	<i>Triumfetta clementii</i>	<0.5

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Easting	Northing				
404883	7656160	21	Rf1	* <i>Cenchrus ciliaris</i>	60
		21	Rf1	* <i>Prosopis pallida</i>	1
		21	Rf1	<i>Acacia coriaceae</i> subsp. <i>pendens</i>	1
		21	Rf1	* <i>Aerva javanica</i>	<0.5
		21	Rf1	<i>Eucalyptus victrix</i>	1
		21	Rf1	<i>Euphorbia schultzei</i>	<0.5
		21	Rf1	<i>Indigofera colutea</i>	<0.5
		21	Rf1	<i>Indigofera linifolia</i>	<0.5
		21	Rf1	<i>Mukia maderaspatana</i>	<0.5
		21	Rf1	<i>Triodia pungens</i>	2
409649	7649380	22	Rf1	* <i>Cenchrus ciliaris</i>	20
		22	Rf1	<i>Acacia coriaceae</i> subsp. <i>pendens</i>	1
		22	Rf1	<i>Alternanthera nodiflora</i>	1
		22	Rf1	<i>Basilicum polystachyon</i>	0.5
		22	Rf1	<i>Corchorus laniflorus</i>	1
		22	Rf1	<i>Eualia aurea</i>	5
		22	Rf1	<i>Eucalyptus victrix</i>	20
		22	Rf1	<i>Goodenia lamprosperma</i>	0.5
		22	Rf1	* <i>Malvastrum americanum</i>	0.5
		22	Rf1	<i>Mukia maderaspatana</i>	0.5
		22	Rf1	<i>Operculina aequiseipala</i>	2
		22	Rf1	<i>Rostellularia adscendens</i> var. <i>clementii</i>	3
		22	Rf1	<i>Sesbania cannabina</i>	<0.5
		22	Rf1	<i>Sporobolus australasicus</i>	<0.5
407890	7653193	23	Px2	* <i>Cenchrus ciliaris</i>	30
		23	Px2	* <i>Prosopis pallida</i>	2
		23	Px2	<i>Acacia amplicipes</i>	1
		23	Px2	<i>Acacia amplicipes</i>	<0.5
		23	Px2	<i>Acacia coriacea</i> subsp. <i>pendens</i>	<0.5
		23	Px2	<i>Acacia coriacea</i> var. <i>coriacea</i>	5
		23	Px2	<i>Acacia xiphophylla</i>	<0.5
		23	Px2	<i>Acaia inaequilatera</i>	20

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Eastings	Northings				
		23	Px2	<i>Chrysopogon fallax</i>	2
		23	Px2	<i>Corchorus laniflorus</i>	1
		23	Px2	<i>Dichanthium fecundum</i>	<0.5
		23	Px2	<i>Dichanthium sericeum</i> subsp. <i>humilius</i>	10
		23	Px2	<i>Eragrostis xerophila</i>	30
		23	Px2	<i>Eremophila maculata</i>	<0.5
		23	Px2	<i>Gomprena cunninghamii</i>	1
		23	Px2	<i>Indigofera linifolia</i>	2
		23	Px2	<i>Ipomoea muellerii</i>	<0.5
		23	Px2	* <i>Malvastrum americanum</i>	<0.5
		23	Px2	<i>Ptilotus gomphrenoides</i> var. <i>conglomeratus</i>	1.5
		23	Px2	<i>Rynchosia minima</i>	1
		23	Px2	<i>Rynchosia minima</i>	<0.5
		23	Px2	<i>Scleroleana costata</i>	1.5
		23	Px2	<i>Scleroleana costata</i>	<0.5
		23	Px2	<i>Sida rohlenae</i>	1
		23	Px2	<i>Solanum horridum</i>	<0.5
		23	Px2	<i>Tephrosia supina</i>	0.5
		23	Px2	<i>Themeda triandra</i>	<0.5
		23	Px2	<i>Triodia pungens</i>	0.5
		23	Px2	<i>Xerochloa imberbis</i>	1
407535	7655380	T24	Rf1	* <i>Cenchrus ciliaris</i>	10
		T24	Rf1	<i>Acacia coriacea</i> subsp. <i>pendens</i>	0.5
		T24	Rf1	<i>Alternanthera nodiflora</i>	0.5
		T24	Rf1	<i>Ammannia multiflora</i>	1
		T24	Rf1	<i>Basilicum polystaehyon</i>	0.5
		T24	Rf1	<i>Blumea tenella</i>	<0.5
		T24	Rf1	<i>Centripeda minima</i>	1
		T24	Rf1	<i>Chrysopogon fallax</i>	20
		T24	Rf1	<i>Corchorus laniflorus</i>	1
		T24	Rf1	<i>Cyperus vaginatus</i>	1.5
		T24	Rf1	<i>Eragrostis xerophila</i>	30
		T24	Rf1	<i>Eriachne</i> aff. <i>helmsii</i>	5
		T24	Rf1	<i>Eriachne benthamii</i>	20
		T24	Rf1	<i>Eucalyptus camaldulensis</i>	20
		T24	Rf1	<i>Eucalyptus victrix</i>	20
		T24	Rf1	<i>Eulalia aurea</i>	0.5
		T24	Rf1	<i>Euphorbia australis</i>	<0.5
		T24	Rf1	* <i>Malvastrum americanum</i>	2
		T24	Rf1	<i>Marselia drummondii</i>	0.5
		T24	Rf1	<i>Mimulus gracilis</i>	0.5
		T24	Rf1	<i>Rostellularia adscendens</i> subsp. <i>clementii</i>	0.5
		T24	Rf1	<i>Sesbania cannabina</i>	0.5
		T24	Rf1	<i>Sporobolus australasicus</i>	10

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Eastings	Northing				
407936	7659997	25	Nh2	<i>Acacia bivenosa</i>	0.5
		25	Nh2	<i>Corchorus laniflorus</i>	2
		25	Nh2	<i>Eremophila maculata</i>	0.5
		25	Nh2	<i>Glycine ?tomentella</i>	0.5
		25	Nh2	* <i>Malvastrum americanum</i>	1
		25	Nh2	<i>Nicotiana rosulata</i> subsp. <i>rosulata</i>	2
		25	Nh2	<i>Polycarpea holtzei</i>	0.5
		25	Nh2	<i>Pterocaulon sphaeranthoides</i>	0.5
		25	Nh2	<i>Ptilotus ?auriculifolius/macrocephalus</i>	10
		25	Nh2	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	2
		25	Nh2	<i>Sclerolaena uniflora</i>	0.5
		25	Nh2	<i>Solanum horridum</i>	1
		25	Nh2	<i>Tephrosia supina</i>	1
		25	Nh2	<i>Trichodesma zeylanicum</i> var. <i>grandiflorum</i>	0.5
		25	Nh2	<i>Triodia wiseana</i>	50
		25	Nh2	<i>Triumfetta clementii</i>	2
404389	7652864	26	Rf1	* <i>Cenchrus ciliaris</i>	60
		26	Rf1	* <i>Prosopis pallida</i>	2
		26	Rf1	<i>Acacia ampliceps</i>	0.5
		26	Rf1	<i>Acacia ancistrocarpa</i>	2
		26	Rf1	<i>Brachyachne convergens</i>	10
		26	Rf1	<i>Chrysopogon fallax</i>	10
		26	Rf1	<i>Cullen lachnostachys</i>	2
		26	Rf1	<i>Dichanthium fecundum</i>	20
		26	Rf1	<i>Eragrostis xerophila</i>	5
		26	Rf1	<i>Eriachne aff. helmsii</i>	1
		26	Rf1	<i>Eucalyptus victrix</i>	20
		26	Rf1	<i>Eulalia aurea</i>	1
		26	Rf1	<i>Euphorbia coghlani</i>	1
		26	Rf1	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	1
		26	Rf1	<i>Indigofera linifolia</i>	<0.5
		26	Rf1	<i>Ipomoea muellerii</i>	1
		26	Rf1	* <i>Malvastrum americanum</i>	<0.5
		26	Rf1	<i>Mukia maderaspatana</i>	<0.5
		26	Rf1	<i>Pterocaulon sphaeranthoides</i>	2
		26	Rf1	<i>Rynchosia minima</i>	<0.5
		26	Rf1	<i>Solanum horridum</i>	1
		26	Rf1	<i>Sporobolus australasicus</i>	2
		26	Rf1	<i>Swainsonia kingii</i>	<0.5
		26	Rf1	<i>Triodia pungens</i>	<0.5

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Easting	Northing				
404682	7654768	27	Mr3	* <i>Cenchrus ciliaris</i>	5
		27	Mr3	<i>Acaia inaequilatera</i>	6
		27	Mr3	<i>Aristida contorta</i>	2
		27	Mr3	<i>Brachyachne convergens</i>	10
		27	Mr3	<i>Chrysopogon fallax</i>	<0.5
		27	Mr3	<i>Corchorus laniflorus</i>	<0.5
		27	Mr3	<i>Dichanthium fecundum</i>	3
		27	Mr3	<i>Dichanthium sericeum</i> subsp. <i>humilis</i>	3
		27	Mr3	<i>Eragrostis xerophila</i>	3
		27	Mr3	<i>Eremophila forrestii</i> subsp. <i>forrestii</i> (ms)	<0.5
		27	Mr3	<i>Eriachne aff. helmsii</i>	0.5
		27	Mr3	<i>Euphorbia australis</i>	0.5
		27	Mr3	<i>Gomprena cunninghamii</i>	0.5
		27	Mr3	<i>Indigofera linifolia</i>	5
		27	Mr3	<i>Ipomoea muellerii</i>	0.5
		27	Mr3	* <i>Malvastrum americanum</i>	<0.5
		27	Mr3	<i>Polygala aff. Isingii</i>	<0.5
		27	Mr3	<i>Pterocaulon sphaeranthoides</i>	<0.5
		27	Mr3	<i>Ptilotus gomphrenoides</i> var. <i>conglomeratus</i>	10
		27	Mr3	<i>Solanum horridum</i>	1
		27	Mr3	<i>Tephrosia supina</i>	<0.5
		27	Mr3	<i>Themeda triandra</i>	0.5
		27	Mr3	<i>Triodia pungens</i>	1
		27	Mr3	<i>Triodia wiseana</i>	0.5
		27	Mr3	<i>Triraphia mollis</i>	1
403819	7655233	28	Mr6	* <i>Cenchrus ciliaris</i>	20
		28	Mr6	* <i>Prosopis pallida</i>	2
		28	Mr6	<i>Acacia marramba</i>	20
		28	Mr6	<i>Acacia victoriae</i>	<0.5
		28	Mr6	<i>Acacia victoriae</i>	15
		28	Mr6	<i>Alectryon oleifolium</i>	2
		28	Mr6	<i>Aristida contorta</i>	1
		28	Mr6	<i>Brachyachne convergens</i>	10
		28	Mr6	<i>Chrysopogon fallax</i>	5
		28	Mr6	<i>Dichanthium sericeum</i> subsp. <i>humilius</i>	1
		28	Mr6	<i>Eragrostis xerophila</i>	20
		28	Mr6	<i>Eriachne aff. helmsii</i>	<0.5
		28	Mr6	<i>Evolvulus alsinoides</i> var. <i>villosicalyx</i>	0.5
		28	Mr6	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	0.5
		28	Mr6	<i>Indigofera colutea</i>	<0.5
		28	Mr6	<i>Indigofera linifolia</i>	1
		28	Mr6	<i>Ptilotus gomphrenoides</i> var. <i>conglomeratus</i>	<0.5
		28	Mr6	<i>Rynchosia minima</i>	<0.5
		28	Mr6	<i>Sida rohlenae</i>	<0.5

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Easting	Northing				
		28	Mr6	<i>Themeda triandra</i>	<0.5
402275	7654927	29	Mr3	* <i>Cenchrus ciliaris</i>	20
		29	Mr3	<i>Acacia ampliceps</i>	<0.5
		29	Mr3	<i>Acacia ancistrocarpa</i>	2
		29	Mr3	<i>Acacia coriacea</i> subsp. <i>pendens</i>	2
		29	Mr3	<i>Acacia coriacea</i> var. <i>coriacea</i>	5
		29	Mr3	<i>Acaia inaequilatera</i>	10
		29	Mr3	<i>Aristida contorta</i>	10
		29	Mr3	<i>Autilon cryptopetalum</i>	0.5
		29	Mr3	<i>Brachyachne convergens</i>	2
		29	Mr3	<i>Chrysopogon fallax</i>	1
		29	Mr3	<i>Corchorus laniflorus</i>	<0.5
		29	Mr3	<i>Dactyloctenium radulans</i>	<0.5
		29	Mr3	<i>Dichanthium sericeum</i> subsp. <i>humilius</i>	1
		29	Mr3	<i>Eragrostis xerophila</i>	2
		29	Mr3	<i>Eriachne aff. helmsii</i>	0.5
		29	Mr3	<i>Eriachne benthamii</i>	2
		29	Mr3	<i>Eriachne pulchella</i> subsp. <i>dominii</i>	<0.5
		29	Mr3	<i>Evolvulus alsinoides</i> var. <i>villosicalyx</i>	<0.5
		29	Mr3	<i>Glycine ?tomentella</i>	<0.5
		29	Mr3	<i>Gomphrena canescens</i> subsp. <i>canescens</i>	<0.5
		29	Mr3	<i>Indigofera colutea</i>	0.5
		29	Mr3	<i>Indigofera linifolia</i>	1
		29	Mr3	<i>Ipomoea muellerii</i>	0.5
		29	Mr3	* <i>Malvastrum americanum</i>	<0.5
		29	Mr3	<i>Polygala aff. Isingii</i>	<0.5
		29	Mr3	<i>Sida rohlenae</i>	1
		29	Mr3	<i>Solanum horridum</i>	1
		29	Mr3	<i>Themeda triandra</i>	<0.5
		29	Mr3	<i>Triodia pungens</i>	2
		29	Mr3	<i>Triraphia mollis</i>	10
		29	Mr3	<i>Triumfetta clementii</i>	1
409448	7658456	30	Hp	<i>Dichanthium fecundum</i>	20
		30	Hp	<i>Eragrostis xerophila</i>	40
		30	Hp	<i>Goodenia forrestii</i>	0.5
		30	Hp	<i>Indigofera trita</i>	<0.5
		30	Hp	<i>Rynchosia minima</i>	0.5
		30	Hp	<i>Scleroleana costata</i>	10
		30	Hp	<i>Sida rohlenae</i>	<0.5
		30	Hp	<i>Streptoglossa liatroides</i>	5
		30	Hp	<i>Xerochloa imberbis</i>	30

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Eastings	Northings				
409214	7658963	31	Px2	* <i>Prosopis pallida</i>	<0.5
		31	Px2	<i>Acacia xiphophylla</i>	20
		31	Px2	<i>Dichanthium fecundum</i>	60
		31	Px2	<i>Enneapogon caerulescens</i>	3
		31	Px2	<i>Eragrostis xerophila</i>	40
		31	Px2	<i>Gomprena cunninghamii</i>	1
		31	Px2	<i>Indigofera colutea</i>	<0.5
		31	Px2	<i>Indigofera trita</i>	<0.5
		31	Px2	* <i>Malvastrum americanum</i>	0.5
		31	Px2	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	0.5
		31	Px2	<i>Rynchosia minima</i>	0.5
		31	Px2	<i>Scleroleana bicornis</i>	1
		31	Px2	<i>Sida rohlenae</i>	0.5
		31	Px2	<i>Sporobolus australasicus</i>	2
		31	Px2	<i>Streptoglossa liatroides</i>	1.5
		31	Px2	<i>Xerochloa imberbis</i>	1
410282	7661433	32	Nh2	<i>Acacia bivenosa</i>	5
		32	Nh2	<i>Aristida contorta</i>	1
		32	Nh2	<i>Autilon cryptopetalum</i>	0.5
		32	Nh2	<i>Chrysopogon fallax</i>	<0.5
		32	Nh2	<i>Corchorus laniflorus</i>	1
		32	Nh2	<i>Enneapogon caerulescens</i>	<0.5
		32	Nh2	<i>Eriachne pulchella</i> subsp. <i>dominii</i>	1
		32	Nh2	<i>Glycine ?tomentella</i>	2
		32	Nh2	<i>Pterocaulon sphaeranthoides</i>	<0.5
		32	Nh2	<i>Ptilotus ?auriculifolius/macrocephalus</i>	15
		32	Nh2	<i>Senna glutinosa</i> ssp. <i>pruinosa</i>	0.5
		32	Nh2	<i>Solanum lasiophyllum</i>	1
		32	Nh2	<i>Tephrosia clementii</i>	<0.5
		32	Nh2	<i>Themeda triandra</i>	0.5
		32	Nh2	<i>Triodia wiseana</i>	30
		32	Nh2	<i>Triumfetta clementii</i>	0.5
411517	7662145	33	Px1	* <i>Cenchrus ciliaris</i>	15
		33	Px1	<i>Acacia xiphophylla</i>	15
		33	Px1	<i>Aristida contorta</i>	0.5
		33	Px1	<i>Peplidium</i> aff. sp. E Evol. Fl. Fauna Arid Australia	0.5
		33	Px1	<i>Pterocaulon sphaeranthoides</i>	<0.5
		33	Px1	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	1
		33	Px1	<i>Scleroleana costata</i>	25
		33	Px1	<i>Sida rohlenae</i>	0.5
		33	Px1	<i>Sporobolus australasicus</i>	1
		33	Px1	<i>Triodia wiseana</i>	10
		33	Px1	<i>Xerochloa imberbis</i>	<0.5

**APPENDIX B: VASCULAR FLORA QUADRAT DATA USED FOR PATN ANALYSIS**

T denotes transects (not quadrats)

\* Denotes introduced (weed) species

GPS		Quadrat No.	Vegetation	Species	% Cover A
Easting	Northing				
413577	7659444	34	Roh1b	<i>Acacia ancistrocarpa</i>	<0.5
		34	Roh1b	<i>Corchorus laniflorus</i>	10
		34	Roh1b	<i>Eremophila maculata</i>	0.5
		34	Roh1b	<i>Eriachne pulchella</i> subsp. <i>dominii</i>	2
		34	Roh1b	<i>Euphorbia australis</i>	<0.5
		34	Roh1b	<i>Evolvulus alsinoides</i> var. <i>villosicalyx</i>	<0.5
		34	Roh1b	<i>Glycine ?tomentella</i>	1
		34	Roh1b	<i>Gomprena cunninghamii</i>	<0.5
		34	Roh1b	* <i>Malvastrum americanum</i>	1
		34	Roh1b	<i>Polycarpea holtzei</i>	0.5
		34	Roh1b	<i>Ptilotus obovatus</i>	0.5
		34	Roh1b	<i>Senna glutinosa</i> ssp. <i>pruinosa</i>	2
		34	Roh1b	<i>Solanum lasiophyllum</i>	0.5
		34	Roh1b	<i>Themeda triandra</i>	0.5
		34	Roh1b	<i>Trichodesma zeylanicum</i> var. <i>grandiflorum</i>	<0.5
		34	Roh1b	<i>Triodia wiseana</i>	30
		34	Roh1b	<i>Triumfetta clementii</i>	1

# Appendix C: Summary of Vascular Flora Species Recorded within Each Vegetation Community within the Balmoral South Project Area, July 2006

APPENDIX C: SUMMARY OF VASCULAR FLORA SPECIES RECORDED WITHIN EACH VEGETATION COMMUNITY, BALMORAL SOUTH PROJECT AREA, JULY 2006

NB: \* denotes introduced (weed) species

Family	Species	HP	Mr3	Mr4	Mr5	Mr6	Nh	Nh2	PP2	PX1	PX2	RC1	Rf1	Rf2	Roh1b	Opp
MARSILEACEAE	<i>Marsilea drummondii</i>															+
POACEAE	* <i>Cenchrus ciliaris</i>		+	+	+	+	+		+	+	+	+	+	+		
	* <i>Cenchrus</i> sp.												+			
	<i>Aristida contorta</i>		+	+		+	+	+		+						+
	<i>Aristida holathera</i>															+
	<i>Brachyachne convergens</i>		+								+		+			
	<i>Chrysopogon fallax</i>		+					+			+		+			
	<i>Cymbopogon procerus</i>															+
	<i>Dactyloctenium radulans</i>		+													
	<i>Dichanthium fecundum</i>	+	+								+		+			
	<i>Dichanthium sericeum</i> subsp. <i>humilius</i>	+	+						+		+					+
	<i>Enneapogon avenaceus</i>										+					
	<i>Enneapogon caerulescens</i>	+		+	+	+		+			+					
	<i>Eragrostis setifolia</i>	+														
	<i>Eragrostis tenellula</i>	+				+					+	+				
	<i>Eragrostis xerophila</i>	+	+		+						+		+			
	<i>Eriachne benthamii</i>		+			+	+		+				+			
	<i>Eriachne pulchella</i> subsp. <i>dominii</i> (Hartley) Lazarides		+				+	+								+
	<i>Eriachne</i> aff. <i>helmsii</i>		+			+							+			
	<i>Eriachne</i> aff. <i>mucronata</i>	+									+					
	<i>Eulalia aurea</i>												+			
	<i>Paspalidium ?tabulatum</i>						+									
	<i>Sporobolus australasicus</i>	+	+	+	+		+		+	+	+		+			
	<i>Themeda triandra</i>	+	+	+		+	+	+	+		+					+
	<i>Triodia pungens</i>		+								+		+			
	<i>Triodia wiseana</i>		+	+		+	+	+	+	+	+		+			+
	<i>Triodia</i> aff. <i>epactia</i>											+				
	<i>Triraphis mollis</i>		+													
	<i>Xerochloa imberbis</i>	+								+	+					

**APPENDIX C: SUMMARY OF VASCULAR FLORA SPECIES RECORDED WITHIN EACH VEGETATION COMMUNITY, BALMORAL SOUTH PROJECT AREA, JULY 2006**

NB: \* denotes introduced (weed) species

Family	Species	HP	Mr3	Mr4	Mr5	Mr6	Nh	Nh2	PP2	PX1	PX2	RC1	RT1	Rf2	Roh1b	Opp
CYPERACEAE	<i>Cyperus bifax</i>															+
	<i>Cyperus vaginatus</i>											+	+			
MORACEAE	<i>Ficus aculeata</i>											+				
PROTEACEAE	<i>Grevillea pyramidalis</i>														+	
CHENOPODIACEAE	<i>Salsola tragus</i> subsp. <i>tragus</i>						+			+	+					
	<i>Sclerolaena uniflora</i>							+		+						
	<i>Scleroleana bicornis</i>	+									+					
	<i>Scleroleana costata</i>	+			+		+		+	+	+				+	
AMARANTHACEAE	* <i>Aerva javanica</i>		+											+	+	
	<i>Achyranthes aspera</i>											+			+	
	<i>Alternanthera nodiflora</i>												+		+	
	<i>Amaranthus pallidiflorus</i>															+
	<i>Gomphrena canescens</i> subsp. <i>canescens</i>		+	+		+	+		+	+	+	+	+	+	+	+
AMARANTHACEAE	<i>Gomprena cunninghamii</i>	+	+	+			+				+				+	
(Cont)	<i>Ptilotus aervooides</i>	+		+	+	+			+		+					
	<i>Ptilotus ?auriculifolius/macrocephalus</i>						+	+		+					+	
	<i>Ptilotus clementii</i>						+			+						
	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>	+		+	+		+	+		+	+				+	
	<i>Ptilotus gomphrenoides</i> var. <i>conglomeratus</i>	+	+		+						+					
	<i>Ptilotus gomprenoides</i> subsp. <i>gomphrenoides</i>	+														
	<i>Ptilotus helipteroides</i>			+											+	
	<i>Ptilotus helipteroides</i> var. <i>helipteroides</i>															+
	<i>Ptilotus obovatus</i>														+	
	<i>Ptilotus villosiflorus</i>						+			+					+	
NYCTAGINACEAE	<i>Boerhavia coccinea</i>		+													
	<i>Boerhavia paludosa</i>								+						+	
	<i>Boerhavia repleta</i>				+											
CARYOPHYLLACEAE	<i>Polycarpaea holtzei</i>							+							+	
	<i>Polycarpaea longiflora</i>														+	
	<i>Cassytha capillaris</i>												+		+	

APPENDIX C: SUMMARY OF VASCULAR FLORA SPECIES RECORDED WITHIN EACH VEGETATION COMMUNITY, BALMORAL SOUTH PROJECT AREA, JULY 2006

NB: \* denotes introduced (weed) species

Family	Species	HP	Mr3	Mr4	Mr5	Mr6	Nh	Nh2	PP2	PX1	PX2	RC1	RF1	RF2	Roh1b	Opp
SURIANACEAE	<i>Stylobasium spathulatum</i>															+
MIMOSACEAE	* <i>Prosopis pallida</i>	+		+	+	+			+		+		+	+		
	<i>Acacia ampliceps</i>		+								+		+			
	<i>Acacia ancistrocarpa</i>		+										+		+	
	<i>Acacia bivenosa</i>			+			+	+	+	+	+	+	+		+	
	<i>Acacia coriacea</i> subsp. <i>coriacea</i>		+									+	+			
	<i>Acacia coriacea</i> subsp. <i>pendens</i>		+					+			+		+			
MIMOSACEAE (CONT.)	<i>Acacia inaequilatera</i>		+			+			+		+	+				
	<i>Acacia marramba</i>															+
	<i>Acacia monticola</i>						+									
	<i>Acacia sclerosperma</i> subsp. <i>sclerosperma</i>		+													
	<i>Acacia synchronicia</i>			+												
	<i>Acacia victoriae</i>		+													
	<i>Acacia xiphophylla</i>					+				+	+					
CAESALPINIACEAE	<i>Petalostylis labicheoides</i>														+	
	<i>Senna artemisioides</i> subsp. <i>oligophylla</i>						+									
	<i>Senna glutinosa</i> subsp. <i>pruinosa</i>						+	+		+						+
	<i>Senna glutinosa</i> subsp. <i>glutinosa</i>									+						+
	<i>Senna glutinosa</i> subsp. <i>x luerssenii</i>								+	+				+		
	<i>Senna ?notabilis</i>						+									
PAPILIONACEAE	<i>Crotalaria medicaginea</i>			+							+					+
	<i>Crotalaria novae - hollandiae</i> subsp. <i>crassipes</i>											+				
	<i>Cullen lachnostachys</i>													+		
	<i>Desmodium filiforme</i>		+												+	
	<i>Erythrina vespertilio</i>															
	<i>Glycine ?tomentella</i>		+			+	+	+	+	+		+	+		+	
	<i>Indigofera colutea</i>	+	+	+							+		+	+		
	<i>Indigofera linifolia</i>	+	+	+		+			+		+		+		+	
	<i>Indigofera trita</i>	+									+				+	

APPENDIX C: SUMMARY OF VASCULAR FLORA SPECIES RECORDED WITHIN EACH VEGETATION COMMUNITY, BALMORAL SOUTH PROJECT AREA, JULY 2006

NB: \* denotes introduced (weed) species

Family	Species	HP	Mr3	Mr4	Mr5	Mr6	Nh	Nh2	PP2	Px1	Px2	RC1	Rf1	Rf2	Roh1b	Opp
PAPILIONACEAE	<i>Rhynchosia minima</i>	+	+	+		+					+	+	+		+	
(Cont)	<i>Sesbania cannabina</i>	+			+							+	+			
	<i>Swainsona kingii</i>												+			
	<i>Templetonia</i> aff. <i>hookeri</i>															+
	<i>Tephrosia clementii</i>	+						+								
	<i>Tephrosia supina</i>		+					+			+					+
	<i>Vigna lanceolata</i> var. <i>lanceolata</i>													+		
GERANIACEAE	<i>Erodium</i> sp.						+									
ZYGOPHYLLACEAE	<i>Tribulus hirsutus</i>						+									+
	<i>Tribulus suberosus</i>															+
POLYGALACEAE	<i>Polygala</i> aff. <i>isingii</i>		+											+		
EUPHORBIACEAE	<i>Adriana urticoides</i> var. <i>hookeri</i>											+				
	<i>Euphorbia australis</i>		+						+		+		+			+
	<i>Euphorbia boophthona</i>						+									
	<i>Euphorbia coghlanii</i>		+	+									+			+
	<i>Euphorbia schultzii</i>												+			
	<i>Flueggea virosa</i> subsp. <i>melanthesoides</i>															+
SAPINDACEAE	<i>Alectryon oleifolius</i>				+											
	<i>Dodonaea coriacea</i>		+													
TILIACEAE	<i>Corchorus laniflorus</i>		+				+	+	+	+	+	+	+	+	+	+
	<i>Corchus walcottii</i>												+			
	<i>Triumfetta clementii</i>		+	+	+	+	+	+	+			+		+	+	
MALVACEAE	<i>Abutilon cryptopetalum</i>		+		+		+	+				+				
	<i>Abutilon lepidum</i>															+
	* <i>Hibiscus austrinus</i>											+				
	* <i>Malvastrum americanum</i>	+	+		+		+	+			+	+	+		+	
	<i>Sida cardiophylla</i>						+									
	<i>Sida fibulifera</i>											+				
	<i>Sida rohlenae</i>	+	+	+	+		+		+	+	+					

**APPENDIX C: SUMMARY OF VASCULAR FLORA SPECIES RECORDED WITHIN EACH VEGETATION COMMUNITY, BALMORAL SOUTH PROJECT AREA, JULY 2006**

NB: \* denotes introduced (weed) species

Family	Species	HP	Mr3	Mr4	Mr5	Mr6	Nh	Nh2	PP2	Px1	Px2	RC1	Rf1	Rf2	Roh1b	Opp
STERCULIACEAE	* <i>Melochia pyramidata</i>															
VIOLACEAE	<i>Hybanthus aurantiacus</i>											+				
PASSIFLORACEAE	* <i>Passiflora foetida</i>															
LYTHRACEAE	<i>Ammannia multiflora</i>														+	
MYRTACEAE	<i>Corymbia aspera</i>		+													
	<i>Eucalyptus camaldulensis</i>														+	
	<i>Eucalyptus victrix</i>											+	+	+		
	<i>Eucalyptus</i> sp.								+							
	<i>Melaleuca linophylla</i>											+				
HALORAGACEAE	<i>Haloragis gossei</i>						+					+				
CONVOLVULACEAE	<i>Evolvulus alsinoides</i> var. <i>villosicalyx</i>		+				+									+
	<i>Ipomoea muellerii</i>		+								+		+			
	<i>Operculina aequisepala</i>											+	+			
	<i>Polymeria ambigua</i>															+
BORAGINACEAE	<i>Heliotropium chrysocarpum</i>								+							
	<i>Heliotropium heteranthum</i>				+		+									
	<i>Trichodesma zeylanicum</i> var. <i>grandiflorum</i>							+								+
LAMIACEAE	<i>Basilicum polystachyon</i>															+
SOLANACEAE	* <i>Datura leichhardtii</i>															+
	<i>Nicotiana rosulata</i> subsp. <i>rosulata</i>							+				+	+			
	<i>Solanum diversiflorum</i>															+
SOLANACEAE (Cont)	<i>Solanum horridum</i>		+		+	+	+	+	+		+		+	+	+	+
	<i>Solanum lasiophyllum</i>							+			+					+
SCROPHULARIACEAE	<i>Mimulus gracilis</i>															+
	<i>Peplidium</i> aff. sp. E Evol. Fl. Fauna Arid Australia (A.S. Weston 12768)									+						
	<i>Stemodia grossa</i>															+
	<i>Stemodia kingii</i>	+														
ACANTHACEAE	<i>Rostellularia adscendens</i> var. <i>clementii</i>										+		+			

APPENDIX C: SUMMARY OF VASCULAR FLORA SPECIES RECORDED WITHIN EACH VEGETATION COMMUNITY, BALMORAL SOUTH PROJECT AREA, JULY 2006

NB: \* denotes introduced (weed) species

Family	Species	HP	Mr3	Mr4	Mr5	Mr6	Nh	Nh2	PP2	PX1	PX2	RC1	Rf1	Rf2	Roh1b	Opp
MYOPORACEAE	<i>Eremophila forrestii</i> subsp. <i>forrestii</i> ms		+													
	<i>Eremophila longifolia</i>		+													
	<i>Eremophila maculata</i>	+	+	+		+	+	+	+		+	+				+
CUCURBITACEAE	* <i>Citrullus lanatus</i>													+		
	<i>Mukia maderaspatana</i>								+			+	+	+	+	
GOODENIACEAE	<i>Goodenia forrestii</i>	+		+			+									
	<i>Goodenia lamprosperma</i>												+			
	<i>Goodenia microptera</i>			+												+
	<i>Goodenia pascua</i> P3	+														
	<i>Goodenia stobbsiana</i>						+									
ASTERACEAE	<i>Blumea tenella</i>													+		
	<i>Centipeda minima</i>													+		
	<i>Pentalepis trichodesmoides</i>															+
	<i>Pterocaulon sphacelatum</i>										+	+				
	<i>Pterocaulon sphaeranthoides</i>		+			+		+	+	+			+			+
	<i>Streptoglossa decurrens</i>			+												
	<i>Streptoglossa liatroides</i>	+										+				

# Appendix D: Summary of Vascular Flora Species Recorded within Each Quadrat, Balmoral South Project Area, July 2006



**APPENDIX D: SUMMARY OF VASCULAR FLORA SPECIES RECORDED WITHIN EACH QUADRAT, BALMORAL  
SOUTH PROJECT AREA, JULY 2006**

NB: \* denotes introduced (weed) species

Family	Species	Quadrat																																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34		
CHENOPODIACEAE	<i>Salsola tragus</i> subsp. <i>tragus</i>		+																																		
	<i>Sclerolaena uniflora</i>		+																								+										
	<i>Scleroleana bicornis</i>													+																				+			
	<i>Scleroleana costata</i>													+		+		+	+						+							+			+		
AMARANTHACEAE	* <i>Aerva javanica</i>														+		+					+															
	<i>Alternanthera nodiflora</i>			+							+	+												+		+											
	<i>Amaranthus pallidiflorus</i>										+																										
	<i>Gomphrena canescens</i> subsp. <i>canescens</i>		+			+	+	+			+			+	+	+		+	+	+	+						+		+	+							
	<i>Gomphrena cunninghamii</i>								+	+												+			+				+				+			+	
	<i>Ptilotus aevroides</i>				+			+						+		+																					
	<i>Ptilotus ?auriculifolius/macrocephalus</i>		+	+					+																		+								+		
	<i>Ptilotus clementii</i>		+	+																																	
	<i>Ptilotus exaltatus</i> var. <i>exaltatus</i>		+	+		+	+	+			+	+		+		+		+			+					+							+		+		
	<i>Ptilotus gomphrenoides</i> var. <i>conglomeratus</i>													+			+					+			+				+	+							
	<i>Ptilotus gomphrenoides</i> subsp. <i>gomphrenoides</i>				+																																
	<i>Ptilotus helipteroides</i>					+		+																													
	<i>Ptilotus helipteroides</i> var. <i>helipteroides</i>															+																					
	<i>Ptilotus obovatus</i>																																				+
<i>Ptilotus villosiflorus</i>		+	+																																		
NYCTAGINACEAE	<i>Boerhavia coccinea</i>																																			+	
	<i>Boerhavia paludosa</i>														+																						
	<i>Boerhavia repleta</i>																																				+
CARYOPHYLLACEAE	<i>Polycarpaea holtzei</i>					+																				+										+	
	<i>Polycarpaea longiflora</i>					+			+		+																										
	<i>Cassytha capillaris</i>				+																																
MIMOSACEAE	* <i>Prosopis pallida</i>			+				+		+	+			+	+	+	+	+	+			+		+		+		+				+					
	<i>Acacia ampliceps</i>																									+		+				+					
	<i>Acacia ancistrocarpa</i>												+															+			+					+	
	<i>Acacia bivenosa</i>		+	+	+			+	+		+	+		+								+				+									+		
	<i>Acacia coriacea</i> subsp. <i>coriacea</i>							+																				+		+					+		
	<i>Acacia coriacea</i> subsp. <i>pendens</i>				+																														+	+	

APPENDIX D: SUMMARY OF VASCULAR FLORA SPECIES RECORDED WITHIN EACH QUADRAT, BALMORAL  
SOUTH PROJECT AREA, JULY 2006

NB: \* denotes introduced (weed) species

Family	Species	Quadrat																																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	
MIMOSACEAE (CONT.)	<i>Acacia inaequilatera</i>					+				+			+	+	+					+		+						+	+							
	<i>Acacia marramba</i>																																		+	
	<i>Acacia monticola</i>	+																																		
	<i>Acacia sclerosperma</i> subsp. <i>sclerosperma</i>														+							+														
	<i>Acacia synchronicia</i>														+																					
	<i>Acacia victoriae</i>																					+								+						
	<i>Acacia xiphophylla</i>		+													+								+									+	+		
CAESALPINIACEAE	<i>Petalostylis labicheoides</i>			+																																
	<i>Senna artemisioides</i> subsp. <i>oligophylla</i>																				+															
	<i>Senna glutinosa</i> subsp. <i>pruinosa</i>	+	+									+																					+	+		
	<i>Senna glutinosa</i> subsp. <i>glutinosa</i>		+									+																								
	<i>Senna glutinosa</i> subsp. <i>x luerssenii</i>		+	+										+																						
PAPILIONACEAE	<i>Senna ?notabilis</i>	+																																		
	<i>Crotalaria medicaginea</i>					+		+																												
	<i>Crotalaria novae-hollandiae</i> subsp. <i>crassipes</i>						+																													
	<i>Cullen lachnostachys</i>																																			+
	<i>Desmodium filiforme</i>															+			+																	
	<i>Glycine ?tomentella</i>	+	+	+		+	+	+			+		+	+	+	+				+		+				+				+	+	+	+	+	+	
	<i>Indigofera colutea</i>							+			+		+	+	+	+			+	+		+							+	+	+	+	+	+	+	
	<i>Indigofera linifolia</i>				+	+		+			+	+	+	+	+	+					+	+		+			+	+	+	+	+	+	+	+	+	
	<i>Indigofera trita</i>			+	+						+																						+	+		
	<i>Rhynchosia minima</i>			+	+		+	+		+	+	+		+	+						+		+					+	+	+	+	+	+	+	+	
	<i>Sesbania cannabina</i>						+		+								+						+		+											
	<i>Swainsona kingii</i>																																			+
	<i>Templetonia</i> aff. <i>hookeri</i>												+																							
	<i>Tephrosia clementii</i>				+																															+
<i>Tephrosia supina</i>								+						+									+		+		+									
GERANIACEAE	<i>Erodium</i> sp.	+									+																									





Appendix E: Summary of Vascular Flora recorded within  
Each Vegetation Community Represented by  
Quadrats, Balmoral South Project Area, for the  
Auststeel Project HGM, 2000)

**APPENDIX E: SUMMARY OF VASCULAR FLORA RECORDED WITHIN EACH VEGETATION COMMUNITY REPRESENTED BY QUADRATS,  
BALMORAL SOUTH PROJECT AREA, FOR AUSTEEL PROJECT (HGM, 2000)**

NB: \* Denotes introduced (weed) species

Family	Species	Vegetation Communities											
		Bx1	Hp	Nc	Nh	Nh2	Nr	Pc	Px1	Px2	Rc3	Rc4	Rf1
MARSILEACEAE	<i>Marsilea hirsuta</i>							+		+		+	
POACEAE	<i>Aristida contorta</i>					+			+				
	* <i>Cenchrus ciliaris</i>	+		+	+	+	+	+	+		+	+	+
	* <i>Cenchrus setiger</i>			+		+	+	+	+		+	+	+
	<i>Chrysopogon fallax</i>			+						+			
	<i>Cymbopogon ambiguus</i>			+	+	+	+						
	<i>Dichanthium fecundum</i>							+				+	
	<i>Digitaria brownii</i>			+	+								
	<i>Digitaria ctenantha</i>			+									
	<i>Enneapogon lindleyanus</i>				+		+						
	<i>Eragrostis xerophila</i>		+								+		
	<i>Eriachne aristidea</i>			+									
	<i>Eriachne benthamii</i>	+		+		+				+			
	<i>Eriachne mucronata</i>			+	+		+						
	<i>Eriachne ovata</i>					+							
	<i>Paraneurachne muelleri</i>			+	+								
	<i>Themeda triandra</i>							+					
	<i>Triodia angusta</i>							+					
	<i>Triodia epactia</i>	+		+						+			
	<i>Triodia pungens</i>			+		+	+		+				
	<i>Triodia wiseana</i>	+		+	+	+	+		+	+			
	<i>Xerochloa imberbis</i>		+										
CYPERACEAE	<i>Cyperus bifax</i>					+		+				+	
	<i>Cyperus bulbosus</i>										+	+	
	<i>Cyperus vaginatus</i>					+		+			+	+	
	<i>Fimbristylis dichotoma</i>				+								
MORACEAE	<i>Ficus platypoda</i>				+		+						
PROTEACEAE	<i>Hakea lorea</i> subsp. <i>suberea</i>								+				
SANTALACEAE	<i>Santalum lanceolatum</i>					+							

**APPENDIX E: SUMMARY OF VASCULAR FLORA RECORDED WITHIN EACH VEGETATION COMMUNITY REPRESENTED BY QUADRATS,  
BALMORAL SOUTH PROJECT AREA, FOR AUSTEEL PROJECT (HGM, 2000)**

NB: \* Denotes introduced (weed) species

Family	Species	Vegetation Communities												
		Bx1	Hp	Nc	Nh	Nh2	Nr	Pc	Px1	Px2	Rc3	Rc4	Rf1	
CHENOPODIACEAE	<i>Enchylaena tomentosa</i>	+		+	+	+	+				+			
	<i>Maireana melanocoma</i>				+									
	<i>Maireana planifolia</i>					+			+	+				
	<i>Rhagodia eremaea</i>	+		+				+			+			
	<i>Rhagodia preissii</i> subsp. <i>obovata</i>													
	<i>Salsola tragus</i>	+			+				+	+				
	<i>Sclerolaena cornishiana</i>		+											
	<i>Sclerolaena costata</i>				+									
	<i>Sclerolaena eriacantha</i>	+			+	+				+	+			
	<i>Sclerolaena uniflora</i>	+												
AMARANTHACEAE	<i>Achyranthes aspera</i>			+	+	+						+	+	+
	<i>Ptilotus astrolasius</i>			+		+								
	<i>Ptilotus calostachyus</i>			+	+		+							
	<i>Ptilotus obovatus</i>			+			+							
NYCTAGINACEAE	<i>Boerhavia burbridgeana</i>				+		+							
	<i>Boerhavia coccinea</i>	+		+	+		+							
	<i>Boerhavia</i> type 1									+				
	<i>Commicarpus australis</i>						+							
MENISPERMACEAE	<i>Tinospora smilacina</i>				+		+	+						
LAURACEAE	<i>Cassytha capillaris</i>			+	+									
CAPPARACEAE	<i>Capparis spinosa</i> var. <i>nummularia</i>				+									
MIMOSACEAE	<i>Acacia ampliceps</i>												+	
	<i>Acacia ancistrocarpa</i>			+	+	+	+							
	<i>Acacia arida</i>			+	+									
	<i>Acacia bivenosa</i>			+	+	+								
	<i>Acacia coriacea</i> subsp. <i>coriacea</i>			+	+		+							
	<i>Acacia coriacea</i> subsp. <i>pendens</i>			+		+	+	+			+	+	+	
	<i>Acacia farnesiana</i>			+	+	+								
<i>Acacia inaequilatera</i>				+										

**APPENDIX E: SUMMARY OF VASCULAR FLORA RECORDED WITHIN EACH VEGETATION COMMUNITY REPRESENTED BY QUADRATS,  
BALMORAL SOUTH PROJECT AREA, FOR AUSTEEL PROJECT (HGM, 2000)**

NB: \* Denotes introduced (weed) species

Family	Species	Vegetation Communities											
		Bx1	Hp	Nc	Nh	Nh2	Nr	Pc	Px1	Px2	Rc3	Rc4	Rf1
MIMOSACEAE (CONT.)	<i>Acacia monticola</i>			+	+		+						
	<i>Acacia pyrifolia</i>			+	+	+	+						
	<i>Acacia trachycarpa</i>			+		+		+					
	<i>Acacia tumida</i>			+			+						
	<i>Acacia victoriae</i>	+		+	+	+					+		
	<i>Acacia xiphophylla</i>	+								+	+		
	<i>Neptunia dimorphantha</i>										+		
CAESALPINIACEAE	* <i>Prosopis pallida</i>	+			+	+	+	+	+	+	+	+	+
	<i>Petalostylis labicheoides</i>			+	+		+						
	<i>Senna artemisioides</i> subsp. <i>oligophylla</i>			+									
	<i>Senna artemisioides</i> subsp. <i>oligophylla</i> (thinly sericeous)				+				+				
	<i>Senna glutinosa</i> subsp. <i>chatelainiana</i>										+		
	<i>Senna glutinosa</i> subsp. <i>glutinosa</i>			+	+		+					+	
	<i>Senna glutinosa</i> subsp. <i>glutinosa</i> x ? <i>pruinosa</i>			+	+	+	+						
	<i>Senna glutinosa</i> subsp. x <i>luerssenii</i>	+											
	<i>Senna notabilis</i>			+	+	+	+						
	<i>Senna venusta</i>			+	+		+						
PAPILIONACEAE	<i>Canavalia rosea</i>						+						
	<i>Crotalaria dissitiflora</i> subsp. <i>benthamiana</i>										+		
	<i>Crotalaria novae-hollandiae</i>								+				+
	<i>Cullen leucanthum</i>						+						
	<i>Cullen pogonocarpum</i>			+									
	<i>Erythrina vespertilio</i>								+			+	+
	<i>Indigastrum parviflorum</i>	+		+	+								
	<i>Indigofera colutea</i>			+	+								
	<i>Indigofera linifolia</i>				+								
	<i>Indigofera monophylla</i>			+	+	+	+						
	<i>Indigofera trita</i>		+										
	<i>Isotropis atropurpurea</i>			+		+							
<i>Rhynchosia cf. minima</i>	+	+	+	+		+				+			

**APPENDIX E: SUMMARY OF VASCULAR FLORA RECORDED WITHIN EACH VEGETATION COMMUNITY REPRESENTED BY QUADRATS,  
BALMORAL SOUTH PROJECT AREA, FOR AUSTEEL PROJECT (HGM, 2000)**

NB: \* Denotes introduced (weed) species

Family	Species	Vegetation Communities											
		Bx1	Hp	Nc	Nh	Nh2	Nr	Pc	Px1	Px2	Rc3	Rc4	Rf1
PAPILIONACEAE (CONT.)	<i>Sesbania cannabina</i>					+	+	+		+	+	+	+
	<i>Swainsona canescens</i>			+									
	<i>Swainsona formosa</i>							+					
	<i>Tephrosia</i> aff. <i>densa</i>						+						
	<i>Tephrosia clementii</i>			+	+	+							
	<i>Tephrosia supina</i>			+	+		+						
	<i>Tephrosia</i> aff. <i>supina</i> (ME Trudgen 12,357)			+	+		+						
	<i>Vigna lanceolata</i> var. <i>lanceolata</i>					+		+				+	+
	ZYGOPHYLLACEAE	<i>Tribulus platypterus</i>				+		+					
<i>Tribulus suberosus</i>					+		+						
EUPHORBIACEAE	<i>Flueggea virosa</i> subsp. <i>melanthesoides</i>										+		
SAPINDACEAE	<i>Alectryon oleifolius</i>				+		+						
	<i>Dodonaea coriacea</i>			+	+								
TILIACEAE	<i>Corchorus laniflorus</i>			+	+	+	+						
	<i>Triumfetta clementii</i>	+		+	+	+	+						
MALVACEAE	<i>Abutilon amplum</i>							+					
	<i>Abutilon cunninghamii</i>				+		+						
	<i>Abutilon fraseri</i>				+					+			
	<i>Abutilon lepidum</i>			+	+		+						
	<i>Abutilon</i> aff. <i>lepidum</i> (1) (MET 15 352)	+		+									
	<i>Abutilon</i> aff. <i>lepidum</i> (3) (MET 16 120)	+											
	<i>Abutilon oxycarpum</i> subsp. <i>prostratum</i>			+	+								
	<i>Abutilon trudgenii</i> (P3)			+									
	<i>Gossypium australe</i>							+					
	<i>Hibiscus apodus</i>						+						+
	<i>Hibiscus brachysiphonius</i> (P3)	+											
	<i>Hibiscus</i> aff. <i>coatesii</i> (site 664)						+						
	<i>Hibiscus</i> aff. <i>platyklamys</i> (M39.14)	+		+	+	+				+			
<i>Hibiscus</i> aff. <i>platyklamys</i> (M9.15)			+	+		+							
<i>Hibiscus</i> aff. <i>platyklamys</i> (site 1139)			+	+	+								

**APPENDIX E: SUMMARY OF VASCULAR FLORA RECORDED WITHIN EACH VEGETATION COMMUNITY REPRESENTED BY QUADRATS,  
BALMORAL SOUTH PROJECT AREA, FOR AUSTEEL PROJECT (HGM, 2000)**

NB: \* Denotes introduced (weed) species

Family	Species	Vegetation Communities											
		Bx1	Hp	Nc	Nh	Nh2	Nr	Pc	Px1	Px2	Rc3	Rc4	Rf1
MALVACEAE	<i>Sida ?cardiophylla</i> (juvenile)			+	+								
(CONT.)	<i>Sida</i> aff. <i>cardiophylla</i> (site 1086)	+		+	+								
	<i>Sida clementii</i>			+	+								
	<i>Sida</i> aff. <i>fibulifera</i> ' var. L'		+										
	<i>Sida</i> aff. <i>fibulifera</i> (M37.16)			+									
	<i>Sida</i> aff. <i>fibulifera</i> (MET Site 1346)									+			
	<i>Sida rohlenae</i>			+	+								+
	<i>Sida</i> sp. 'rugose'			+				+					
STERCULIACEAE	<i>Keraudrenia nephrosperma</i>					+							
	<i>Waltheria indica</i>			+									
VIOLACEAE	<i>Hybanthus aurantiacus</i>			+	+	+	+						
PASSIFLORACEAE	* <i>Passiflora foetida</i>				+	+					+	+	+
MYRTACEAE	<i>Corymbia hamersleyana</i>			+									
	<i>Eucalyptus camaldulensis</i>					+		+			+	+	+
	<i>Eucalyptus victrix</i>					+		+			+	+	+
	<i>Melaleuca argentea</i>							+					
	<i>Melaleuca glomerata</i>					+					+	+	+
	<i>Melaleuca linophylla</i>							+					
PRIMULACEAE	<i>Samolus repens</i>											+	
PLUMBAGINACEAE	<i>Plumbago zeylanica</i>					+							
OLEACEAE	<i>Jasminum didymum</i> subsp. <i>lineare</i>			+				+					
APOCYNACEAE	<i>Wrightia saligna</i>							+	+				+
ASCLEPIADACEAE	<i>Sarcostemma viminale</i> subsp. <i>australe</i>				+								
CONVOLVULACEAE	<i>Bonamia media</i> var. <i>villosa</i>			+	+	+	+			+			
	<i>Bonamia pannosa</i>			+	+								
	<i>Evolvulus alsinoides</i>			+									+
	<i>Evolvulus alsinoides</i> var. <i>villosicalyx</i>	+		+	+	+	+	+	+				
	<i>Evolvulus</i> sp.			+									
	<i>Ipomoea coptica</i>									+			
	<i>Ipomoea muelleri</i>			+		+		+			+	+	+
	<i>Operculina aequisejala</i>				+		+				+		+

**APPENDIX E: SUMMARY OF VASCULAR FLORA RECORDED WITHIN EACH VEGETATION COMMUNITY REPRESENTED BY QUADRATS,  
BALMORAL SOUTH PROJECT AREA, FOR AUSTEEL PROJECT (HGM, 2000)**

NB: \* Denotes introduced (weed) species

Family	Species	Vegetation Communities											
		Bx1	Hp	Nc	Nh	Nh2	Nr	Pc	Px1	Px2	Rc3	Rc4	Rf1
BORAGINACEAE	<i>Ehretia saligna</i>				+	+	+			+			
	<i>Heliotropium ovalifolium</i>			+		+							
	<i>Heliotropium</i> sp.		+							+			
	<i>Trichodesma zeylanicum</i>	+		+	+	+	+	+		+	+	+	
VERBENACEAE	<i>Clerodendrum floribundum</i> var. <i>angustifolium</i>			+									
SOLANACEAE	<i>Solanum diversiflorum</i>			+	+								
	<i>Solanum gabrielae</i>			+	+	+	+			+			
	<i>Solanum horridum</i>	+		+	+	+	+			+		+	
	<i>Solanum lasiophyllum</i>	+		+	+	+	+		+	+			
ACANTHACEAE	<i>Rostellularia adscendens</i> var. <i>clementii</i>					+			+		+	+	+
MYOPORACEAE	<i>Eremophila forrestii</i> subsp. <i>forrestii</i> (ms)	+		+		+							
	<i>Eremophila longifolia</i>	+		+	+	+	+						
CUCURBITACEAE	* <i>Citrullus lanatus</i>										+		
	* <i>Cucumis melo</i> subsp. <i>agrestis</i>			+	+	+			+			+	+
	<i>Mukia</i> aff. <i>maderaspatana</i> sp. C			+			+						
	<i>Mukia</i> aff. <i>maderaspatana</i> sp. D				+								
	<i>Mukia</i> aff. <i>maderaspatana</i> sp. E			+									
	<i>Mukia</i> aff. <i>maderaspatana</i> sp. F			+	+		+						+
GOODENIACEAE	<i>Trichosanthes cucumerina</i>				+		+						
	<i>Goodenia stobbsiana</i>			+	+	+							
	<i>Scaevola spinescens</i>			+	+		+						
ASTERACEAE	<i>Pluchea rubelliflora</i>										+	+	

# Appendix F: Species of Reptiles and Amphibians Captured or Observed at Each Transect Site and During Spotlighting Exercises

## Appendix F: Species of Reptiles and Amphibians Captured or Observed at Each Transect Site and During Spotlighting Exercises

	Site 1	Site 2	Site 3	Site 4	Spot 1	Spot 2	Total
<b>Reptilia</b>							
<b>Agamidae</b>							
<i>Ctenophorus caudicinctus caudicinctus</i>			1				1
<i>Ctenophorus isolepis isolepis</i>		3		4			7
<i>Ctenophorus nuchalis</i>		2		1			3
<i>Lophognathus longirostris</i>				2			2
<i>Pogona mitchelli</i>		1	2	2			5
<i>Tympanocryptis cephalus</i>			4				4
<b>Boidae</b>							
<i>Antaresia perthensis</i>					1		1
<b>Elapidae</b>							
<i>Acanthophis wellsi</i>					1		1
<i>Pseudechis australis</i>	1						1
<i>Pseudonaja nuchalis</i>			1				1
<i>Furina ornata</i>					1		1
<b>Gekkonidae</b>							
<i>Diplodactylus conspicillatus</i>	4	3	2	1			10
<i>Diplodactylus savagei</i>			1				1
<i>Gehyra pilbara</i>		1		1			2
<i>Gehyra variegata</i>		1	9	5			15
<i>Heteronotia binoei</i>				3		1	4
<i>Nephrurus levis occidentalis</i>				1		1	2
<b>Pygopodidae</b>							
<i>Lialis burtonis</i>			1				1
<i>Pygopus nigriceps</i>		1	1				2
<b>Scincidae</b>							
<i>Ctenotus schomburgkii</i>	1	3	1	2			7
<i>Ctenotus duricola</i>	1		1				2
<i>Ctenotus affin helenae</i>	1	3		5			9
<i>Ctenotus pantherinus ocellifer</i>				1			1
<i>Ctenotus rufescens</i>			1				1
<i>Ctenotus affin robustus</i>			1				1
<i>Ctenotus saxatilis</i>				2			2
<i>Glaphyromorphus isolepis</i>				1			1

	Site 1	Site 2	Site 3	Site 4	Spot 1	Spot 2	Total
<i>Lerista bipes</i>	1	6					7
<i>Lerista muelleri</i>	1			2			3
<i>Menetia greyii</i>	4	2		1			7
<i>Morethia ruficauda exquisita</i>		3					3
<i>Notoscincus ornatus ornatus</i>				1			1
<b>Typhlopidae</b>							
<i>Ramphotyphlops grypus</i>	1						1
<b>Varanidae</b>							
<i>Varanus acanthurus</i>	2						2
<i>Varanus brevicauda</i>		1					1
<i>Varanus gigantus</i>					1		1
<i>Varanus gouldii</i>		1					1
<i>Varanus panopties</i>			1				1
Total number of individuals							<b>86</b>
Total number of Species	10	14	14	17	4	2	
Total Species Number	<b>38</b>						
<b>Amphibia</b>							
<b>Hylidae</b>							
<i>Cyclorana maini (Mains Frog)</i>					1		1
Total Species Number	<b>1</b>						

# Appendix G: Species of Birds Identified in the Study Area

## Appendix G: Species of Birds Identified in the Study Area

Species	Site1	Site2	Site3	site4	River	BDT1	BDT2	BDT3	Total
<b>Casuariidae</b>									
<i>Dromaius novaehollandiae</i> (Emu)	4			2	6		6	1	19
<b>Phasianidae</b>									
<i>Coturnix ypsilophora</i> (Brown Quail)	6	8		4	10		6		34
<b>Turnicidae</b>									
<i>Turnix velox</i> (Little Button Quail)	2				2				4
<b>Anatidae</b>									
<i>Anas superciliosa</i> (Black Duck)				5	10			3	18
<i>Anas gracilis</i> (Grey Teal)					3				3
<b>Phalacrocoracidae</b>									
<i>Phalacrocorax sulcirostris</i> (Little Black Cormorant)				5	30			1	36
<b>Threskiornidae</b>									
<i>Threskiornis spinicollis</i> (Straw Necked Ibis)				2	5			2	9
<b>Pelecanidae</b>									
<i>Pelecanus conspicillatus</i> (Australian Pelican)					33				33
<b>Ardeidae</b>									
<i>Ardea pacifica</i> (White-necked Heron)				10	15			3	28
<i>Egretta garzetta</i> (Little Egret)				2	5			2	9
<i>Egretta novaehollandiae</i> (White - faced Heron)				6	3			1	10
<b>Accipitridae</b>									
<i>Accipiter fasciatus</i> (Brown Goshawk)			1	1	2				4
<i>Aquila audax</i> (Wedge tailed Eagle)	2	2	1	1	4	2			12
<i>Milvus migrans affinis</i> (Black kite)			1		1		1		3
<i>Haliaeetus leucogaster</i> (White - bellied sea eagle)					1				1
<i>Haliastur sphenurus</i> (Whistling kite)			2	1	3		1		7
<i>Hieraaetus morphnoides</i> (Little eagle)		2		1	2				5
<b>Falconidae</b>									
<i>Falco cenchroides</i> (Nankeen Kestrel)		1		1	1				3

<b>Species</b>	<b>Site1</b>	<b>Site2</b>	<b>Site3</b>	<b>site4</b>	<b>River</b>	<b>BDT1</b>	<b>BDT2</b>	<b>BDT3</b>	<b>Total</b>
<i>Falco berigora</i> (Brown Falcon)			1		1				2
<b>Otididae</b>									
<i>Ardeotis australis</i> (Australian Bustard) (P4)		2	2	2	4				10
<i>Grus rubicunda</i> (Brolga)					3				3
<b>Charadriidae</b>									
<i>Euseyonis melanops</i> (Black Fronted Dotteral)					8				8
<i>Vanellus tricolor</i> (Banded Lapwing)	6	6	10	8	3	12		3	48
<b>Laridae</b>									
<i>Chlidonias hybridus</i> (Whiskered Tern)				1	1				2
<b>Columbidae</b>									
<i>Geopelia cuneata</i> (Diamond Dove)				2	6				8
<i>Geopelia striata placida</i> (Peaceful Dove)				1	4		2		7
<i>Geophaps plumifera</i> (Spinifex Pigeon)	4	10	10	36	20	6	13	6	105
<i>Ocyphaps lophotes</i> (Crested Pigeon)	6	12	16	25	30	10		3	102
<b>Cacatuidae (Cockatoos)</b>									
<i>Cacatua roseicapilla</i> (pink and grey)	10	50	50	100	100		18	12	340
<i>Cacatua sanguinea</i> (Little Corella)	16	60		100	100		21		297
<i>Nymphicus hollandicus</i> (Cockatiel)	13	10	20	20	30			7	100
<b>Psittacidae</b>									
<i>Melopsittacus undulatus</i> (Budgerigar)	20								20
<b>Cuculidae</b>									
<i>Cuculus pallidus</i> (Pallid Cuckoo)				1	1				2
<b>Caprimulgidae</b>									
<i>Eurostopodus argus</i> (Spotted Nightjar)					1				1
<i>Podargus streigoides</i> (Tawney Frogmouth)					1				1
<b>Halcyonidae</b>									
<i>Dacelo leachii leachii</i> (Blue -winged Kookaburra)					1				1
<i>Todiramphus sanctus</i> (Sacred Kingfisher)				1	1			1	3

<b>Species</b>	<b>Site1</b>	<b>Site2</b>	<b>Site3</b>	<b>site4</b>	<b>River</b>	<b>BDT1</b>	<b>BDT2</b>	<b>BDT3</b>	<b>Total</b>
<b>Meropidae</b>									
<i>Merops ornatus</i> (Bee Eater)		10	2	4	10		4	2	<b>32</b>
<b>Maluridae</b>									
<i>Malurus lamberti</i> (Variegated fairy - wren)	2	6		2	2	4			<b>16</b>
<b>Pardalotidae</b>									
<i>Gerygone tenebrosa</i> (Dusky Gerygone)		2		1	2				<b>5</b>
<b>Meliphagidae</b>									
<i>Lichenostomus virescens</i> (Singing Honeyeater)	1	2	1	1	4				<b>9</b>
<i>Lichmera indistincta</i> (Brown Honeyeater)				2	1		1	2	<b>6</b>
<i>Manorina flavigula</i> (Yellow Throated Minor)	2	2		5	4		2	2	<b>17</b>
<b>Dicruridae</b>									
<i>Rhipidura leucophrys</i> (Wagtails)	1	1	1	3	3	1		1	<b>11</b>
<i>Grallina cyanoleuca</i> (Magpie Lark)			1	6	8	2			<b>17</b>
<b>Campephagidae</b>									
<i>Coracina novaehollandiae</i> (Cuckoo Shrike)	2	3	2	6	11	2	3	1	<b>30</b>
<b>Artamidae</b>									
<i>Artamus cinereus</i> (Black faced Woodswallow)	4	4	3	3	2				<b>16</b>
<i>Artamus personatus</i> (Masked Woodswallow)			2	3	2		2		<b>9</b>
<i>Artamus minor</i> (Little Woodswallow)	2		1	1					<b>4</b>
<i>Cracticus nigrogularis</i> (Pied Butcherbird)				3	2				<b>5</b>
<i>Gymnorhina tibicen</i> (Magpie)				1	1				<b>2</b>
<b>Corvidae</b>									
<i>Corvus orru</i> (Torresian Crow)	1	2	4	2	2		2		<b>13</b>
<b>Motacillidae</b>									
<i>Anthus novaeseelandiae</i> (Richards pipit)		1		1	1				<b>3</b>
<b>Passeridae</b>									
<i>Taeniopygia guttata</i> (Zebra Finch)	100	30	32	> 30	100	20	9	13	<b>&gt;334</b>

<b>Species</b>	<b>Site1</b>	<b>Site2</b>	<b>Site3</b>	<b>site4</b>	<b>River</b>	<b>BDT1</b>	<b>BDT2</b>	<b>BDT3</b>	<b>Total</b>
<b>Hirundinidae</b>									
<i>Hirundo nigricans</i> (Tree martins)					10				<b>10</b>
<i>Hirundo neoxena</i> (Welcome Swallow)					2				<b>2</b>
<b>Petroicidae (Australian Robins)</b>									
<i>Petroica goodenovii</i> (Red - capped Robin)		4			2				<b>6</b>
Total number of individuals									<b>1845</b>
Total number of Species	20	23	21	42	55	9	15	19	
Total Species Number	<b>57</b>								

# Appendix H: Species of Mammals Recorded During Field Survey

## Appendix H: Species of Mammals recorded During Field Survey

(C = Common, T = Tracks and S = Scats)

	Site 1	Site 2	Site 3	Site 4	River	BDT1	BDT2	BDT3	Total
<b>Mammalia</b>									
<b>Tachyglossidae</b>									
<i>Tachyglossus acueatus</i> (Echidna)	S								1
<b>Dasyuridae</b>									
<i>Sminthopsis macroura</i> (Stripe Faced Dunart)		2		2					4
<b>Macropodidae</b>									
<i>Macropus robustus</i> <i>erubescens</i> (Euro)				C	C			C	C
<i>Macropus rufus</i> (Red Kangaroo)	C		C	C	C	C	C	C	C
<b>Muridae</b>									
<i>Mus musculus</i> (House Mouse)		4							2
<i>Pseudomys</i> <i>hermannsburgensis</i> (Inland Sandy Mouse)		2							3
<b>Vespertilionidae</b>									
Vespertilionidae spp									10
<b>Felidae</b>									
<i>Felis catus</i> (Feral Cat)	1								1
<b>Canidae</b>									
<i>Canis lupus dingo</i> (Dingo)					T				T
<b>Total number of individuals</b>									<b>20</b>
<b>Total Species number</b>	<b>9</b>								

# Appendix I: Recommended Weed Control Methods

## Algaroba (\**Prosopis pallida*)

### Category: P1

**Location:** for the whole of the State.

### Category: P2

**Location:** for the whole of the State, except for the area on Mardie Station bordered by the coast, the boundary between Mardie and Karratha stations, the North West Coastal Highways, Peter's Creek and the boundary between Yarraloola and Mardie stations.

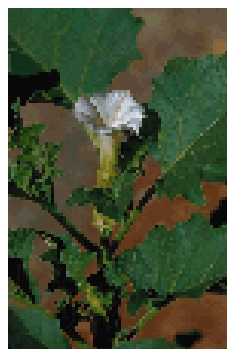
### Category: P4

**Location:** for the area on Mardie Station bordered by the coast, the boundary between Mardie and Karratha stations, the North West Coastal Highway, Peter's Creek and the boundary between Yarraloola and Mardie stations.

Standard Control Codes (these may vary for individual plants)

<p><b>P1</b></p> <p><b>REQUIREMENTS</b></p> <p>Prohibits movement</p>	<p>The movement of plants or their seeds is prohibited within the State.</p> <p>This prohibits the movement of contaminated machinery and produce including livestock and fodder.</p>
<p><b>P2</b></p> <p><b>REQUIREMENTS</b></p> <p>Aims to eradicate infestation</p>	<p>The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery.</p>
<p><b>P4</b></p> <p><b>REQUIREMENTS</b></p> <p>Aims to prevent infestation spreading beyond existing boundaries of infestation.</p>	<p>The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery.</p> <p>Treat to destroy and prevent seed set all plants:-</p> <ul style="list-style-type: none"> <li>• within 100 metres inside of the boundaries of the infested property</li> <li>• within 50 metres of roads and highwater mark on waterways</li> <li>• within 50 metres of sheds, stock yards and houses</li> </ul> <p>Treatment must be done prior to seed set each year. Properties with less than 2 hectares of infestation must treat the entire infestation.</p> <p>Additional areas may be ordered to be treated.</p>

## Native Thornapple (*Datura leichhardtii*)



### Category: P1

**Location:** for the whole of the State except the municipal districts of Ashburton, Broome, Derby-West Kimberley, East Pilbara, Halls Creek, Port Headland, Roeburne and Whyndam-East Kimberley.

### Category: P3

**Location:** for the municipal districts of the City of Albany, Broomehill, Chapman Valley, Collie, Cranbrook, Denmark, Dumbleyung, the City of Geraldton, Greenough, Harvey, Irwin, Jerramungup, Gnowangerup, Katanning, Kent, Kojonup, Mandurah, Mullewa, Murray, Northampton, Plantagenet, Ravensthorpe, Serpentine-Jarrahdale, Tambellup, Wagin, Waroona, West Arthur and Woodanilling.

### Category: P4

**Location:** for the municipal districts of Augusta-Margaret River, Boddington, Boyup Brook, Bridgetown-Greenbushes, Brookton, Bruce Rock, the City of Bunbury, Busselton, Capel, Carnarvon, Chittering, Coolgardie, Corrigin, Cuballing, Cue, Cunderdin, Dandaragan, Dalwallinu, Dardanup, Donnybrook-Balingup, Dowerin, Dundas, Esperance, Exmouth, Gingin, the City of Kalgoorlie-Boulder, Kelleberrin, Koorda, Laverton, Leonora, Manjimup, Meekatharra, Menzies, Merredin, Moora, Mt Magnet, Mt Marshall, Mukinbudin, Murchison, Nannup, Narembeen, Narrogin, Nungarin, Ngaanyatjaraku, Pingelly, Sandstone, Shark Bay, Tammin, Trayning, Upper Gascoyne, Victoria Plains, Wandering, Westonia, Wickepin, Wiluna, Williams, Wongan-Ballidu, Wyalkatchem, Yalgoo and Yilgarn.

Standard Control Codes (these may vary for individual plants)

<p><b>P1 REQUIREMENTS</b></p> <p>Prohibits movement</p>	<p>The movement of plants or their seeds is prohibited within the State.</p> <p>This prohibits the movement of contaminated machinery and produce including livestock and fodder.</p>
<p><b>P3 REQUIREMENTS</b></p> <p>Aims to control infestation by reducing area and/or density of infestation</p>	<p>The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery.</p> <p>Treat to destroy and prevent seed set all plants:-</p> <ul style="list-style-type: none"> <li>• Within 100 metres inside of the boundaries of the infestation</li> <li>• within 50 metres of roads and highwater mark on waterways</li> <li>• within 50 metres of sheds, stock yards and houses</li> </ul> <p>Treatment must be done prior to seed set each year.</p> <p>Of the remaining infested area:-</p> <p>Where plant density is 1-10 per hectare treat 100% of infestation.          Where plant density is 11-100 per hectare treat 50% of infestation.          Where plant density is 101-1000 per hectare treat 10% of infestation.</p>

	<p>Properties with less than 2 hectares of infestation must treat the entire infestation. Additional areas may be ordered to be treated.</p>
<p><b>P4</b></p> <p><b>REQUIREMENTS</b></p> <p>Aims to prevent infestation spreading beyond existing boundaries of infestation.</p>	<p>The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery.</p> <p>Treat to destroy and prevent seed set all plants:-</p> <ul style="list-style-type: none"> <li>• within 100 metres inside of the boundaries of the infested property</li> <li>• within 50 metres of roads and highwater mark on waterways</li> <li>• within 50 metres of sheds, stock yards and houses</li> </ul> <p>Treatment must be done prior to seed set each year. Properties with less than 2 hectares of infestation must treat the entire infestation.</p> <p>Additional areas may be ordered to be treated.</p>

# Appendix J: Balmoral South Iron Ore Project Fauna Survey



# Balmoral South Iron Ore Project Fauna Survey

Australasian Resources

December 2006

MAUNSELL | AECOM

# Fauna Survey

Prepared for

**Australasian Resources**

Prepared by

**Maunsell Australia Pty Ltd**

Level 1, 629 Newcastle Street, PO Box 81, Leederville 6902, Western Australia  
T +61 8 9281 6100 F +61 8 9281 6295 www.maunsell.com

ABN 20 093 846 925

December 2006

60020130

© Maunsell Australia Pty Ltd 2006

The information contained in this document produced by Maunsell Australia Pty Ltd is solely for the use of the Client identified on the cover sheet for the purpose for which it has been prepared and Maunsell Australia Pty Ltd undertakes no duty to or accepts any responsibility to any third party who may rely upon this document.

All rights reserved. No section or element of this document may be removed from this document, reproduced, electronically stored or transmitted in any form without the written permission of Maunsell Australia Pty Ltd.

# Quality Information

Document Fauna Survey

Ref 60020130

Date December 2006

Prepared by Ian Harris, Elizabeth Zajc, Clayton Pritchard

Reviewed by Jamie Shaw

## For Information

### Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	11/12/2006			

# Table of Contents

1.0	Introduction	5
1.1	Project Background	5
1.2	Survey Personnel	5
2.0	Methods	6
2.1	Licences and Permits	6
2.2	Field Survey	6
2.2.1	Survey Locations	6
2.2.2	Trapping for frogs, reptiles and mammals	9
2.2.3	Bird Surveys	1
2.2.4	Spotlighting	1
2.3	Survey Limitations	2
3.0	Results	3
3.1	Desktop Surveys	3
3.1.1	Schedule 1	3
3.1.2	Priority 1	3
3.1.3	Priority 3	3
3.1.4	Priority 4	4
3.2	Field Survey	4
3.2.1	Reptiles	5
3.2.2	Birds	8
3.2.3	Mammals	13
3.2.4	Introduced Mammals	14
4.0	Discussion	16
4.1	Reptiles	16
4.2	Birds	16
4.3	Mammals	16
4.4	Conclusions and Recommendations	17
5.0	References	18

## 1.0 Introduction

The Balmoral South project is based on part of the extensive Balmoral magnetite deposit in the south west Pilbara Region of Western Australia. The Balmoral deposit is located within existing Mining Leases and other *Mining Act* tenements held by Mineralogy Pty Ltd (Mineralogy) and the deposit is divided into the Southern, Central and Northern "blocks". The Balmoral South project focuses on the Southern Block. The project proposed for the Central Block is here referred to as the Mineralogy Project, since they are the proponent for the environmental assessment process.

A fauna survey was completed for the Balmoral South Project Area. The survey was conducted in order to gather data on fauna species richness and distribution throughout the Project Area. The data is used to inform the environmental assessment process for the Project.

Previous fauna surveys for the general project area were conducted for the Mineralogy Project including the mine, plant, tailings and waste dump sites, as well as the conveyor corridor and port facilities (Halpern Glick Maunsell, 2000). This survey indicates fauna diversity which may be present at this adjacent site.

An additional survey was conducted between 21<sup>st</sup> and 29<sup>th</sup> October 2006. The work consisted of trapping for frogs, reptiles and mammals within the lease areas; bird surveys on the lease areas and along the Fortescue River and Du Boulay Creek; targeted fauna searches along defined transects; micro-habitat searches; and spot-lighting searches within the lease areas and on adjacent roads. This report discusses the methods and results from this 2006 survey.

### 1.1 Project Background

The Balmoral South Project will consist of mining of an average of 77Mtpa comprising of 42 Mtpa of iron ore and 35Mtpa of waste for a minimum of 25 years. The ore will be concentrated and processed on-site in preparation for subsequent export through the adjacent Cape Preston port facility (to be built by the Mineralogy Project). Therefore, the project footprint is proposed to consist of the mine, two waste dumps, a tailings dam, a gas power plant, and a concentrator and processing plant complex. Additionally, an accommodation camp will be built on-site to house a portion of the estimated 700 permanent workers for the mine. This footprint area is estimated to be 2,692ha.

### 1.2 Survey Personnel

The fauna survey was led by Mr. Ian Harris, an experienced fauna biologist. He was assisted by Mr. Clayton Pritchard.

## 2.0 Methods

The fauna survey was conducted during nine days from 21<sup>st</sup> to 29<sup>th</sup> October, 2006. The fauna assessment and preparation of this report have been carried out with reference to the Environmental Protection Authority (EPA) guidance and position statements on fauna surveys (EPA 2002, 2004). The survey was conducted by qualified fauna biologists, and with a systematic sampling effort in order to representatively survey the project area.

### 2.1 Licences and Permits

The fauna sampling for this survey was conducted under DEC Regulation 17 "Licence To Take For Scientific Purposes" No SF005496.

### 2.2 Field Survey

The main field component of the fauna survey was conducted between the 21<sup>st</sup> and 29<sup>th</sup> of October 2006. Work consisted of:

- trapping for frogs, reptiles and mammals within the lease areas;
- bird surveys on the lease areas, Fortescue River and Du Boulay creek;
- targeted searches along defined transects;
- turning over rocks and searching micro-habitats; and
- spotlighting within the lease areas and on roads adjacent to the lease areas.

Opportunistic observations were made at all times during the field survey.

#### 2.2.1 Survey Locations

Survey locations concentrated on areas which had been under-sampled in previous surveys. Vegetation mapping and aerial photography of the project areas was reviewed prior to the field survey in an effort to locate potential fauna trapping sites. Nominated areas were inspected on site and assessed for suitability and accessibility. Four transect sites were identified, representing a large proportion of the project area. These areas were defined on the requirements of a range of vertebrate species, including reptiles, mammals and birds and were partially dependant on the level of cattle grazing activity in the immediate area.

A description of the habitat and soil types at each trapping transect is provided.

##### a) Transect 1 – North - Western section of the bore field lease

Location: E 402683.63 N 7655308.79 to E 402937.18 N 7654982.24 (GDA 95 Zone 50). Soil association generally heavy clay with occasional sandy rises. The transect encompassed transitions between vegetation systems SG, LAGS and RF2.

**Figure 1 Typical habitat of transect 1**



b) Transect 2 – Southern section of bore field

Location: E 404900.30, N7654171.64 to E 404508.44 N 7654513.55 (GDA 94 Zone 50). The soil association is generally heavy clay with occasional stony and sandy rises. The transect encompassed vegetation system RF1.

**Figure 2 Typical habitat of Transect 2**



c) Transect 3 – North western end of tailings dam

Location: E 413651.26 N 7666543.71 to E 413271.74 N 7666696.26 (GDA 94 Zone 50). Soils were clays and cracking clays that encompassed vegetation systems HP and Px2.

**Figure 3 Typical habitat of transect 3.**



**d) Transect 4 – Eastern block tailings dam and Du Boulay Creek**  
Location: E 411368 N 7661768 to E 411274.75 N 7662132.55 (GDA 94, Zone 50).

**Figure 4 Typical habitat of transect 4.**



Bird surveys generally followed the four transects. For each transect, the bird survey extended 500 m beyond the end of the trapping transect. Additionally, bird surveys were conducted along the Fortescue River and Du Boulay Creek. Additional bird transects (BFTs) were located in the survey area.

Numerous non-systematic surveys were conducted to gather additional fauna data for the greater survey area. Night-time spot-lighting surveys were conducted by vehicle and by foot to increase data on fauna diversity in the Project Area.

### **2.2.2 Trapping for frogs, reptiles and mammals**

Methods employed for the sampling of vertebrate species included the use of pitfall, funnel and small box (Elliot) traps within the lease areas. Traps were deployed in four transects with the aim of sampling both differing vegetation communities and soil types (Table 1).

**Table 1 Trapping grid locations and trap effort**

Site	Location	Date Set-up	Date Closed	Nights Open	Pit Traps	Elliott Traps	Funnel Traps	Pit Trap Effort	Elliott Trap Effort	Funnel Trap Effort	Total Trap Effort (trap nights)
1		21/10/06	27/10/06	5	10	10	10	50	50	50	150
2		22/10/06	27/10/06	5	10	10	10	50	50	50	150
3		23/10/06	28/10/06	5	10	10	10	50	50	50	150
4		24/10/06	29/10/06	5	10	10	10	50	50	50	150
<b>Total</b>								200	200	200	600

Each transect line was approximately 300m and comprised of 10 pitfall traps, each placed at an interval of approximately of 25 - 30m, with Elliott traps placed adjacent to every pitfall (10 Elliott traps per transect). Pitfall traps were 40 L PVC buckets with a 25 cm high flywire drift fence extending approximately 2.5m on either side of the pitfall.

Each pitfall fence was linked to a 15 cm wide and 60 cm long funnel trap. Funnel traps were set up at the end of each drift fence with the funnel's 5cm entrance bisected by the fence. Each funnel trap was covered with shade cloth and, where possible, positioned under the cover of vegetation. Elliott traps were positioned under vegetation to provide maximum cover and baited with a mixture of rolled oats, peanut butter and sardines.

Sampling site selection and trap placement was hampered by intensive trampling by livestock and reduced vegetation cover, presumably caused by grazing pressure. Consequently, the pitfall traps were spaced at 25 – 30 m intervals in order to reduce damage by grazing livestock. The survey did not use continuously linked pitfall traps because interference by cattle was considered likely. By spacing the traps, it was felt that interference by cattle may have been reduced, as all the trap effort was not confined to a single location. Furthermore, spacing the pitfalls allowed a degree of flexibility in placement and helped capture varying soil types over short distances.

Due to the high temperatures during the survey period, trap clearing commenced at first light and was concluded by 8am each day. Elliot traps were closed each morning and then re-opened in the late afternoon. Funnel traps were left unzipped during the heat of the day and then re-set in the late afternoon. The procedure of closing and opening traps, whilst time consuming, was necessary to help reduce the chance of fauna mortality due to over-heating or dehydration.

Each transect was operated for a total of five nights equating to a total of 200 pitfall, 200 Elliott and 200 funnel trap nights.

Taxonomic identification and nomenclature was according to appropriate and current sources. Reptiles taxonomy follows Storr *et al.* (1999), Storr *et al.* (2002) and Cogger (2000); mammal taxonomy follows How *et al.* (2001), Menkhorst and Knight (2004); and frogs nomenclature follows Tyler *et al.* (2000). The taxonomic order of reptiles and mammals presented in this report are generally based on the Western Australian Museum. Where a discrepancy exists between reference, taxonomy follows that used by the Western Australian Museum.

### **2.2.3 Bird Surveys**

Bird sampling was conducted in conjunction with the checking of traps. Both visual and auditory cues were used to identify species, and each sighting was recorded. Bird survey transect, therefore, corresponded to vertebrate trap transects with the addition of extended sampling of approximately 500 m past the last trap. Targeted surveys were also conducted along the Fortescue River, in the central tailings dam area, along Du Boulay Creek and in the central bore field. Opportunistic observations were also recorded whilst driving around site and during night time spotlighting surveys. Avian taxonomy and nomenclature follows Christidis and Boles (1994) and Simpson and Day (1999). The taxonomic order of birds presented in this report follows that of Christidis and Boles (1994).

### **2.2.4 Spotlighting**

Spotlighting surveys were conducted in order to search for nocturnal species. They was conducted on five nights commencing at approximately 1900 hrs and concluded at approximately

2200 hrs. Spotlighting was conducted from a vehicle over all access tracks within the survey areas. Portions of the creek lines within the tailings dam area were traversed on foot.

### 2.3 Survey Limitations

A number of limitations were experienced during the October 2006 survey. A selection of suitable trapping sites was difficult to establish due to the extent of cattle grazing on Balmoral Station. A large portion of the survey area is currently heavily stocked, and vegetated ground cover in many areas was not present. This extensive grazing resulted in interference with trap lines, particularly at sites one and two. This may have resulted in under-sampling in these areas.

Climatic conditions during the survey also limited trapping duration. The high temperatures increased the demand on trap opening/closing, and this in turn lead to a reduced amount of opportunistic search. Species that are difficult to trap or observe may be under represented in this survey.

Lastly, an extensive bat survey was not conducted as a part of this fauna survey. Bats have been identified as important fauna that may inhabit the Project Area. The schedule 1 species, *Mormopterus loriae cobourgiana* (Little North-Western Bat), has been identified as possibly occurring in the Project Area. Any bat observations were incidental, and the survey did not target bat habitat areas.

## 3.0 Results

### 3.1 Desktop Surveys

Initial information was gathered for background fauna information for the Project Area. A search for threatened and priority fauna was conducted to gather information on vulnerable species in the Project Area. A database search was conducted by the Department of Environment and Conservation (DEC), for the project area 21.4707°S 115.882° E / 20.8749°S 116.415°E (Mardie plus 15 km buffer). The search identified one threatened species.

Seven Priority species were identified in the database search. These priority fauna are not necessarily considered threatened under the *Wildlife Conservation Act, 1950*, but they are poorly known or poorly represented in the conservation estate. The four classifications of priority fauna are listed in Table 2.

Table 2 Explanation of Priority Codes

Category	Code	Description
Priority 1	P1	Taxa with few, poorly known populations on threatened lands
Priority 2	P2	Taxa with few, poorly known populations on conservation lands.
Priority 3	P3	Taxa with several, poorly known populations, some on conservation lands.
Priority 4	P4	Taxa in need of monitoring

The desktop search for fauna of concern for the Project Area influenced the field survey. Survey personnel were particularly aware of the identification of these species. Targeted surveys were conducted for some of these species. Only one Priority 4 species was identified during the 2006 field survey. The following threatened and Priority fauna were identified in the database search:

#### 3.1.1 Schedule 1

- *Pezoporus occidentalis* (Night Parrot). This species was not recorded during the field survey. It has been recorded approximately 12km south of the search area, where it inhabits areas dominated by *Triodia spp.*

#### 3.1.2 Priority 1

- *Mormopterus loriae cobourgiana* (Little North-western Bat). This species was not recorded during the field survey. It was recorded in 2000 in the mangrove vegetation community at Cape Preston, west of the survey area.

#### 3.1.3 Priority 3

- *Lagorchestes conspicillatus leichardti* (Spectacle Hair Wallaby). This species was not recorded during the field survey. It is known to have declined from many parts of its home range. This species is susceptible to predation by introduced carnivores.

### 3.1.4 Priority 4

- *Leggadina lakedownensis* (Lakeland Downs Mouse, Kerakenga). This species was not recorded during the field trip. It has been recorded on Mardie station, with three individuals captured or trapped in 2000. Prior surveys (HGM 2001) suggest that the preferred habitat of this species may be crackling clay, as cracking clays are wide-spread throughout the project area. It is expected that this species will occur in the project area.
- *Pseudomys chapmani* (Western Pebble Mound Mouse). This species was not recorded during this field trip. It is known to inhabit low slopes and rocky hills. A single active mound was observed at Mardie in a 2000 survey; however, despite searching the small area of potentially suitable habitat (stony slopes and rises), no evidence of this species was encountered in the project area.
- *Ardeotis australis* (Bustard). This species was recorded at four locations in the survey area, including sites two, three, four and along the Fortescue River. It was also observed outside of the survey area in the general location of the Balmoral shearing shed.
- *Burhinus grallarius* (Bush Stonecurlew). This species was not recorded during this field trip; it was recorded along the North West Coastal Highway in 2000.
- *Numenius madagascariensis* (Eastern Curlew). This species was not recorded during this field survey. It has been recorded along the mud flats adjacent to mangroves west of the Project Area.

## 3.2 Field Survey

The October 2006 field survey recorded a total of 104 vertebrate species, with faunal groups represented in table 2. A total of 114 individuals were captured, identified at site and released.

**Table 3 Total species recorded during field survey**

<b>Faunal Group</b>	<b>Total</b>
Native Mammals	6
Introduced Mammals	3
Avifauna	57
Reptiles	37
Amphibians	1
<b>Total</b>	<b>104</b>

### 3.2.1 Reptiles

A total of 37 reptile and one amphibian species were recorded during the October 2006 field survey. The 37 species were represented by 114 individual captures, 39.5% of which were attributed to the Scincidae (Skinks), 28% Gekkonidae (Geckoes) and 20.2% Agamidae (Dragons). The Boidae (Pythons), Elapidae (Front Fanged Snakes), Pygopodidae (Legless Lizards), Typhlopidae (Blind Snakes) and Varanidae (Monitors) all contributed < 5% of total captures. Appendix 1 summarises data recorded for all reptile species recorded. Each species is discussed in the following annotation.

#### Agamidae

- *Ctenophorus caudicinctus caudicinctus*. Uncommon. One individual was captured at Site 3 (T23) on a stony rise over clay.
- *Ctenophorus isolepis isolepis*. Uncommon. It was recorded from Site 2 at Traps 11 and 13 and at Site 4, Traps 36 and 40. *Triodia* spp. was the dominant vegetation in all areas in which this species was found.
- *Ctenophorus nuchalis*. Uncommon. This species was recorded from Site 2 at Traps 14 and 15 and from Site 4 at Trap 40. All sites were dominated by *Triodia* spp.
- *Lophognathus longirostris*. Common. This species was regularly observed at Site 4 along the creek, and it was trapped at Site 4 in Traps 35 and 38. It was also recorded from vegetated areas along Fortescue River and associated feeder creeks.
- *Tympanocryptis cephalus*. This species is uncommon, with only four individuals trapped at Site 3. All four were captured at Trap 23 on a small rise of stony ground over heavy clay. Individuals ranged in size, indicating that the same individual was not re-captured.
- *Pogona mitchelli*. Individuals captured at Site 2 from Trap 18 where the vegetation was dominated by grasses and *Triodoo* spp.; from Site 3, Traps 23 & 29 on unvegetated areas of stones over clay; and from Site 4 Trap 31, which consisted of coarse sand dominated by *Triodia* spp.

#### Boidae

- *Antaresia perthensis*. Only one individual was observed during a spotlighting transect of the northern end of the tailings dam area. This individual was recorded near a rocky ridge on the edge of the lease area.

#### Elapidae

- *Pseudonaja nuchalis*. One individual was observed dead on a road adjacent to Site 3.
- *Pseudechis australis*. Only one individual was sighted near Trap 10 at Site 1. An individual was also recorded dead on the North west Highway; however, this individual was outside of the survey area.

- *Acanthophis wellsii*. One individual was observed during a spotlighting excursion at the northern end of the tailings dam area. This individual was recorded near a rocky ridge on the edge of the lease area.

### Gekkonidae

- *Diplodactylus conspicillatus*. This species is considered relatively common, with individuals captured over a variety of soil and vegetation types at Sites 1, 2, 3, and 4.
- *Diplodactylus savagei*. Only one individual was captured at Site 3 in an area of cracking clays at Trap 30. No other sightings of this species were recorded.
- *Gehyra pilbara*. Two individuals were captured at Sites 2 in cracking clay and at Site 4 along the creek bank in coarse sandy soil.
- *Gehyra variegata*. This is the most common gecko species captured. Individuals were recorded across a range of soil types at Sites 2, 3, and 4.
- *Nephrurus levis occidentalis*. Two individuals were captured: one at Site 4, Trap 40 and one at northern section of the bore field lease.
- *Heteronotia binoei*. Three individuals were captured at Site 4 at Traps 34 & 37 and one individual was captured whilst spotlighting the northern section of the bore field lease.

### Pygopodidae

- *Lialis burtonis*. One individual was captured on crackling clays at Site three, Trap 26.
- *Pygopus nigriceps*. Two individuals were captured: one at Site 2 on sandy loam dominated by *Triodia* spp. and one at Site 3 on an area of crackling clay with little ground cover.

### Scincidae

- *Ctenotus schomburgkii*. Individuals were captured over a range of soil types including coarse sand, gravel and cracking clays. Captures included: one at Site 1, three at Site 2, one at Site 3 and two at Site 4.
- *Ctenotus duricola*. Two individuals were captured, one at Site 1 in a well grassed area and one at Site three on cracking clays.
- *Ctenotus affinis helenae*. Individuals were captured at Sites 1, 2 and 4. With the exception of Site 1, this species was typically captured from areas of stone and gravel substrate dominated by *Triodia* spp. The majority of individuals were captured at Site 4 along Du Boulay Creek.
- *Ctenotus pantherinus ocellifer*. One individual was captured in Trap 32 at Site 4. The soil type at this location was gravel to coarse sand dominated by *Triodia* spp.

- *Ctenotus rufescens*. One individual was captured on a stony rise over clay at Trap 28, Site three.
- *Ctenotus affinis robustus*. One individual was recorded at Site three. This species has not yet been classified by the Museum of Western Australia; however, its presence has previously been recorded in the Pilbara. Photographs of this individual were presented to the Museum, and its identity was confirmed.
- *Ctenotus saxatilis*. Two individuals were captured from Traps 35 & 38 at Site 4.
- *Glaphyromorphus isolepis*. There was only one record of this species from Trap 38 along Du Boulay Creek.
- *Lerista bipes*. This species was commonly trapped in the sandy substrates at Site 2, and it was also recorded from Site 1.
- *Lerista muelleri*. Three individuals were captured: one at Site 1 and two from Site 4.
- *Menetia greyii*. Four individuals were captured at Site 1, in areas of grass on clay; two individuals were captured at an area of grass on clay at Site 2; and one individual was captured from a sandy substrate at Site 4.
- *Morethia ruficauda exquisite*. Three individuals were captured among *Triodia* spp. in Trap 15 at Site 2.
- *Notoscincus ornatus ornatus*. One individual was captured at Site 4 in River bank vegetation.

### **Typhlopidae**

- *Ramphotyphlops grypus*. One individual was captured in a grassed area over clay at Site 1.

### **Varanidae**

- *Varanus acanthurus*. Two captured individuals were at Site 1: one in funnel Trap 9 and one in Elliott Trap 10.
- *Varanus brevicauda*. One individual was captured at Site 2 in Trap 12 and another was observed at Trap 14 Site 2.
- *Varanus gigantus*. One individual was recorded as road kill at the northern end of the tailings dam lease.
- *Varanus panopties*. One individual was captured on the access track through the tailings dam lease.
- *Varanus gouldii*. One individual was observed at Site 2 basking at the base of an Acacia tree.

## Amphibians

- *Cyclorana maini* (Mains Frog). One individual was recorded whilst spotlighting adjacent to the tailings dam lease area.

### 3.2.2 Birds

A total of 57 bird species were recorded during the survey of the project area, representing 31 families. The 57 species were represented by approximately 1844 records, 40% of which were attributed to one family group, Cacatuidae, with Galas, Little Corellas and Cockatiels observed in large groups (Appendix 2). The family Passeridae was well represented by *Taeniopygia guttata* (Zebra Finch) accounting for 18% of total sightings and the family Columbidae, represented by *Geophaps plumifera* (Spinifex Pigeon) and *Ocyphaps lophotes* (Crested Pigeon) accounting for 11.3% of sightings. A total of 41 species were represented by less than 30 sightings, with 5 species represented by between 30 - 40 individuals, and they include: *Coturnix ypsilophora* (Brown Quail), *Phalacrocorax sulcirostris* (Little Black Cormorant), *Pelecanus conspicillatus* (Australian Pelican), *Vanellus tricolor* (Banded Lapwing) and *Merops ornatus* (Bee Eater).

Of particular interest was the recording of two species listed as migratory species under the *Environmental Protection and Biodiversity Act 1999* (EPBC act):

- a) *Merops ornatus* Bee Eater (recorded regularly throughout the survey area), and
- b) *Haliaeetus leucogaster* White-bellied sea eagle (one sighting recorded).

Records of breeding behavior were made for only one species, *Dromaius novaehollandiae* (Emu). Two adult males were observed on different occasions, one with four chicks and the other with two chicks. Appendix 2 summarises data recorded for bird species present. Each species is discussed in the following annotation.

#### Casuariidae

- *Dromaius novaehollandiae* (Emu). Common. This species was recorded on five occasions, from Sites 1, 4, the River, BDT2 and BDT3. Adult birds with chicks were observed on two occasions, at the River and at BDT2.

#### Phasianidae

- *Coturnix ypsilophora* (Brown Quail). Common. This species was recorded on five occasions from Sites 1, 2, 4, River and BDT2 in small groups. Individuals were recorded from grasses on each occasion.

#### Anatidae

- *Anas superciliosa* (Black Duck). Uncommon. Individuals were recorded on three occasions from water holes along the River and Du Boulay Creek.
- *Anas gracilis* (Grey Teal)

Uncommon. This species was recorded on one occasion at the River.

#### Phalacrocoracidae

- *Phalacrocorax sulcirostris* (Little Black Cormorant). Uncommon. Recorded on two occasions: one flock of 30 individuals was observed on the River and five individuals were observed at Du Boulay Creek.

#### **Pelecanidae**

- *Pelecanus conspicillatus* (Australian Pelican). Uncommon. One flock of 33 individuals was observed on the River late in the afternoon.

#### **Ardeidae**

- *Ardea pacifica* (White-Necked Heron). Uncommon. This species was recorded at three locations: Site 4, at the River and at BDT3. Individuals were regularly observed at the same water bodies each day, indicating the same birds were regularly seen.
- *Egretta garzetta* (Little Egret). Uncommon. Individuals were recorded from three locations: Site 4, the River and BDT3. Individuals were sighted daily at the same locations.
- *Egretta novaehollandiae* (White-Faced Heron). Uncommon. Individuals were recorded from three locations: Site 4, the River and BDT3. Individuals were sighted daily at the same locations.

#### **Threskiornidae**

- *Threskiornis spinicollis* (Straw Necked Ibis). Uncommon. Individuals were recorded on three occasions from Site 4, the River and BDT3; at each time they were observed foraging adjacent to remaining water bodies.

#### **Accipitridae**

- *Accipiter fasciatus* (Brown Goshawk). Uncommon. This species was recorded on three occasions from Sites 3, 4 and the River. Two individuals were observed whilst flying and the third individual was observed while perched on a dead trees.
- *Aquila audax* (Wedge - Tail Eagle). Uncommon. This species was recorded on six occasions from Sites 1, 2, 3, 4, the River and BDT1. These same individuals may have been observed more than once.
- *Milvus migrans affinis* (Black Kite). Scarce. A single bird was observed on three occasions at Sites 3, the River and BDT2.
- *Hieraaetus morphnoides* (Little Eagle). Single individuals were observed on different days at three locations: Sites 2, 4 and the River. These sightings were possibly the same individuals.
- *Haliastur sphenurus* (Whistling Kite). A single bird was recorded on different days at Sites 3, 4, the River and BDT2. Three sightings at the River transect possibly reflect observation of the same individual.
- *Haliaeetus leucogaster* (White - Bellied Sea Eagle). There was a single sighting of this species at the River. The individual was observed moving along the River between two large water bodies.

### **Falconidae**

- *Falco berigora* (Brown Falcon). This species was observed on only two occasions: once at Site 3 and once at the River.
- *Falco cenchroides cenchroides* (Nankeen Kestrel). Individuals were recorded at three locations: Sites 2,4 and the River.

### **Gruidae**

- *Grus rubicunda* (Brolga). Three individuals were recorded daily at the same large body of water along the River.

### **Otididae**

- *Ardeotis australis* (Australian Bustard). This species was recorded once at four locations: Sites 2, 3, 4 and the River. It was also observed on Balmoral adjacent to the shearing shed and on the road linking Northwest Highway. Both sites are outside of the Project Area.

### **Turnicidae**

- *Turnix velox* (Little Button Quail). Uncommon. This species was recorded at two locations: Site 1 and at the River. On both occasions it was observed in pairs.

### **Charadriidae**

- *Elseynornis melanops* (Black Fronted Dotterel). Four pairs were recorded regularly at the same large body of water along the River.
- *Vanellus tricolor* (Banded Lapwing). Common. This species was recorded at seven locations: Sites 1, 2 ,3, 4, the River, BDT1 and BDT3. As many as twelve individuals were observed at one time. This species was observed at livestock watering points throughout the greater area.

### **Laridae**

- *Sterna caspia* ( Caspian Tern). Uncommon. A single individual was recorded at two locations: Site 4 and the River. Individuals were observed flying low over water bodies, circling, and then landing at the water's edge.

### **Columbidae**

- *Ocyphaps lophotes* (Crested Pigeon). Common. This species was recorded at seven sites in large groups. Large flocks were observed at water bodies and stock troughs. Also, this species was observed as individuals or pairs throughout the greater area.
- *Geophaps plumifera* (Spinifex Pigeon). Common. This species was recorded at all locations. Large flocks were observed along the River and stony creek lines. It was often observed at stock watering points and along access tracks throughout the site.
- *Geopelia cuneata* (Diamond Dove). A single pair was recorded from Site 4 adjacent to a creek line, and a group of six individuals were recorded at the River.

- *Geopelia striata placida* (Peaceful Dove). This species was recorded at three locations, each time adjacent to the River or creek lines. The largest group recorded comprised of four individuals drinking at the River.

#### **Cacatuidae**

- *Nymehicus hollandicus* (Cockatiel). Common. This species was observed in flocks of up to 30 at Sites 1, 2, 3, 4, the River and BDT3. It was regularly seen throughout survey area, particularly during the early morning along the River.
- *Cacatua roseicapilla* (Galah). Common. This species was observed in large flocks at all sites except for Site BDT1. It was observed in large numbers around water holes and stock troughs.
- *Cacatua sanguinea* (Little Corella). Common. This species was observed in large flocks at Sites 1, 2, 4, the River and BDT2. It was observed in large numbers around water holes and stock troughs.

#### **Psittacidae**

- *Melopsittacus undulatus* (Budgerigar). Uncommon. One flock of approximately 20 individuals was recorded from Site 1 late in the afternoon.

#### **Cuculidae**

- *Cuculus pallidus* (Pallid Cuckoo). Uncommon. Individuals were recorded from Sites 4 and the River. Both individuals were observed in *Eucalyptus* sp. adjacent to a water body.

#### **Podargidae**

- *Podargus streigoides* (Tawney Frogmouth). Uncommon. A single individual was recorded whilst spotlighting along the River.

#### **Caprimulgidae**

- *Eurostopodus argus* (Spotted Nightjar). Uncommon. A single individual was observed whilst spotlighting on the main access track adjacent to the River.

#### **Halcyonidae**

- *Dacelo leachii leachii* (Blue Winged Kookaburra). Uncommon. A single individual was recorded on one occasion from the River. The individual was recorded drinking from a water body early in the morning.
- *Todiramphus sanctus* (Sacred Kingfisher). Uncommon. Individuals were recorded at Sites 4, the River and BDT3. Each individual was recorded adjacent to water bodies.

#### **Meropidae**

- *Merops ornatus* (Bee Eater). Common. Recorded from Sites, 2, 3, 4, river, BDT2 and BDT3. Often observed along the banks of water courses in small groups and feeding as singles or in pairs above survey areas.

### Maluridae

- *Malurus lamberti* (Variegated Fairy Wren). This species was recorded from five locations: Sites 1, 2, 4, the River and BDT1. This species was generally observed in association with small shrubs.
- *Malurus leucopterus* (White Winged Fairy wren). Uncommon. This species was observed at Site 2 and one sighting at the River. It was often heard at Site 2 but only visually recorded twice, and both observations may have been the same individual.

### Pardalotidae

- *Gerygone tenebrosa* (Dusky Gerygone) Uncommon. Individuals were recorded at Sites 2, 4 and the River. Individuals were observed in the crowns of large eucalyptus trees.

### Meliphagidae

- *Lichmera indistincta indistincta* (Brown Honeyeater). Uncommon. This species was recorded at Sites 4, the River, BDT2 and BDT3, and it was seen as individuals or pairs. It was only recorded once from each site.
- *Lichenostomus virescens* (Singing Honeyeater). This species was recorded at Sites 1, 2, 3, 4 and the River. However, only single birds or pairs were observed. It was also observed outside of the project area closer to the coast.
- *Manorina flavigula* (Yellow Throated Miner). Moderately common. This species was recorded at sites 1, 2, 4, the River, BDT2 and BDT3 with greater numbers observed along the River and creek line of Site 4.

### Dicruridae

- *Grallina cyanoleuca* (Magpie Lark). Moderately common. This species was observed at Sites 3, 4, the River and BDT1, with larger numbers recorded from along the creek at Site 4 and the River.
- *Rhipidura leucophrys* (Wagtails). Moderately common. This species was recorded at all sites with the exception of Site BDT2. It was recorded as individuals at all sites.

### Campephagidae

- *Coracina novaehollandiae* (Cuckoo Shrike)

Common. This species was recorded from all sites as individuals or in pairs. Greater numbers were observed along the creek at Site 4 and the River.

### Artamidae

- *Artamus cinereus* (Black Faced Woodswallow). Uncommon. This species was recorded from at sites, 1, 2, 3, 4, and river. Recorded as individuals or in pairs.

- *Artamus minor* (Little Woodswallow). Uncommon. One pair was recorded at Sites 1 and individuals were observed at Sites 3 and 4.
- *Cracticus nigrogularis* (Pied Butcherbird). Uncommon. This species was recorded along the creek at Site 4 and the River. Repeated sightings at Site 4 indicate that it may have been the same individual.
- *Artamus personatus* (Masked Woodswallow). Uncommon. Pairs were observed at Sites 3, the River and BDT2. Individuals were recorded at Site 4.
- *Gymnorhina tibicen* (Magpie). Uncommon. An individual was recorded from the creek line at Site 4 and one individual was observed drinking at the River.

### **Corvidae**

- *Corvus orru* (Torresian Crow). Uncommon. This species was recorded on six occasions from Sites 1, 2, 3, 4, the River and BDT2, and they were mostly observed in pairs.

### **Motacillidae**

- *Anthus novaeseelandiae* (Richards Pipit). Uncommon. Individuals were recorded at Sites 2, 4 and the River.

### **Passeridae**

- *Taeniopygia guttata* (Zebra Finch). Common. This species was observed in large numbers at all occasions, particularly from around water bodies and stock troughs.

### **Hirundinidae**

- *Hirundo neoxena* (Welcome Swallow). Uncommon. Two individuals were recorded at the River. Another possible sighting was at the Fortescue River Bridge, outside of the survey area.
- *Hirundo nigricans* (Tree Martins). Uncommon. This species was seen in pairs or individuals along the River on numerous occasions.

### **3.2.3 Native Mammals**

A total of nine mammal species were recorded during the field survey, including six native species and three introduced species. The most commonly recorded native species was *Macropus robustus erubescens* (Euro) and *Macropus rufus* (Red Kangaroo). Moderate numbers of both these species were recorded early in the mornings and during spotlighting events, often with young at foot.

Whilst searching the remains of the old shearer's quarters on Balmoral station, approximately ten bats were recorded roosting in old cupboards. Three individuals were captured and identified as belonging to the family *Vespertilionidae*. Positive identification of these individuals beyond the family group was not achieved. Although these bats were not located within the lease area, they would be expected to feed around water bodies, such as the Fortescue River and so were included in the results.

The species *Sminthopsis macroura* (Stripe Faced Dunnart) and *Pseudomys hermannsburgensis* (Inland Sandy Mouse) were also recorded during the field survey. Scats of *Tachyglossus aculeatus* (Echidna) were also observed. Appendix 3 summarises mammal species recorded, and each species is discussed in the following annotation.

#### **Tachyglossidae**

- *Tachyglossus aculeatus* (Echidna). Scats of this species were observed on a rocky out-crop at the northern end of the tailings dam area. Prior to the October field survey, one individual was recorded by the botanical team to the west of the tailings dam area.

#### **Dasyuridae**

- *Sminthopsis macroura* (Stripe Faced Dunnart). Four individuals were captured: two from a sparse area of *Triodia* spp. at Traps 13 and 12 at Site 2 and two at Site 4, Trap 40, an area dominated by *Triodia* spp.

#### **Macropodidae**

- *Macropus robustus erubescens* (Euro). Common. The Euro was commonly sighted during the day along creek lines at Sites 4, the River and BDT3. This particular species was recorded in abundance on spotlighting excursions through out the survey area, particularly on grassy plains.
- *Macropus rufus* (Red Kangaroo). Common. This species was recorded at all sites with the exception of Site 2. It was commonly sighted early in the morning and on spotlighting excursions throughout the study areas and beyond.

#### **Muridae**

- *Pseudomys hermannsburgensis* (Inland Sandy Mouse). Two individuals were captured at Site 2 in Traps 11 and 12.

#### **Vespertilionidae**

- *Vespertilionidae* spp. Approximately ten individuals were observed in old cupboards in the Balmoral shearing quarters adjacent to the survey area.

### **3.2.4 Introduced Mammals**

A number of introduced mammals were observed at the project site.

#### **Muridae**

- *Mus musculus* (House Mouse). Four individuals were captured at Site 2, three of which were captured from Trap 19 on different days. This suggests that the same animal may have been captured repetitively.

#### **Canidae**

- *Canis lupus dingo* (Dingo). A single set of large dog tracks was observed on the track that bisects Site 4 at Du Boulay Creek.

## **Felidae**

- *Felis catus* (Feral Cat). A single individual was recorded during a spotlighting excursion at the northern section of the bore field location.

## 4.0 Discussion

### 4.1 Reptiles

The October 2006 survey recorded 37 species and this confirmed that the Project Area supports a diverse reptilian assemblage. The diversity of species recorded can partly be attributed to the range of habitats sampled, with creek lines and cracking clays dominated by *Triodia* spp. yielding the highest number of species. The species *Ctenotus* aff *robustus* has not yet been described, and its distribution is poorly understood. However, it has been recorded in previous surveys throughout the Pilbara region. Further sampling of the area would be required to determine its distribution.

A search of the Western Australian Museums Fauna Base identified a potential 65 reptile species occurring in this region. Biota Environmental services identified 60 species during a 2000 survey in an area adjacent to the proposed development site. The relatively high number of species recorded may reflect the size of the survey area and the range of habitat sites encountered. It should be noted that many of the expected species prefer rocky habitats, which comprise only a very small proportion of the survey area.

### 4.2 Birds

The majority of species recorded during the field survey were identified along the Fortescue River and relatively well-vegetated creek lines. Most of the species observed in these areas were recorded in ephemeral pools. Three species of conservation significance were recorded:

- White - Bellied Sea Eagle (EPBC listed as migratory);
- Rainbow Bee Eater (EPBC listed as migratory); and
- Bustard (Priority four).

Simpson and Day (1999) describe the habitat of the White Bellied Sea Eagle as large rivers, lakes coastal seas and islands. This species is considered widespread but erratic in distribution and rarely common (Flegg 2002).

The Rainbow Bee Eater was observed on numerous occasions, particularly along the River and creek lines. They are widespread in distribution. They prefer to excavate burrows for the purpose of breeding, and they often use the banks of rivers and streams. Flegg (2002) described the Rainbow Bee Eater as quite common.

The Australian Bustard is a nomadic species that prefers open grassland, light scrub, open woodland and occasionally agricultural fields (Flegg 2002). It has declined in numbers as a result of disturbances such as the introduction of predators, land clearing, livestock grazing and illegal hunting. This species is regarded as wide spread, but generally scarce.

### 4.3 Mammals

No mammal species of conservation significance were recorded during the field survey. A targeted search of low stony rises failed to identify any signs of the priority species *Pseudomys*

*chapmani* (Western Pebble Mound Mouse) and targeted trapping of cracking clays failed to record *Leggadina lakedownensis* Lakeland Downs Mouse. This may have been partly due to unsuitable habitat and many years of livestock grazing.

#### 4.4 Conclusions and Recommendations

The number of species recorded in creek lines and along the Fortescue River suggests that these areas are of significance to local vertebrate populations. Consequently, disturbance of these areas should be minimised as much as possible. The general Project Area did not appear to contain habitat unique to the area. In fact, many years of livestock grazing has reduced the quality of available fauna habitat.

As a result of the October 2006 field survey the following recommendations are made:

- Conduct bat census in the project area to determine if the Schedule 1 species *Mormopterus loriae cobourgiana* (Little North-Western Bat) is present;
- Plan construction activities to minimise the impacts on the Fortescue River and Du Boulay Creek by the creation of buffer zones around water courses;
- Conduct groundwater modelling to determine the effects on the Fortescue River vegetation;
- Develop and implement environmental awareness training for all site personnel, including awareness of local fauna and the potential for road kills;
- Conduct an additional vertebrate fauna survey in autumn, as per Environmental Protection Authority (EPA) guidelines for Level Two surveys;
- Develop ongoing fauna monitoring program, including the monitoring of fauna sightings and fauna fatalities; and
- Liaise with DEC in relation to potential effects on Migratory species.

## 5.0 References

Christidis, L., and Boles, W.E. (1994). The Taxonomy and Species of Birds of Australia and its Territories. (RAOU, Melbourne)

Cogger, H.G. (2000) Reptiles and Amphibians of Australia. Reed New Holland, Australia.

Flegg, J. 2002. Birds of Australia. Australian Museum, Reed New Holland Publishing.

Halpern Glick Maunsell 2001. Austeel Biological Survey, Phase 1. Prepared with Biota Environmental Sciences and MF Trudgen & Associates.

Menkhorst, P. and Knight, F. 2004. A Field Guide to the Mammals of Australia. Oxford University Press.

Simpson, K. and Day, N. 1999. The Clement Field Guide to the Birds of Australia. Penguin Books Australia.

Storr, G.M., Smith, L.A. and Johnstone, R.E. 2002. Snakes of Western Australia. Western Australian Museum.

Storr, G.M., Smith, L.A. and Johnstone, R.E. 1999. Lizards of Western Australia. Western Australian Museum.

Tyler, M.J., Smith, L.A. and Johnstone, R.E. 2000. Frogs of Western Australia. Western Australian Museum.

## Appendix 1 Reptile Survey Results

Species	Site 1	Site 2	Site 3	Site 4	Spot 1	Spot 2	Total
<b>Agamidae</b>							
<i>Ctenophorus caudicinctus</i> <i>caudicinctus</i>			1				2
<i>Ctenophorus isolepis isolepis</i>		3		4			7
<i>Ctenophorus nuchalis</i>		2		1			3
<i>Lophognathus longirostris</i>				2			2
<i>Pogona mitchelli</i>		1	2	2			5
<i>Tympanocryptis cephalus</i>			4				4
<b>Boidae</b>							
<i>Antaresia perthensis</i>					1		1
<b>Elapidae</b>							
<i>Acanthophis wellsi</i>					1		1
<i>Pseudechis australis</i>	1						1
<i>Pseudonaja nuchalis</i>			1				1
<i>Furina ornata</i>					1		1
<b>Gekkonidae</b>							
<i>Diplodactylus conspicillatus</i>	4	3	2	1			10
<i>Diplodactylus savagei</i>			1				1
<i>Gehyra pilbara</i>		1		1			2
<i>Gehyra variegata</i>		1	9	5			15
<i>Heteronotia binoei</i>				3		1	3
<i>Nephrurus levis occidentalis</i>				1		1	1
<b>Pygopodidae</b>							
<i>Lialis burtonis</i>			1				1
<i>Pygopus nigriceps</i>		1	1				2
<b>Scincidae</b>							
<i>Ctenotus schomburgkii</i>	1	3	1	2			7
<i>Ctenotus duricola</i>	1		1				2
<i>Ctenotus affinis helenae</i>	1	3		5			9
<i>Ctenotus pantherinus ocellifer</i>				1			1
<i>Ctenotus rufescens</i>			1				1
<i>Ctenotus affinis robustus</i>			1				1
<i>Ctenotus saxatilis</i>				2			2
<i>Glaphyromorphus isolepis</i>				1			1

<b>Species</b>	<b>Site 1</b>	<b>Site 2</b>	<b>Site 3</b>	<b>Site 4</b>	<b>Spot 1</b>	<b>Spot 2</b>	<b>Total</b>
<i>Lerista bipes</i>	1	6					7
<i>Lerista muelleri</i>	1			2			3
<i>Menetia greyii</i>	4	2		1			7
<i>Morethia ruficauda exquisita</i>		3					3
<i>Notoscincus ornatus ornatus</i>				1			1
<b>Typhlopidae</b>							
<i>Ramphotyphlops grypus</i>	1						1
<b>Varanidae</b>							
<i>Varanus acanthurus</i>	2						2
<i>Varanus brevicauda</i>		1					1
<i>Varanus gigantus</i>					1		1
<i>Varanus gouldii</i>		1					1
<i>Varanus panopties</i>			1				1
Total	16	30	27	35	6	2	
	114						37
<b>Amphibians</b>							
<i>Cyclorana maini (Mains Frog)</i>					1		1

## Appendix 2 Bird Survey Results

	1	2	3	4	River	BDT1	BDT2	BDT3	Total
<b>Casuariidae</b>									
<i>Dromaius novaehollandiae</i> (Emu)	4			2	6		6	1	19
<b>Phasianidae</b>									
<i>Coturnix ypsilophora</i> (Brown Quail)	6	8		4	10		6		34
<b>Anatidae</b>									
<i>Anas superciliosa</i> (Black Duck)				5	10			3	18
<i>Anas gracilis</i> (Grey Teal)					3				3
<b>Phalacrocoracidae</b>									
<i>Phalacrocorax sulcirostris</i> (Little Black Cormorant)				5	30			1	36
<b>Pelecanidae</b>									
<i>Pelecanus conspicillatus</i> (Australian Pelican)					33				33
<b>Ardeidae</b>									
<i>Ardea pacifica</i> (White-necked Heron)				10	15			3	28
<i>Egretta garzetta</i> (Little Egret)				2	5			2	9
<i>Egretta novaehollandiae</i> (White -faced Heron)				6	3			1	10
<b>Threskiornidae</b>									
<i>Threskiornis spinicollis</i> (Straw -necked Ibis)				2	5			2	9

	1	2	3	4	River	BDT1	BDT2	BDT3	Total
<b>Accipitridae</b>									
<i>Accipiter fasciatus</i> (Brown Goshawk)			1	1	2				4
<i>Aquila audax</i> (Wedge - tail Eagle)	2	2	1	1	4	2			12
<i>Milvus migrans affinis</i> (Black kite)			1		1		1		3
<i>Hieraaetus morphnoides</i> (Little Eagle)		2		1	2				5
<i>Haliastur sphenurus</i> (Whistling Kite)			2	1	3		1		7
<i>Haliaeetus leucogaster</i> (White - bellied Sea Eagle)					1				1
<b>Falconidae</b>									
<i>Falco berigora</i> (Brown Falcon)			1		1				2
<i>Falco cenchroides cenchroides</i> (Nankeen Kestral)		1		1	1				3
<b>Gruidae</b>									
<i>Grus rubicunda</i> (Brolga)					3				3
<b>Otididae</b>									
<i>Ardeotis australis</i> (Australian Bustard)		2	2	2	4				10
<b>Turnicidae</b>									
<i>Turnix velox</i> (Little Button Quail)	2				2				4
<b>Charadriidae</b>									
<i>Euseyornis melanops</i> (Black fronted Dotterel)					8				8
<i>Vanellus tricolor</i> (Banded Lapwing)	6	6	10	8	3	12		3	48
<b>Laridae</b>									
<i>Sterna caspia</i> (Caspian Tern)				1	1				2

	1	2	3	4	River	BDT1	BDT2	BDT3	Total
<b>Columbidae</b>									
<i>Ocyphaps lophotes</i> (Crested Pigeon)	6	12	16	25	30	10		3	<b>103</b>
<i>Geophaps plumifera</i> (Spinifex Pigeon)	4	10	10	36	20	6	13	6	<b>105</b>
<i>Geopelia cuneata</i> (Diamond Dove)				2	6				<b>8</b>
<i>Geopelia striata placida</i> (Peaceful Dove)				1	4		2		<b>5</b>
<b>Cacatuidae (Cockatoos)</b>									
<i>Nymehicus hollandicus</i> (Cockatiel)	13	10	20	20	30			7	<b>100</b>
<i>Cacatua roseicapilla</i> (Galah)	10	50	50	100	100		18	12	<b>340</b>
<i>Cacatua sanguinea</i> (Little Corella)	16	60		100	100		21		<b>297</b>
<b>Psittacidae</b>									
<i>Melopsittacus undulatus</i> (Budgerigar)	20								<b>20</b>
<b>Cuculidae</b>									
<i>Cuculus pallidus</i> (Pallid Cuckoo)				1	1				<b>2</b>
<b>Podargidae</b>									
<i>Podargus streigoides</i> (Tawney Frogmouth)					1				<b>1</b>
<b>Caprimulgidae</b>									
<i>Eurostopodus argus</i> (Spotted Nightjar)					1				<b>1</b>
<b>Halcyonidae</b>									
<i>Dacelo leachii leachii</i> (Blue -winged Kookaburra)					1				<b>1</b>

	1	2	3	4	River	BDT1	BDT2	BDT3	Total
<i>Todiramphus sanctus</i> (Sacred Kingfisher)				1	1			1	3
<b>Meropidae</b>									
<i>Merops ornatus</i> (Bee Eater)		10	2	4	10		4	2	32
<b>Maluridae</b>									
<i>Malurus lamberti</i> (Variegated fairy - wren)	2	6		2	2	4			16
<i>Malurus leucopterus</i> (White – winged Fairy – wren)		4			2				6
<b>Pardalotidae</b>									
<i>Gerygone tenebrosa</i> (Dusky Gerygone)		2		1	2				5
<b>Meliphagidae</b>									
<i>Lichmera indistincta indistincta</i> (Brown Honeyeater)				2	1		1	2	6
<i>Lichenostomus virescens</i> (Singing Honeyeater)	1	2	1	1	4				9
<i>Manorina flavigula</i> (Yellow Throated Minor)	2	2		5	4		2	2	17
<b>Dicruridae</b>									
<i>Grallina cyanoleuca</i> (Magpie Lark)			1	6	8	2			17
<i>Rhipidura leucophrys</i> (Wagtails)	1	1	1	3	3	1		1	11
<b>Campephagidae</b>									
<i>Coracina novaehollandiae</i> (Cuckoo Shrike)	2	3	2	6	11	2	3	1	30
<b>Artamidae</b>									
<i>Artamus cinereus</i> (Black faced Woodswallow)	4	4	3	3	2				16

	1	2	3	4	River	BDT1	BDT2	BDT3	Total
<i>Artamus minor</i> (Little Woodswallow)	2		1	1					4
<i>Artamus personatus</i> (Masked Woodswallow)			2	3	2		2		9
<i>Cracticus nigrogularis</i> (Pied Butcherbird)				3	2				5
<i>Gymnorhina tibicen</i> (Magpie)				1	1				2
<b>Corvidae</b>									
<i>Corvus orru</i> (Torresian Crow)	1	2	4	2	2		2		13
<b>Motacillidae</b>									
<i>Anthus novaeseelandiae</i> (Richards Pipit)		1		1	1				3
<b>Passeridae</b>									
<i>Taeniopygia guttata</i> (Zebra Finch)	100	30	32	> 30	100	20	9	13	334
<b>Hirundinidae</b>									
<i>Hirundo neoxena</i> (Welcome Swallow)					2				2
<i>Hirundo nigricans</i> (Tree martins)					10				>10
	<b>20</b>	<b>23</b>	<b>21</b>	<b>42</b>	<b>55</b>	<b>9</b>	<b>15</b>	<b>19</b>	
<b>Total Species</b>	<b>57</b>							<b>Total</b>	<b>1844</b>

## Appendix 3 Mammal Survey Results

C = Common, T = Tracks and S = Scats

Mammals	Site 1	Site 2	Site 3	Site 4	River	BDT1	BDT2	BDT3	Total
<b>Tachyglossidae</b>									
<i>Tachyglossus acueatus</i> (Echidna)	S								1
<b>Dasyuridae</b>									
<i>Sminthopsis macroura</i> (Stripe Faced Dunart)		2		2					4
<b>Macropodidae</b>									
<i>Macropus robustus erubescens</i> (Euro)				C	C			C	C
<i>Macropus rufus</i> (Red Kangaroo)	C		C	C	C	C	C	C	C
<b>Muridae</b>									
<i>Mus musculus</i> (House Mouse)		4							2
<i>Pseudomys hermannsburgensis</i> (Inland Sandy Mouse)		2							3
<b>Vespertilionidae</b>									
Vespertilionidae spp									10
<b>Felidae</b>									
<i>Felis catus</i> (Feral Cat)	1								1

	Site 1	Site 2	Site 3	Site 4	River	BDT1	BDT2	BDT3	Total
<b>Mammals</b>									
<b>Canidae</b>									
<i>Canis lupus dingo</i> (Dingo)					T				T
									9

# Appendix K: Additional Threatened Fauna Enquires

## Memorandum

---

Date: 16 November 2006  
To: Jamie Shaw  
From: Richard Sharp  
File/ref number: 60019851  
Subject: Balmoral South Project - EPBC Act Analysis

---

Distribution: Project File

---

### Analysis

Based on the limited information that Paul Holmes and yourself have provided me, I have analysed the proposed action known as the Balmoral South Project and its potential impact on matters of national environmental significance (NES) in the context of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The results of my analysis are as follows:

- I found that the area to be affected by the proposed action is likely to be inhabited by a threatened mammal species known as *Mulgara Dasycercus cristicauda*. This species is listed as vulnerable under the EPBC Act. It inhabits spinifex and colonies of this species are known to occur in drainage lines amongst the sandy plains and sand dunes. I note that the Balmoral South Project is located across the drainage system of the Fortescue River which I assume contains spinifex. If a population of *Mulgara* exists in the area of the proposed action and this population is a key source population for breeding then it could be considered an important population. This means that any destruction of spinifex or any fragmentation of this important population through the construction of water pipelines or roads is likely to have a significant impact on this vulnerable species.
- I found that the area to be affected by the proposed action is likely to be inhabited by a threatened mammal species known as the Pilbara Leaf-nosed Bat *Rhinonicteris aurantius (Pilbara form)*. This species is listed as vulnerable under the EPBC Act. Colonies of this species are known to roost in abandoned mines and caves. I note that road kills of this species have been recorded in the locality of the Balmoral South Project, near the Fortescue River roadhouse. If a population of the Pilbara Leaf-nosed Bat exists in the area of the proposed action and this population is a key source population for breeding then it could be considered an important population. This means that any modification or destruction to abandoned mines or caves is likely to have a significant impact on this vulnerable species.
- I found that the area to be affected by the proposed action is likely to be inhabited by a threatened reptile species known as the Olive Python (Pilbara subspecies) *Morelia olivacea barroni*. This species is listed as vulnerable under the EPBC Act. It prefers water holes located in close proximity to rock outcrops. I note that the Balmoral South Project is located across the drainage system of the Fortescue River which I assume contains water holes. If a population of the Olive Python exists in the area of the proposed action and this population is a key source population for breeding then it could be considered an important population. This means that any destruction of rock outcrops near water holes is likely to have a significant impact on this vulnerable species.

- I found that the area to be affected by the proposed action is also likely to contain habitat for two terrestrial and three wetland bird species which are all listed as migratory under the EPBC Act. I note that these migratory species are widely distributed across Australia and therefore I have assumed that the area of the proposed action is not likely to contain important habitat that supports an ecologically significant proportion of the Australian population of each of these bird species.

### **Recommendation**

I am of the opinion that there is exists 'some potential' for the proposed action to impact on nationally listed threatened species and therefore I recommend that the proposed action be referred to the Minister for Environment and Heritage for approval.

It should be noted that there is a degree of uncertainty regarding my findings and that this could be improved if a more detailed description of the affected area was provided for the analysis and that this included vegetation characteristics, water and geological features, and existing developments.

