Great Northern Highway

Muchea to Wubin Upgrade - Stage 2

MAIN ROADS WESTERN AUSTRALIA

Muchea North - SLK 38.6 - 51.4 | Purpose Permit to Clear Native Vegetation | Environmental Offset Proposal

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Date :	10 / 04 / 2017
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Client Contract Number :	187/15

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Document Control

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Project :	Great Northern Highway - Muchea to Wubin Upgrade - Stage 2
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Issue summary

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3	12-05-2016	Final	Main Roads WA
4	30-03-2017	Revised Draft	CDR / Technical / PAG Review
5	10-04-2017	Final	Main Roads WA

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Appendix C. Completed EPBC Offset Guide

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Glossary

Abbreviation	Description
AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
AHA	*Aboriginal Heritage Act 1972*
AHD	Australian Height Datum
AHIS	Aboriginal Heritage Inquiry System
APHA	American Public Health Association
ARI	Average Recurrence Interval
ARRB	Australian Road Research Board
AS	Australian Standards
ASD	Approach Sight Distance
ASJV	Arup Jacobs Joint Venture
ASRIS	Australian Soil Resource Information System
ASS	Acid Sulfate Soils
ASST	Applied Scientific Services and Technology
ASTM	American Society for Testing and Materials
ATLM	Audio tactile line marking
ATLS	Atterberg Limits and linear shrinkage
AUL	Auxiliary Left turn treatment
AUR	Auxiliary Right turn treatment
BAL	Basic Left turn treatment
BAM Act	*Biosecurity and Agriculture Management Act 2007*
BAR	Basic Right turn treatment
BGL	Below ground level
BH	Borehole
BoM	Bureau of Meteorology
CBR	California Bearing Ratio
CEMP	Construction Environmental Management Plan
Cha	Chainage
CHL	Channelised Left
CHR	Channelised Right
CN	Contract Number
CN0X	Contract XX – [Contract Name]
CPTED	Crime prevention through environmental design
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAA	Department of Aboriginal Affairs

Abbreviation	Description
DAFWA	Department of Agriculture and Food WA
DBYD	Dial Before You Dig
DCP	Dynamic Cone Penetrometer
DEM	Digital Elevation Model
DER	Department of Environment and Regulation
DGS	Digital Ground Survey
DoEE	Department of the Environment and Energy
DoW	Department of Water
DSEWPaC	Department of Sustainability Environment Water Planning and Community
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	Environmental Protection Authority
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESA	Environmentally Sensitive Area
FWD	Falling Weight Deflectometer
GDA94	Geocentric Datum of Australia 1994
GDE	Groundwater Dependent Ecosystems
GIS	Geographic Information System
GNH	Great Northern Highway
GPS	Global Positioning System
ha	Hectare
HWL	High Wide Loads
IBA	Important Bird Area
IBRA	Interim Biogeographic Regionalisation of Australia
ICP-OES	Inductively coupled plasma optical emission spectrometry
IRIS	Integrated Road Information System
IS	Infrastructure Sustainability
IUCN	International Union for Conservation of Nature
km	Kilometre
LGA	Local Government Authority
LISC	Low Impact Screening List (Main Roads)
m	Metre
Ma	Mega-annum (period of 1 million years)
Main Roads WA	Main Roads Western Australia
Ma	Mega-annum (period of 1 million years)

Abbreviation	Description
MC	Moisture content
MDCS	Maximum dry compressive strength
MDD	Maximum Dry Density
MGA94	Map Grid of Australia 1994
MI	Municipal Inventory
MNES	Matters of National Environmental Significance
mm	Millimetre
MMDD	Maximum Modified Dry Density
MoU	Memorandum of Understanding
M2W	Muchea to Wubin
M2W team	Muchea to Wubin Integrated Project Team, comprising Main Roads WA and industry partners Jacobs and Arup
NATA	National Association of Testing Authorities
NNTT	National Native Title Tribunal
NVCP	Native Vegetation Clearing Permit
OMC	Optimum Moisture Content
OSOM	Over Size Over Mass
PAG	Project Advisory Group
Parks and Wildlife	Department of Parks and Wildlife
PDNH	Perth to Darwin National Highway
PDO	Property Damage Only
PEC	Protected Ecological Communities
PEIA	Preliminary Environmental Impact Assessment
Phoenix	Phoenix Environmental Sciences
Project Area	Refers to the entire upgrade project. The project area extends 218 km between Muchea and Wubin along the GNH.
PP	Pavement pit
PSD	Particle size distribution
RAV	Restricted Access Vehicle
RCBC	Reinforced Concrete Box Culvert
RCP	Reinforced Concrete Pipe
Regolith	Layer of loose material covering the bedrock of the earth and moon, etc, comprising soil, sand, rock fragments, volcanic ash, glacial drift etc.
RISC	Roadside Impact Severity Calculator
RIWI	Rights in Water and Irrigation (Act)
RRM	Road Reference Marks
RRPM	Retro-reflective Pavement Markers

Abbreviation	Description
RTE	Road and Traffic Engineering Branch of Main Roads WA
RTK	Real Time Kinematic GPS observation method
SiD	Safety in Design
SISD	Safe Intersection Sight Distance
SSD	Stopping Sight Distance
SLIP	State Land Information Portal
SLK	Straight Line Kilometre
SPT	Standard penetration test
SSM	State Survey Marks
STATS	Specialist Testing and Technical Services
SWALSC	South West Aboriginal Land and Sea Council
t	Metric tonne
tc	Time of concentration
TEC	Threatened Ecological Communities
TP	Test pit
USEPA	United States Environmental Protection Authority
WA	Western Australia
WAOL	Western Australian Organism List
WAPC	Western Australian Planning Commission
WC Act	Wildlife Conservation (Act)
WCLT	Wide Centreline Treatment
WoNS	Weeds of National Significance

1. Introduction

1.1 Project Background

In 2014 Main Roads Western Australia (Main Roads) established the Muchea to Wubin Integrated Project Team (M2W Team), comprising Main Roads and industry partners Arup and Jacobs (combining to form Arup Jacobs Joint Venture, ASJV) to conduct a comprehensive planning review of the full Muchea to Wubin link along the Great Northern Highway (GNH). This planning review is a critical component of the Great Northern Highway: Muchea to Wubin Upgrade Stage 2, which has been funded with $384.8 million from the Federal and State Governments.

Among the improvements to be considered as part of the planning review were additional passing lanes, flattening crests and easing curves, safer roadsides, more rest stops and additional facilities for heavy vehicles. The review examined the previous upgrade strategy developed in the 1990s and, having carefully considered current requirements for the movement of people and freight, delivered a revised upgrade strategy.

The M2W team has identified and prioritised construction packages to be delivered over the four-year period from 2015/16 to 2018/19. The construction programme includes the currently funded sections New Norcia Bypass (7 km), Miling Straight (22km), Miling Bypass (9km), Pithara (16km), Muchea North (13km), Dalwallinu to Wubin (33km) and Walebing (18km), and identifies additional priority packages to be constructed as funding becomes available.

1.2 Proposal Description

1.2.1 Purpose and Location

Main Roads proposes to upgrade and improve the GNH between Straight Line Kilometre (SLK) 38.6 and SLK 51.4 (referred to as Muchea North). Construction of the upgrade will require the clearing of 52.5 ha of foraging habitat for Carnaby's Black Cockatoo and up to six known nesting trees for the species. Impacts to known nesting trees will be managed through the installation of artificial hollows in proximity to the cleared trees and adjacent to adequate feeding areas. It is proposed to allocate a portion on Lot M2091, Ioppolo Road, Chittering (**Figure 1-1**), in order to offset the required clearing of foraging habitat at Muchea North.

1.2.2 Proposed Activities

In general, works will be undertaken to improve the horizontal and vertical geometry of the road, increase the seal and formation widths, and improve sight distances and clear zones. Construction activities will include:

- construction of approximately 3.7 km of dual carriageway from the end of the Perth – Darwin National Highway (Swan Valley Section) [also referred to as Northlink]. Each carriageway will be a 9.0 m wide seal on an 11.0 m wide formation;
- construction of approximately 5.7 km of single carriageway with a 10 m wide seal on a 12 m wide formation;
- construction of approximately 1.4 km of four lane carriageway with two 3.5 m wide northbound and southbound lanes, separated by a minimum 4.65 m median;
- widening of approximately 2 km of the existing GNH;
- realignment of the intersections at Old Gingin Road, Reserve Road, Wandena Road, Maddern Road and Sugar Gum Drive;
- construction of access roads with controlled access to the highway to service properties near Reserve Road, Sugar Gum Drive, at approximately SLK 48.8 and opposite the Chittering Roadhouse;

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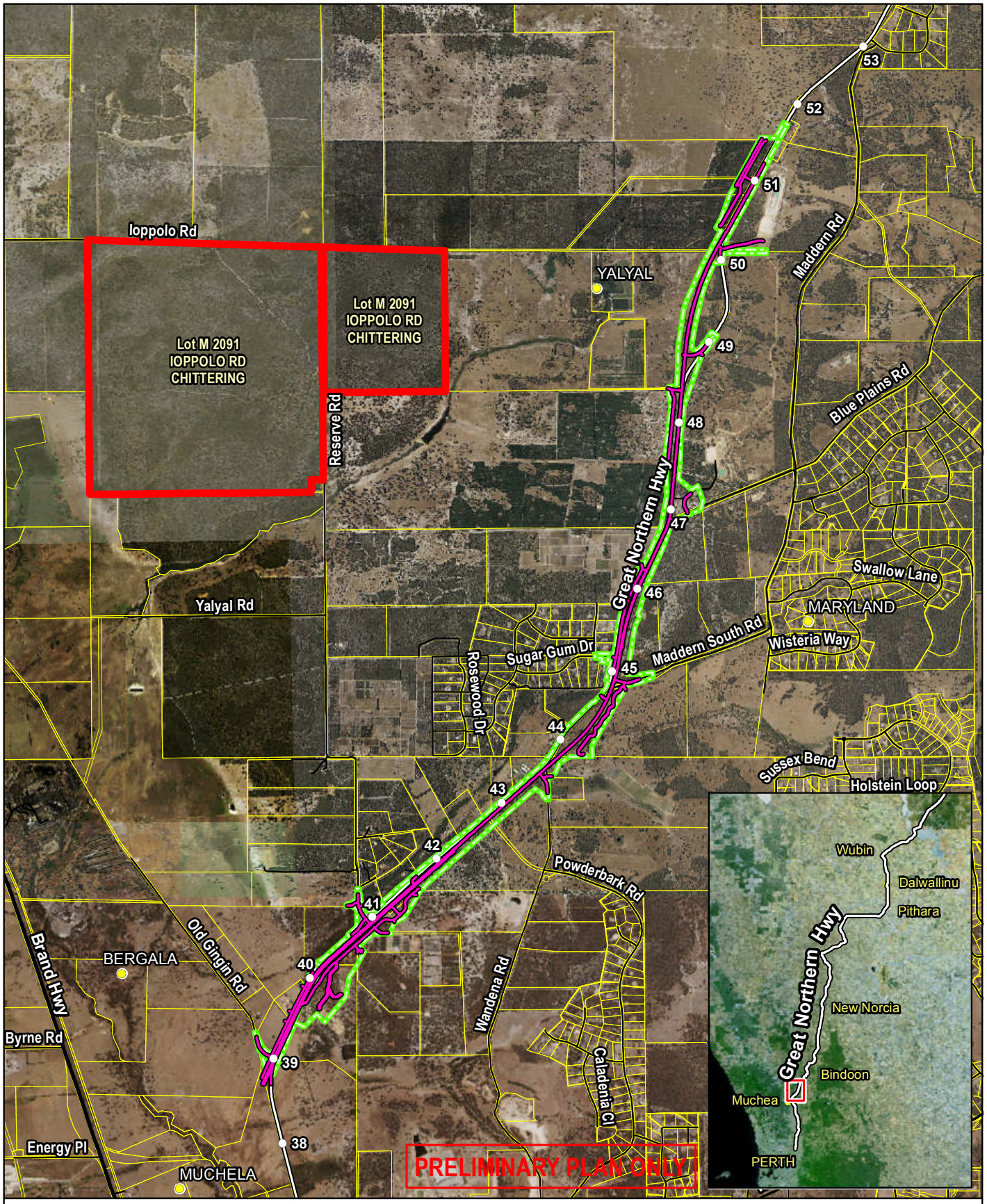

Legend

- Town
- Straight Line Kilometre Marker (1km)
- Muchea North Alignment
- Existing GNH Alignment
- Freeway / Highway
- Major Road
- Minor Road
- Approval Boundary
- LOT M2091 Ioppolo Rd, Chittering
- Cadastral Boundary

Data Source: Main Roads WA, Landgate

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Metres

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1:60,000

Coordinate System: GDA 1994 MGA Zone 50

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Great Northern Highway
Muchea to Wubin Upgrade Stage 2

Figure 1-1: Location of Muchea North and Lot M2091 Ioppolo Road, Chittering

Drawing No	Issue
GNH-CN03-EN01-GIS-0053	A

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- provision of new intersections to link the existing GNH (retained as a local access road) to the new sections of the GNH;
- construction and realignment of private driveways;
- upgrade and installation of culverts;
- removal of redundant existing fenceline and installation of new fenceline;
- installation of signage and line markings and removal of redundant signage;
- installation of safety barriers where required;
- relocation of utilities within the road reserve corridor (communications and power); and
- installation of road lighting.

1.3 Existing Environment

A detailed description of the existing environment is provided in *Muchea North - SLK 38.6 - 51.4 | Environment EPBC 2016/7656 - Preliminary Documentation* (ASJV, 2016). A summary of this information is provided below.

The proposal is located in the Swan Coastal Plain and Jarrah Forest Bioregions as defined by the Interim Biogeographic Regionalisation for Australia (IBRA), version 7 (Department of the Environment, 2012). The Swan Coastal Plain bioregion is a low lying coastal plain, mainly covered with woodlands. It is dominated by Banksia or Tuart on sandy soils and paperbark in swampy areas (Desmond, 2001).

1.3.1 Vegetation and Flora

Vegetation mapped by Phoenix Environmental Sciences (Phoenix) (2015; 2017) comprised 20 vegetation associations. Broadly, the vegetation associations recorded represent a mix of Jarrah, Marri, Wandoo and Banksia medium woodlands with some areas of mixed heath shrublands. Areas described as road, cleared (townships, driveways), cleared and planted (non-native species) and pasture accounted for the majority (54%) of the area surveyed.

The condition of vegetation mapped by Phoenix (2015; 2017) ranged from completely degraded to pristine, with excellent condition vegetation comprising approximately 20% of the area surveyed. The areas of vegetation recorded to be in excellent or pristine condition may be considered locally significant as they represent patches of comparatively high native species diversity.

1.3.2 Fauna

Fauna habitats of the proposal area were defined by Phoenix (2015; 2017) as follows:

- Cleared (agriculture, road, infrastructure);
- Woodland (Jarrah, Marri, Wandoo and/or banksia);
- Forest (Jarrah and/or Marri);
- Shrubland; and
- Cleared and revegetated non-native woodland mosaic.

Of particular interest to the proposal is the presence of the endangered Carnaby's Black Cockatoo. Surveys undertaken by Phoenix (2015; 2017) have recorded a total of 228.8 ha of foraging habitat, 2,369 potential breeding trees (diameter at breast height greater than 500 mm), 32 trees with hollows suitable for use by the species and 22 known nesting trees.

1.3.3 Conservation Areas

Two conservation areas occur adjacent to the existing GNH in the area of the proposed action. Barracca Nature Reserve (Class A) covers 17 ha is located to the west of the GNH between SLK 44.22 and 44.79 and Barracca

Springs Reserve (Reserve 209, under a management order with the Shire of Chittering as the primary interest holder), also to the west of the existing GNH, is located between SLK 40.2 and 40.8.

1.3.4 Hydrology

The proposal area is located in the Ellen Brook sub-catchment of the Swan Avon Catchment. The area is within the Proclaimed Swan River System surface water area and the Proclaimed Gingin Groundwater Area (Department of Water, 2009a, 2009b). In general, watercourses flow west and south to Ellen Brook via Rocky Creek and Yalyal Brook.

The main hydrological feature is Rocky Creek, which runs along the western side of the existing GNH from SLK 40 up to SLK 44.5. Tributaries of Rocky Creek cross GNH between SLK 42.5 and SLK 44. Rocky Creek flows into Ellen Brook at the confluence with Chandala Brook.

Yalyal Brook collects surface water runoff from the northern section of the proposal area (north of SLK 47). Tributaries of Yalyal Brook cross GNH between SLK 47 and SLK 50. Yalyal Brook flows into both Chandala Brook and Rocky Creek via a series of drains, just south of the Tronox mineral sands processing plant on Brand Highway.

2. Predicted Impacts

This offset proposal has been based on the total extent of clearing required for the proposed action. While many areas cleared during construction will be landscaped and revegetated, the extent of revegetation will be dependent on the final landscape plan. As these plans have not yet been developed, the residual impact cannot be accurately calculated and a conservative approach has been adopted by inputting the total clearing quantity in the offset calculator with no deduction related to landscaping and revegetation.

An assessment of the proposed clearing against the 10 Clearing Principles defined in Schedule 5 of the *Environmental Protection Act 1986* was undertaken as part of the application for a Purpose Permit to clear Native Vegetation. This assessment indicated that clearing is likely to be at variance with Principles (a), (b), (d) and (f) and may be at variance with Principles (e) and (h). The full assessment is provided in **Appendix A**.

2.1 Vegetation and Flora

Up to 53 ha of native vegetation will be cleared for construction of the proposed upgrades to Muchea North. **Table 2-1** details the preliminary clearing requirements per vegetation type and vegetation condition. Regionally the area is not an extensively cleared landscape, with 44.6% of the area within 10 km of the NVCP application area being covered by native vegetation.

Of the 53 ha to be cleared, 7.49 ha has been mapped as the Banksia Woodlands of the Swan Coastal Plain with a further 4.78 ha within the buffer zone for the TEC.

Table 2-2 details the Priority Flora likely to be cleared.

Table 2-1 : Preliminary Clearing Requirements for Muchea North – Native Vegetation

Vegetation Type	Preliminary Clearing Amount by Vegetation Condition (ha)					Total (ha)
	Degraded	Good	Very Good	Excellent	Pristine	
4	0.15	0.22	3.36	-	-	**3.73**
23	0.23	0.73	1.50	0.67	-	**3.13**
27	0.33	-	0.40	-	-	**0.73**
37	1.65	-	-	-	-	**1.65**
48	1.90	-	0.02	-	-	**1.92**
946	-	-	0.20	-	0.27	**0.47**
949	0.07	0.14	1.12	2.25	1.11	**4.69**
965	1.79	2.09	1.02	0.65	0.72	**6.27**
968	0.73	1.23	0.60	2.90	-	**5.46**
975	-	0.05	0.96	1.06	-	**2.07**
992	0.68	-	1.11	0.42	-	**2.21**
999	0.28	0.01	0.67	0.89	-	**1.85**
1003	-	-	0.40	0.09	-	**0.49**
1006	-	3.98	0.08	0.18	-	**4.24**
1008	1.50	1.52	0.01	-	-	**3.03**
1017	0.57	0.32	5.18	0.43	-	**6.5**
1019	-	-	-	1.18	-	**1.18**

Vegetation Type	Preliminary Clearing Amount by Vegetation Condition (ha)					Total (ha)
	Degraded	Good	Very Good	Excellent	Pristine	
1027	-	-	2.62	-	-	**2.62**
1182	0.12	0.56	-	0.08	-	**0.76**
Total (ha)	**10.00**	**10.85**	**19.25**	**10.80**	**2.10**	**53.00**

Table 2-2 : Priority Flora likely to be cleared

Scientific name (common name)	Conservation Category	Number of records within the NVCP Application Area	Number of records outside the NVCP Application Area	Total number of records	Number of records likely to be cleared
Acacia drummondii subsp. *affinis*	Priority 3	119 location records; 769 plants	29 location records; 137 plants	148 location records; 906 plants	443 plants
Eucalyptus caesia (Caesia)	Priority 4	Single plant	None recorded by Phoenix (2015; 2017)	Single plant	1 plant
Haemodorum loratum	Priority 3	Single plant	None recorded by Phoenix (2015; 2017)	Single plant	1 plant
Verticordia serrata var. *linearis*	Priority 3	Single plant	Eight location records; 69 plants	Eight location records; 70 plants	1 plant

2.2 Fauna and Fauna Habitat

The fauna species most likely to be impacted by the upgrades proposed for Muchea North are Carnaby's Black Cockatoo, which has been recorded in the application area, and the Forest Red-tailed Black Cockatoo, as suitable foraging and roosting habitat has been identified. **Table 2-3** details the likely clearing requirements in relation to Black Cockatoo habitat.

Table 2-3 : Preliminary Clearing Requirements for Muchea North – Black Cockatoos

	Maximum Cleared	Mapped*
Carnaby's Black Cockatoo		
Known Nesting Trees	6	22
Trees with Suitable Hollows	7	32
Potential Breeding Trees	744	2,369
Foraging Habitat (ha)	52.5	228.69
Forest Red-Tailed Black Cockatoo		
Potential Foraging Habitat (ha)	48.79	226.5

** Mapped by Phoenix (2015; 2017)*

3. Proposed Environmental Offset

Main Roads proposes to offset the predicted impact to Carnaby's Black Cockatoo habitat and the Banksia Woodlands of the Swan Coastal Plain through the provision of 200 ha of land at Lot M2091 Ioppolo Road, Chittering. This property has been acquired by Main Roads and a portion of the land allocated to offsetting impacts from the Perth to Darwin National Highway (Swan Valley Section) (EPBC 2013/7042 and Ministerial Statement of Approval 1036) and Tonkin Highway Grade Separation projects (EPBC 2014/7385) (**Figure 3-1**).

The entirety of Lot M2091 was surveyed by Coffey Environments in June and July 2014 (**Appendix B**). The key findings of the survey were (Coffey Environments, 2015):

- Vegetation condition was mapped as Good to Pristine with Pristine areas generally towards the middle of the property;
- A dieback assessment was undertaken and the property mapped as "Uninfested";
- Sixteen vegetation units were mapped across the property;
- One Threatened flora species (*Chamelaucium* sp. Gingin, Gingin Wax) was recorded from the north western corner of the property, in the vicinity of the known location provided by Parks and Wildlife;
- Six weeds were recorded across the property, none are Weeds of National Significance while one (*Zantedeschia aethiopica*, Arum Lily) is a Declared Plant;
- Three fauna habitats were mapped – Banksia Woodland, Eucalypt Woodland and a Dampland; and
- A black cockatoo habitat assessment was undertaken with the Eucalypt Woodland identified as high value habitat, the Banksia Woodland as moderate value and the Dampland and low value habitat.

The 200 ha portion of Lot M2091 to be assigned to the Muchea North Project is shown on **Figure 3-2** and includes:

- *Banksia attenuata* and *Banksia menziesii* woodland over *Melaleuca preissiana* and/or *Adenanthos cygnorum* subsp. *cygnorum* shrubland (**foraging habitat** for Carnaby's Black Cockatoo);
- *Banksia attenuata*, *Banksia menziesii* and *Nuytsia floribunda* shrubland (**foraging habitat** for Carnaby's Black Cockatoo);
- *Corymbia calophylla* and *Eucalyptus marginata* woodland over *Banksia attenuata* and *Banksia menziesii* woodland (**foraging and potential breeding habitat** for Carnaby's Black Cockatoo);
- *Eucalyptus marginata* woodland over *Banksia attenuata*, *Banksia menziesii* and *Adenanthos cygnorum* subsp. *cygnorum* shrubland (**foraging and potential breeding habitat** for Carnaby's Black Cockatoo);
- *Eucalyptus todtiana* mid sparse to mid-isolated mallee woodland with occasional *Nuytsia floribunda* low isolated trees over *Banksia attenuata*, *Banksia menziesii* and *Adenanthos cygnorum* subsp. *cygnorum* tall sparse shrubland (**foraging habitat** for Carnaby's Black Cockatoo); and
- *Eucalyptus todtiana* and *Nuytsia floribunda* mid sparse to mid-isolated mallee woodland over *Banksia attenuata*, *Banksia menziesii* and *Adenanthos cygnorum* subsp. *cygnorum* tall open to tall sparse shrubland (**foraging** habitat for Carnaby's Black Cockatoo).

The entirety of the site has been designated as *Banksia* Woodland in relation to fauna habitat. The offset site also encompasses the *Chamelaucium* sp. Gingin records from Coffey Environments (2015), representing at least 200 individuals.

A Memorandum of Understanding (MoU) has been established between Main Roads and Parks and Wildlife for the management of Lot M2091 as a whole. This sets out the funding arrangements, including amount and term of funding, responsibilities of both parties, and the requirements for an operational works plan to be developed, implemented and reported upon.

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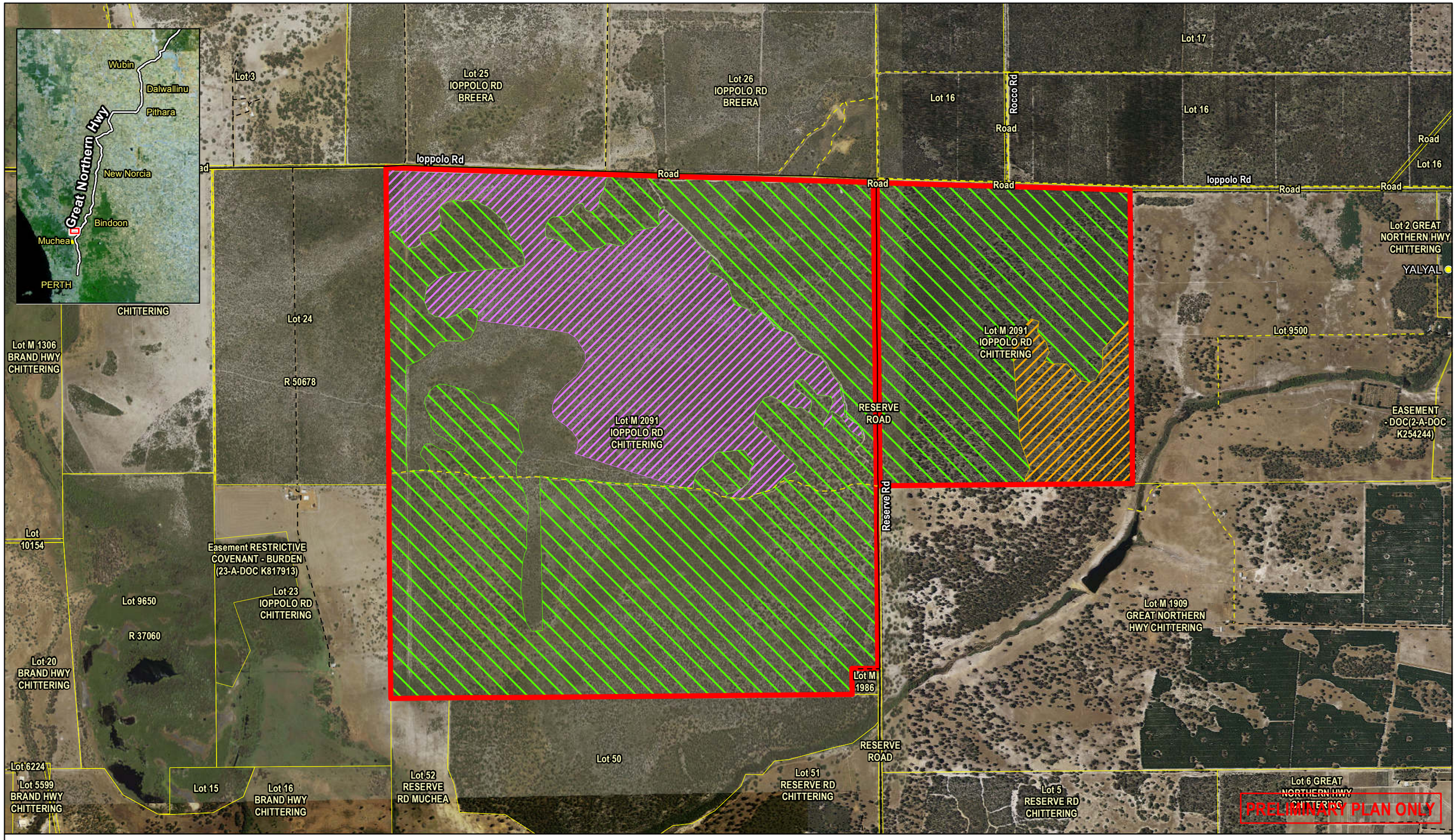

Legend

- Town
- Minor Road
- Track
- Other Road
- LOT M2091 Ioppolo Rd, Chittering
- Cadastral Boundary
- Muchea North Offset Site Boundary
- PDNH Offset Site Boundary
- Tonkin Grade Separation Offset Site Boundary

Data Source: Main Roads WA, Landgate

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Coordinate System: GDA 1994 MGA Zone 50

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Main Roads Western Australia

Project
Great Northern Highway
Muchea to Wubin Upgrade Stage 2

Figure 3-1: Lot M2091 Ioppolo Road, Chittering

Drawing No	Issue
GNH-CN03-EN01-GIS-0050	A

Task No	Drawing Status / Other
GNH-1358	Draft / Other Info

Date	By	Chkd	Appd
13/03/2017	SR	LB	XX

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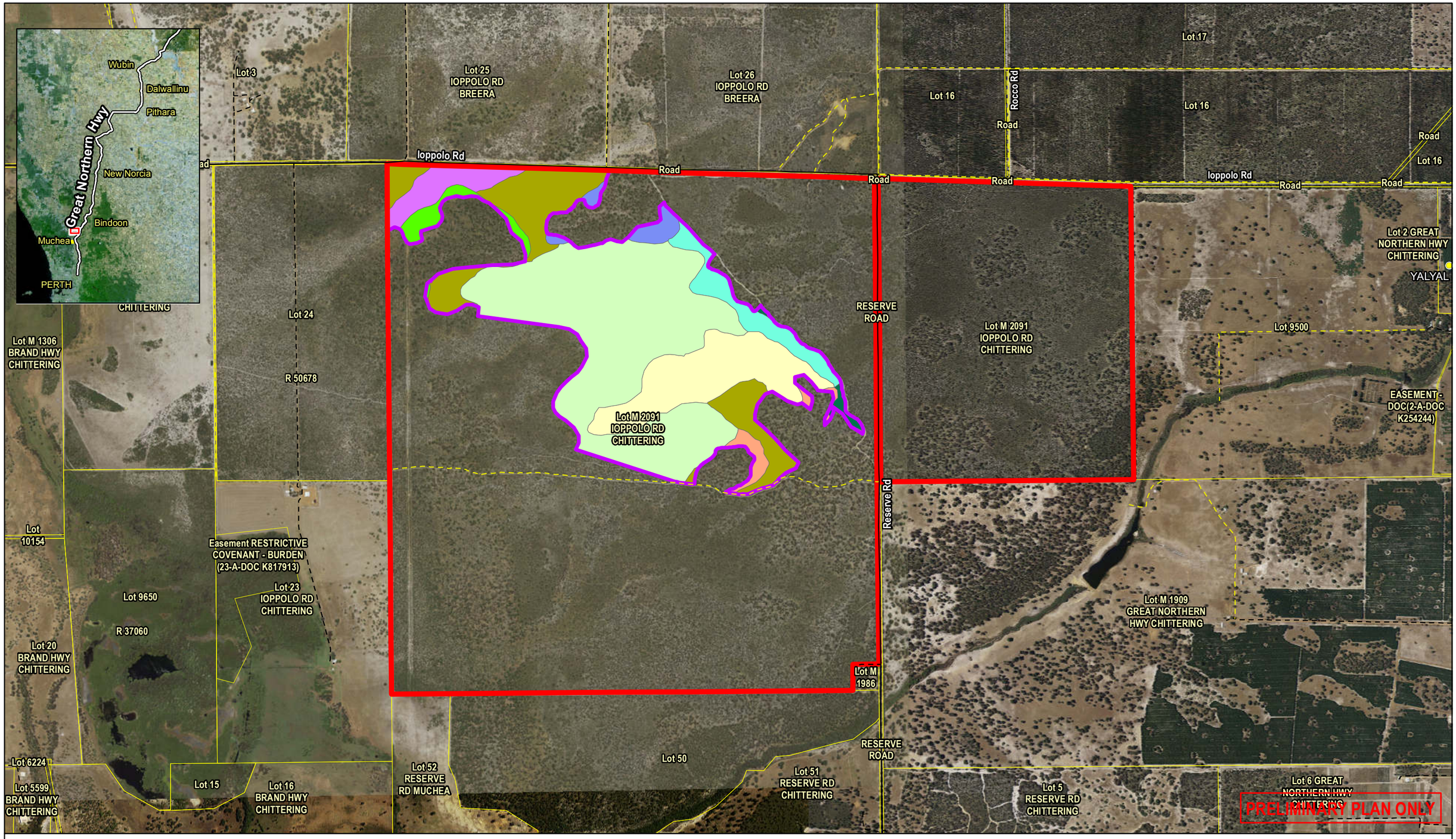

Legend

- Town
- Minor Road
- Track
- Other Road
- LOT M2091 Ioppolo Rd, Chittering
- Cadastral Boundary
- Muchea North Offset Site Boundary

Vegetation Units of the Offset Site (Coffey Environments, 2015)

- BaBm1
- BaBm2
- BaBmNf
- CcEm
- Em
- Em2
- Em3
- Et
- EtNf

Data Source: Main Roads WA, Landgate

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Metres

Scale at A3
1:20,000

Coordinate System: GDA 1994 MGA Zone 50

Client
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Project
Great Northern Highway
Muchea to Wubin Upgrade Stage 2

Figure 3-2: Muchea North Offset Site

Drawing No	Issue
GNH-CN03-EN01-GIS-0051	A

Task No	Drawing Status / Other
GNH-1358	Draft / Other Info

Date	By	Chkd	Appd
13/03/2017	SR	LB	XX

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4. Offset Guide Inputs and Justification

Table 4-1 provides the inputs used in the EPBC Offset Guide in relation the Carnaby's Black Cockatoo and the justifications for these while **Table 4-2** provides the inputs and justifications in relation to the *Banksia* Woodlands of the Swan Coastal Plain TEC. As Lot M2091 also provides direct offset for the Perth to Darwin Nation Highway (Swan Valley Section) and Tonkin Highway Grade Separation projects, the same input values have been used for the start quality, future quality with and without offset and risk of loss with and without offset. The purpose of this is to provide consistency between the offset proposals for the three projects. The completed EPBC Offset Guide is provided in **Appendix C**.

Table 4-1 : Offsets Guide Inputs and Justifications – Carnaby's Black Cockatoo Habitat

Offset Guide Item	Input Value	Justification
EPBC Act Status	Endangered	Current EPBC Act listing
Impact Area	52.5 ha	Total amount of clearing required for the proposal. This area is larger than the ultimate residual impact as some of this area will be landscaped and revegetated. As landscape designs have not been finalised a conservative approach to offsets has been adopted and the total clearing amount has been used to calculate the offset required.
Quality of Impact Area	7	The quality of the impact area has been determined based on the value of the habitat as mapped by Phoenix (2015; 2017). The vegetation to be cleared includes vegetation identified as "Quality" foraging habitat as well as areas identified as "Low Value" foraging habitat. The majority (80%) of the foraging habitat to be cleared has been mapped as "Quality" and a corresponding Quality rating of 7 selected.
Time over which Loss is averted	20 years	The transfer of the offset site to Park and Wildlife will provide protection and management in perpetuity.
Time until ecological benefit	1 year	As the acquired land is vegetated and has been incorporated into the conservation estate to be managed by Parks and Wildlife, the ecological benefit will be realised within 1 year.
Start Area	200 ha	This area achieves 100% direct offset, based on the other inputs used
Start Quality	7	Mapping undertaken by Coffey Environments (2015) shows that the vegetation present at Lot M2091 is in Very Good to Excellent condition, which is expected to equate to "Quality" or "High Value" foraging habitat for Carnaby's Black Cockatoo, corresponding to a Quality rating of 7.
Future Quality without offset	6	If the offset site was to remain private freehold land there is a risk of degradation to the site. This may be through grazing of the site by stock or clearing of vegetation for economic purposes such as farming or housing.
Future Quality with offset	7	The quality of the vegetation will, at a minimum, be maintained through management of the offset site by Parks and Wildlife.

Offset Guide Item	Input Value	Justification
Risk of Loss (%) without offset	30%	If the offset site was to remain private freehold land there is a risk of degradation to the site. This may be through grazing of the site by stock or clearing of vegetation for economic purposes such as farming or housing. This risk input is consistent with that used for offset proposals associated with the Perth to Darwin Nation Highway (Swan Valley Section) and Tonkin Highway Grade Separation projects.
Risk of Loss (%) with offset	5%	As the offset site will be transferred to Parks and Wildlife for management and incorporation into the conservation estate, there is a 95% confidence level that the environmental values being offset will not be lost (i.e. a 5% risk that the values will be lost).
Confidence in result (averted risk)	90%	As the offset site will be transferred to Parks and Wildlife for management and incorporated into the conservation estate, there is a high level of confidence that the averted risk will be realised.
Confidence in result (Change in habitat quality)	90%	As the site will be incorporated into the conservation estate, there is a high level of confidence that the change in the quality score will be realised.

Table 4-2 : Offsets Guide Inputs and Justifications – *Banksia* Woodlands of the Swan Coastal Plain

Offset Guide Item	Input Value	Justification
EPBC Act Status	Endangered	Current EPBC Act listing
Impact Area	7.49 ha	Total amount of clearing required within the TEC for the proposal. This area is larger than the ultimate residual impact as some of this area will be landscaped and revegetated. As landscape designs have not been finalized a conservative approach to offsets has been adopted and the total clearing amount has been used to calculate the offset required.
Quality of Impact Area	7	The quality of the impact area has been determined based on the value of the habitat as mapped by Phoenix (2015; 2017). The vegetation to be cleared includes a mix of vegetation condition from completely degraded to pristine. The average condition rating based on the amounts of each to be cleared has been determined to be Very Good to Excellent, corresponding to a Quality rating of 7.
Time over which Loss is averted	20 years	The transfer of the offset site to Park and Wildlife will provide protection and management in perpetuity.
Time until ecological benefit	1 year	As the acquired land is vegetated and has been incorporated into the conservation estate to be managed by Parks and Wildlife, the ecological benefit will be realised within 1 year.
Start Area	**28.15 ha**	This area achieves 100% direct offset, based on the other inputs used
Start Quality	7	Mapping undertaken by Coffey Environments (2015) shows that the vegetation present at Lot M2091 is in Very Good to Excellent condition, corresponding to a Quality rating of 7.

Offset Guide Item	Input Value	Justification
Future Quality without offset	6	If the offset site was to remain private freehold land there is a risk of degradation to the site. This may be through grazing of the site by stock or clearing of vegetation for economic purposes such as farming or housing.
Future Quality with offset	7	The quality of the vegetation will, at a minimum, be maintained through management of the offset site by Parks and Wildlife.
Risk of Loss (%) without offset	30%	If the offset site was to remain private freehold land there is a risk of degradation to the site. This may be through grazing of the site by stock or clearing of vegetation for economic purposes such as farming or housing or introduction of weeds and disease due to uncontrolled access. This risk input is consistent with that used for offset proposals associated with the Perth to Darwin Nation Highway (Swan Valley Section) and Tonkin Highway Grade Separation projects.
Risk of Loss (%) with offset	5%	As the offset site has been transferred to Parks and Wildlife for management and incorporation into the conservation estate, there is a 95% confidence level that the environmental values being offset will not be lost (i.e. a 5% risk that the values will be lost).
Confidence in result (averted risk)	90%	As the offset site has been transferred to Parks and Wildlife for management and incorporated into the conservation estate, there is a high level of confidence that the averted risk will be realised.
Confidence in result (Change in habitat quality)	90%	As the site will be incorporated into the conservation estate, there is a high level of confidence that the change in the quality score will be realised.

The EPBC Offset Guide has also been used to calculate the number of artificial hollows that should be installed to mitigate the impact of clearing known nesting trees. The use of artificial hollows is considered to be a management and mitigation action, rather than an offset. **Table 4-3** provides the inputs used and justification for these. A further detail on the placement and management of artificial hollows is provided in the *Muchea North - SLK 38.6 - 51.4 EPBC 2016/7656 - Preliminary Documentation*.

Table 4-3 : Offsets Guide Inputs and Justifications – Clearing of Known Nesting Trees

Offset Guide Item	Input Value	Justification
EPBC Act Status	Endangered	Current EPBC Act listing
Number of Features (Total Quantum of Impact)	6	Maximum number of known nesting trees to be cleared.
Time Horizon (years)	1	Artificial hollows will be installed by the construction contractor as part of the main works. Recent studies show artificial hollows may be used in the first year following installation (Groom, 2010)
Start Value	1	There is an existing artificial hollow at Muchea North. This will require relocation as the tree to which it is attached is within the clearing footprint.
Future Value Without Offset	1	No additional artificial hollows installed
Future Value with Offset	**8**	This achieves 100% direct offset, based on the other inputs used

Offset Guide Item	Input Value	Justification
Confidence in result	90%	Recent studies show that Carnaby's Black Cockatoo will readily nest in artificial hollows with a strong correlation between the use of artificial hollows and their proximity to currently used natural hollows (Groom, 2010; BirdLife Australia, 2017). Additionally, the artificial hollow currently installed at Muchea North has been used in previous seasons by Carnaby's Black Cockatoo. The artificial hollows will be installed in proximity to the cleared trees, adjacent to adequate foraging areas, such that they are not visible from the GNH in order to reduce the risk of poaching of eggs, chicks or birds. These factors combine to give a high level of confidence that the desired result will be achieved.

5. Conclusions

Main Roads proposes to offset impacts to Carnaby's Black Cockatoo and the *Banksia* Woodlands of the Swan Coastal Plain through the provision of 200 ha at Lot M2091, Ioppolo Road, Chittering. The offset site encompasses 200 ha of Carnaby's Black Cockatoo habitat, including 16 ha of potential breeding habitat, and at least 54.5 ha of *Banksia* woodland meeting the diagnostic criteria outlined in the approved conservation advice for the *Banksia* Woodlands of the Swan Coastal Plain TEC (Threatened Species Scientific Committee, 2016).

The offset proposed will provide adequate and commensurate offsetting of the relevant environmental impacts. A conservative approach has been adopted in calculating the offset required by using the total amount of clearing to be undertaken, rather than the residual impact following landscaping and revegetation activities. This is likely to provide a nett gain in the overall conservation outcome.

The EPBC Offset Guide has also been used to calculate the total number of artificial hollows to be installed (eight) to appropriately mitigate the impact of clearing up to six known nesting trees.

6. References

BirdLife Australia (2017) Cocky Notes. Issue 24: Summer 2016-17. Available at http://birdswa.com.au/Cockatoos/CockyNotes/Cocky%20Notes%2024%20Jan%202017.pdf

Coffey Environments (2015) Flora, Vegetation and Fauna Assessment. Lot M2091 Ioppolo Road, Chittering. Unpublished report for Main Roads Western Australia

Department of the Environment, 2012. Interim Biogeographic Regionalisation for Australia (IBRA).

Desmond, A, 2001. Swan Coastal Plain 1 (SWA1—Dandaragan Plateau subregion), In: May, J. E. & McKenzie, N. L. (eds) A biodiversity audit of Western Australia's 53 biogeographical subregions in 2002. Department of Conservation and Land Management, Perth, W.A.

Groom C (2010) Artificial hollows for Carnaby's black cockatoo. An investigation of the placement, use, monitoring and maintenance requirements of artificial hollows for Carnaby's black cockatoo. Department of Environment and Conservation, Perth. Available at: https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/carnabys/Research_into_the_success_of_artificial_hollows_for_Carnabys_cockatoo.pdf

Phoenix Environmental Sciences (2015). Flora and fauna assessment for the Muchea North and Chittering Study Area, Great Northern Highway, Muchea to Wubin Upgrade Stage 2 Project. Phoenix Environmental Sciences Pty Ltd, Balcatta, WA. Unpublished report prepared for Muchea to Wubin Integrated Project Team (Main Roads WA, Jacobs and Arup).

Phoenix Environmental Sciences, (2017). Flora and fauna assessment for the Muchea North and Chittering Study Area - Report Addendum, Great Northern Highway Muchea to Wubin Upgrade Stage 2 Project, Prepared for Muchea to Wubin Integrated Project Team (Main Roads WA, Jacobs and Arup).

Thackway, R. and Cresswell, I.D. (Editors), 1995. An Interim Biogeographic Regionalisation for Australia: a framework for establishing the national system of reserves (No. Version 4.0). Australian Nature Conservation Agency, Canberra.

Threatened Species Scientific Committee (2016). Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain Ecological Community. Canberra: Department of the Environment and Energy. Available from: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/131-conservation-advice.pdf.

Williams, K., Mitchell, D., 2001. Jarrah Forest 1 (JF1 - Northern Jarrah Forest Subregion), in: May, J.E., McKenzie, N.L. (Eds.), A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002. Department of Conservation and Land Management, Perth.

Appendix A. Assessment Against 10 Clearing Principles

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Principle		Assessment	Outcome
A	Native vegetation should not be cleared if it comprises a high level of biological diversity.	A maximum of 53 ha of native vegetation will be cleared. The NVCP application area includes vegetation which is considered to be in very good, excellent or pristine condition. This vegetation typically comprises of high native species diversity than the surrounding, more degraded remnants Seven Priority listed flora species occur within or in the vicinity of the NVCP application area. Four patches of the EPBC listed TEC Banksia Woodlands of the Swan Coastal Plain have been mapped in the NVCP application area. Areas described as road, cleared (townships, driveways), cleared and planted (non-native species) and pasture accounted for the majority of the area surveyed, and account for approximately 48.7% of the NVCP application area.	**At Variance**
B	Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia	The NVCP application area is within the known breeding range for Carnaby's Black Cockatoo and suitable breeding and foraging habitat has been identified within the NVCP application area. Breeding habitat and known nesting trees in particular are considered to be significant habitat for this species. Construction of the project will require clearing of 52.5 ha Carnaby's Black Cockatoo foraging habitat, 44.2 ha of breeding habitat and up to six known nesting trees and seven trees with suitable hollows will be cleared. Reserve 40350 (Main Roads WA gravel pit) is considered of local importance for Carnaby's Black Cockatoo due to the high density of known nesting trees. 48.79 ha of potential habitat for the Forest Red-tailed Black Cockatoo will be cleared however it is unlikely that the species breeds in the area and, if present, would be in low numbers either foraging or potentially roosting.	**At Variance**
C	Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.	No rare flora has been recorded in the NVCP application area.	Not at Variance
D	Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of a threatened ecological community.	Up to 7.49 ha of the Banksia Woodlands of the Swan Coastal Plain will be cleared. An additional 4.78 ha within the buffer area for the TEC will also be cleared.	**At Variance**

Principle		Assessment	Outcome
E	Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.	Eleven of the mapped vegetation types are considered underrepresented as the current extent of these is less than 30% of the pre-European extent. However, the area within which the NVCP application area is located has not been extensively cleared with 44.6% of the area within a 10 km radius of the NVCP application area being covered by native vegetation.	May be at Variance
F	Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.	Vegetation clearing will occur in the vicinity of Rocky Creek, associated with the upgrade of culverts on Reserve Road, and a number of un-named creek crossings along the main GNH alignment.	**At Variance**
G	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.	Due to the linear nature and small scale of the required clearing, clearing of native vegetation is not expected to increase soil acidity or salinity. Given the gentle slopes present along the preferred alignment, it is also unlikely that clearing will result in increased erosion, particularly water erosion. Clearing activities are unlikely to increase the percentage coverage of weeds within the application area. Management controls will reduce the risk of the spread or introduction of weeds and disease in the application area. It is considered unlikely that the required clearing will cause appreciable land degradation.	Not at Variance
H	Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.	Barracca Nature Reserve is the only known Parks and Wildlife managed nature reserve within close proximity to the Muchea North proposed alignment. It is adjacent to the alignment between SLK 44.22 and 44.79. Barracca Springs Reserve (Reserve 209, under a management order with the Shire of Chittering as the primary interest holder) also borders the NVCP application area between SLK 40.2 and 40.8. Clearing within the vicinity of these areas will be managed in accordance with Main Roads AS2124 Specifications, the PEMP and/or CEMP.	May be at Variance
I	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.	Impacts to groundwater are not expected to occur as there are no surface expressions of the groundwater table within the application area and no direct interactions between clearing activities and groundwater. Clearing may result in increased sediment loads to local water courses, however given the gentle nature of the slopes within the NVCP application area, the risk of significant erosion is considered minimal.	Not at Variance
J	Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.	Given the limited amount of clearing of native vegetation required and linear nature of the project, it is unlikely that the clearing will cause, exacerbate of increase the incidence of flood in the application area or surrounds.	Not at Variance

Principle		Assessment	Outcome
A	Native vegetation should not be cleared if it comprises a high level of biological diversity.	A maximum of 53 ha of native vegetation will be cleared. The NVCP application area includes vegetation which is considered to be in very good, excellent or pristine condition. This vegetation typically comprises of high native species diversity than the surrounding, more degraded remnants Seven Priority listed flora species occur within or in the vicinity of the NVCP application area. Four patches of the EPBC listed TEC Banksia Woodlands of the Swan Coastal Plain have been mapped in the NVCP application area. Areas described as road, cleared (townships, driveways), cleared and planted (non-native species) and pasture accounted for the majority of the area surveyed, and account for approximately 48.7% of the NVCP application area.	**At Variance**
B	Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia	The NVCP application area is within the known breeding range for Carnaby's Black Cockatoo and suitable breeding and foraging habitat has been identified within the NVCP application area. Breeding habitat and known nesting trees in particular are considered to be significant habitat for this species. Up to six known nesting trees and seven trees with suitable hollows will be cleared. Reserve 40350 (Main Roads WA gravel pit) is considered of local importance for Carnaby's Black Cockatoo due to the high density of known nesting trees.	**At Variance**
C	Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.	No rare flora have been recorded in the NVCP application area.	Not at Variance
D	Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of a threatened ecological community.	Up to 7.49 ha of the Banksia Woodlands of the Swan Coastal Plain will be cleared. An additional 4.78 ha within the buffer area for the TEC will also be cleared.	**At Variance**
E	Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.	Eleven of the mapped vegetation types are considered underrepresented as the current extent of these is less than 30% of the pre-European extent. However, the area within which the NVCP application area is located has not been extensively cleared with 44.6% of the area within a 10 km radius of the NVCP application area being covered by native vegetation.	May be at Variance

Principle		Assessment	Outcome
F	Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.	Vegetation clearing will occur in the vicinity of Rocky Creek, associated with the upgrade of culverts on Reserve Road, and a number of un-named creek crossings along the main GNH alignment.	**At Variance**
G	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.	Due to the linear nature and relatively small scale of the required clearing, clearing of native vegetation is not expected to increase soil acidity or salinity. Given the gentle slopes present along the preferred alignment, it is also unlikely that clearing will result in increased erosion, particularly water erosion. Clearing activities are unlikely to increase the percentage coverage of weeds within the application area. Management controls will reduce the risk of the spread or introduction of weeds and disease in the application area. It is considered unlikely that the required clearing will cause appreciable land degradation.	Not at Variance
H	Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.	Barracca Nature Reserve is the only known Parks and Wildlife managed nature reserve within close proximity to the Muchea North proposed alignment. It is adjacent to the alignment between SLK 44.22 and 44.79. Barracca Springs Reserve (Reserve 209, under a management order with the Shire of Chittering as the primary interest holder) also borders the NVCP application area between SLK 40.2 and 40.8. Clearing within the vicinity of these areas will be managed in accordance with the PEMP, Early Works EMP and/or CEMP.	May be at Variance
I	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.	Impacts to groundwater are not expected to occur as there are no surface expressions of the groundwater table within the application area and no direct interactions between clearing activities and groundwater. Clearing may result in increased sediment loads to local water courses, however given the gentle nature of the slopes within the NVCP application area, the risk of significant erosion is considered minimal.	Not at Variance
J	Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.	Given the limited amount of clearing of native vegetation required and linear nature of the project, it is unlikely that the clearing will cause, exacerbate of increase the incidence of flood in the application area or surrounds.	Not at Variance

Appendix B. Lot M2091 Flora, Vegetation and Fauna Assessment. Lot M2091 Ioppolo Road, Chittering

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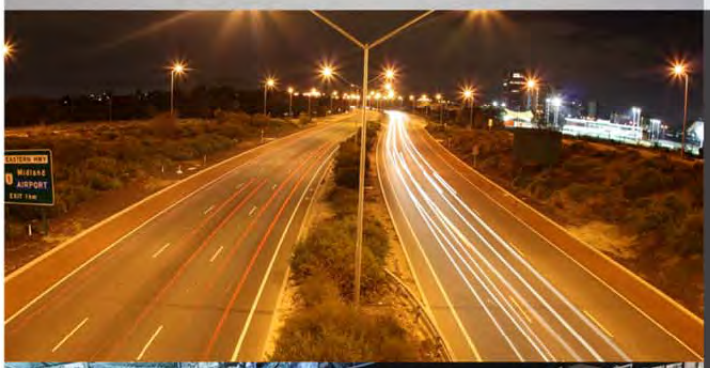
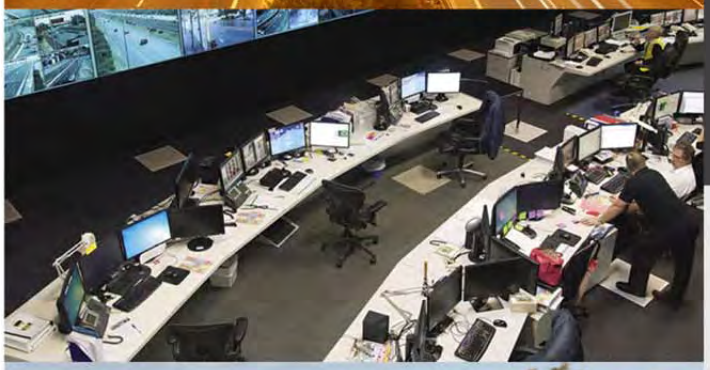
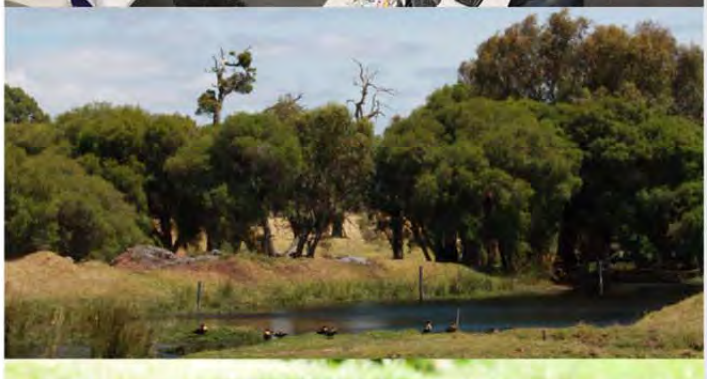
NorthLinkWA

Perth-Darwin National Highway







Flora, Vegetation and Fauna Assessment

Lot M2091 Ioppolo Road, Chittering

DOC NO / NLWA-00-EN-RP-0009

REV / 0

DATE / 15 April 2015

coffey

Australian Government

mainroads WESTERN AUSTRALIA

NorthLinkWA

EXECUTIVE SUMMARY

Main Roads Western Australia (MRWA) commissioned Coffey Environments Australia Pty Ltd (Coffey) to complete a Level 1 flora, vegetation and fauna and Black Cockatoo assessment, at Lot M2019 Ioppolo Road, Chittering (the study area), located approximately 50 kilometres (km) north of Perth in the Swan Coastal Plain bioregion of Western Australia.

The purpose of the study was to undertake an assessment of the ecological values of the study area. The outcome of the assessment will be used to determine the suitability of the land as an offset for values to be impacted by the NorthLink WA project. The study area is 986 hectare (ha) and is adjacent to a C Class Nature Reserve to the west, which is 163 ha.

The survey was conducted over four days 8 to 10 June and 17 June 2014. The key findings of the desktop assessment are:

- Twenty Threatened (Declared Rare-extant) flora listed under the *Wildlife Conservation Act 1950* and the *Environment Protection and Biodiversity Conservation Act 1999* were identified as potentially occurring within close proximity to the study area.
- Thirty four Priority listed flora recognised by the Department of Parks and Wildlife were identified as potentially occurring within close proximity to the study area. Ten taxa are considered Likely to occur; 15 as Possible; and 30 as Unlikely to occur in the study area.
- Seven ecological communities listed as conservation significant, including four Threatened Ecological Communities and three Priority Ecological Communities were identified for the study area.
- 221 fauna species have been previously recorded in the vicinity of the study area; these include 12 amphibians, 47 reptiles, 134 birds and 28 mammals.
- 14 conservation significant fauna species were identified as potentially occurring within close proximity to the study area, of these one species is considered Likely to occur, three as Possible and four species as Unlikely to occur in the study area.

The key findings of the field survey are:

- The vegetation condition of the study area was considered to be Good to Pristine as per Bush Forever (Government of Western Australia, 2000 and Keighery, 1994) vegetation condition scale.
- The areas of vegetation considered to be pristine were generally located within the middle of the study area where introduced taxa and human visitation is low or non-existent.
- Dieback in the study was considered uninfested and presents a low risk of spreading the disease into other areas.
- Dieback risk assessment allocated 87.6 ha as Low risk vegetation, with 12.2 ha as moderate and 19.4 ha as high risk.
- Sixteen vegetation units were described, four are considered to be representative of Priority 2 Ecological Community Banksia Yellow-Orange Sands and two Threatened Ecological Communities.
- A total of 154 vascular taxa were recorded from the study area.
- One Threatened taxa *Chamelaucium* sp. Gingin (N.G. Marchant 6) and One Priority taxa *Hypolaena robusta* (P4) were recorded in the study area.

- Six introduced taxa were recorded from the study area. None of them are considered to be Weeds of National Significance.
- **Zantedeschia aethiopica* is registered as a Declared Pest under the *Biosecurity and Agriculture Management Act 2007* and three species, **Zantedeschia aethiopica, *Lupinus* sp. and **Brassica tournefortii,* have a High rating under the Environmental Weed Strategy for Western Australia.
- Three fauna habitats were recorded in the study area: Banksia Woodland, Eucalypt Woodland and a Dampland.
- The Black Cockatoo Habitat assessed Eucalypt Woodland (315 ha) as high value Black Cockatoo habitat, Banksia Woodland (663 ha) as being moderate and Dampland (3 ha) as low value Black Cockatoo habitat.
- All habitat types contained multiple foraging resources for Black cockatoos which equates to approximately 981 ha of foraging habitat.
- Thirty nine fauna species were recorded during the survey including one species of amphibian, three species of reptile, 32 species of bird and three species of mammal.
- The Western Brush Wallaby (*Macropus irma*) listed as Priority 4 under Department of Parks and Wildlife's Priority listing was the only conservation significant fauna species recorded during the survey.
- Black-eared Cuckoo (*Chrysococcyx osculans*) was recorded during the survey this record is considered to occur just outside of the southerly distribution of this otherwise common species.

The study area is considered to be of high conservation value comprising habitat for a high number of threatened flora and fauna species. The vegetation is representative of a number of Threatened and Priority Ecological Communities, some of these are likely to be impacted by the NorthLink WA Project. The addition of the study area to the conservation estate will substantially increase the estate with the adjacent Class C Reserve and provide protection of an important ecological linkage.

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F Relevé Floristic Data
G Vascular Plant Taxa Recorded
H Fauna Habitat Assessment Data
I Black Cockatoo Breeding Trees
J Vertebrate Fauna Predicted to Occur within the Study Area

Document *Control*

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ABBREVIATIONS AND UNITS

Term	Definition
°C	decimal degrees
%	percentage
ANZECC	Australian and New Zealand Environment and Conservation Council
BAM Act	*Biosecurity and Agriculture Management Act 2007*
BOM	Bureau of Meteorology
CALM	Conservation and Land Management
CCW	conservation category wetland
Coffey	Coffey Environments Australia Pty Ltd
Cwlth	Commonwealth
DBH	diameter at breast height
DEC	Department of Environment and Conservation
DOTE	Department of the Environment
DOW	Department of Water
DPAW	Department of Parks and Wildlife
DSEWPAC	Department of Sustainability, Environment, Water, Population and Communities
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EWSWA	Environmental Weed Strategy for Western Australia
FCT	Floristic Community Type
GPS	global positioning system
ha	hectare
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
km	kilometres
m	metres
mm	millimetres
MNES	Matters of National Environmental Significance
MRWA	Main Roads Western Australia

Term	Definition
MUW	multiple use wetland
NVIS	National Vegetation Information System
PEC	Priority Ecological Community
REW	resource enhancement wetland
SCP	Swan Coastal Plain
TEC	Threatened Ecological Community
UFI	unique feature identifier
WC Act	*Wildlife Conservation Act 1950*
WA	Western Australia
WALGA	Western Australian Local Government Association
WAPC	Western Australian Planning Commission

1 INTRODUCTION

MRWA has purchased an area of land (986 ha) in the Chittering area for the purpose of offsetting impacts of the NorthLink WA Project (including this Perth–Darwin National highway and the Tonkin Grade Separations projects). Both projects have been deemed a 'controlled action' by the Commonwealth Department of the Environment (DOTE) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) given their impacts to Matter of National Environmental Significance (MNES), specifically Black Cockatoos. These projects are also being assessed under the *Environmental Protection Act 1986* (EP Act).

To determine the suitability of this land as an offset site for these projects, MRWA commissioned the NorthLink WA Consultancy Services Team to complete an environmental survey of the study area.

1.1 Location and Tenure

The study area is Lot M2091 Ioppolo Road (Certificate of Title 1169-601), Chittering, located approximately 50 kilometres (km) north of Perth within the Swan Coastal Plain bioregion of Western Australia (Figure 1). The study area is approximately 986 ha (Figure 2) in size and is bordered by a C Class Nature Reserve managed by the Department of Parks and Wildlife to the west, private land bordering Ioppolo Road to the north, private land to the southwest, south and east.

The study area is currently zoned "Agriculture Resource" under the Shire of Chittering Town Planning Scheme No. 6. MRWA have purchased the study area for the purpose of conservation management by the Department of Parks and Wildlife. The addition of the study area to the existing C Class Nature Reserve to the west will increase the size of the Nature Reserve from 163 ha to 1146 ha.

1.2 Objective

The objectives of the environmental assessment were to identify the existing environmental values of the study area to determine the suitability of the site as an offset for the project. The environmental assessment included a Level 1 flora and vegetation survey and a Level 1 fauna survey and Black Cockatoo habitat assessment.

The objective of the Level 1 flora and vegetation survey was to:

- Compile an inventory of vascular plants.
- Identify and map the extent of vegetation communities.
- Record the occurrence of introduced plant species.
- Identify and record conservation significant species and ecological communities.
- Locate the presences of wetlands, including rivers, creeks and floodways.

The objective of the Level 1 fauna survey and Black Cockatoo habitat assessment was to:

- Identify the fauna values of the habitats present in the study area.
- Determine the significance of the habitats to support Black Cockatoos.
- Identify conservation significant fauna occurring or likely to occur in the study area.
- Assess the regional and local significance of the study area.

1.3 Scope

The scope of works for the Level 1 flora and vegetation survey included:

- A desktop literature review of databases and previous surveys completed in the vicinity of the study area, including:
  - A search of the Commonwealth's DOTE protected matters search tool for MNES.
  - Department of Parks and Wildlife's (DPAW's) Threatened and Priority flora database.
  - DPAW's Threatened and Priority ecological communities' database.
  - DPAW's combined biological database NatureMap.
  - Environmentally Sensitive Area's listed under the EP Act.
  - Previous flora and vegetation surveys undertaken in close proximity to the study area.
  - A search of DPAW's *Geomorphic Wetlands of the Swan Coastal Plain* dataset.
- A Level 1 flora and vegetation survey, which included:
  - Mapping and description of the plant communities according to a broad floristic formation level and a vegetation association level, using a combination of recent aerial photography and field surveys to ground-truth.
  - Mapping of vegetation condition using the vegetation condition rating scale developed by Keighery (1994) and published in Government of Western Australia (2000).
  - Compiling a list of native and non-native plant species occurring within the study area as recorded from relevé sampling, opportunistic collections and observations.
  - Identifying, locating (GPS point) and mapping any significant plant species or ecological communities recorded on the DPAW Threatened species, Priority species, Threatened Ecological Community (TEC) and Priority Ecological Community (PEC) databases.
  - A targeted search, involving a site walk-over, for conservation-significant species potentially occurring within the study area.

The fauna assessment included:

- A desktop literature review of databases and previous surveys completed in the vicinity, which included:
  - The online DPAW NatureMap database to identify potential vertebrate fauna within the study area based on previous fauna surveys conducted in the region.
  - DPAW's Threatened and priority species database.
  - Commonwealth Government's database of fauna MNES to identify species potentially occurring within the area that are protected under the EPBC Act or international migratory bird agreements.
  - Previous fauna surveys conducted in the area.
- A level 1 fauna survey, to:
  - Identify the major fauna habitats present within the study area.
  - Record opportunistic fauna sightings, including conservation significant fauna.

- Map the major fauna habitats present surrounding the study area to assess the regional significance of the study area and the importance of ecological linkages.
- Assess the likely presence of conservation significant fauna.
- Identify significant features or habitat for conservation significant fauna species.

- A Black Cockatoo habitat assessment, comprising:
  - A site walkover to search for signs of evidence that Black Cockatoo utilise the study area.
  - The determination of the density of Black Cockatoo breeding habitat.
  - The identification of Black Cockatoo feeding habitat.

2 ENVIRONMENTAL LEGISLATION AND POLICY

2.1 Environmental Legislation

The assessment of native vegetation within the study area was undertaken in accordance with the requirements of the following key environmental legislation and regulations:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Cwlth).
- *Environmental Protection Act 1986* (EP Act) (WA).
- *Wildlife Conservation Act 1950* (WC Act) (WA).
- *Biosecurity and Agriculture Management Act 2007* (BAM Act) (WA).
- State Planning Policy 2.8 Bushland Policy for the Perth Metropolitan Region.

2.2 Environmental Policies

The EPA has produced a number of policy statements, guidelines and technical guides, which provide guidelines and advice regarding the EPA's position. Position statements, guidelines and technical guides relevant to fauna, flora and vegetation, including:

- Guidance for the Assessment of Environmental Factors No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004a).
- Guidance for Assessment of Environmental Factors No. 56 – Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004b).
- Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA/DEC, 2010).
- Guidance for the Assessment of Environmental Factors No. 6 Rehabilitation of Terrestrial Ecosystems (EPA, 2006).
- Position Statement No. 2 Environmental Protection of Native Vegetation in Western Australia (EPA, 2000).
- Position Statement No. 3 Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA, 2002).
- Position Statement No. 7 Principles of Environmental Protection (EPA, 2004c).
- Western Australia Environmental Offset Guidelines (EPA, 2014) and WA Environmental Offsets Policy (EPA, 2011).

3 EXISTING ENVIRONMENT

3.1 Climate

Pearce RAAF Airbase in Bullsbrook is the nearest reliable Bureau of Meteorology (BOM) weather station to the study area approximately 20 km south. The climate of the Chittering region is described typically as Mediterranean with dry summers and wet winters. The average maximum temperature reaches 33.5°C in summer, while in winter the temperature drops to 8.1°C. The region receives an average annual rainfall of 680 mm, with the majority of this falling in the winter months (1937-2014) (BOM, 2014).

The three months prior to the survey commencing (April to June 2014), RAAF Airbase received 234.5 mm, or 7% below the long-term average rainfall of 253.2 mm (1937-2014) for the same period. The 12 months before the survey the rainfall was 683.8 mm (July 2013 to Jun 2014), which is 0.5% above the long term average of 680.0 mm (1939-2014) for the same period (Figure 3).

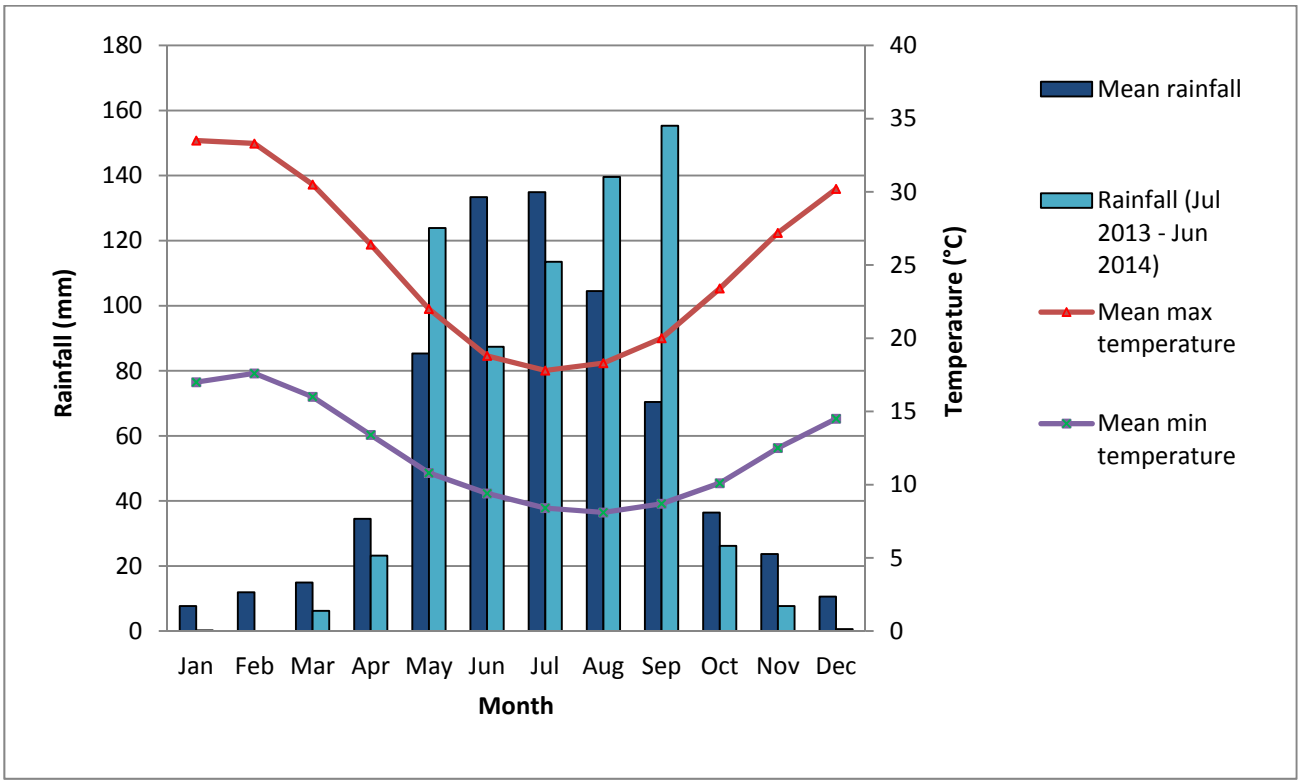


Figure 3 Climate

3.2 Topography and Landforms

The study area is situated on a consolidated sand dune consisting of hill rises, lateritic slopes and plains. A seasonally inundated depression (basin) in the southwest corner of the study area can be associated with Chandala Brook. The soil profile is medium to coarse-grained sand, therefore surface water would infiltrate readily through the porous nature of the soil.

3.3 Geology and Soils

The study area is located on the Swan Coastal Plain bioregion, which in the Perth Region is 34 km wide in the north and 23 km wide in the south and is bounded by the Gingin and Darling Fault Scarps, which rise to over 200 m above sea level (Davidson, 1995). The Swan Coastal Plain consists of a series of distinct landforms (McArthur and Bettenay 1974), roughly parallel to the coast. The distinct landforms, from east to west include the Ridge Hill Shelf, the Pinjarra Plain, the Bassendean Dune system, the Spearwood dune system and the Quindalup dune system (Davidson, 1995).

The study area is located on the Ridge Hill Shelf and the Pinjarra Plain, directly west of the Gingin Scarp and the Dandaragan Plateau. The Ridge Hill Shelf and the Pinjarra Plain are described as:

- Ridge Hill Shelf – comprises the colluvial slopes which form the foothills of the Darling and Dandaragan Plateaus and which represent dissected remnants of a sand covered, wave cut platform.
- Pinjarra Plain – a piedmont and valley-flat alluvial plain consisting predominantly of clayey alluvium that has been transported by rivers and streams from the Darling and Dandaragan Plateaus. The plain is generally about 5 km wide west of the colluvial slopes.

Churchward and McArthur (1978) mapped the soil landforms of the System Six region. According to the mapping by Churchward and McArthur (1978), the study area occurs in association five soil landforms.

- Yanga – Poorly drained plain with grey sandy benches and intervening swamps; also in areas of bog iron ore, marl or solonetzic soils.
- Coonambidgee – Gently sloping fringe to the Dandaragan Plateau; deep grey sands.
- Reagan – Gently sloping scarp dominated by yellow or grey sands; some duricrust and gravels present.
- Mogumber – Gently undulating landscapes; duricrust and gravels on crests and grey sands in broad shallow depressions.
- Moondah – Valleys with deep red and yellow brown sands; occasional swamps.

3.4 Hydrology and Wetlands

According to the Department of Water's (DOWs) Hydrogeological Atlas, there are four aquifers occurring in close proximity to the study area. The four aquifers occur at three levels, with two unconfined aquifers, the Mirrabooka and Surficial, occurring at Level 1 (DOW, 2014). The Leederville-Parmelia confined aquifer occurs at Level 2, while the Perth-Yarragadee North confined aquifer is located at Level 3 and represents the bottom aquifer in relation to the study area (DOW, 2014).

According to drainage and contour mapping viewed on the Shared Land Information Platform, a small drainage line passes through the northwest corner of the study area and an additional drainage line, Chandala Brook, runs in a northeast to southwest direction just outside the southern boundary of the study area. The drainage contour in the northwest of the study area is considered to be minor and is unnamed. It does not have a formal channel, but more a flowline between two small rises.

The surface hydrology of the study area flows into the two drainage contours located in close proximity to the study area before discharging into Chandala Lake and other larger creek systems or floodplains in the vicinity of the study area.

DPAW's Geomorphic Wetlands Swan Coastal Plain dataset displays the location, boundary, geomorphic classification (wetland type) and management category of wetlands on the Swan Coastal Plain. The

information contained within this dataset was originally digitised from the Wetlands of the Swan Coastal Plain Volume 2B Wetland mapping, Classification and Evaluation: Wetland Atlas, which was captured at a scale of 1:25, 000 (Hill et al., 1996).

Wetlands on the Swan Coastal Plain have been classified using a geomorphic wetland classification system based on the characteristics of landform and water permanence. Table 1 below details the geomorphic classification of wetlands the DPAW (2014a) have adopted for the Swan Coastal Plain, which have been identified by Semeniuk and Semeniuk (1995).

Table 1 Geomorphic wetland classification types

Hydroperiod	Landform				
	Basin	Channel	Flat	Slope	Highland
Permanent inundation	Lake	River	-	-	-
Seasonal inundation	Sumpland	Creek	Floodplain	-	-
Intermittent inundation	Playa	Wadi	Barlkarra	-	-
Seasonal waterlogging	Dampland	Trough	Palusplain	Paluslope	Palusmont

DPAW has assigned wetland management categories based on their ecological, hydrological and geomorphological significance, and took into account the degree of disturbance that had occurred. The three Wetland Management Categories on the Swan Coastal Plain can be summarised as follows:

1. Conservation Category (CCW) – wetlands that support a high level of ecological attributes and functions (generally having intact vegetation and natural hydrological processes), or that have a reasonable level of functionality and are representative of wetland types that are rare or poorly protected.
2. Resource Enhancement (REW) – wetlands that have been modified (degraded) but still support substantial ecological attributes (wetland dependant vegetation covering more than 10%) and functions (hydrological properties that support wetland dependent vegetation and associated fauna), and have some potential to be restored to the Conservation management category. Typically, such wetlands still support some elements of the original native vegetation, and hydrological function.
3. Multiple Use (MUW) – wetlands that are assessed as possessing few remaining ecological attributes and functions. While such wetlands can still play an important role in regional or landscape ecosystem management, including water management, they are considered to have low intrinsic ecological value. Typically, they have very little or no native vegetation remaining (less than 10%).

According to DPAW's *Geomorphic Wetlands Swan Coastal Plain Dataset*, one MUW (UFI 15732; Palusplain) occurs in the extreme southwest of the study area. An additional four CCWs occur in close proximity to the study area. The four CCWs occur approximately 500 m to 1,200 m to the west of the southwest corner and are associated with Chandala Lake within Chandala Nature Reserve.

3.5 Biological Context of Study Area

The Interim Biogeographic Regionalisation for Australia (IBRA) divides Australia into 89 bioregions based on major biological and geographical attributes. The bioregions have been further divided into 419 subregions. The study area is located in the Swan Coastal Plain (SCP) bioregion, subregion Dandaragan Plateau (SWA01) and a small portion in the southwest of the study area in the Perth subregion (SWA02).

The Dandaragan Plateau (SWA1) subregion consists of cretaceous marine sediments with sand and lateritic mantle. It is boarded by the Derby and Dandaragan Faults. The vegetation includes scrub-heaths on laterite pavement and gravelly sandplains, Jarrah and Marri woodlands and *Banksia* low woodlands. Dominant land use is mainly dry-land agriculture and areas of conservation.

The Perth (SWA2) subregion is a low lying coastal plain which consists of colluvial and Aeolian sands, alluvial river flats and coastal limestone. In the east it rises to duricrusted Mesozoic sediments while to the south there are widespread outwash plains. A complex series of seasonal wetlands and swamps extend north to south. The vegetation includes heath and/or Tuart woodlands on limestone, Banksia and Jarrah- *Banksia* woodlands on Quaternary marine dunes of various ages, Marri on colluvial and alluvial soils *Casuarina obesa* on out wash plains and paperbark (*Melaleuca* sp.) in wetland areas (Mitchell et al., 2002.)

3.6 Regional Vegetation

Heddle et al. (1980) have described and mapped vegetation complexes of the Darling System at a board floristic scale of 1:250,000 (as recognised by Diels, 1906; and Gardner, 1942). The vegetation complex mapping is based on data collected from the literature, ground surveys, road traverses and aerial photographs and is related to the landforms, soils and climatic conditions.

Based on the mapping undertaken by Heddle et al. (1980) the study area is considered to be representative of five vegetation complexes (Figure 4). The five vegetation complexes have been described as:

- Coonambidgee complex: consists of vegetation ranging from a low open forest and low woodland of Pricklybark (*Eucalyptus todtiana*) and Banksia species (*Banksia attenuata, Banksia menziesii* and *Banksia ilicifolia*) with local admixtures of *Banksia prionotes*, to open woodland of Marri (*Corymbia calophylla*) and Banksias (*Banksia* spp.). The Coonambidgee complex is located on the fluviatile deposits of the Swan Coastal Plain.
- Karamal complex-south: is dominated by an open forest of Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) with a definite second storey of *Banksia grandis* on the gravelly soils and *Banksia attenuata* and *Banksia menziesii* on the sandier soils. The Karamal complex-south is located on the lateritic uplands of the Dandaragan Plateau.
- Mogumber complex-south: dominated by an open woodland of Marri (*Corymbia calophylla*) with a well-defined second storey of Pricklybark (*Eucalyptus todtiana*) and Banksia species (*Banksia attenuata, Banksia menziesii* and *Banksia ilicifolia*). The Mogumber complex-south is located on the lateritic uplands of the Dandaragan Plateau.
- Moondah complex: supports predominantly a low closed to low open forest of *Banksia attenuata, Banksia menziesii, Banksia prionotes* and *Eucalyptus todtiana* on the slopes and an open woodland of Marri (*Corymbia calophylla*) and Banksia (*Banksia* spp.) in the valleys. The Moondah complex is located in the valleys of the Dandaragan Plateau.
- Reagan complex: supports vegetation ranging from low open woodland of *Banksia attenuata, Banksia menziesii* and *Eucalyptus todtiana* to closed heath, depending on the depth of soil. The Reagan complex is located on the scarps of the Dandaragan Plateau.

The extent of each vegetation complex located within the study area is presented in Table 2 below.

Table 2 Vegetation complex extent

Land unit	Extent within the study area (ha)	Extent within the study area (%)
Coonambidgee complex	8.7	0.9
Karamal complex-south	181.3	18.4
Mogumber complex-south	424.9	43.1
Moondah complex	105.2	10.7
Reagan complex	266.3	27.0

4 METHODS

4.1 Flora and Vegetation

4.1.1 Desktop Assessment

In accordance with the EPA's Guidance Statement No. 51 for a Level 1 flora and vegetation survey, a desktop assessment was undertaken prior to the field survey component of the assessment. The desktop assessment involved a review of existing environmental or biological data available for the study area and lands adjacent to the study area. The desktop assessment involved the review of State and Federal databases, regional and local contextual data for the northern Swan Coastal Plain and existing biological surveys undertaken on the Swan Coastal Plain. The results of the desktop assessment are detailed in Section 5.

4.1.1.1 Databases

A request for searches of DPAW's threatened flora and ecological community's database was submitted on 30 May 2014 for a central coordinate (-31.487441°S; 115.985779°E) within the study area with a 5 km buffer for Threatened and Priority listed flora and a 10 km buffer for Threatened and Priority listed ecological communities (Appendix A). The search was undertaken for:

- The Department's Threatened (Declared Rare) and Priority Flora database.
- The Western Australian Herbarium Specimen database for Priority species opportunistically collected in the area of interest.
- The Department's Threatened and Priority Flora List, which contains species that are declared rare (Conservation Code T or X for those presumed to be extinct), poorly known (Conservation Codes 1, 2 or 3), or require monitoring (Conservation Code 4).
- The Department's Threatened and Priority Ecological Communities database.

A search of DOTE (2014a) online publicly available database for MNES was undertaken for the study area. A central point (-31.48843S; 115.98843E) with a 10 km buffer was undertaken for the study area (Appendix B).

4.1.1.2 Regional Perspective

A review of regional and local contextual data, with reference to flora and vegetation, was completed prior to the field survey component of the assessment. The review was undertaken to identify the flora and plant communities considered to be significant from a regional and local context. The review also concentrated on broad scale mapping of plant communities and floristic units. The documents that have been reviewed include:

- Vegetation complexes of the Darling System Western Australia (Heddle et al., 1980).
- Floristic Survey of the Southern Swan Coastal Plain (Gibson et al., 1994).
- The Bush Forever Strategy: Volume 1 (Government of Western Australia, 2000a) and Volume 2 (Government of Western Australia, 2000).
- Plant Life of Western Australia (Beard, 1990).

- Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Region (WALGA, 2004).
- The Darling System – System 6, Part I: General Principles and Recommendations (DCE, 1983).
- Native Vegetation in Western Australia: Technical Report 249 (Shepherd et al., 2002).

4.1.1.3 Existing Biological Surveys

Several biological surveys have been undertaken within the study area and in close proximity to the study area. These reports were reviewed to identify the known plant communities occurring within and adjacent to the study area. The review also identified the condition of the vegetation and the location of known conservation significant flora and ecological communities occurring within and adjacent to the study area. The existing biological surveys reviewed, included:

- Perth–Darwin National Highway – Tonkin Highway Link Alignment Definition Study: Environmental Impact Assessment and Biological Survey (GHD, 2013a).
- Swan Valley Bypass, Perth–Darwin National Highway: Level 2 Flora and Vegetation Survey (360 Environmental, 2014).
- A flora and vegetation survey of Lots 46 and 47 Maralla Road and Lexia Avenue, Ellenbrook (M.E. Trudgen & Associates, 1999).
- East Landsdale Flora and Fauna Assessment – Lots 50 and 51 (Ecoscape, 2009a).
- East Landsdale Flora and Fauna Assessment – Lot 154 (Ecoscape, 2009b).
- Level 2 Flora and Vegetation Survey, North Ellenbrook (360 Environmental, 2012).
- Level 1 flora and fauna assessment of Gaston Road, Muchea (GHD, 2009).
- Flora and fauna assessment, Mitchell Freeway Extension (Burns Beach Road to Romeo Road) (GHD, 2013b).
- Level 2 flora and vegetation survey of Lot 5 Mornington Drive, Mariginuiup (Monocot-Dicot Botanical Research, 2010).
- Flora and vegetation assessment, M70/138 Hopkins Road, Nowergup (Coffey Environments, 2010).

4.1.2 Field Survey

A Level 1 flora and vegetation survey, consistent with the EPA's Guidance for the Assessment of Environmental Factors No. 51 (EPA, 2004a), was conducted of the study area. The survey was completed from 8 to 10 June and 17 June 2014.

The field survey component of the assessment was led by Mr Clinton van den Bergh, assisted by Ms Lucy Dadour and Ms Michelle Holliday. Clinton has over 8 years' experience conducting flora and vegetation surveys in Western Australia with relevant experience on the Swan Coastal Plain.

The survey was conducted under a Licence to take flora for scientific or other prescribed purposes (licence number SL010743) and a Permit to take Declared Rare Flora (permit number 73–1314) from DPAW. All flora specimens were collected during the survey under these licences and permits, in accordance with the conditions required under each licence/permit.

4.1.2.1 Flora and Vegetation Assessment

A total of 30 relevés were sampled within the study area. Relevés are unmarked quadrats where a central point is marked with a Global Positioning System (GPS) and an approximate radius is sampled around this

point for the purpose of recording vegetation structure, species composition, dominance and compiling a species inventory. For the purpose of this assessment a radius of approximately 20 m was sampled. Flora sampling quadrats on the Swan Coastal Plain are 100 m^2 in size, therefore the size of the relevé was sufficient to sample the flora and vegetation within the study area.

Information recorded at each relevé included landform features, soil colour and texture, leaf litter cover, rock size and type, vegetation structure, vegetation condition and fire age. Structural information on the dominant species (species with a cover higher than 1%) including height and percentage cover were recorded for each relevé.

Common species that were well known to the survey botanists were identified in the field, while remaining species unknown to the survey botanist were collected during the field survey and assigned a unique number to facilitate tracking. The specimens were pressed during that day, following recommendations provided by the Western Australia Herbarium. The specimens were then sufficiently dried prior to submitting to a consultant taxonomist, Mr Malcolm Trudgen, for identification.

The broad floristic formations and vegetation associations were described based on the floristic data recorded from the relevés and from visual observations while traversing the study area, utilising the standardised terminology for vegetation structural classes detailed in the Australian Vegetation Attribute Manual (ESCAVI, 2003). The vegetation structural terminology of the National Vegetation Information System (NVIS) was adapted from Specht (1970), Specht et al. (1974), and Walker and Hopkins (1990) (ESCAVI, 2003).

The vegetation recorded from the study area has been described to a NVIS hierarchical level III (Broad Floristic Formation) and V (Vegetation Association). Hierarchical level III requires the dominant growth form, cover, height and dominant land cover genus for the upper most or the ecologically or structurally dominant stratum. Hierarchical level V requires the dominant growth form, cover, height and dominant species (three for each stratum) for each of the three traditional strata (i.e. upper, mid and ground). The hierarchical structure and the vegetation structural terminology are described in Table 3 and Table 4, while the NVIS height class definition is provided in Table 5.

Table 3 NVIS hierarchical structure

Hierarchical level	Description	NVIS structural/floristic component required
I	Class	Dominant growth form for the ecologically or structurally dominant stratum.
II	Structural Formation	Dominant growth form, cover and height for the ecologically or structurally dominant stratum.
III	Broad Floristic Formation	Dominant growth form, cover, height and dominant land cover genus for the upper most or the ecologically or structurally dominant stratum.
IV	Sub-formation	Dominant growth form, cover, height and dominant genus for each of the three traditional strata (i.e. Upper, Mid and Ground).
V	Association	Dominant growth form, height, cover and species (3 species) for each of the three traditional strata (i.e. Upper, Mid, Ground).
VI	Sub-Association	Dominant growth form, height, cover and species (5 species) for all layers/sub-strata.

Source: Table 1 from ESCAVI (2003).

Table 4 NVIS structural terminology

Stratum	Growth form	Height ranges (m)[1]	Structural formation classes (% cover)					
			80–100	50–80	20–50	0.25–20	0–0.25	Unknown
U	Tree, palm	<10 = low 10-30 = mid >30 = tall	Closed forest	Open forest	Woodland	Sparse woodland	Isolated trees	Isolated clumps of trees
	Tree mallee	<3 = low <10 = mid 10-30 = tall	Closed mallee forest	Open mallee forest	Mallee woodland	Sparse mallee woodland	Isolated mallee trees	Isolated clumps of tree mallees
M	Shrub, cycad, tree-fern	<1 = low 1-2 = mid >2 = tall	Closed shrubland	Shrubland	Open shrubland	Sparse shrubland	Isolated shrubs	Isolated clumps of shrubs
	Mallee shrub	<3 = low <10 = mid 10-30 = tall	Closed mallee shrubland	Mallee shrubland	Open mallee shrubland	Sparse mallee shrubland	Isolated mallee shrubs	Isolated clumps of mallee shrubs
	Heath shrub	<1 = low 1-2 = mid >2 = tall	Closed heath shrubland	Heath shrubland	Open heath shrubland	Sparse heath shrubland	Isolated heath shrubs	Isolated clumps of heath shrubs
	Chenopod shrub	<1 = low 1-2 = mid >2 = tall	Closed chenopod shrubland	Chenopod shrubland	Open chenopod shrubland	Sparse chenopod shrubland	Isolated chenopod shrubs	Isolated clumps of chenopod shrubs
	Samphire shrub	<0.5 = low >0.5 = mid	Closed samphire shrubland	Samphire shrubland	Open samphire shrubland	Sparse samphire shrubland	Isolated samphire shrubs	Isolated clumps of samphire shrubs
G	Hummock grass	<2 = low >2 = mid	Closed hummock grassland	Hummock grassland	Open hummock grassland	Sparse hummock grassland	Isolated hummock grasses	Isolated clumps of hummock grasses
	Tussock grass	<0.5 = low >0.5 = mid	Closed tussock grassland	Tussock grassland	Open tussock grassland	Sparse tussock grassland	Isolated tussock grasses	Isolated clumps of tussock grasses
	Other grass	<0.5 = low >0.5 = mid	Closed grassland	Grassland	Open grassland	Sparse grassland	Isolated grasses	Isolated clumps of grasses
	Sedge	<0.5 = low >0.5 = mid	Closed sedgeland	Sedgeland	Open sedgeland	Sparse sedgeland	Isolated sedges	Isolated clumps of sedges

Stratum	Growth form	Height ranges (m)[1]	Structural formation classes (% cover)					
			80–100	50–80	20–50	0.25–20	0–0.25	Unknown
	Rush	<0.5 = low >0.5 = mid	Closed rushland	Rushland	Open rushland	Sparse rushland	Isolated rushes	Isolated clumps of rushes
	Vine	<10 = low 10-30 = mid >30 = tall	Closed vineland	Vineland	Open vineland	Sparse vineland	Isolated vines	Isolated clumps of vines
	Herbs	<0.5 = low >0.5 = mid	Closed herbland	Herbland	Open herbland	Sparse herbland	Isolated herbs	Isolated clumps of herbs

Source: ESCAVI (2003). Note growth forms that do not occur or were not sampled within the study area were omitted (i.e. seagrass bed).
1. Refer to Table 5 for height range information.

Table 5 NVIS height class definition

Height class	Height range (m)	Growth forms			
		Tree, palm, vine	Shrub, heath shrub, chenopod, samphire shrub, tree-fern	Tree mallee, mallee shrub	Hummock grass, tussock grass, other grass, sedge, rush, herb
8	>30	Tall			
7	10-30	Mid		Tall	
6	<10	Low		Mid	
5	<3			Low	
4	>2		Tall		Tall
3	1-2		Mid		Tall
2	0.5-1		Low		Mid
1	<0.5		Low		Low

Source: ESCAVI (2003).

The condition of the vegetation recorded within the study area was described based on the condition rating scale developed by Keighery (1994) and published in the Bush Forever Strategy (Government of Western Australia, 2000b) (Table 6).

Table 6 Vegetation condition rating scale

Condition code	Definition
P Pristine	Pristine or nearly so, no obvious signs of disturbance.
Ex Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are nonaggressive species.
VG 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.
G Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate. 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.
Deg 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 to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
CD 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 referred to as parkland cleared with the flora composing weed or crop species with isolated native trees or shrubs.

Source: Bush Forever (Government of Western Australia, 2000), originally developed by Keighery (1994).

4.1.2.2 Targeted Searches

Sections of the study area were traversed on foot, with known locations of conservation significant flora or habitat likely to support conservation significant flora targeted during the searches. For populations of potential or known significant flora, a specimen, GPS location, photo, estimated population size and description of vegetation was documented. Further opportunistic collections of taxa not recorded in the relevés and introduced flora were also recorded. The focus of the targeted introduced flora surveys were:

- Weeds of National Significance listed under the EPBC Act.
- Declared Pests under Section 22 of the BAM Act.
- Environmental weed species with a “High” rating as listed by DPAW.

4.1.3 Limitations of Survey

The field survey component of the assessment was not undertaken at the most appropriate time for conducting flora and vegetation surveys on the Swan Coastal Plain. The survey was undertaken in winter, while the optimal time is spring. However, this is not considered to be a major limiting factor, as only a Level 1 flora and vegetation survey was required to identify the dominant vegetation structures.

No numerical analysis of the floristic data collected from the field survey was undertaken. Fungi and non-vascular flora (e.g. bryophytes, mosses etc.) were not collected or recorded during the field survey. The collection of fungi and non-vascular flora was outside the scope of this survey.

Table 7 below details the botanical survey limitations associated with the flora and vegetation assessment of the Study area.

Table 7 Botanical survey limitations

Limitation	Constraint and significance*	Comments
Competency/experience of the scientist conducting the survey	No	The survey and reporting was executed by Senior Botanist Clinton Van Den Bergh and Environmental Ecologist Lucy Dadour. A specialist consultant taxonomist, Malcolm Trudgen, undertook the specimen identifications.
Level of survey	No	A single phase Level 1 flora and vegetation survey was completed in accordance with the EPA's Guidance Statement 51 (EPA, 2004a).
Sources of information	No	The Swan Coastal Plain has been comprehensively surveyed in the past as a result of urban development. The sources of information were reviewed prior to, during and after the survey.
Scope	No	The entire scope was met.
Proportion of: a) Flora collected and identified. b) Task achieved and further work that may be required.	a) Yes; low b) No	a) It is estimated that between 70 and 80% of the potential flora occurring in the study area has been recorded. b) All tasks were achieved.
Completeness	No	The study area was adequately sampled and traversed.
Mapping reliability	No	The study area was traversed on foot and was easily accessible. The upper stratums of the plant communities were fairly homogenous over the entire study area. As a result the mapping reliability from a broad floristic formation is considered to be high. The mapping reliability at the vegetation association level is considered to be moderate to high.
Timing/weather/season/cycle	Yes	The survey was undertaken in winter so does not constitute a comprehensive inventory of annual and ephemeral species.
Disturbances which affected the results of the survey	No	The study area was considered to be in excellent condition with very minor disturbances. In some sections, the Banksia species were dying as a result of the drought or poor rainfall in the years preceding the survey.
Intensity of the survey	No	The survey was undertaken at an intensity which is in accordance with the EPA guidance (EPA, 2004a).
Completeness	No	The study area was adequately traversed on foot or via vehicle.
Resources	No	Adequate resources were assigned to the field surveys, specimen identifications and reporting components of the assessment.
Remoteness and/or access problems	No	Several unmade roads and informal tracks were located across the study area. These were accessed during the field survey component of the assessment.
Availability of contextual information	No	The greater Swan Coastal Plain region has been extensively surveyed, therefore a large amount of contextual information is available for the study area.

* Indicates whether the limitation is a constraint (yes/no) and, if yes, the significance of the constraint (low/moderate/high).

4.2 Fauna

4.2.1 Desktop Assessment

In accordance with the EPA's Guidance Statement No. 56 for a Level 1 fauna survey, a desktop assessment was undertaken prior to the field survey component of the assessment. The desktop assessment involved a review of existing environmental or biological data available for the study area and lands adjacent to the study area. The desktop assessment involved the review of State and Federal databases, regional and local contextual data for the northern Swan Coastal Plain and existing biological surveys undertaken on the Swan Coastal Plain. The results of the desktop assessment are detailed in Section 5.

4.2.1.1 State and Federal Government Databases

State and federal database searches were undertaken using:

- DPAW NatureMap online database (DPAW, 2014a). The search area was a 15 km circle around the coordinates 31°29'12"S 115°59'05"E.
- DPAW list of Threatened and Priority fauna (DPAW, 2014b). The search area was a 15 km circle around the coordinates 31°29'12"S 115°59'05"E.
- The Protected Matters Search Tool maintained by the DOTE bounded by a 10 km buffer area for the coordinates -31.486074°S, 115.989609°E (DOTE, 2014a).

4.2.1.2 Regional and Local Contextual Data

A review of regional and local contextual data, with reference to fauna, was completed prior to the field survey component of the assessment. The documents that have been reviewed include:

- Birds Australia Birdata (Birdata, 2014). The search area was a one degree square containing the point -31.41522 °S, 115.9935 °E.
- General texts to provide supplementary information including Tyler and Doughty (2009) for frogs; Storr et al., (1983, 1990, 1999, 2002), Bush et al. (2010), Bush et al. (2007) and Wilson and Swan (2010) for reptiles; Johnstone and Storr (1998; 2004), Simpson and Day (2010) and Johnstone and Storr (1998; 2004) for birds; and Menkhorst and Knight (2011) and van Dyck and Strahan (2008) for mammals; Churchill (2008) for bats.

4.2.1.3 Existing Biological Surveys

Several biological surveys have been undertaken within the study area and in close proximity to the study area. These reports were reviewed to identify the fauna assemblages occurring within and adjacent to the study area. The review also identified the location of known conservation significant fauna occurring within and adjacent to the study area. The existing biological surveys reviewed, included:

- Egerton Fauna Survey (Tingay and Associates, 1994).
- A Biological Survey of Boonaring Nature Reserve (Burbidge et al., 1996).
- Flora, Vegetation and Vertebrate Fauna Assessment Neerabup Industrial Area (ATA, 2007).
- Neerabup Road Extension Level 2 Fauna Survey (GHD, 2014).

Collectively these sources of information were used to create lists of species expected to utilise the study area. It should be noted that these lists include historic records of species that have since become locally extinct and species that have been recorded in the general region, but are vagrants, and are generally not found in the area because of a lack of suitable habitat. Many previously recorded fauna have specific habitat requirements that may be present in the general area but not located in the study area (e.g. marine

species). As such, erroneous records and species that have habitat specificity to habitats not present in the study area (wetland and marine species) have been omitted from the list of species expected to occur.

4.2.2 Field Survey

The field survey was conducted on 8 to 11 July by John Trainer and Michelle Holliday. The survey included an inspection of the major fauna habitats, Black Cockatoo habitat assessment and opportunistic fauna observations. The site was traversed by foot and a list of fauna recorded during the survey was assembled. The presence or evidence of any conservation significant fauna had its details recorded (GPS location, sex, habitat and picture taken if possible).

4.2.2.1 Fauna Habitat

Fauna habitats were classified according to vegetation and landform types and then mapped using a combination of aerial photography and ground-truthing. Fauna habitat assessments were conducted to record the habitat features and habitat values across the site. Fauna habitats were assessed on the microhabitats they provide to the expected faunal assemblage, habitat/vegetation condition and also the number of conservation significant fauna they potentially support.

4.2.2.2 Black Cockatoo Habitat Assessment

The vegetation of the study area was assessed on its ability to provide habitat to the three threatened species of Black Cockatoo. Based upon the current distribution maps in the EPBC Act referral guidelines for three threatened Black Cockatoo species (herein referred to as the Cockatoo referral guidelines) the study area is located in the known range of two of the three species: the Carnaby's Cockatoo and on the extreme northern range of the Forest Red-tailed Black Cockatoo (DSEWPAC, 2012). The methodology used to conduct the Black Cockatoo habitat assessment is consistent with that specified in the Cockatoo referral guidelines.

Habitats were mapped as High, Moderate or Low value for Black Cockatoos based on the level of suitable habitat they provide. High value habitats provide breeding, foraging and roosting habitat. Moderate value habitats provide quality foraging habitat or quality foraging habitat and roosting habitat. Low value habitats provide limited foraging habitat.

Foraging Assessment

The site was examined for evidence of current and historic foraging by Black Cockatoos, with particular focus upon the species of plant that are known foraging resources of these species (Valentine and Stock, 2008, Johnstone et al., 2008 and Chapman, 2007). Evidence in the form of chewed Marri or Jarrah nuts/fruits, chewed/broken Banksia seed pods and stripped tree bark are usually located on the ground underneath foraging resources. Due to the differing beak morphology of each of the Black Cockatoo species, characteristic chew marks are created upon Marri nuts which can be used to provide species identification (Fleming, 2011). Foraging habitat is mapped according to the presence of foraging resources.

Roosting Assessment

According to the Cockatoo referral guidelines roosting habitat is classified as a group of tall trees that are located close to riparian environments or other permanent water sources, usually close to or within foraging habitat (DSEWPAC, 2012). Trees or stands of trees that match this description were examined for evidence of recent use as a roost site (feathers and droppings) and a database searches was conducted for known roost sites in the vicinity of the site. Any stand of tall trees was classified and mapped as potential roosting habitat due to the study areas close proximity to riparian environments and permanent water sources.

Breeding Assessment

All three species of Black Cockatoo breed in large tree hollows which are found in trees usually more than 200 years old (DSEWPAC, 2012). The size of a tree is measured by its diameter at breast height (DBH) in millimetres (mm) and is used to establish its hollow bearing potential. Trees with a DBH of 500 mm or above (300 mm DBH for Salmon Gum and Wandoo) are classified as providing breeding habitat.

Due to the large size of the study area (988 ha) a tree density survey was deemed the most appropriate method to establish the level of breeding habitat present. Within each large stand of tree in the Eucalypt Woodland, a one hectare quadrat (100 m x 100 m) was conducted in an area of representative tree density. The number of trees with a DBH over 500 mm per quadrat and their details (species, height and presence of hollows) was recorded per site. This information was used to provide breeding tree density for each Eucalypt Woodland stand (number of trees/hectare) and extrapolated based on habitat mapping to give a total estimate of the number of breeding trees in the study area. In the stands of trees where multiple tree density surveys were completed an average of total tree density was used.

Additionally, the details (GPS location, species, height and size of hollows) of trees with suitable breeding hollows were opportunistically recorded while traversing the study area.

4.2.3 Limitations of Survey

As this survey was a level 1 survey with no trapping program, small ground dwelling fauna such as skinks, snakes and small mammals are unlikely to be recorded. However, the lack of conservation significant fauna that fall into this category and the high number of previous surveys completed in the vicinity should not impact upon this assessments ability to identify them as part of the wider fauna assemblage.

Both field participants (Mr John Trainer and Ms Michelle Holliday) are experienced in conducting fauna assessments in the South West.

As numerous terrestrial fauna surveys have been conducted in the region, fauna assemblages are well characterised. As such, there is sufficient quantitative terrestrial fauna data collected from study area to allow for comparison to regional data.

Weather was cold and intermittently wet during the assessment with maximum ambient temperatures between 15.7 and 17.2°C and minimum ambient temperatures down to 2.4°C (BOM, 2014). With 11 mm recorded over the survey period. The survey was conducted out of season (EPA, 2004b and EPA/DEC, 2010), which deem that late spring/early summer is the most appropriate time to conduct fauna surveys in the South West. However, as this was a Level 1 survey with no trapping program, the focus of the survey was on habitat assessments rather than recording the faunal assemblage and is considered a low value constraint. The cold weather experienced during the survey would have impacted the number of opportunistic fauna records obtained during the survey, in particular observations of retiles.

There were no access issues throughout the study area and the entire area was adequately surveyed. A statement of the fauna survey limitations for the project is provided in Table 8.

Table 8 Fauna survey limitations

Limitation	Constraint and significance*	Comments
Competency/experience of the scientist conducting the survey	No	An experienced zoologist undertook the field survey and the reporting.
Level of survey	No	A Level 1 fauna survey was considered appropriate to identify the habitat and conservation significant fauna values of the study area.

Limitation	Constraint and significance*	Comments
Sources of information	No	The Swan Coastal Plain region has been extensively surveyed with several comprehensive fauna surveys undertaken in within comparable habitats to those found in the study area.
Scope	No	The entire scope was met.
Proportion of: a) Fauna identified, recorded and/or collected; and b) Task achieved and further work that may be required	a) Yes; low b) No	a) The lack of pit fall traps reduces the number of small reptiles and mammals identified. However, the lack of conservation significant fauna that fall into this category and the high number of previous surveys completed in the region should not impact upon this assessments ability to identify them as part of the wider fauna assemblage. b) No further work is considered necessary to meet the current objectives and scope.
Completeness	No	The study area was adequately sampled and traversed.
Mapping reliability	No	The mapping reliability is considered to be high due to the homogenous nature of the study area and the quadrat sampling undertaken across the study area.
Timing/weather/season/cycle	Low	The survey was conducted out of season (EPA, 2004b and EPA/DEC, 2010), which deem that late spring/early summer is the most appropriate time to conduct fauna surveys in the South West. However, as this was a Level 1 survey with no trapping program, the focus of the survey was on habitat assessments rather than recording the faunal assemblage and is considered a low value constraint.
Disturbances which affected the results of the survey	No	There were no disturbances that affected the results of the survey.
Intensity of the survey	No	The intensity of the survey is sufficient to identify the presence of conservation significant fauna within the study area and to conduct a Black Cockatoo habitat assessment.
Completeness	No	The study area was adequately traversed on foot or via vehicle.
Resources	No	Adequate resources were assigned to the field survey and the reporting associated with the project.
Remoteness and/or access problems	No	The study area was adequately traversed on foot or via vehicle.
Availability of contextual information	No	The Swan Coastal Plain has been extensively surveyed, with all contextual information accessed prior, during and after the field survey (refer to Section 4.2.1).

* Indicates whether the limitation is a constraint (yes/no) and, if yes, the significance of the constraint (low/moderate/high).

4.3 Dieback

Phytophthora Dieback (Dieback) is a soil borne pathogen. In the southwest of Western Australia there is a number of plant hosts, including the Ericaceae, Fabaceae, Myrtaceae, Proteaceae, and Xanthorrhoeaceae families. While not all plants are susceptible to the disease, the ones that are affected by the pathogen generally results in chlorosis, dieback and often death (Terratree, 2014).

A linear dieback assessment of the main access tracks (approximately 119 ha) was conducted for the study area (Terratree, 2014 Appendix C). The following categorisation for vegetation was applied to determine the risk of dieback:

- High Risk: Areas where *Phytophthora cinnamomi* has been recovered from samples and disease symptoms are consistent with the presence of Dieback.
- Moderate Risk: Areas exhibiting past or current disturbances (logging, grazing, dumping etc.) which has altered vegetation structure and composition and areas downslope of confirmed infestations, or vegetation exhibiting disease symptoms but have not returned positive results for *P. cinnamomi*.
- Low Risk: Areas of protectable uninfested vegetation (as determined by a registered Dieback interpreter), which exhibit multiple healthy indicator species, vegetation in Pristine to Very Good condition, no disease pattern or chronology, and no significant risks from disease vectors or current land use.

5 RESULTS

5.1 Flora and Vegetation

5.1.1 Desktop Assessment

The desktop review and database searches yielded a total of 55 conservation significant taxa occurring or potentially occurring within the proximity of the study area (Appendix D). The 55 conservation significant taxa occurring or potentially occurring in the study area included 20 Threatened (declared rare-extant) taxa, three Priority 1 taxa, eight Priority 2 taxa, seventeen Priority 3 taxa and six Priority 4 taxa.

The desktop review identified one Threatened, *Chamelaucium* sp. Gingin (D. Marchant 6), and six Priority taxa (*Acacia cummingiana* (P3); *Caustis* sp. Gigas (A.S. George 9318) (P2); *Hypolaena robusta* (P4); *Schoenus griffinianus* (P3); *Verticordia rutilastra* (P3); and *Verticordia serrata* var. *linearis* (P3)) as occurring within the study area (Figure 5). The likelihood of the remaining 19 Threatened and 29 Priority listed taxa is detailed in Appendix D and is based on the following criteria:

- **Likely**: suitable habitat present and records within or less than 2 km from the study area.
- **Possible**: suitable habitat present, with records within 2-10 km from the study area.
- **Unlikely**: lacks of suitable habitat present, and/or there are no records closer than 10 km from the study area.

Based on the assessment of likelihood of occurrence, ten conservation significant taxa are known to occur or expected to occur within the study area, and a further 15 conservation significant taxa may potentially occur within the study area based on known locations and habitat preferences. The remaining 30 conservation significant taxa are not expected to occur within the study area based on habitat preferences and the current known locations (Appendix D).

Of the ten conservation significant taxa known to occur or expected to occur within the study area, only *Chamelaucium* sp. Gingin (N.G. Marchant 6) is listed as Threatened taxa under the WC Act and the EPBC Act. The remaining nine conservation significant taxa are listed as Priority taxa by DPAW.

Seven ecological communities listed as conservation significant, including four Threatened Ecological Communities and three Priority Ecological Communities are known to occur. Of the four TECs, three are listed as TECs under the EPBC Act. The list of TECs and PECs known to occur or potentially occur in the study area are presented in Table 9. The TEC SCP20c and the PECs SCP23b and Banksia yellow-orange sands, occur within the study area (see Figure 5), while the buffer for the Wooded waterbird wetlands PEC occurs across the southwest corner of the study area. The remainder of the TECs occur between 7 and 10 km of the study area.

Table 9 Threatened and Priority Ecological Communities occurring within close proximity to the study area

Community name	Community description	Federal listing[1]	State listing[1]
NTHIRON	Perth to Gingin Ironstone Association.	Endangered	Critically Endangered
Mound Springs SCP	Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain).	Endangered	Critically Endangered
Muchea Limestone	Shrublands and woodlands on Muchea Limestone.	Endangered	Endangered
SCP20c	*Banksia attenuata* woodland over species rich dense shrublands.		Endangered
Banksia yellow-orange sands	*Banksia* woodland of the Gingin area restricted to soils dominated by yellow to orange sands.		Priority 2
Wooded waterbird wetlands	Wooded wetlands which support colonial waterbird nesting areas.		Priority 2
SCP23b	Swan Coastal Plain *Banksia attenuata* – *Banksia menziesii* woodlands.		Priority 3

1. See Appendix E for the definitions of Federal and State listing categories.

5.1.2 Vegetation Condition

The condition of the vegetation recorded within the study area ranged from Good to Pristine (Figure 6) according to the vegetation condition rating scale in Table 6. The majority (84%) of the vegetation was in excellent condition due to the intact vegetation structure, minimal anthropogenic disturbances and minimal signs of disturbance as a result of pathogens, diseases and overgrazing from native and non-native fauna.

The sections of vegetation in good condition were generally located in areas of higher visitation from humans and non-native fauna. These areas were located in the southwest corner, the eastern and northern boundaries of the study area and along the unmade Reserve Road that goes through the centre of the study area. Old car bodies and higher concentrations of introduced taxa were located along the eastern boundary, associated with a gate in the fence that allowed stock to graze within the study area and uncontrolled movement from the paddocks.

In addition to the areas of the study area that were considered to have a lower condition rating, there were several areas that were considered to have a higher condition rating. The areas of vegetation considered to be pristine were generally located within the middle of the study area were introduced taxa and human visitation is low to non-existent.

5.1.3 Dieback

The majority of the study area (87.6 ha) is categorised as Low risk vegetation, with 12.2 ha rated as moderate and 19.4 ha assessed as high risk. Most of the study area is uninfested and presents a low risk of spreading the disease into other areas (Terratree, 2014; Appendix C).

5.1.4 Vegetation Units

The vegetation units recorded from the study area can be broadly categorised into four broad floristic formations. The broad floristic formations have been mapped on Figure 7 and are described below:

- *Corymbia* woodland – The *Corymbia* woodland broad floristic formation occurred as a dominant and as a co-dominant with *Eucalyptus* species along the higher landforms of the study area and generally in association with lateritic soils. The dominant upper stratum species was *Corymbia calophylla*. The extent of *Corymbia* woodland covers 17% of the study area.
- *Eucalyptus* woodland – The *Eucalyptus* woodland broad floristic formation occurred across the study area and occurred as either the dominant upper stratum or as a co-dominant with *Corymbia calophylla*. The *Eucalyptus* woodland occurred on lateritic soils and deep sands higher in the landscape. The dominant species in the upper stratum was *Eucalyptus marginata*. The extent of *Eucalyptus* woodland covers 56% of the study area.
- *Banksia* woodland – The *Banksia* woodland occurred in small isolated patches and has been identified as a separate formation compared to the *Banksia* shrubland due to the height of woodland (over 10 m) and the lack of *Eucalyptus* or *Corymbia* species. The dominant *Banksia* species were *Banksia attenuata* and *Banksia menziesii*. The extent of *Banksia* woodland covers 10% of the study area.
- *Banksia* shrubland – The *Banksia* shrubland is distinct from the *Banksia* woodland due to the isolated or sparse presence of *Eucalyptus todtiana* in the upper stratum. The Banksia species (commonly *Banksia attenuata* and *Banksia menziesii*) were generally lower than 10 m in height. The *Banksia* shrubland broad floristic formation was the dominant formation across the study area. The extent of *Banksia* shrubland covers 17% of the study area.

A total of 16 vegetation units were identified from the study area (Table 10). The vegetation units have been described to a vegetation association level (Hierarchical Level V) and have been divided further from the four broad floristic formations. The vegetation association units have been mapped on Figure 8, while the floristic data collected from the 30 relevés sampled within the study area are provided in Appendix F.

5.1.5 Vegetation Significance

5.1.5.1 Boregional and Subregional Protection

The bioregions and subregions are the reporting unit for assessing the status of native ecosystems and their level of protection in the National Reserve System. In this way, IBRA is used as a dynamic tool for monitoring progress towards building a comprehensive, adequate and representative (CAR) reserve system (DOTE, 2014b). Such information assists governments to decide how to best prioritise funding to meet national protection targets.

The study area is located within the Swan Coastal Plain bioregion and the Perth subregion. According to the National Reserve System, the Swan Coastal Plain bioregion is not considered to be a bioregion with less than 10% protection. Both the Swan Coastal Plain bioregion and the Perth subregion have between 10-15% of their current area protected within International Union for Conservation of Nature (IUCN) Class I-IV Reserves (i.e. National Parks, Nature Reserves).

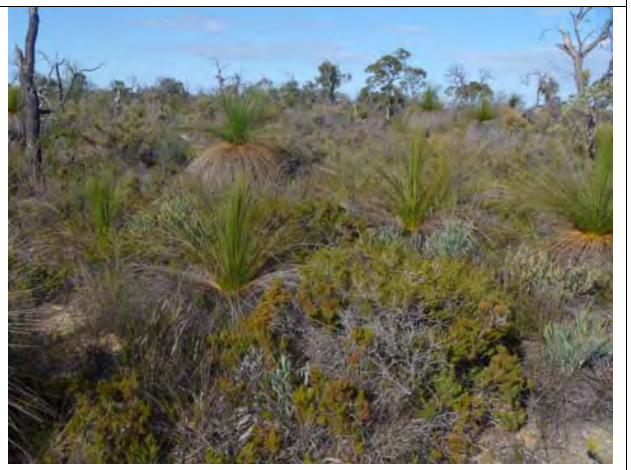
Table 10 Vegetation units recorded

Unit code	Quadrats	Broad floristic formation and site preference	Vegetation description	Area of study area	Photograph
EmCc[1]	COR01 & COR09	*Eucalyptus* woodland Lateritic slopes and rises	*Eucalyptus marginata* and occasional *Corymbia calophylla* mid sparse woodland over *Xanthorrhoea preissii* and *Allocasuarina humilis* mid open to mid sparse shrubland over *Hibbertia hypericoides*, *Conostephium pendulum* and occasional *Hakea stenocarpa* low open shrubland over *Lepidosperma pubisquameum* (flat form) and *Mesomelaena tetragona* and *Mesomelaena pseudostygia* low sparse sedgeland on lateritic coarse black, brown sandy loam on lateritic rises and slopes.	1.2% / 11.5 ha	
BaBmNf	COR03, COR11, COR18, COR26 & COR27	*Banksia* shrubland Consolidated dunes and plains	*Banksia attenuata, Banksia menziesii* and *Nuytsia floribunda* tall sparse to tall open shrubland over *Allocasuarina humilis, Xanthorrhoea preissii* and *Daviesia divaricata* subsp. *divaricata* mid sparse to mid open shrubland over *Eremaea pauciflora* var. *pauciflora, Melaleuca systena* and *Leucopogon conostephioides* low open shrubland over *Mesomelaena pseudostygia* and *Schoenus efoliatus* low sparse sedgeland on yellow, grey-brown coarse grained sand on consolidated dunes.	15.0% / 147.9 ha	

Unit code	Quadrats	Broad floristic formation and site preference	Vegetation description	Area of study area	Photograph
EmCc[2]	COR05	*Eucalyptus* woodland Lateritic slopes	*Eucalyptus marginata* and *Corymbia calophylla* mid woodland over *Xanthorrhoea preissii* mid sparse shrubland over *Hibbertia hypericoides* low open shrubland over *Mesomelaena tetragona* low sparse sedgeland on a lateritic slope with brown coarse grained sandy loam with a laterite subsurface on lateritic slopes.	0.5% / 4.8 ha	
Em[1]	COR06	*Eucalyptus* woodland Consolidated plains	*Eucalyptus m*arginata low sparse woodland over *Banksia attenuata, Banksia menziesii* and *Adenanthos cygnorum* subsp. *cygnorum* tall open shrubland over *Jacksonia floribunda* mid isolated shrubs over *Hibbertia hypericoides* and *Stirlingia latifolia* low open shrubland over *Hypolaena exsulca*, *Lyginia imberbis* and *Alexgeorgea nitens* low sparse rushland on a plain with grey brown coarse grained sand on consolidated plain.	3.6% / 35.9 ha	

Unit code	Quadrats	Broad floristic formation and site preference	Vegetation description	Area of study area	Photograph
EtNf	COR10 & COR24	*Eucalyptus* woodland Consolidated dunes	*Eucalyptus todtiana* and *Nuytsia floribunda* mid sparse to mid isolated mallee woodland over *Banksia attenuata, Banksia menziesii* and *Adenanthos cygnorum* subsp. *cygnorum* tall open to tall sparse shrubland over *Beaufortia elegans, Xanthorrhoea preissii* and *Jacksonia floribunda* mid sparse shrubland over *Calothamnus sanguineus, Scholtzia involucrata*, and *Eremaea pauciflora* var. *pauciflora* low open to low sparse shrubland over *Mesomelaena pseudostygia* low isolated sedges over *Lyginia imberbis* low isolated rushes on grey coarse-grained sand on consolidated dunes.	25.0% / 246.3 ha	
Cc[1]	COR12 & COR13	*Corymbia* woodland Lateritic slopes and rises	*Corymbia calophylla* with occasional *Eucalyptus marginata* and *Nuytsia floribunda* mid sparse woodland over emergent patches of *Banksia sessilis* var. *sessilis* tall sparse shrubland over *Xanthorrhoea preissii* mid open shrubland over *Hibbertia hypericoides, Acacia celastrifolia* and *Calothamnus sanguineus* low open to low sparse shrubland on black, brown coarse-grained loamy, sand on lateritic rises and slopes.	3.0% / 29.3 ha	

Unit code	Quadrats	Broad floristic formation and site preference	Vegetation description	Area of study area	Photograph
Ba	COR14	*Banksia* woodland Seasonally waterlogged depressions	*Banksia attenuata* mid sparse woodland over *Kunzea glabrescens* and *Banksia menziesii* tall shrubland over *Macrozamia riedlei* and *Xanthorrhoea preissii* mid sparse shrubland over various sparse herbs with brown grey white coarse grained sand in a seasonally inundated depression.	0.4% / 4.2 ha	
CcEm	COR15 & COR17	*Corymbia* woodland Consolidated dunes with lateritic subsurface	*Corymbia calophylla* and *Eucalyptus marginata* mid sparse woodland over *Banksia attenuata* and *Banksia menziesii* low sparse to isolated woodland over *Xanthorrhoea preissii* and *Daviesia divaricata* subsp. *divaricata* tall sparse shrubland over *Hakea trifurcata* and *Macrozamia riedlei* mid sparse shrubland over *Hibbertia hypericoides, Conostephium pendulum* and *Stirlingia latifolia* low open shrubland over *Mesomelaena pseudostygia* low sparse sedgeland on grey, brown coarse-grained sand on consolidated dunes with lateritic subsurface.	11.0% / 108.6 ha	

Unit code	Quadrats	Broad floristic formation and site preference	Vegetation description	Area of study area	Photograph
BaBm[1]	COR19	*Banksia* shrubland Consolidated dunes	*Banksia attenuata* and *Banksia menziesii* low sparse woodland over *Adenanthos cygnorum* subsp. *cygnorum* tall open shrubland over *Xanthorrhoea preissii* and *Beaufortia elegans* mid sparse shrubland over *Hibbertia hypericoides, Scholtzia involucrata* and *Calothamnus sanguineus* low sparse shrubland over *Mesomelaena pseudostygia* low sparse sedgeland with grey brown coarse grained sandy loam on consolidated dunes.	2.4% / 23.7 ha	
Cc[2]	COR20	*Corymbia* woodland Consolidated dunes	*Corymbia calophylla* with occasional *Eucalyptus marginata* mid isolated trees over *Banksia attenuata* tall sparse shrubland over *Allocasuarina humilis* and *Xanthorrhoea preissii* mid sparse shrubland over *Eremaea pauciflora* var. *pauciflora, Calothamnus sanguineus* and *Stirlingia latifolia* low open shrubland over *Mesomelaena pseudostygia* low sparse sedgeland with yellow brown coarse grained sand on consolidated dunes.	1.3% / 12.5 ha	

Unit code	Quadrats	Broad floristic formation and site preference	Vegetation description	Area of study area	Photograph
Em[2]	COR25	*Eucalyptus* woodland Consolidated dunes	*Eucalyptus marginata* mid woodland over *Banksia attenuata* and *Banksia menziesii* tall sparse shrubland over *Eremaea pauciflora* var. *pauciflora*, *Hibbertia hypericoides* and *Daviesia triflora* low open shrubland over *Mesomelaena pseudostygia* low isolated sedges over *Lyginia imberbis* low isolated rushes with grey white coarse grained sand on consolidated dunes.	7.1% / 70.1 ha	
Cc[3]	COR28	*Corymbia* woodland Consolidated dunes	*Corymbia calophylla* mid isolated trees over *Eucalyptus todtiana* mid isolated mallee trees over *Banksia attenuata, Banksia menziesii* and *Daviesia divaricata* subsp. *divaricata* tall sparse shrubland over *Eremaea pauciflora* var. *pauciflora*, *Calothamnus sanguineus* and *Hibbertia hypericoides* low sparse heath shrubland over *Mesomelaena pseudostygia* low sparse sedgeland with yellow brown coarse grained sand on consolidated dunes.	2.0% / 19.2 ha	

Unit code	Quadrats	Broad floristic formation and site preference	Vegetation description	Area of study area	Photograph
BaBm[2]	COR30	*Banksia* woodland Seasonally waterlogged swale	*Banksia attenuata* and *Banksia menziesii* low woodland over *Melaleuca preissiana* and *Adenanthos cygnorum* subsp. *cygnorum* tall sparse shrubland over *Calytrix angulata* and *Xanthorrhoea preissii* mid sparse shrubland over *Leucopogon conostephioides* and *Hibbertia subvaginata* low sparse shrubland with grey brown coarse grained sand in a swale.	1.0% / 9.7 ha	
Em[3]	COR02, COR07 & COR21	*Eucalyptus* woodland Consolidated dunes	*Eucalyptus marginata* with occasional *Corymbia calophylla* mid sparse woodland over *Xanthorrhoea preissii* mid sparse shrubland over *Hibbertia hypericoides, Calothamnus sanguineus* and *Conostephium pendulum* low heath shrubland over *Mesomelaena pseudostygia* and *Lepidosperma pubisquameum* (flat form) low sparse sedgeland over *Lyginia imberbis* low isolated rushes on grey, yellow, white coarse-grained sand on consolidated dunes.	12.7% / 125.5 ha	

Unit code	Quadrats	Broad floristic formation and site preference	Vegetation description	Area of study area	Photograph
Em[4]	COR04	*Eucalyptus* woodland Consolidated dunes	*Eucalyptus marginata* mid sparse woodland over *Banksia attenuata, Banksia grandis* and *Nuytsia floribunda* tall sparse shrubland over *Jacksonia floribunda* and *Adenanthos cygnorum* subsp. *cygnorum* mid open shrubland over *Eremaea pauciflora* var. *pauciflora*, *Hibbertia hypericoides* and *Melaleuca systena* low heath shrubland over *Mesomelaena pseudostygia* low sparse sedgeland with white brown coarse grained sand on consolidated dune rises.	5.1% / 50.6 ha	
Et	COR08, COR16, COR22, COR23 & COR29	*Eucalyptus* woodland Consolidated dunes	*Eucalyptus todtiana* mid sparse to mid isolated mallee woodland with occasional *Nuytsia floribunda* low isolated trees over *Banksia attenuata, Banksia menziesii* and *Adenanthos cygnorum* subsp. *cygnorum* tall sparse shrubland over *Allocasuarina humilis, Xanthorrhoea preissii* and *Jacksonia floribunda* mid open shrubland over *Eremaea pauciflora* var. *pauciflora, Hibbertia hypericoides* and *Calothamnus sanguineus* low open to low sparse shrubland over *Mesomelaena pseudostygia* low sparse sedgeland on yellow, brown coarse-grained sand on consolidated dunes.	8.7% / 86.3 ha	

5.1.5.2 Floristic Community Types

The floristic information collected from the 30 relevés was compared against the floristic data from *'A Floristic Survey of the southern Swan Coastal Plain'* (Gibson *et al*., 1994) to determine the nearest match to the Floristic Community Types (FCTs) known to occur on the Swan Coastal Plain.

The results of the presence/absence comparison between the 30 relevés and the floristic data collected by Gibson *et* al. (1994) are presented in Table 11.

Table 11 Inferred floristic community types

Relevé	Nearest matches (FCT)	Landform	Inferred match	Description
COR01	28; 1a; 20a; 20b; & 21a	Ridge Hill/ Pinjarra	20b	Eastern *Banksia attenuata* and/or *Eucalyptus marginate.*
COR02	28; 20a; 21a; 21b; & 23a	Spearwood	28	Spearwood *Banksia attenuata* or *Banksia attenuata-Eucalyptus marginata* woodlands.
COR03	28; 23b; 20a; 20b; & 21a	Spearwood/ Pinjarra	20a	*Banksia attenuata* woodlands over species rich dense shrublands.
COR04	28; 20a; 23a; 23b; & 21a	Bassendean	23b	Northern *Banksia attenuata-Banksia menziesii* woodlands.
COR05	28; 1a; 20b; 21a; & 3a	Ridge Hill/ Pinjarra	20b	Eastern *Banksia attenuata* and/or *Eucalyptus marginate.*
COR06	28; 21c; 23a; 23b; & 21a	Bassendean	23b	Northern *Banksia attenuata-Banksia menziesii* woodlands.
COR07	28; 21a; 1a; 21b; & 21c	Bassendean/ Spearwood	21a	Central *Banksia attenuata-Eucalyptus marginata* woodlands.
COR08	28; 20a; 21a; 23a ;& 23b	Spearwood/ Pinjarra	20a	*Banksia attenuata* woodlands over species rich dense shrublands.
COR09	28; 1a; 3b; 3b ;& 1b	Bassendean/ Spearwood	21a	Central *Banksia attenuata-Eucalyptus marginata* woodlands.
COR10	23a; 28; 23b; 21a; & 20a	Bassendean	23b	Northern *Banksia attenuata-Banksia menziesii* woodlands.
COR11	28; 23b; 20b; 20a; & 21a	Bassendean	23b	Northern *Banksia attenuata-Banksia menziesii* woodlands.
COR12	28; 1a; 21a; 3b; & 3b	Bassendean/ Spearwood	21a	Central *Banksia attenuata-Eucalyptus marginata* woodlands.
COR13	28; 1a; 21a; 1b; & 21b	Bassendean/ Spearwood	21a	Central *Banksia attenuata-Eucalyptus marginata* woodlands.
COR14	28; 21a; 24; 21c; & 23a	Bassendean	21c	Low lying *Banksia attenuata* woodlands or shrublands.
COR15	28; 21a; 23a; 24; & 26b	Bassendean/ Spearwood	21a	Central *Banksia attenuata-Eucalyptus marginata* woodlands.
COR16	28; 21a; 23a; 23b; & 20a	Bassendean/ Spearwood	21a	Central *Banksia attenuata-Eucalyptus marginata* woodlands.

Relevé	Nearest matches (FCT)	Landform	Inferred match	Description
COR17	28; 20b; 21a; 1a; & 21b	Ridge Hill/ Pinjarra	20b	Eastern *Banksia attenuata* and/or *Eucalyptus marginate.*
COR18	21a; 23b; 28; 23a; & 20a	Bassendean	23b	Northern *Banksia attenuata-Banksia menziesii* woodlands.
COR19	28; 23b; 23a; 20a; & 21c	Bassendean	23a	Central *Banksia attenuata-Banksia menziesii* woodlands.
COR20	28; 20a; 21b; 23a; & 20b	Spearwood/ Pinjarra	20a	*Banksia attenuata* woodlands over species rich dense shrublands.
COR21	28; 21a; 23a; 26b; & 26b	Bassendean	23b	Northern *Banksia attenuata-Banksia menziesii* woodlands.
COR22	28; 23b; 23a; 20a; & 21a	Bassendean	23a	Central *Banksia attenuata-Banksia menziesii* woodlands.
COR23	28; 20a; 23a; 23b; & 20b	Spearwood/ Pinjarra	20a	*Banksia attenuata* woodlands over species rich dense shrublands.
COR24	23b; 23a; 28; 21c; & 20a	Bassendean	23a	Central *Banksia attenuata-Banksia menziesii* woodlands.
COR25	28; 20a; 21a; 23a; & 23b	Spearwood/ Pinjarra	20a	*Banksia attenuata* woodlands over species rich dense shrublands.
COR26	28; 20a; 23b; 21a; & 23a	Bassendean	23b	Northern *Banksia attenuata-Banksia menziesii* woodlands.
COR27	28; 20a; 23b; 20b; & 21a	Bassendean	23b	Northern *Banksia attenuata-Banksia menziesii* woodlands.
COR28	28; 20a; 23b; 20b; & 21a	Bassendean	23b	Northern *Banksia attenuata-Banksia menziesii* woodlands.
COR29	28; 20a; 23b; 21a; & 23a	Bassendean	23b	Northern *Banksia attenuata-Banksia menziesii* woodlands.
COR30	21c; 23a; 23b; 28; & 20c	Bassendean	21c	Low lying *Banksia attenuata* woodlands or shrublands.

It must be noted that the determination of the FCTs from the floristic data collected from the 30 relevés is considered to be an inference. To accurately determine the FCTs, systematic sampling of quadrats located in representative vegetation associations and multivariate analysis against the floristic data collected by Gibson *et al.* (1994), is required.

According to the comparison (Table 11), the following FCTs potentially occur in the study area:

- FCT20a – *Banksia attenuata* woodlands over species rich dense shrublands.
- FCT20b – Eastern *Banksia attenuata* and/or *Eucalyptus marginate.*
- FCT21a – Central *Banksia attenuata-Eucalyptus marginata* woodlands.
- FCT21c – Low lying *Banksia attenuata* woodlands or shrublands.
- FCT23a – Central *Banksia attenuata-Banksia menziesii* woodlands.

- FCT23b – Northern *Banksia attenuata-Banksia menziesii* woodlands.
- FCT28 – Spearwood *Banksia attenuata* or *Banksia attenuata-Eucalyptus marginata* woodlands.

According to DPAW information on ecological communities on the Swan Coastal Plain, FCT20a (also known as SCP20a) and FCT20b (also known as SCP20b) are considered to be Threatened Ecological Communities. FCT21c and FCT23b, also known as SCP21c and SCP23b respectively, are considered to be Priority Ecological Communities.

The locations of the inferred TECs and PECs are provided in Figure 9 and discussed in more detail in Section 5.1.4.3.

5.1.5.3 Threatened and Priority Ecological Communities

The floristic information collected from the 30 relevés was compared against the floristic data collected from the Gibson *et al.* (1994) survey of the Southern Swan Coastal Plain and the descriptions available for the TECs and PECs from DPAW to infer the presence of any additional TECs and PECs.

The majority of the study area is considered to be representative of the P2 PEC Banksia Yellow-Orange Sands and the PEC SCP23b. Both PECs are known to occur extensively within and adjacent to the study area. The description for the PEC Yellow-Orange Sands is:

> Species-rich Banksia woodlands on deep yellow-red sands that appears restricted to the western Dandaragan Plateau. The vegetation is described as scattered *Eucalyptus todtiana* and *Corymbia calophylla* over *Banksia menziesii* and *Banksia attenuata* low open woodland over *Jacksonia sternbergiana* and *Adenanthos cygnorum* high open shrubland over *Allocasuarina humilis* and *Chamelaucium* sp. Gingin (N.G. Marchant 6)(T) open shrubland over *Eremaea pauciflora* and *Astroloma xerophyllum* low shrubland over *Mesomelaena pseudostygia* open sedgeland.

Vegetation associations BaBm[1], BaBmNf, Et and EtNf are considered to be representative of the Priority 2 Banksia Yellow-Orange Sands. The four vegetation associations listed above consist of *Eucalyptus todtiana* over Banksia spp. with an understorey layer dominated by *Allocasuarina humilis* and *Eremaea pauciflora* var. *pauciflora* over a sedge layer consisting of *Mesomelaena pseudostygia* on coarse-grained deep yellow-brown sands. This is considered to be consistent with the description of the PEC.

In addition to the known locations of the TEC and the PECs, based on a comparison between the floristic data collected from the 30 relevés with Gibson *et al.* (1994), an additional two TECs (SCP20a, SCP20b) and one PEC (SCP21c) potentially occur within the study area. The comparison confirmed the presence of the PEC SCP23b, known to occur within the study area. The location of the TECs and the PECs are presented in Figure 9.

The descriptions as provided by DPAW, for the additional TECs and the PECs are detailed below:

- Threatened Ecological Communities:
  - SCP20a – *Banksia attenuata* woodland over species rich dense shrublands. The TEC SCP20a is classified as Endangered. SCP20a corresponded with relevés COR03, COR08, COR20, COR23 and COR25. These relevés correspond with vegetation associations BaBmNf, Et, Cc[2] and Em[2].
  - SCP20b – *Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain. The TEC SCP20b is classified as Endangered. The TEC SCP20b corresponded with relevés COR01, COR05 and COR17, which corresponded with vegetation associations EmCc[1], EmCc[2] and CcEm.
  - SCP20c – Shrublands and woodlands of the eastern side of the Swan Coastal Plain. The TEC SCP20c is classified as Critically Endangered. According to DPAW data, the TEC SCP20c occurs

in the southeast of the study area. The exact location is difficult to determine based on the information provided by DPAW. The buffer associated with the TEC is 500 m which indicates that the TEC is located in association with vegetation association Em[3] and relevé COR07. Relevé COR07 was inferred to represent FCT21a, which is not listed as a TEC or a PEC.

- Priority Ecological Communities:
  - SCP21c – Low lying *Banksia attenuata* woodlands or shrublands. This P3 PEC occurs sporadically between Gingin and Bunbury, and is largely restricted to the Bassendean system. The PEC tends to occupy lower lying wetter sites and is variously dominated by *Melaleuca preissiana, Banksia attenuata, Banksia menziesii, Regelia ciliata, Eucalyptus marginata* or *Corymbia calophylla*. Structurally, this community type may be either a woodland or occasionally shrubland. The PEC SCP21c corresponded with relevés COR14 and COR30 and occurred in low lying areas with *Melaleuca preissiana* present. The vegetation associations that correspond with COR14 and COR30 are Ba and BaBm[2].
  - SCP23b – Swan Coastal Plain *Banksia attenuata - Banksia menziesii* woodlands. These woodlands occur in the Bassendean system, from Melaleuca Park to Gingin. The P3 PEC occurs in reasonably extensive Banksia woodlands north of Perth. The PEC SCP23b is represented by relevés COR04, COR06, COR10, COR11, COR18, COR21, COR26, COR27, COR28 and COR29. These relevés corresponded with vegetation associations Em[4], Em, EtNf, BaBmNf, Em[3], Cc[3] and Et.

There is significant overlap between the inferred TECs and PECs and the known TECs and PECs (according to DPAW data). To remove the overlap and accurately confirm the presence of TECs or PECs, a systematic quadrat sampling survey with multivariate analysis needs to be completed across the study area.

In the case of an overlap between the PEC Banksia Yellow-Orange Sands and the inferred TECs and PECs, the PEC Banksia Yellow-Orange Sands has been mapped. This is based on the accurate vegetation description provided by DPAW compared to the data available on the remaining TECs and PECs and the reliance on multivariate analysis.

DPAW also identify Banksia dominated woodlands on the Swan Coastal Plain bioregion as a Priority 3 ecological community. The main feature of these Banksia woodlands is the presence of Banksia attenuata and/or Banksia menziesii occurring on deep sands, with the species commonly co-occurring. The community occurs on the Quindalup, Spearwood and Bassendean dunes and rarely on the Pinjarra Plain landforms, which comprise the dominant landforms of the Swan Coastal Plain.

5.1.5.4 Vegetation Complexes

The study area is located across five vegetation complexes; the Mogumber complex-south, Reagan complex, Karamal complex-south, Coonambidgee complex and Moondah complex. The pre-European extent, extent remaining in 2013 and the pre-European extent remaining in formal protection is provided in Table 12. Formal protection includes native vegetation remaining in conservation estate, Bush Forever sites in conservation estate and Bush Forever sites in Regional Parks.

The National Objectives and Targets for Biodiversity Conservation 2001-2005 recognises that a retention of 30% or more of the pre-clearing extent of each ecological community is necessary if Australia's biological diversity is to be protected (ANZECC, 2000). In addition to the Australian and New Zealand Environment and Conservation Council (ANZECC) 30% retention target, the EPA has adopted a 10% level of pre-clearing extent as representing 'endangered' (EPA, 2000).

The pre-European extent remaining on the Swan Coastal Plain for each vegetation complex is greater than 30%; however, only the Coonambidgee (10%) and the Karamal Complex-South (27%) have greater than 10% of the pre-European extent remaining in formal protection.

Table 12 Native vegetation extent by vegetation complexes on the Swan Coastal Plain

Vegetation Complex	Pre-European extent (ha)	2013 extent (ha)	Pre-European extent remaining (%)	Formal protection[1] (ha)	Pre-European extent with formal protection (%)	Extent within the study area	Inclusion of the study area (%)
Coonambidgee	6,272.3	2,859.5	45.6	647.7	10.3	8.7	10.5
Karamal (south)	24,016.7	15,225.9	63.4	6,513.5	27.1	181.3	27.9
Mogumber (south)	13,985.5	5,621.9	40.2	175.3	1.3	424.9	4.3
Moondah	17,858.8	7,279.8	40.8	1,742.8	9.8	105.2	10.4
Reagan	9,080.5	3,052.4	33.6	341.4	3.8	266.3	6.7

Source: Perth Biodiversity Program (WALGA 2013).
1: Formal protection includes DPAW conservation estates, Bush Forever on conservation estate and Bush Forever in Regional Parks.

The vesting of the study area as conservation estate will increase the formal protection of each of the vegetation complexes. However, the increase is not sufficient to increase the pre-European extents above the 30% threshold.

The inclusion of the study area into the conservation estate will not increase the pre-European extent within formal protection above the endangered 10% level for any of the vegetation complexes within the study area. However, the pre-European extent of the Moondah vegetation complex within formal protection will be increased above the 10% endangered level (an increase of 0.6% to 10.4%).

5.1.6 Ecological Corridors

The study area is located within the Perth subregion which has historically been cleared for urban development, industrial development and agriculture. As a result only 42% (or 473,176 ha) of the pre-European extent for the Perth subregion (1,117,757 ha) remains intact (DPAW, 2013a).

The study area is located within an ecological corridor linking Boonanarring Nature Reserve and Leda Nature Reserve. The corridor runs in a north to south alignment and is fragmented in sections and crosses the Great Northern Highway.

The study area is not located within an east-west ecological corridor. The east-west movement of flora and fauna is impeded by the historical clearing of native vegetation along both sides of the Brand Highway.

5.1.7 Taxa Recorded

A total of 154 vascular taxa were recorded from the study area during the site visit. This included 148 native taxa and six introduced taxa from 36 families and 88 genera. Two taxa were not identified to genus level, one was from the Orchidaceae family. The taxon was not identified to genus level because only the basal leaf was present. The remaining taxon that was not identified to genera level had inadequate material to make an accurate identification to genera.

An additional seven taxa, *Austrodanthonia* sp., *Haemodorum* sp., *Anigozanthos* sp., *Pimelea* sp. 1, *Pimelea* sp. 2, *Stylidium* sp. and **Lupinus* sp., were only identified to genus level. The taxa within the field were not flowering and/or fruiting at the time of the survey which is required to ensure a positive identification.

The dominant families recorded from the study area are listed in Table 13, while the dominant genera recorded from the study area is listed in Table 14. The entire list of vascular taxa recorded from the study area is provided in Appendix G.

Table 13 Dominant families recorded from the study area

Family name	Common name	Native taxa	Introduced taxa
Proteaceae	Banksia family	28	0
Fabaceae	Legume or Pea family	24	1
Myrtaceae	Myrtle family	19	0
Ericaceae	Heath family	12	0
Cyperaceae	Sedge family	8	0

Of the 36 families recorded from the study area, 18 families were only represented by one genera, while the vast majority of the taxa were members of four families, the Proteaceae, Fabaceae, Myrtaceae and Ericaceae, which constituted approximately 55% of the total number of taxa recorded.

Table 14 Dominant genera recorded from the study area

Genera	Common name	Native taxa	Introduced taxa
Acacia	Wattle	10	0
Banksia	Banksias	7	0
Hakea	Hakeas	7	0
Daviesia	Daviesias	6	0

Of the 88 genera recorded from the study area, 58 genera were only represented by one taxon. The dominant nine genera (*Acacia, Banksia, Hakea, Daviesia, Calytrix, Hibbertia, Lepidosperma, Lomandra* and *Petrophile*) represented approximately 33% of the total number of taxa recorded.

5.1.8 Taxa of Significance

One Threatened and six Priority listed taxa are known to occur in the study area. The known locations were traversed to locate the conservation significant taxa and to further refine the population size. The Threatened taxa, *Chamelaucium* sp. Gingin (N.G. Marchant 6), was located in the northwest of the study area. *Chamelaucium* sp. Gingin (N.G. Marchant 6) (Plates 1 to 3) is a Threatened taxon under the WC Act with a classification of Vulnerable and it is listed as Endangered under the Commonwealth EPBC Act (see Figure 9).

Chamelaucium sp. Gingin (N.G. Marchant 6) is endemic to Western Australia and is apparently confined to the Gingin/Chittering area where it is known from a range of only 3 km and six populations (Stack and English, 2003). The six known populations contain a total of approximately 4700 adult plants and 1800 juveniles. This species occurs on white/yellow sand supporting open low woodland with *Eucalyptus todtiana, Banksia attenuata* and *Hibbertia* species.

Plate 1 ***Chamelaucium* sp. Gingin (N.G. Marchant 6) growing along fence line between offset site and nature reserve**

Plate 2 ***Chamelaucium* sp. Gingin (N.G. Marchant 6), close-up of buds before flowering**

Plate 3 **Chamelaucium sp. Gingin (N.G. Marchant 6), close-up of flowers**

Plate 4 ***Hypolaena robusta* (Priority 4)***

* Photography by A.D. Crawford. Image used with the permission of the Western Australian Herbarium, Department of Parks and Wildlife (http://florabase.dpaw.wa.gov.au/help/copyright). Accessed on Tuesday, 26 August 2014.

Plate 5 **Arum Lily (****Zantedeschia aethiopica***)**

Chamelaucium sp. Gingin (N.G. Marchant 6) is an open straggly shrub growing to a height of 1 to 2 m tall and has many slender stiff branches that bear numerous long axillary shoots. Its erect, glandular, bright green leaves are 5.4-11.5 mm long by 1.2-1.4 mm wide, and are scattered along the main branches, but are mostly crowded on numerous short axillary shoots. The inflorescence is composed of a small head on short axillary shoots or sometimes a larger flower head at the end of main branches. The flowers occur in groups of two to nine in small heads on axillary shoots. Up to 20 flowers are held in clusters at the end of main branches. The flowers are pale pinkish-white, and the buds are tinged a deeper pink (adapted from Stack and English, 2003).

Critical habitat is defined as habitat that is identified as being critical to the survival of the threatened taxon. The critical habitat for *Chamelaucium* sp. Gingin (N.G. Marchant 6) comprises:

- The area of occupancy of known populations.
- Areas of similar habitat within 200 m of known populations, i.e. white/yellow sand supporting open low woodland over open scrub (these provide potential habitat for natural range extensions).
- Corridors of remnant vegetation that link populations (these are necessary to allow pollinators to move between populations and are usually road and rail verges).
- Additional occurrences of similar habitat that do not currently contain the species but may have done so in the past (these represent possible translocation sites).

The study area represents critical habitat for *Chamelaucium* sp. Gingin (N.G. Marchant 6) for the existing population and areas of similar habitat within 200 m and providing a vegetated corridor linking populations.

Of the six Priority listed taxa recorded from the study area, only one was re-recorded, *Hypolaena robusta* (P4). The remaining five Priority listed taxa were not identified during the July 2014 site visit. No other Priority listed taxa were recorded from the study area.

Hypolaena robusta is listed a Priority 4 taxon and is a member of the Restionaceae or rush family. *Hypolaena robusta* (see Plate 4) is described as a tall stout, dioecious rhizomatous, perennial rush with well-spaced culms on thick rhizomes (Meney and Pate, 1999; DPAW, 2014c). It is known to occur on white sand on the sandplains of the northern Swan Coastal Plain and the Northern Sandplain (DPAW, 2014c). It flowers in early to mid-spring (September and October) (DPAW, 2014c; Meney and Pate, 1999).

The locations of *Chamelaucium* sp. Gingin (N.G. Marchant 6) (T) and *Hypolaena robusta* (P4) recorded from the study area are provided in Table 15. The locations of Threatened and Priority listed flora within the study area is provided in Figure 9.

Table 15 Threatened and Priority listed taxa recorded from the study area

Taxa	Phenology and life form	Individuals	Zone 50J, GDA 94	
			Easting	Northing
Chamelaucium sp. Gingin (N.G. Marchant 6) (T)	Adults and seedlings. Buds present on adults.	50+	402225	6517206
Chamelaucium sp. Gingin (N.G. Marchant 6) (T)			402229	6517194
Chamelaucium sp. Gingin (N.G. Marchant 6) (T)			402235	6517193
Chamelaucium sp. Gingin (N.G. Marchant 6) (T)			402222	6517190
Chamelaucium sp. Gingin (N.G. Marchant 6) (T)			402226	6517212
Chamelaucium sp. Gingin (N.G. Marchant 6) (T)	Adults with buds.	10+	402227	6517251

Taxa	Phenology and life form	Individuals	Zone 50J, GDA 94	
			Easting	Northing
Chamelaucium sp. Gingin (N.G. Marchant 6) (T)	Adults with buds.	20+	402232	6517409
Chamelaucium sp. Gingin (N.G. Marchant 6) (T)	Adults with buds.	30+	402298	6517414
Chamelaucium sp. Gingin (N.G. Marchant 6) (T)	Adults and seedlings. Adults with buds.	70+	402324	6517417
Chamelaucium sp. Gingin (N.G. Marchant 6) (T)	Adults.	3	402365	6516987
Chamelaucium sp. Gingin (N.G. Marchant 6) (T)	Adults.	1	402383	6516980
Chamelaucium sp. Gingin (N.G. Marchant 6) (T)	Adults and seedlings. Adults with buds.	10+	402460	6517417
Hypolaena robusta (P4)	Last season's flowers and buds.	Unknown	403976	6514919
Hypolaena robusta (P4)	Last season's flowers and buds.	Unknown	403985	6516766

5.1.9 Introduced Taxa

A total of six introduced taxa were recorded from the study area during the site visit. The six introduced taxa were reviewed to determine if they are WONS, a Declared Pest under the BAM Act or an Environmental Weed with a 'High' rating (Table 16).

Table 16 Introduced taxa recorded from the study area

Species	Common name	Family	WONS (EPBC Act)	Declared pest (BAM Act)	Environmental weed rating (CALM, 1999)	Species-led ranking (DPAW, 2013b)
**Zantedeschia aethiopica*	Arum Lily	Araceae	No	Declared Pest (s22)	High	Medium
**Lupinus* sp.	Lupin	Fabaceae	No	Permitted (s11)	High	High[1]
**Brassica tournefortii*	Wild Turnip	Brassicaceae	No	Permitted (s11)	High	Low
**Briza maxima*	Quaking Grass	Poaceae	No	Permitted (s11)	Moderate	Low
**Hypochaeris glabra*	Smooth Catsear	Asteraceae	No	Permitted (s11)	Moderate	Low
**Gladiolus caryophyllaceus*	Wild Gladiolus	Iridaceae	No	Permitted (s11)	Moderate	Medium

1: The highest ranked Lupin (**Lupinus angustifolia* and **Lupinus cosentinii*) has been chosen to ensure the introduced taxa is appropriately managed at the upper limit.

5.1.9.1 WONS and Declared Pests

None of the six introduced taxa are WONS. Arum Lily (**Zantedeschia aethiopica*) is considered to be a Declared Pest under Section 22 of the BAM Act (see Figure 6). The remaining five introduced taxa are classified as Permitted under Section 11 of the BAM Act.

The BAM Act and regulations were enacted on 1 May 2013. The BAM Act replaces the *Agriculture and Related Resources Protection Act 1976*. The main purposes of the BAM Act that relate to weeds are to:

- Prevent new animal and plant pests (vermin and weeds) and diseases from entering Western Australia.
- Manage the impact and spread of those pests already in Western Australia.

Organisms are grouped into four main classifications:

- Declared pests (under Section 22 of the Act).
- Permitted (under Section 11 of the Act).
- Prohibited (under Section 12 of the Act).
- Permitted requiring a permit (under Section 73 of the BAM Regulations 2013).

Under the BAM Act, all Declared Pests are placed in one of three categories, namely C1 (exclusion), C2 (eradication) or C3 (management). Arum Lily has been placed in the C3 (management) category and it is prohibited to keep in WA. Arum Lily was recorded from one location in the southwest corner of the study area (Table 17; see Plate 5).

Table 17 GPS coordinate (Zone 50J, GDA94) for the known Arum Lily location

	Easting	Northing
Arum Lily (**Zantedeschia aethiopica*)	402409	6514543

5.1.9.2 Environmental Weeds and Weed Prioritisation Process

The Environmental Weed Strategy for Western Australia (EWSWA) (CALM, 1999) has detailed criteria for the assessment and rating of introduced flora based on their impact on biodiversity. The criteria included:

- Invasiveness – ability to invade bushlands in good to excellent condition or ability to invade waterways (score of yes or no).
- Distribution – wide current or potential distribution including consideration of known history of widespread distribution elsewhere in the world (score as a yes or no).
- Environmental impacts – ability to change the structure, composition and function of ecosystems in particular an ability to form a monoculture in a vegetation community (score as a yes or no).

The EWSWA uses the following scoring system:

- High – an introduced flora species that scores yes to all three criteria. An introduced flora species with a high rating would indicate prioritising this weed for control and/or research.
- Moderate – an introduced flora species that scores yes to tow of the three criteria. Rating an introduced flora species as moderate would indicate that control or research effort should be directed if funds are available, however it should be monitored.

- Mild – an introduced flora species that scores yes to one of the three criteria. A mild rating would indicate that monitoring and control of the introduced flora species is necessary where appropriate.
- Low – an introduced flora species that scores no to all three criteria. A low rating would mean that this species would require a low level of monitoring.

The EWSWA (CALM, 1999) provided a ranking of weed species on a state-wide basis against three criteria – invasiveness, distribution and environmental impacts (as detailed above). A total of 1350 weeds were rated through this process as high, moderate, mild or low, with 34 weed species being rated as high.

The State-wide ratings from the Strategy are now considered to be too broad to be of use from an on-ground operational perspective and are now out of date (DPAW, 2013b). In an effort to address these issues and implement an integrated approach to weed management on DPAW-managed lands in WA, the Weed Prioritisation Process for DPAW was developed in 2008.

DPAW proposed that the Weed Prioritisation Process was to prioritise in each DPAW Region, with the aim being to establish both a species-led and an asset-protection-based approach to weed management (DPAW, 2013b). The species-led process assessed weed species for their invasiveness, ecological impacts, potential and current distribution and feasibility of control. The resulting priorities focus on infestations of species which are considered to be high impact, rapidly invasive and still at a population size which is feasible to eradicate or contain to a manageable size. Hence, weed species which are already widespread did not rank as a high priority through this part of the process.

The rating for each of the six introduced taxa with regards to the EWSWA and the Species-led process is detailed in Table 16.

5.2 Fauna

5.2.1 Fauna Habitats

A total of three fauna habitats were recorded in the study area: Banksia Woodland, Eucalypt Woodland and a Dampland (Figure 10). Tracks comprised 9 ha. Habitat assessments were completed at 26 sites across the study area (Appendix H). Habitats are summarised in Table 18 and detailed in the following sections.

Table 18 Fauna habitat types

Habitat type	Area (ha)	Habitat value	Black Cockatoo value
Banksia Woodland	663	Moderate	Moderate
Eucalypt Woodland	315	High	High
Dampland	3	Moderate	Low

5.2.1.1 Banksia Woodland

The vegetation of this habitat type is typified by *Banksia attenuata, Banksia menziesii, Eucalyptus todtiana* and *Nuytsia floribunda* woodland over *Allocasuarina humilis, Xanthorrhoea preissii* and *Macrozamia riedlei* over various herb and sedge species. The Banksia Woodland habitat is generally located on the geographically flat section of the study area. This habitat type has occasional and sporadic mature Jarrah trees growing with in it and they are usually associated with the buffer zone between the Banksia woodland and Eucalypt Woodland habitats. The sandy soils of this habitat provide ideal substrate for burrowing species such as dragons and goannas. Microhabitats provided by this habitat include leaf litter, exfoliating bark and Banksia flowers which provide a feeding resource to nectivores. Due to the dominance of the Banksia species this habitat type does not contain many tree hollows or hollows logs. The Banksia

Woodland habitat is classified as being in excellent condition with little weed impact, old fire age and some dieback effected areas and it provides moderate habitat value.

5.2.1.2 Eucalypt Woodland

The vegetation of this habitat type is typified by *Eucalyptus marginata*, *Eucalyptus todtiana* and *Corymbia calophylla* over *Banksia attenuata* and *Banksia menziesii* over herbs and sedges. The Eucalypt Woodland habitat is generally dominated by jarrah over most of the study area with Marri becoming increasingly more common along the western border of the site. The sandy soils of this habitat provide ideal substrate for burrowing species such as dragons and goannas. Microhabitats provided by this habitat include sandy soils, leaf litter, exfoliating bark, hollow logs and tree hollows. The dense canopy foliage and presence of tree hollows provides suitable habitat for a range of birds, specifically for the species that nest in tree hollows such as parrots. The abundant leaf litter and fallen logs produce refuge for ground dwelling fauna. The Eucalypt Woodland habitat is classified as being in excellent condition with little weed impact, old fire age and some dieback effected areas and it provides high habitat value.

5.2.1.3 Dampland

The vegetation of this habitat type is typified by *Banksia attenuata* woodland over *Kunzea glabrescens* and *Banksia menziesii* shrubland over *Macrozamia riedlei* and *Xanthorrhoea preissii* over various sparse herbs in a seasonally inundated depression. The Dampland habitat is located in the low lying part, in the southwest of the study area. The Dampland is a small remnant (3 ha) after the rest of the habitat was cleared and used as pastures in the surrounding properties. This habitat type as its name suggests is an area where moisture collects and during the winter months becomes seasonally waterlogged. The damp nature of this habitat provides an ideal environment for amphibians. Microhabitats provided by this habitat include damp soil, leaf litter, exfoliating bark and dense mid-story vegetation which provide habitat for many bird species. The Dampland habitat is classified as being in excellent condition with little weed impact, old fire age and it provides moderate habitat value.

5.2.2 Black Cockatoo Habitat Assessment

The habitat types of the study area were assessed upon the habitat they provide to Black Cockatoos and classified as being high, moderate or low value habitats. The Eucalypt Woodland provides quality foraging, roosting and breeding habitat and is classified as being high value Black Cockatoo habitat. The Banksia Woodland provides quality foraging habitat and is classified as being moderate value Black Cockatoo habitat, due to the lack of breeding habitat. The Dampland provides limited foraging habitat and is classified as being low value Black Cockatoo habitat (Table 18 and Figure 11). A description of the foraging, roosting and breeding habitat is provided in the following sections.

5.2.2.1 Foraging Assessment

The study area contains 17 plant species that are known foraging resources for Black Cockatoos (Valentine and Stock, 2008, and Chapman, 2007) (Table 19). All habitat types contained multiple foraging resources, as such the entire study area can be classified as foraging habitat for Black Cockatoos which equates to approximately 981 ha of foraging habitat. No signs of current and historical foraging evidence were located.

Table 19 Foraging Resources of the study area

Foraging species	Foraging resource
Banksia attenuata	flowers, seeds
Banksia dallanneyi	flowers, seeds
Banksia grandis	flowers, seeds

Foraging species	Foraging resource
Banksia menziesii	flowers, seeds
Banksia sessilis	flowers, seeds
Corymbia calophylla	flowers, seeds, nectar
Eucalyptus marginata	seeds
Eucalyptus todtiana	seeds
Hakea costata	seeds
Hakea lissocarpha	seeds
Hakea prostrata	seeds
Hakea ruscifolia	seeds
Hakea stenocarpa	seeds
Hakea trifurcata	seeds
**Lupinus* sp.	seeds
Mesomelaena tetragona	seeds
Mesomelaena pseudostygia	seeds
Xanthorrhoea preissii	seeds

5.2.2.2 Roosting Assessment

The Eucalypt Woodland habitat contains stands of tall trees that are located close to riparian environments and permanent water sources, which according to the Cockatoo referral guidelines constitutes roosting habitat for Black Cockatoos (DSEWPAC, 2012). Trees or stands of trees that match this description were examined for evidence of recent use as a roost site (feathers and droppings), however none was located.

A database search was completed for known roost locations for Carnaby's Cockatoos with none located in the study area or its immediate surrounds. The closest known roost sites occur in Gingin and Yanchep which are approximately 17 km north and west of the study area respectively (Burnham et al., 2010).

5.2.2.3 Breeding Assessment

As the study area was too large to accurately measure individual trees, a tree dentistry survey was used to give an estimate of the number of potential breeding trees (Appendix I). The study area contains an estimated 6,353 trees that have a DBH over 500 mm. This number is most likely an underestimate as the Banksia Woodland contained some suitable sized trees, however these were omitted from the total tree estimate as their sporadic nature would make the tree density estimates inaccurate. The Cockatoo referral guidelines states "in a woodland stand with trees of suitable diameter at breast height, all trees of all ages and size are potentially important for maintaining breeding in the long term," as such the Eucalypt Woodland is classified as breeding habitat (approximately 315 ha). The tree density survey identified areas of high, moderate and low tree densities within the Eucalypt Woodland. Areas containing a tree density of between 0-9 trees per hectare were classified as low density, areas with densities of 10-19 trees per hectare were classified as moderate density and areas containing 20 or more trees per hectare were classified as being high density (Table 20 and Figure 11).

Table 20 Breeding tree density

Tree density	Area (ha)
Eucalypt Woodland – High Density	193
Eucalypt Woodland – Moderate Density	112
Eucalypt Woodland – Low Density	10

A total of 30 trees with hollows classified as suitable for current breeding (with an opening greater than 20 cm diameter) were opportunistically identified across the site (Appendix I). However, there was no evidence of their use as historic breeding sites (chew marks around hollow openings and droppings). As stated these records were opportunistically recorded while walking around the study area and do not represent the full breeding capability of the site.

The availability of foraging habitat within 6 to 12 km of breeding sites is important in providing the resources necessary for raising chicks (DSEWPAC, 2012). The study area and the surrounding nature reserves (Boonanarring Nature Reserve and Leda Nature Reserve) contain large amounts of quality foraging habitat supporting any potential breeding sites in the vicinity.

5.2.3 Faunal Assemblage

From the desktop assessment a total of 221 species have been previously recorded in the vicinity of the study area (Appendix J). These include 12 amphibians, 47 reptiles, 134 birds and 28 mammals. As stated earlier all marine and aquatic species have been omitted from this list as no suitable habitat is present. Of these 39 species were recorded during the survey including one species of amphibian, three species of reptile, 32 species of bird and three species of mammal. The Black-eared Cuckoo (*Chrysococcyx osculans*) was recorded during the survey but has not been previously recorded form the vicinity. This record is just outside of the southerly distribution of this otherwise common species.

5.2.3.1 Amphibians

From the desktop review a total of 12 species of amphibian were identified as being previously recorded in the vicinity of the study area. One species, the Quacking Frog (*Crinia georgiana*) was recorded in the Eucalypt Woodland habitat type during the survey (Appendix J).

5.2.3.2 Reptiles

From the desktop review a total of 47 species of Reptile were identified as being previously recorded in the vicinity of the study area. Three species, the Buchanan's Snake-eyed Skink (*Cryptoblapherus buchananii*), West Coast *Ctenotus* (*Ctenotus fallens*) and the Southern Shovel-nosed Snake (*Brachyurophus semifasciatus*) were recorded in the Eucalypt Woodland habitat type during the survey (Appendix J).

5.2.3.3 Birds

From the desktop review a total of 134 species of birds were identified as being previously recorded in the vicinity of the study area. A total of 32 species were recorded during the survey. The most speciose families recorded during the survey were Psittacidae (Parrots) with four species, Meliphagidae (Honeyeaters) with four species and Cuculidae (Cuckoos) with three species (Appendix J).

5.2.3.4 Mammals

From the desktop review a total of 28 species of mammals were identified as being previously recorded in the vicinity of the study area. A total of three species of mammal were recorded during the survey, the Western Grey Kangaroo (*Macropus fuliginosus*), Western Brush Wallaby (*Macropus irma*) and the Red Fox (*Vulpes vulpes*) which is an introduced species (Appendix J).

5.2.4 Conservation Significant Fauna

The Western Brush Wallaby (*Macropus irma*) listed as Priority 4 was the only conservation significant fauna species recorded during the survey (Table 21 and Figure 10).

From the desktop assessment a total of 14 conservation significant species have been previously recorded in the study area. Of these one species was recorded, six species are classified as 'Likely' to occur, three species are classified as 'Possible' to occur and four species are classified as 'Unlikely' to occur (Table 22).

Table 21 Location of recorded conservation significant fauna

Species	Conservation status	Habitat type	Easting	Northing
Western Brush Wallaby (*Macropus irma*)	P4	Eucalypt Woodland	50J 404973	6515779

Table 22 Likelihood of occurrence for conservation significant fauna

Species	Conservation status	Habitat relevance	Likelihood[1]
Western Carpet Python (*Morelia spilota imbricata*)	S4	All habitat types within the study area provide habitat for this species. Especially the Eucalypt Woodland which contains Tree hollows and hollow logs used by this species to shelter in. The Western Carpet Python has been previously recorded 20 km southwest of the study area (GHD, 2013a).	Likely
Black-striped Snake (*Neelaps calonotos*)	P3	The Banksia and Eucalypt Woodland of the study area contain the leaf litter and loose soil preferred by this species. The Black-striped Snake has been previously recorded 8 km south of the study area in Muchea (DPAW, 2014b).	Likely
Peregrine Falcon (*Falco peregrinus*)	S4	The study area does not contain the cliff faces this species prefers to nest on. However, due to the vagrant nature of the Peregrine Falcon it may use the study area as part of a wider foraging territory. This species has been previously recorded in the vicinity of the study area (ATA, 2007, DPAW, 2014a and Birdata, 2014).	Possible
Bush Stone-curlew (*Burhinus grallarius*)	P4	Although suitable habitat exists in the study area for this species there have been limited recent records of this species on the Swan Coastal Plain and is thought to be locally extinct due to predation from feral species.	Unlikely
Brush Bronzewing (*Phaps elegans*)	P4	The Eucalypt Woodlands provides marginal habitat for this species, but lacks the dense shrubs and understory this species prefers. This species is thought to be locally extinct on the Swan Coastal Plain (Johnstone and Storr, 1998).	Unlikely
Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)	Vu, S1	The Eucalypt Woodland provides both foraging and breeding habitat for this species and the Banksia Woodland provides foraging habitat for this species. Based upon the distribution map in the referral guidelines the study area is at the northern extent of this species distribution. There have been no records of this species in the vicinity of the study area, the closest occurring approximately 40 km south of the study area (DPAW, 2014b).	Possible
Carnaby's Cockatoo (*Calyptorhynchus latirostris*)	En, S1	The Eucalypt Woodland provides both foraging and breeding habitat for this species and the Banksia Woodland provides foraging habitat for this species. There have been numerous records of this species occurring in the vicinity of the study area (Burbidge *et al*, 1996; ATA, 2007; GHD, 2013a; DPAW, 2014a, b).	Likely

Species	Conservation status	Habitat relevance	Likelihood[1]
Baudin's Cockatoo (*Calyptorhynchus baudinii*)	Vu, S1	The Eucalypt Woodland provides both foraging and breeding habitat for this species and the Banksia Woodland provides foraging habitat for this species. The study area is mapped as occurring outside of this species current distribution (DSEWPAC, 2012) and the most recent record of this species in the vicinity is from more than 30 years ago (DPAW, 2014a).	Unlikely
Barking Owl (*Ninox connivens*)	P2	This species prefers the thick vegetation present is the forests of the deep southwest of Western Australia, rather than the open woodlands located in the study area. The closest recent record of this species is from an isolated record approximately 50 km south of the study area.	Unlikely
Fork-tailed Swift (*Apus pacificus*)	Mi, S3	The Fork-tailed Swift is an almost exclusively aerial species, foraging and sleeping on the wing. This species is independent of terrestrial habitats. This species has been previously recorded in the vicinity of the study area (Birdata, 2014).	Possible
Rainbow Bee-eater (*Merops ornatus*)	Mi, S3	The Rainbow Bee-eater is one of the most widespread bird species in Australia (Barrett et al., 2003) occurring in a range of habitats. All habitat types of the study area provide suitable habitat for the Rainbow Bee-eater. This species has been previously recorded in the vicinity of the study area (Tingay, 1994, Burbidge, 1996, ATA, 2007, GHD, 2013a, DPAW, 2014a and DPAW, 2014b)	Likely
Western Quoll (*Dasyurus geoffroii*)	Vu, S1	The Western Quoll occurs in a wide range of habitats including woodlands, dry sclerophyll forests and riparian vegetation, where it creates dens in hollow logs, burrows, tree hollows and cavities. All habitats in the study area provide foraging habitat for this species with the Eucalypt Woodland providing potential den sites with the presence of tree hollows and hollow logs. There are scattered records of this species in the vicinity of the study area, the closest occurring in Bindoon (DPAW, 2014a).	Likely
Southern Brown Bandicoot (*Isoodon obesulus fusciventer*)	P5	The Southern Brown Bandicoot is occurs in areas containing dense ground cover such as forests, woodlands, scrub and heathlands. It is particularly prevalent in areas surrounding wetlands and damplands. The Dampland habitat provides ideal habitat for this species however the conical diggings typical of this species were not identified during the survey. This species has been previously recorded in Bindoon (DPAW, 2014a) and in the vicinity of the study area (Tingay, 1994, GHD, 2013a and DPAW, 2014b).	Likely

Species	Conservation status	Habitat relevance	Likelihood[1]
Western Brush Wallaby (*Macropus irma*)	P4	The Western Brush Wallaby occurs in open forests or woodlands, favouring open seasonally wet flats and thickets (van Dyck and Strahamn, 2008). The Eucalypt Woodland and Banksia Woodland provide ideal habitat for this species and one individual was recorded in the Eucalypt Woodland during the survey. This species has been previously recorded in the vicinity to the study area (Burbidge, 1996).	Recorded

1. Likelihood definitions:
   Recorded – The species was recorded within the study area, historically or during the survey.
   Likely – Suitable habitat is present and records of this species exist close to the study area.
   Possible – Suitable habitat is present however no records exist in the vicinity, or records exist in the vicinity but suitable habitat is nearby but not in the study area.
   Unlikely – Neither suitable habitat nor records exist near the study area.

6 DISCUSSION

6.1 Flora

A detailed Level 1 flora and vegetation assessment, in accordance with the EPA's Guidance Statement No. 51 (EPA, 2004a), was undertaken. The assessment involved a desktop review of available and relevant literature and a site reconnaissance involving the sampling of 30 relevés (simplified floristic sampling points) located throughout the study area.

The site reconnaissance survey involved the identification of vascular plant taxa recorded from the 30 relevés and from site traverses to identify additional vascular plant taxa not identified at each of the relevés. The survey also included an assessment of the presence/absence and population size of the Threatened and Priority listed taxa known to occur in the study area.

6.1.1 Vegetation

A total of four broad floristic formations and 16 vegetation associations were delineated from the study area during the July 2014 site visit. The vegetation associations recorded from the study area were considered to be in excellent condition with isolated patches of very good and good condition vegetation. The areas of vegetation in good and very good condition were located on the outer edges of the study area against the cleared paddocks and along areas of previously disturbed areas (i.e. the power line infrastructure corridor along the western boundary).

The four broad floristic formations included: *Eucalyptus* woodland, *Corymbia* woodland, *Banksia* woodland and *Banksia* shrubland. The dominant formation across the study area was *Eucalyptus* woodland which included vegetation associations with an upper storey dominated by *Eucalyptus todtiana* and *Eucalyptus marginata*. The *Banksia* shrubland and *Banksia* woodland was separated into two separate formations based on the height and dominance of the *Banksia* species. The *Banksia* woodland formation consisted of associations with *Banksia attenuata* and *Banksia menziesii* greater than 10 m high.

The sixteen vegetation associations are not considered to be unique to the study area, however they do represent two Priority Ecological Communities (SCP23b and Banksia Yellow-Orange Sands) and one Threatened Ecological Community (SCP20c) according to data provided by DPAW. The presence of the TEC and two PECs was identified during the desktop review, while the distribution and extent of the PEC Banksia Yellow-Orange Sands is considered to be wider spread throughout the study area based on the vegetation association descriptions and extent.

In addition to the TEC and two PECs identified by DPAW during the desktop review, an additional two TECs, SCP20a and SCP20b, and one PEC, SCP21c, are inferred to occur in the study area. The TECs and PECs are located throughout the study area and in association with the known TEC and PECs locations, the majority of the vegetation within the study area is considered to be significant.

The presence and extent of the TECs and the two PECs cannot be accurately confirmed due to the lack of systematic quadrat sampling of the floristic composition recorded within the study area and a multivariate analysis and comparison of regional and existing datasets (including the dataset from Gibson *et al*., 1994) has not been completed. However, a comparison of the floristic information collected at each of the 30 relevés and the biological and geological information known for each of the TEC and PECs has been completed. An inference on the floristic community type described from Gibson *et al*. (1994) can be made to identify possible TECs and PECs present within the study area.

The retention and vesting of the study area into a DPAW conservation estate will increase the pre-European extent within formal protection (DPAW conservation estates, Bush Forever sites in DPAW managed lands and Bush Forever sites in Regional Parks). The new extent within formal protection will not significantly increase to ensure they are above the 30% threshold however will push the Moondah complexes above the 10% endangered level.

The study area is located within a north-south ecological corridor that connects the Boonanarring Nature Reserve in the north and Leda Nature Reserve in the south. The corridor will allow the continual movement of genetic material (via insect and wind pollination) in a north-south movement to maintain genetic integrity.

6.1.2 Flora

A total of 154 vascular plant taxa from 38 families and 88 genera were recorded from the study area, including 148 native taxa and six introduced taxa. This number is considered to significantly increase if the survey was undertaken at the optimum time in spring for the Swan Coastal Plain.

One Threatened taxon, *Chamelaucium* sp. Gingin (N.G. Marchant 6) and one Priority listed taxon, *Hypolaena robusta* (P4), were recorded from the study area. An additional five Priority listed taxa, *Acacia cummingiana* (P3); *Caustis* sp. Gigas (A.S. George 9318) (P2); *Schoenus griffinianus* (P3); *Verticordia rutilastra* (P3); and *Verticordia serrata* var. *linearis* (P3), have previously been recorded from the study area. These five Priority listed taxa were not recorded at the time of the site reconnaissance.

The five Priority listed taxa not recorded at the time of the survey may still persist in the study area. The timing of the survey was not optimal for identifying the two *Verticordia* species and the *Schoenus* and *Caustis* species. Searches were conducted for *Acacia cummingiana* at the known location along Reserve Road but it was not recorded.

Chamelaucium sp. Gingin (N.G. Marchant 6) was recorded from 12 point locations totalling approximately 200 individuals. This number is considered to only represent a subset of the individuals known to occur in the northwest corner of the study area and the adjacent DPAW managed lands.

The study area is considered to represent critical habitat for *Chamelaucium* sp. Gingin (N.G. Marchant 6) according to the interim recovery plan (Stack and English, 2003). The study area represents current known occupancy, similar within 200 m and a corridor for pollination between populations located adjacent to the study area (Stack and English, 2003).

Hypolaena robusta (P4) was recorded from two locations within the study area and is known from one other location within the study area.

An assessment of the likelihood of the conservation significant flora identified from the desktop review occurring within the study area, concluded that ten conservation significant taxa are likely to occur within the study area. An additional 15 conservation significant taxa may potentially occur within the study area based on known locations and habitat preferences. The remaining 30 conservation significant taxa are not expected to occur within the study area based on habitat preferences and the current known locations of these taxa (Appendix D).

Of the ten conservation significant species likely to occur in the study area, only one, *Chamelaucium* sp. Gingin (N.G. Marchant 6), is listed Threatened (Declared Rare-Extant) under the WC Act and the EPBC Act. The remaining 19 Threatened taxa identified from the desktop review are not expected to occur in the study area based on their known distribution and preferred habitat requirements.

A total of six introduced taxa were recorded from the study area. The six introduced taxa are not considered to be WONS, while the Arum Lily (**Zantedeschia aethiopica*), recorded from the southwest corner in vegetation association Ba, is considered to be a Declared Pest under the BAM Act. The remaining

five introduced taxa are common weed species of disturbed or degraded sites and are present within the study area in low densities. The majority of the weeds are encroaching from the cleared paddocks located to the southwest and east of the study area.

6.2 Fauna

6.2.1 Fauna Habitats

The study area contains approximately 663 ha of Banksia Woodland, 315 ha of Eucalypt Woodland and 3 ha of Dampland habitat. The majority of the study area is classified as excellent condition, with dieback being the only major disturbance.

The fauna habitats present in the study area are considered to be common on a local scale with similar habitat existing in the immediate vicinity. Chandala Nature Reserve, Barracca Nature Reserve, Breera Road Nature Reserve and Yeal Nature Reserve are all located within 10 km of the study area. The close proximity of the study area to these permanent sections of native vegetation increases its local importance and value as an offset site. Habitat connectivity occurs with Breera nature reserve to the north, Chandala Nature Reserve to the east and even Bullsbrook Nature Reserve along a drainage line to the south of the study area. Drainage lines are well known conduits for fauna movement as they provide a well-covered/vegetated habitat to provide safe passage between areas. Due to its position and surrounding habitats the study area has an importance far greater than its 988 ha size suggests.

The large size of the study area and the excellent condition of the habitats indicates the full suite of microhabitats native fauna rely upon is present, e.g.: thick leaf litter, old logs and hollows, fruit/flower bearing trees. As such, the vast majority of the species in Appendix J are expected to occur in the study area. The large area of Banksia Woodland (663 ha) provides a wealth of foraging resource for nectivorous species such as honeyeaters and Honey Possums that are not readily supported by the fragmented landscapes present in urban areas.

The moderate to old age of the trees in the study area means they have become a hollow bearing resource, many species of bird and mammal rely on as integral part of their life cycle e.g.: for breeding and shelter. Galahs and Australian Ringnecks were seen using hollows during the survey. The lack of recent fire in some sections of the study area has meant that tree branches and limbs have fallen but are yet to produce tree hollows or hollow logs, which would increase the habitat value of the study area.

6.2.2 Black Cockatoo Habitat

The study area provides suitable foraging, roosting and breeding habitat for the Carnaby's Cockatoo and to a lesser extent the Forest Red-tailed Cockatoo (due to the study area occurring at the northern extent of its distribution). During the survey no evidence of either species of Black Cockatoo was recorded in the study area however the presence of such species can be difficult to assess due to their seasonal movement patterns and sporadic nature.

The location of the study area is strategic as it supports Carnaby's Cockatoos during their migration to and from breeding sites in the Wheatbelt. Carnaby's Cockatoos that have been breeding in the Dandaragan, Moora and Bindoon regions potentially move through the vicinity of the study area prior to their movement south through the Swan Coastal Plain. Bindoon and the areas around it have been identified as an appropriate location to be recommended as offset site and Chittering has been identified as an area under pressure (Johnstone and Kirkby, 2011).

The study area contains 17 species of known foraging resources for Black Cockatoos and approximately 981 ha classified as foraging habitat. The habitats present are dominated by Jarrah, Marri and *Banksia* species which are all important foraging species. The mature age of the foraging species (predominantly

Jarrah, Marri and *Banksia* species) allows a greater yield of fruiting bodies/seed pods as compared to immature habitats. Given the large area of foraging habitat and the excellent condition of the vegetation the study area provides an important foraging resource for Black Cockatoos in the vicinity.

Roost sites for Black Cockatoos typically have tall, dense canopied trees, are close to water where the birds can drink and close to food trees such as *Banksias* and Marri. The roost trees are usually clumped and at larger roosts, cover an area of at least five hectares (Burnham et al., 2010). The study area provides ideal setting as a potential roost site, as it contains these conditions. The closest known roost sites for Carnaby's Cockatoos occur in Gingin and Yanchep which are approximately 17 km north and west of the study area respectively (Burnham et al., 2010). These sites are known from their inclusion in the Great Cocky Count where potential roost sites are surveyed. As no roost surveys have been conducted in the study area or its direct surrounds an accurate assessment of its use as a roost site cannot be ascertained. The entire Eucalypt Woodland habitat is classified as containing roosting habitat which equates to approximately 315 ha.

The tree age in the study area is sufficient to produce large hollows with potential to yield more with subsequent fires. For hollows to be of use to Carnaby's Cockatoos dimensions must be a minimum of 14 cm entrance size and at least 50 cm deep (Groom, 2011). As such, the study area contains habitat that can be classified as having current breeding potential for Carnaby's Cockatoos in a region known to have breeding records (Johnstone and Kirkby, 2011). The Cockatoo referral guidelines states "in a woodland stand with trees of suitable diameter at breast height, all trees of all ages and size are potentially important for maintaining breeding in the long term," as such the Eucalypt Woodland is classified as breeding habitat (approximately 315 ha). The tree density survey results show that the study area contains large areas (192 ha) with a high tree density, with more than 20 trees with a DBH over 500 mm per hectare. An estimated 6,353 trees with a DBH over 500 mm occur in the study area. As such, the study area contains large areas of high quality breeding habitat for Black Cockatoos.

6.2.3 Conservation Significant Fauna

The only conservation significant fauna recorded in the study area was the Priority 4 listed Western Brush Wallaby (*Macropus irma*). A further six species of conservation significance are considered Likely to occur in the study area.

The Western Brush Wallaby is listed as Priority 4, rare, near threatened and other species in need of monitoring under the DPAW Priority listings. It occurs only in the South West of Western Australia and has undergone a massive decline due to habitat fragmentation in the Wheatbelt and fox predation. Due to foxes some populations have experienced an 80% reduction between the 1970s and 1990s. However, fox control has allowed this species to become more common throughout its range (Van Dyck and Strahan, 2008). Limited records for this species occur for the vicinity of the study area (DPAW, 2014b). One individual was recorded in the Eucalypt Woodland but it is also expected to occur across the Banksia Woodland habitat.

The Western Carpet Python (*Morelia spilota imbricata*) occurs only along the southwestern portions of Western Australia and is listed as Schedule 4 under the WC Act. Threatening processes include habitat destruction and changed fire regimes, with the impact of feral predators being unknown (Pearson et al., 2005 and DEC, 2012). This species requires large areas of undisturbed bushland (Bush et al., 2007) and is expected to occur in all habits types of the study area. The large area of excellent condition habitat and abundance of logs and tree hollows suggest the study area is ideal habitat for this species.

The Black-striped Snake (*Neelaps calonotos*) is listed as Priority 3, poorly-known species under the DPAW Priority listings. It occurs only along the Swan Coastal Plain with the bulk of this species known distribution occurring in the Perth region, however there have been recent records of this species further north near Dongara and Eneabba suggesting it has a broader distribution (Bush et al., 2010). Threatening processes

involve habitat destruction within its small distribution. Both the Banksia Woodland and Eucalypt Woodland provide ideal habitat for this species. There have been records of this species from the vicinity of the study area from Muchea and Gingin (DPAW, 2014b).

The Carnaby's Cockatoo (*Calyptorhynchus latirostris*) is listed as Endangered under the EPBC Act and Schedule 1 under the WC Act. This species is endemic to the southwest of Western Australia, from Kalbarri in the north to Esperance (DSEWPAC, 2012). In the last 45 years the Carnaby's Cockatoo population has dropped to by 50% to an estimated 40,000 individuals (Johnstone et al., 2008 and Cale, 2003). The major threats to this species include clearing of their core breeding habitat in the Wheatbelt and the clearing of foraging resources on the Swan Coastal Plain (Cale, 2003). There are numerous records of this species in the vicinity of the study area (Burbidge et al., 1996, ATA, 2007, GHD, 2013a, b, DPAW, 2014a and DPAW, 2014b), including breeding records form Bindoon and Gingin (Johnstone and Kirkby, 2011). As mentioned previously the Banksia Woodland provides foraging habitat for this species and the Eucalypt Woodland provides foraging, roosting and breeding habitat for this species.

The Rainbow Bee-eater (*Merops ornatus*) is listed as Migratory under the EPBC Act and Schedule 3 under the WC Act. The Rainbow Bee-eater is one of the most widespread birds species in Australia distributed across mainland Australia (Barrett et al., 2003). There are no known threats to this common species. All habitat types are expected to be used by this species.

The Western Quoll (*Dasyurus geoffroii*) is listed as Vulnerable under the EPBC Act and Schedule 1 under the WC Act. Once distributed over 70% of Australian this species distribution is now down to 5% of its former range, restricted to the southwest of Western Australia (Orell and Morris, 1994). The major threats to this species include feral predators, habitat clearing and changed fire regimes (Smith et al., 2004). The Western Quoll has large home range, 400 ha for females and 900 ha for males. Given the connectivity with surrounding areas of bush and the large size of the site the potential exists for this species to reside in the study area or its surrounds. All habitat types would be used as foraging habitat and the hollows logs found in the Eucalypt Woodland provides suitable den site locations. The Western Quoll has been recently recorded In Bindoon.

The Southern Brown Bandicoot (*Isoodon obesulus fusciventer*) is listed as Priority 5, conservation dependent species under the DPAW Priority listing. The West Australian sub species is distributed along the coast from Guilderton to Esperance (DPAW, 2014b). The major threatening processes for this species are fragmentation and loss of habitat, predation by foxes, cats and in residential areas dogs. The Dampland habitat and the surrounding Woodlands provide habitat for this species. This species has been previously recorded in Bindoon and in the vicinity of the study area (Tingay, 1994, GHD, 2013a and DPAW, 2014b).

6.3 Conservation Value

In summary, the study area is considered to be of high conservation value comprising habitat for a significant number of threatened flora and fauna species. Some of these species are likely to be impacted by the NorthLink WA project. The vegetation is representative of a number of Threatened and Priority Ecological Communities, some of which likely to be impacted by the NorthLink WA Project. The addition of the study area to the conservation estate will substantially increase the estate with the adjacent Class C Reserve and provide protection of an important ecological linkage.

7 REFERENCES

360 Environmental. 2012. North Ellenbrook Level 2 Flora and Vegetation Survey. July. Draft report prepared for Greg Rowe and Associates by 360 Environmental Pty Ltd. Perth, Western Australia.

360 Environmental. 2014. Swan Valley Bypass, Perth–Darwin National Highway: Level 2 Flora and Vegetation Survey. February. Draft report prepared for Main Roads Western Australia by 360 Environmental Pty Ltd. Perth, Western Australia.

ANZECC. 2000. Review of the National Strategy for the Conservation of Australia's Biological Diversity, Australian and New Zealand Environment and Conservation Council, Environment Australia, Canberra, Australian Capital Territory.

ATA Environmental. 2007. Flora, Vegetation and Vertebrate Fauna Assessment, Neerabup Industrial Area (NIA), Neerabup. August. Report prepared for City of Wanneroo, Landcorp and Various Landowners by ATA Environmental. Perth, Western Australia.

Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. 2003. The New Atlas of Australian Birds. Royal Australasian Ornithologists Union, Melbourne, Victoria.

Beard, J. S. 1990. *Plant Life of Western Australia*. Kangaroo Press, Kenthurst, New South Wales.

Birdata. 2014. Atlas Distribution Maps. A WWW publication accessed in June at www.birdata.com.au/maps.vm. Birdlife Australia.

BOM. 2014. Monthly climate statistics for Australian locations: Pearce RAAF Base, Western Australia. A WWW publication accessed on 1 October 2014 at http://bom.gov.au/climate/. Bureau of Meteorology.

Burbidge, A. H., Boscacci, L. J., Alford, J. J., and Keighery, G. J. 1996. A biological survey of Boonanarring Nature Reserve. CALMScience 2 (2):153–187.

Burnham, Q., Barrett, G., Blythman, M. and Scott, R. 2010. Carnaby's Cockatoo (Calyptorhynchus latirostris) identification of nocturnal roost sites and the 2010 Great Cocky Count. August. Report prepared for the Department of Environment and Conservation, Western Australia.

Bush, B, Maryan, B., Browne-Cooper, R. and Robinson, D. 2007. Reptiles and Frogs in the Bush: Southwestern Australia. UWA Press, Nedlands, Western Australia.

Bush, B., Maryan, B., Browne-Cooper, R. and Robinson, D. 2010. *Field Guide to Reptiles and Frogs of the Perth Region*. 2nd ed. Western Australian Museum, Welshpool, Western Australia.

Cale, B. 2003. Carnaby's Black-Cockatoo (Calyptorhynchus latirostris) Recovery Plan. Report prepared by Department of Conservation and Land Management. Perth, Western Australia.

CALM. 1999. Environmental Weed Strategy for Western Australia. May. Department of Conservation and Land Management. Perth, Western Australia.

Chapman, T. 2007. Forest Black Cockatoo (Baudin's Cockatoo Calyptorhynchus baudinii and Forest Red-tailed Black Cockatoo Calyptorhynchus banksii naso) Recovery Plan 2007–2016. January. Report prepared for the Forest Black Cockatoo Recovery Team by Department of Environment and Conservation, Western Australia.

Churchill, S. 2008. *Australian Bats*. 2nd ed. Allen & Unwin. Crows Nest, New South Wales.

Churchward, H. M. and McArthur, W. M. 1978. Landforms and Soils of the Darling System. Land Resources Management. Commonwealth Scientific and Industrial Research Organisation, Perth, Western Australia.

Coffey Environments. 2010. Flora and Vegetation Assessment, M70/138 Hopkins Road, Nowergup. August. Report prepared for Cockburn Cement by Coffey Environments Australia Pty Ltd, Burswood, Western Australia.

Davidson, W. A. 1995. Hydrogeology and Groundwater Resources of the Perth Region Western Australia. Western Australia Geological Survey, Bulletin 142. Perth, Western Australia.

DEC. 1983. Conservation Reserves for Western Australia. The Darling System - System 6. Department of Conservation and Environment. Perth, Western Australia.

DEC. 2012. Fauna profiles: Carpet Python *Morelia spilota*. Fauna profiles. February. Department of Environment and Conservation. Perth, Western Australia.

Diels, L. 1906. Die Pflanzenwelt von West Australien sudlich des wendeskreises, in A. Engler & O. Drude (eds) Die Vegetation der Erde. W. Engleman, Leipzig.

DOTE. 2014a. EPBC Act Protected Matters Report. A custom report generated on 4 July 2014 using the Protected Matters Search Tool at http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf. Department of the Environment. Perth, Western Australia.

DOTE. 2014b. Australia's Bioregions (IBRA). A WWW publication accessed in July at http://www.environment.gov.au/topics/land/national-reserve-system/science-maps-and-data/australias-bioregions-ibra. Department of the Environment. Perth, Western Australia.

DOW. 2014. Hydrogeological Atlas. A WWW publication accessed on 1 September 2014 at http://www.water.wa.gov.au/idelve/hydroatlas/. Department of Water. Perth, Western Australia.

DPAW. 2013a. 2013 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of June 2013. A WWW publication available at https://www2.landgate.wa.gov.au/web/guest/downloader. Department of Parks and Wildlife, Perth, Western Australia.

DPAW. 2013b. Weed Prioritisation Process for DPAW (formerly DEC) - "An integrated approach to Weed Management on DPAW-managed lands in WA". November. Department of Parks and Wildlife. Perth, Western Australia.

DPAW. 2014a. NatureMap Species Report. A custom report generated on 4 July 2014 using the Species By Area tool at http://naturemap.dpaw.wa.gov.au/default.aspx. Department of Parks and Wildlife. Perth, Western Australia.

DPAW. 2014b. Threatened and Priority Fauna Database. Custom report No. 4825 generated on 6 June 2014 by Department of Parks and Wildlife. Perth, Western Australia.

DPAW. 2014c. FloraBase custom search. A WWW publication at https://florabase.dpaw.wa.gov.au/. Department of Parks and Wildlife. Perth, Western Australia.

DSEWPAC. 2012. EPBC Act referral guidelines for three threatened black cockatoo species. Department of Sustainability, Environment, Water, Population and Communities. Canberra, Australia.

Ecoscape. 2009a. East Landsdale Flora and Fauna Assessment – Lots 50 and 51. February. Report prepared for Stockland by Ecoscape (Australia) Pty Ltd. North Fremantle, Western Australia.

Ecoscape. 2009b. East Landsdale Flora and Fauna Assessment – Lot 154. February. Report prepared for Stockland by Ecoscape (Australia) Pty Ltd. North Fremantle, Western Australia.

EPA and DEC. 2010. Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment. September. Environmental Protection Authority and Department of Environment and Conservation. Perth, Western Australia.

EPA. 2000. Position Statement No. 2: Environmental Protection of Native Vegetation in Western Australia. December. Environmental Protection Authority. Perth, Western Australia.

EPA. 2002. Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection. March. Environmental Protection Authority. Perth, Western Australia.

EPA. 2004a. Guidance for the Assessment of Environmental Factors – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia No. 51. June. Environmental Protection Authority, Western Australia. Perth, Western Australia.

EPA. 2004b. Guidance for the Assessment of Environmental Factors – Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia No. 56. June. Environmental Protection Authority, Western Australia. Perth, Western Australia.

EPA. 2004c. Position Statement No. 7: Principles of Environmental Protection. August. Environmental Protection Authority. Perth, Western Australia.

EPA. 2006. Guidance for the Assessment of Environmental Factors. No. 6. Rehabilitation of Terrestrial Ecosystems. June. Environmental Protection Authority. Perth, Western Australia.

EPA. 2011. WA Environmental Offsets Policy. September. Environmental Protection Authority. Perth, Western Australia.

EPA. 2014. WA Environmental Offsets Guidelines. August. Environmental Protection Authority. Perth, Western Australia.

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

Fleming, R. 2011. Identification of chewed Marri nuts eaten by cockatoos and parrots. Western Australian Museum. Perth, Western Australia.

Gardner, C. A. 1942. The vegetation of Western Australia: with special reference to the climate and soils: presidential address. Royal Society of Western Australia. Perth, Western Australia.

GHD. 2009. Wetlands assessment along Raphael Road and Stock Road - PDNH alignment. Memorandum. GHD Pty Ltd. Perth, Western Australia.

GHD. 2013a. Perth–Darwin National Highway – Tonkin Highway Link Alignment Definition Study: Environmental Impact Assessment and Biological Survey. October. Report prepared for Main Roads Western Australia by GHD Pty Ltd. Perth, Western Australia.

GHD. 2013b. Mitchell Freeway extension. Flora and fauna assessment report. November. Report prepared for Main Roads Western Australia by GHD Pty Ltd. Perth, Western Australia.

GHD. 2014. Neerabup Road extension: Fauna movement study. February. Report prepared for Main Roads Western Australia by GHD Pty Ltd. Perth, Western Australia.

Gibson, N., Keighery, B. J., Keighery, G. J., Burbidge, A. H. and Lyons, M. N. 1994. A Floristic Survey of the southern Swan Coastal Plain. Unpublished report for the Australian Heritage Commission prepared by Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc).

Government of Western Australia. 2000. *Keeping the Bush in the City:* Bush Forever. Department of Environmental Protection. Perth, Western Australia.

Groom, C. 2011. Plants used by Carnaby's Black Cockatoo. April. Department of Environment and Conservation. Perth, Western Australia.

Heddle, E. M., Loneragan, O. W., and Havel, J. J. 1980. Vegetation Complexes of the Darling System. IN: Atlas of Natural Resources, Darling System, Western Australia. Department of Conservation and Land Management. Perth, Western Australia.

Hill, A. L., Semeniuk, C. A., Semeniuk, V. and Del Marco, A. 1996. Wetlands of the Swan Coastal Plain. Vol. 2b. Wetland Mapping, Classification and Evaluation, Wetland Atlas. Water and Rivers Commission and Department of Environment Protection. Perth, Western Australia.

Johnstone, R. E. and Kirkby, T. 2011. Black Cockatoos on the Swan Coastal Plain. Carnaby's Cockatoo (*Calyptorhynchus latirostris*), Baudin's Cockatoo (*Calyptorhynchus baudinii*) and the Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) on the Swan Coastal Plain (Lancelin–Dunsborough), Western Australia. Studies on distribution, status, breeding, food, movements and historical changes. Report prepared for Department of Planning. Perth, Western Australia.

Johnstone, R. E., and Storr, G. M. 1998. *Handbook of Western Australian Birds.* Vol 1 – Non-Passerines (Emu to Dollarbird). Western Australian Museum. Perth, Western Australia.

Johnstone, R. E., and Storr, G. M. 2004. *Handbook of Western Australian Birds*. Vol. 2 – Passerines (Blue-Winged Pitta to Goldfinch). Western Australian Museum. Perth, Western Australia.

Johnstone, R. E., Johnstone, C. and Kirkby, T. 2008. Carnaby's Cockatoo (*Calyptorhnchus latirosis*) on the northern Swan Coastal Plain (Lancelin-Perth). Report prepared for the Department of the Environment, Water, Heritage and the Arts.

Keighery, B. 1994. *Bushland plant survey: A Guide to plant community survey for the community.* Wildflower Society of Western Australia. Nedlands, Western Australia.

M. E. Trudgen and Associates. 1999. A flora and vegetation survey of Lots 46 and 47 Maralla Road and Lexia Avenue, Ellenbrook. December. Report prepared for The Crown Solicitors Office, Government of Western Australia.

McArthur, W. M. and Bettenay, E. 1974. *The Development and Distribution of the Soils of the Swan Coastal Plain, Western Australia.* Soil Publication No. 16. Commonwealth Scientific and Industrial Research Organisation, Australia, Melbourne, Victoria.

Meney, K. A. and Pate, J. S. 1999. *Australian Rushes. Biology, Identification and Conservation of Restionaceae and Allied Families.* University of Western Australia Press. Nedlands, Western Australia.

Menkhorst, P., and Knight, F. 2011. *A Field Guide to the Mammals of Australia.* 3rd ed. Oxford University Press. South Melbourne, Victoria.

Mitchell, D., Williams, K. and Desmond, A. 2002. Swan Coastal Plain 2 (SWA2 – Swan Coastal Plain subregion). In A biodiversity audit of Western Australia's 53 Biogeographical Subregions. January. Department of Conservation and Land Management. Perth, Western Australia.

Monocot Dicot Botanical Research. 2010. Level 2 Flora and Vegetation Survey, Lot 5 Mornington Drive, Mariginiup, City of Wanneroo. December. Report prepared for RPS Environment by Monocot Dicot Botanical Research. Padbury, Western Australia.

Orell, P. and Morris, K. 1994. Chuditch Recovery Plan: Western Australian Wildlife Management Program No. 13. Report prepared for the Chuditch Recovery Team by Western Australian Department of Conservation and Land Management. Wanneroo, Western Australia.

Pearson, D., Shine, R. and Williams, A. 2005. Spatial ecology of a threatened python (*Morelia spilota imbricata*) and the effects of anthropogenic habitat change. *Austral Ecology* 30:261-274.

Semeniuk, C. A. and Semeniuk, V. 1995. A geomorphic approach to global classification for inland wetlands. *Vegetatio* 118:103-124.

Shepherd, D. P., Beeston, G. R. and Hopkins, A. J. M. 2002. Native Vegetation in Western Australia: Extent, Type and Status. Resource Management Technical Report 249. February. Report prepared by Department of Agriculture. Perth, Western Australia.

Simpson, K. and Day, N. 2010. *Field Guide to the Birds of Australia*. 8th ed. Penguin Group Australia. Melbourne, Victoria.

Smith, J. A., Wright, L. J. and Morris, K. D. 2004. Bibliochuditch: The Chuditch, *Dasyurus geoffroii* (Gould 1841), a Wildlife Science Library subject-specific bibliography. *Conservation Science*. 5 (1):6-19.

Specht, R. L. 1970. Vegetation. *In The Australian Environment*.4th ed. Commonwealth Scientific and Industrial Research Organisation Australia, Australian and Melbourne University Press, Melbourne, Victoria.

Specht, R. L., Roe, E. M and Boughton, V. H. 1974. *Conservation of major plant communities in Australia and Papua New Guinea*. Commonwealth Scientific and Industrial Research Organisation Australia, Melbourne, Victoria.

Stack, G. and English, V. 2003. Interim Recovery Plan No. 140: Gingin Wax (*Chamelaucium* sp. Gingin) 2003–2008. March. Report prepared by Department of Conservation and Land Management. Wanneroo, Western Australia.

Storr, G. M., Smith, L. A. and Johnstone, R. E. 1983. *Lizards of Western Australia.* Vol. II. Dragons and Monitors. Western Australian Museum. Perth, Western Australia.

Storr, G. M., Smith, L. A. and Johnstone, R. E. 1990. *Lizards of Western Australia*. Vol. III. 2nd ed. Geckoes and Pygopods. Western Australian Museum. Perth, Western Australia.

Storr, G. M., Smith, L. A. and Johnstone, R. E. 1999. *Lizards of Western Australia*. Vol. I. Skinks. 2nd ed. Western Australian Museum, Perth, Western Australia.

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

Terratree. 2014. Linear *Phytophthora* Dieback Risk Assessment of M2091 Ioppolo Road, Chittering. December. Report prepared for Coffey Environments Australia Pty Ltd by Terratree Pty Ltd. Fremantle, Western Australia.

Tingay. 1994. Egerton Fauna Survey – Technical Report: Supplement to Consultative Environmental Review. February. Prepared for Multiplex Constructions Pty Ltd by Alan Tingay and Associates. Perth, Western Australia.

Tyler, M. J. and Doughty, P. 2009. *Field Guide to Frogs of Western Australia*. 4th ed. Western Australian Museum. Welshpool, Western Australia.

Valentine, L. E. and Stock, W. 2008. Food Resources of Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*) in the Gnangara Sustainability Strategy study area. December. Prepared by Department of

Environment and Conservation for the Gnangara Sustainability Strategy Taskforce, Department of Water. Perth, Western Australia.

Van Dyck, S., and Strahan, R. 2008. *The Mammals of Australia.* 3rd ed. Reed New Holland. Chatswood, New South Wales.

WALGA. 2004. Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Region. 1st ed. June. Western Australian Local Government Association. West Perth, Western Australia.

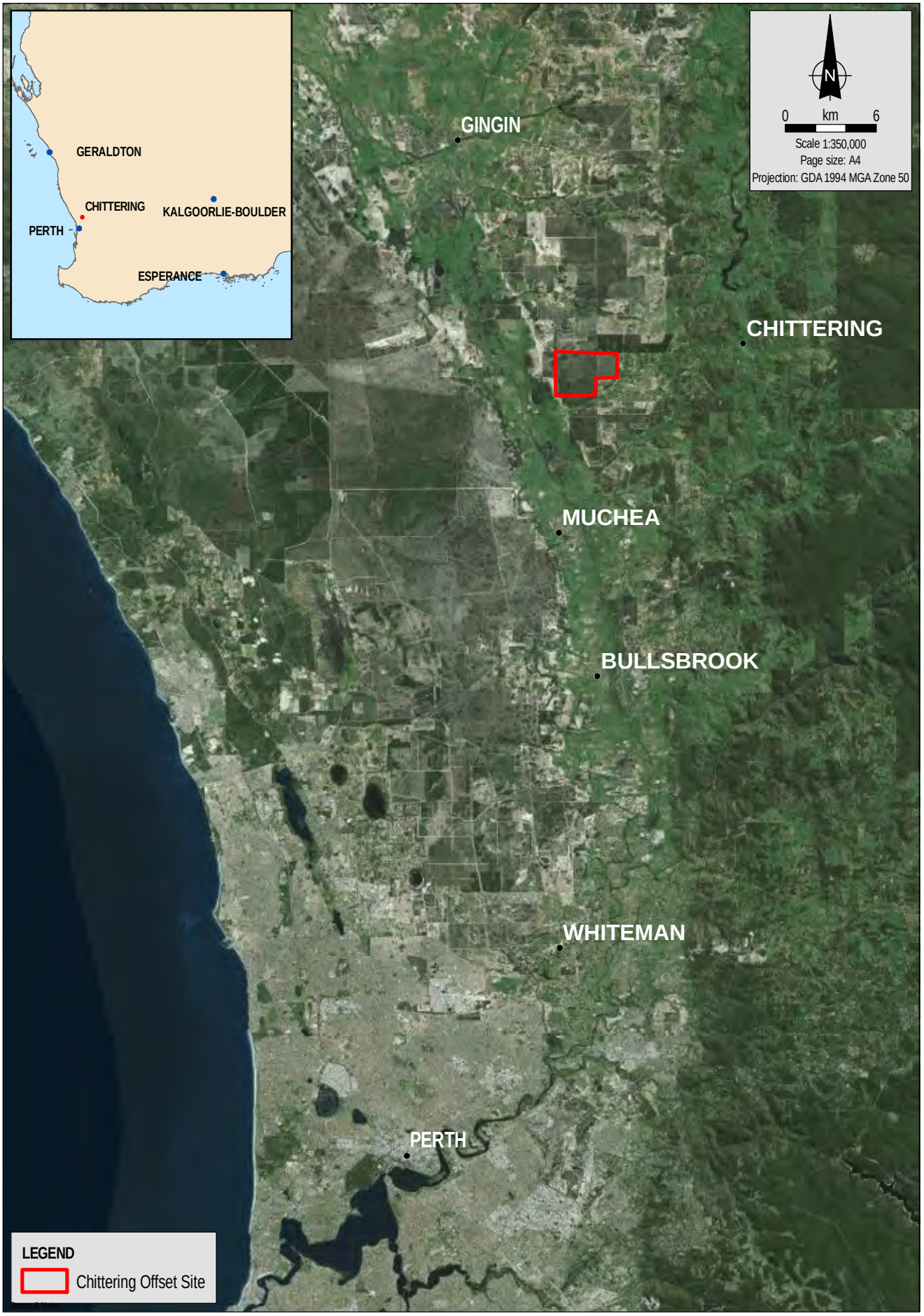
WALGA. 2013. 2013 Native Vegetation extent by Vegetation complexes on the Swan Coastal Plain south of Moore River (Local Biodiversity Program, 2013). A WWW publication at http://pbp.walga.asn.au/Publications.aspx. Western Australian Local Government Association.

Walker, J. and Hopkins, M. S. 1990. Vegetation. In: McDonald, R. C., Isbell, R., F., Speight, J. G., Walker, J. and Hopkins, M. S. *Australian Soil and Land Survey. Field Handbook*. 2nd ed. Inkata Pres. Melbourne, Victoria.

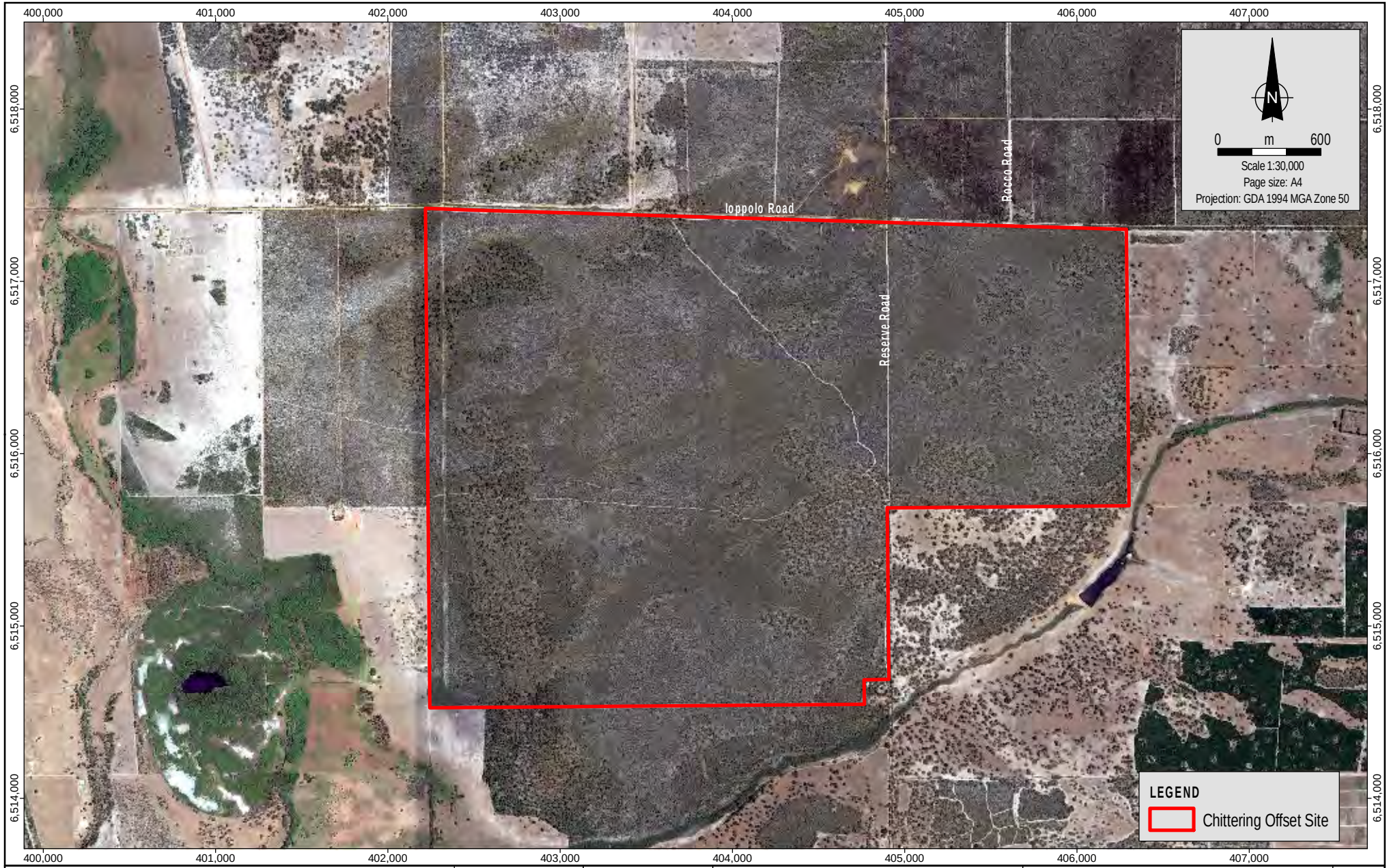
WAPC. 2010 State Planning Policy 2.8. Bushland Policy for the Perth Metropolitan Region. June. Western Australian Planning Commission. Perth, Western Australia.

Wilson, S. and Swan, G. 2010. *A Complete Guide to Reptiles of Australia.* 3rd ed. New Holland Publishers. Chatswood, New South Wales.

Figures



coffey	Date: 14.04.2015 MXD: 4483AA_06_GIS001_1 File Name: 4483AA_06_F001_GIS	Main Roads WA NorthLinkWA	Regional Location Flora, Vegetation and Fauna Assessment	Figure No: 1



Source & Notes
Aerial Imagery from Google Earth Pro (10.01.2015).

coffey

Date: 14.04.2015
MXD: 4483AA_06_GIS002_1
File Name: 4483AA_06_F002_GIS

Main Roads WA

NorthLinkWA

Study Area
Flora, Vegetation and Fauna Assessment

Figure No: 2

Source & Notes
Vegetation complex mapping from DPAW (January 2015).
Aerial Imagery from Google Earth Pro (10.01.2015).

coffey

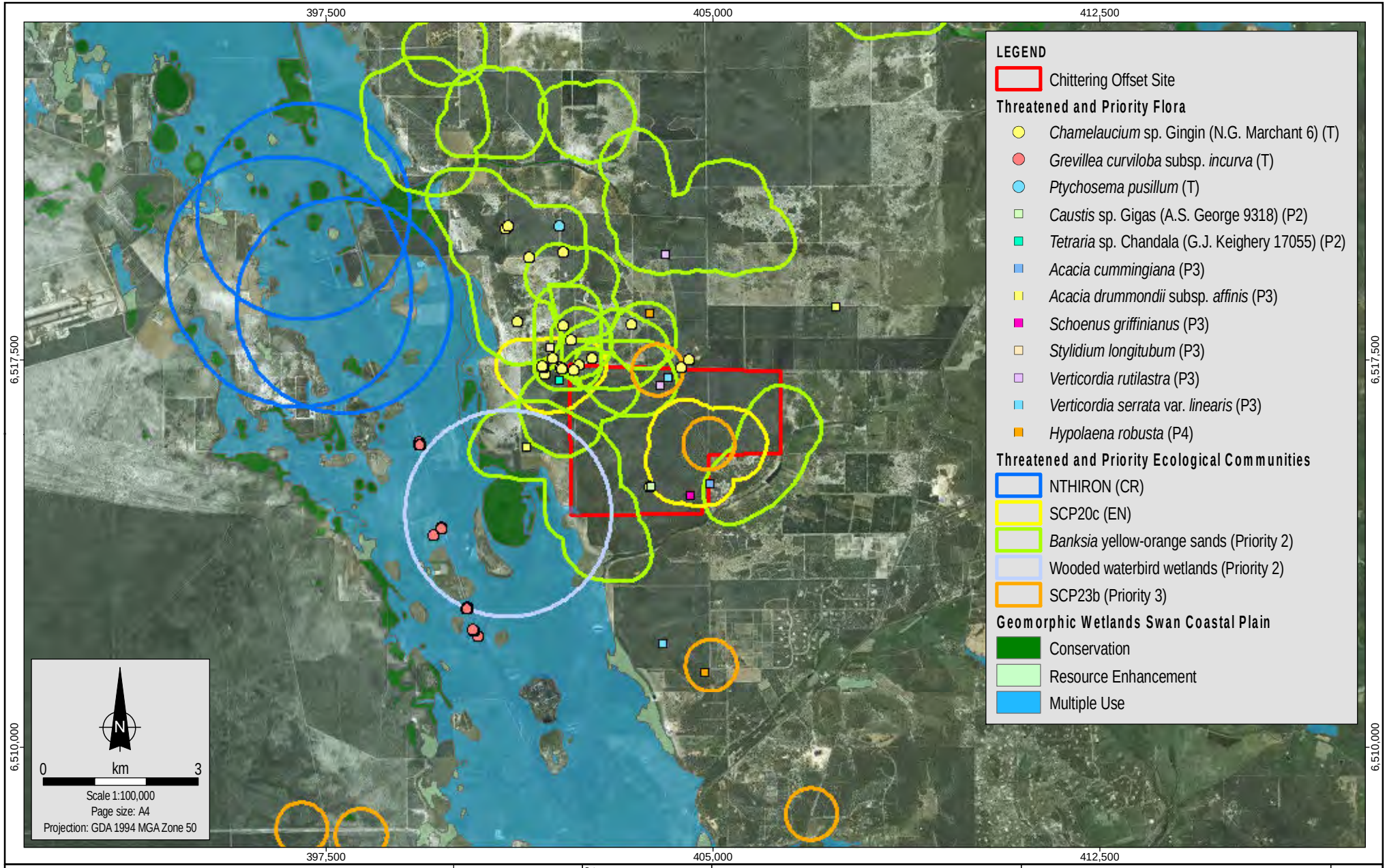
Date: 14.04.2015
MXD: 4483AA_06_GIS012_1
File Name: 4483AA_06_F004_GIS

Main Roads WA

NorthLinkWA

Vegetation Complexes
Flora, Vegetation and Fauna Assessment

Figure No: 4



Source & Notes
Conservation significant flora and vegetation mapping from Coffey (August 2014).
Aerial imagery from ArcGIS Online.

coffey

Date: 14.04.2015
MXD: 4483AA_06_GIS023_1
File Name: 4483AA_06_F008_GIS

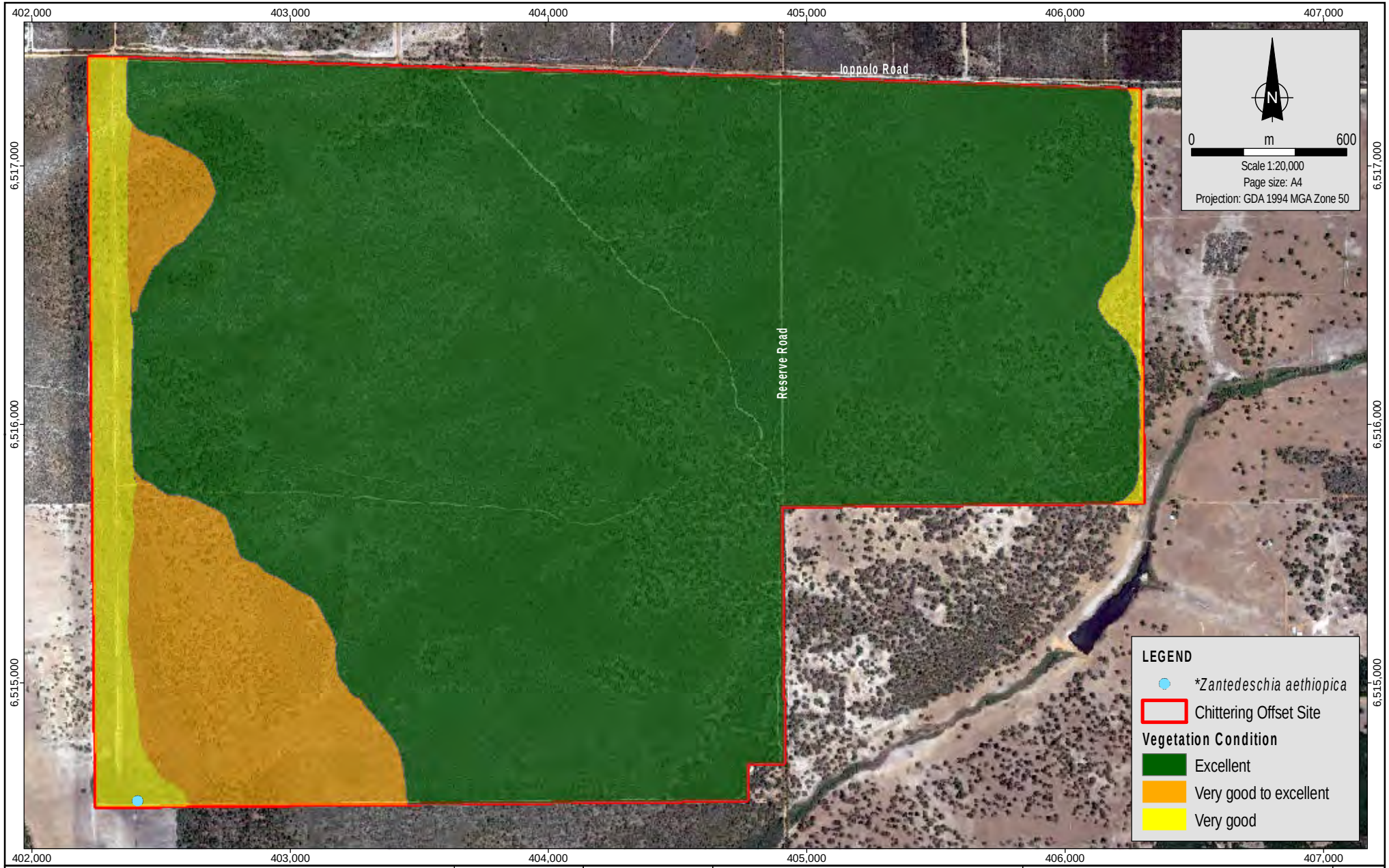
Main Roads WA

NorthLinkWA

Flora and Vegetation Constraints

Flora, Vegetation and Fauna Assessment

Figure No: 5



Source & Notes
*<ita>Zantedeschia aethiopica</ita> location and vegetation condition mapping from Coffey (2014)
Aerial Imagery from Google Earth Pro (10.01.2015).

coffey

Date: 14.04.2015
MXD: 4483AA_06_GIS005_1
File Name: 4483AA_06_F006_GIS

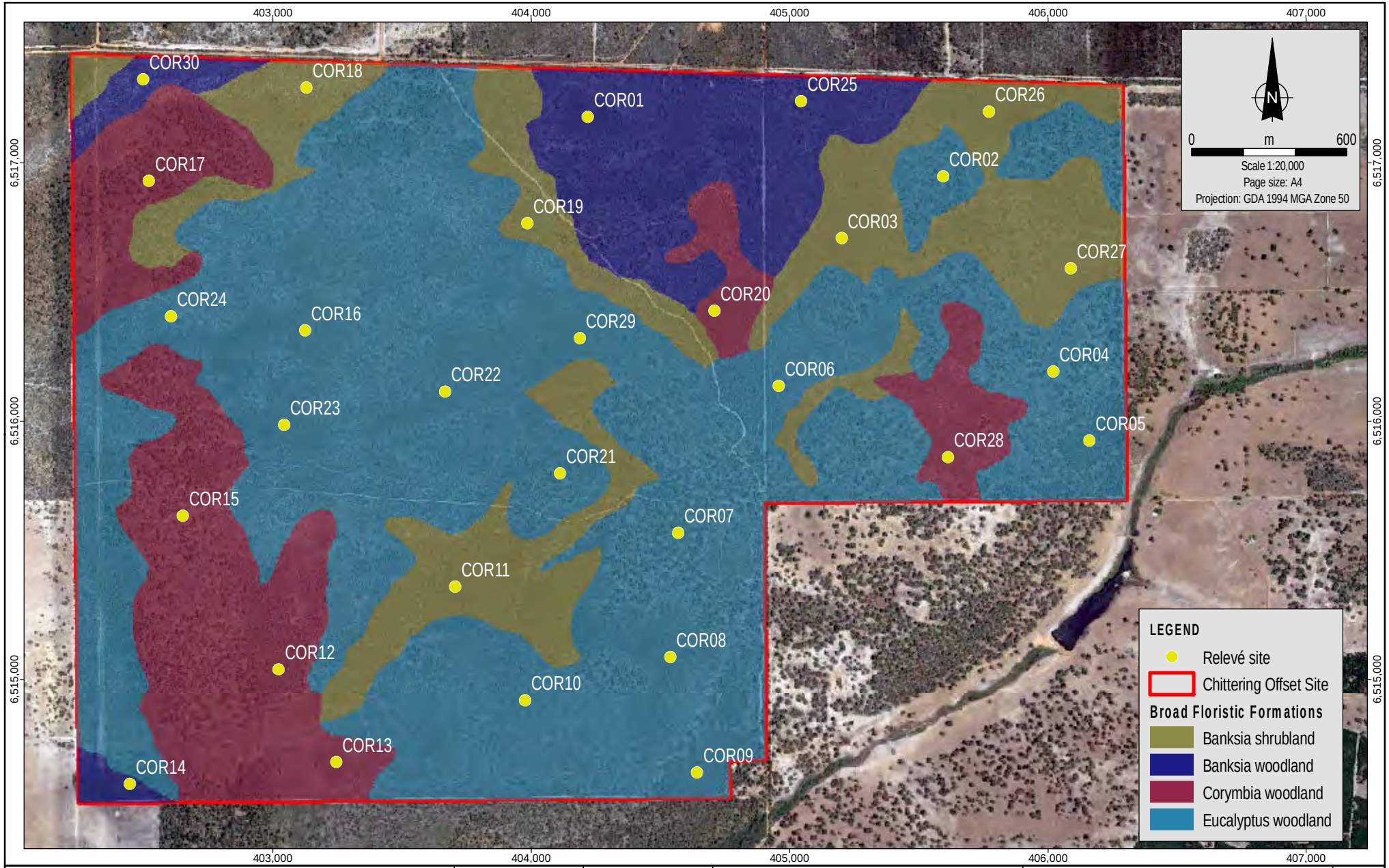
Main Roads WA

NorthLinkWA

Vegetation condition and introduced flora

Flora, Vegetation and Fauna Assessment

Figure No: 6



Source & Notes
Relevé sites and broad floristic formation mapping from Coffey (2014).
Aerial Imagery from Google Earth Pro (10.01.2015).

coffey

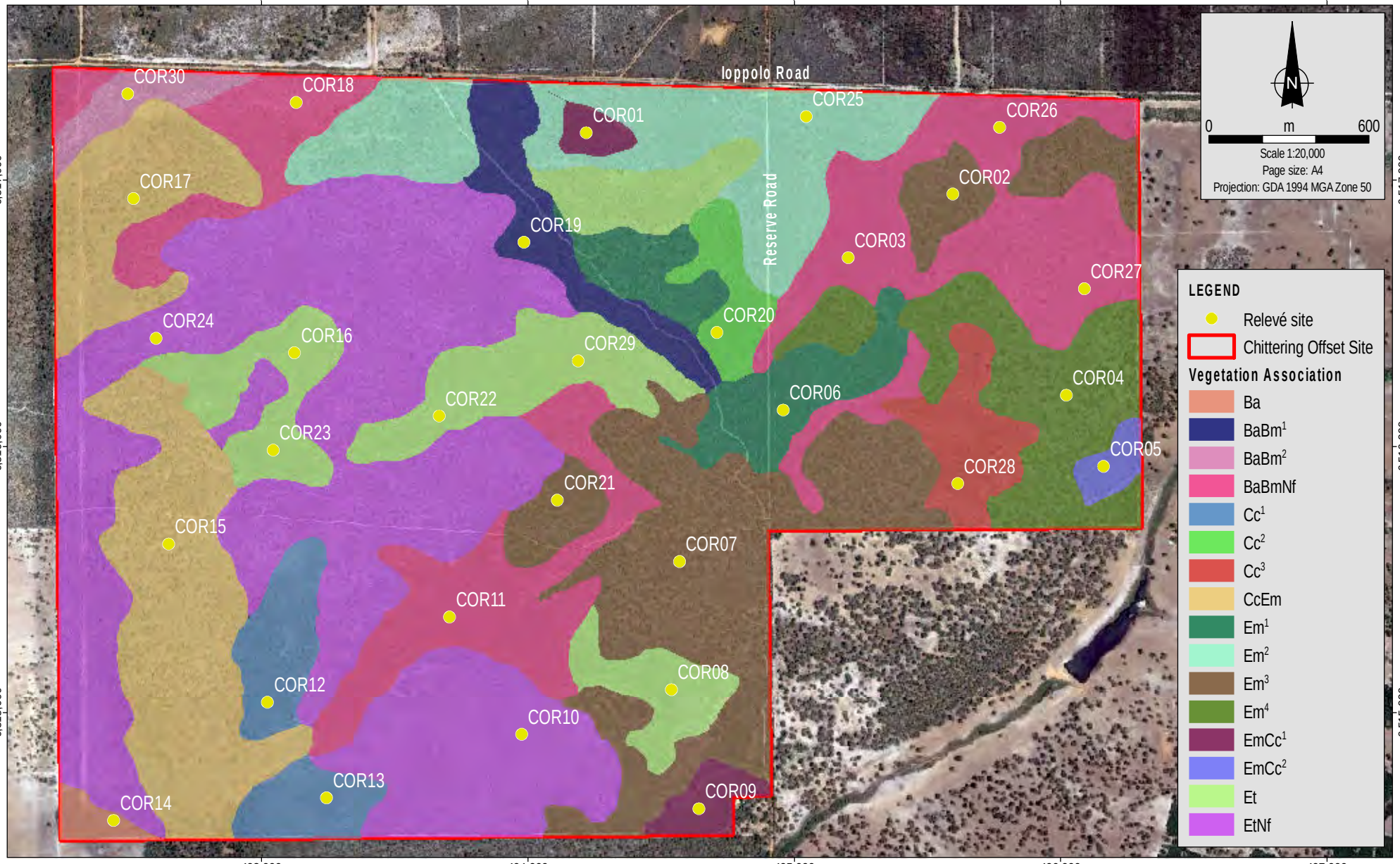
Date: 14.04.2015
MXD: 4483AA_06_GIS006_1
File Name: 4483AA_06_F007_GIS

Main Roads WA

NorthLinkWA

Broad Floristic Formations
Flora, Vegetation and Fauna Assessment

Figure No: 7



Source & Notes
Relevé sites and vegetation association mapping from Coffey (August 2014).
Aerial imagery from Google Earth Pro (10.01.2015).

coffey

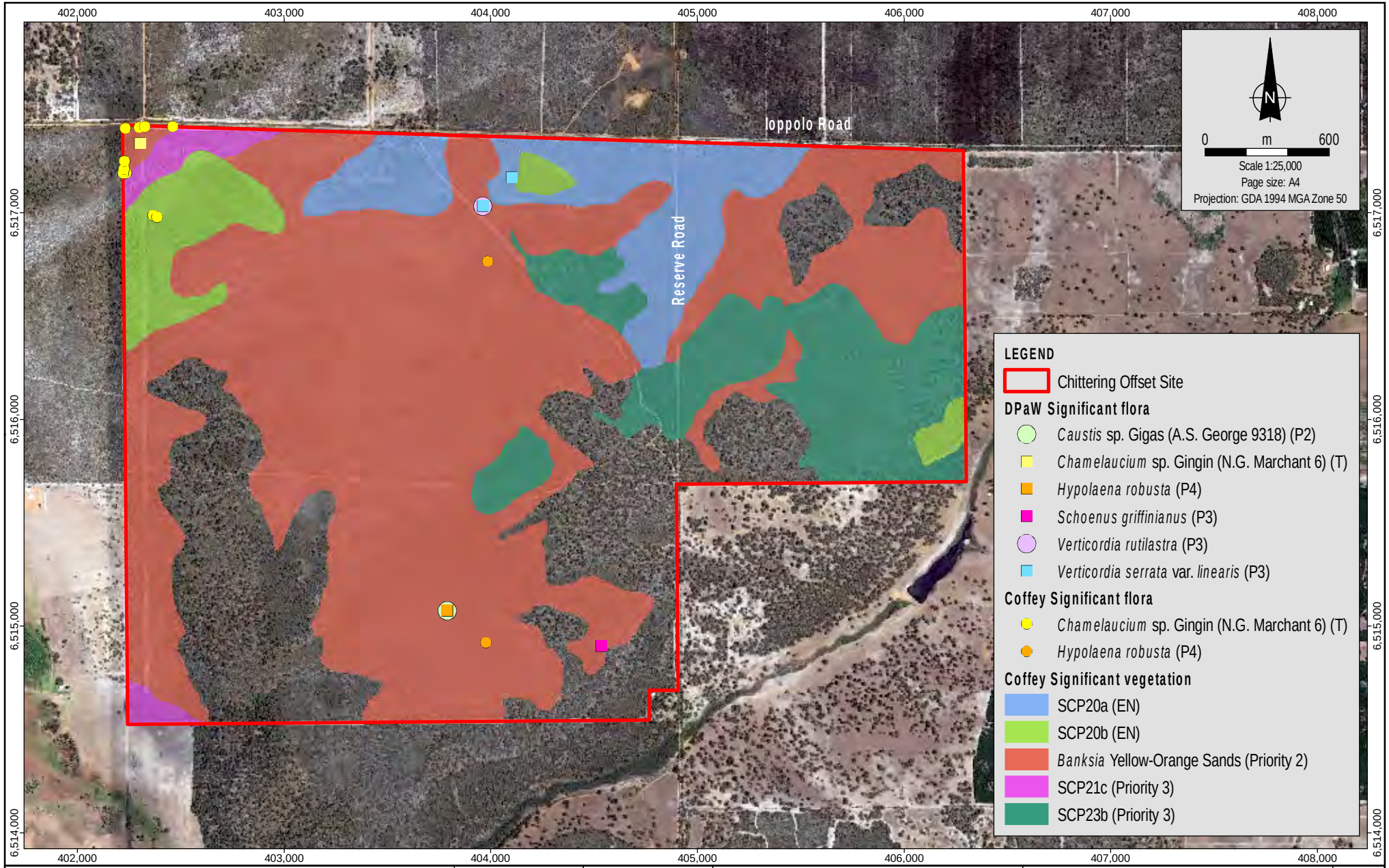
Date: 14.04.2015
MXD: 4483AA_06_GIS022_1
File Name: 4483AA_06_F008_GIS

Main Roads WA

NorthLinkWA

Vegetation Associations
Flora, Vegetation and Fauna Assessment

Figure No: 8



Source & Notes
Conservation significant flora and vegetation mapping from Coffey (August 2014).
Aerial imagery from Google Earth Pro (10.01.2015).

coffey

Date: 14.04.2015
MXD: 4483AA_06_GIS021_1
File Name: 4483AA_06_F009_GIS

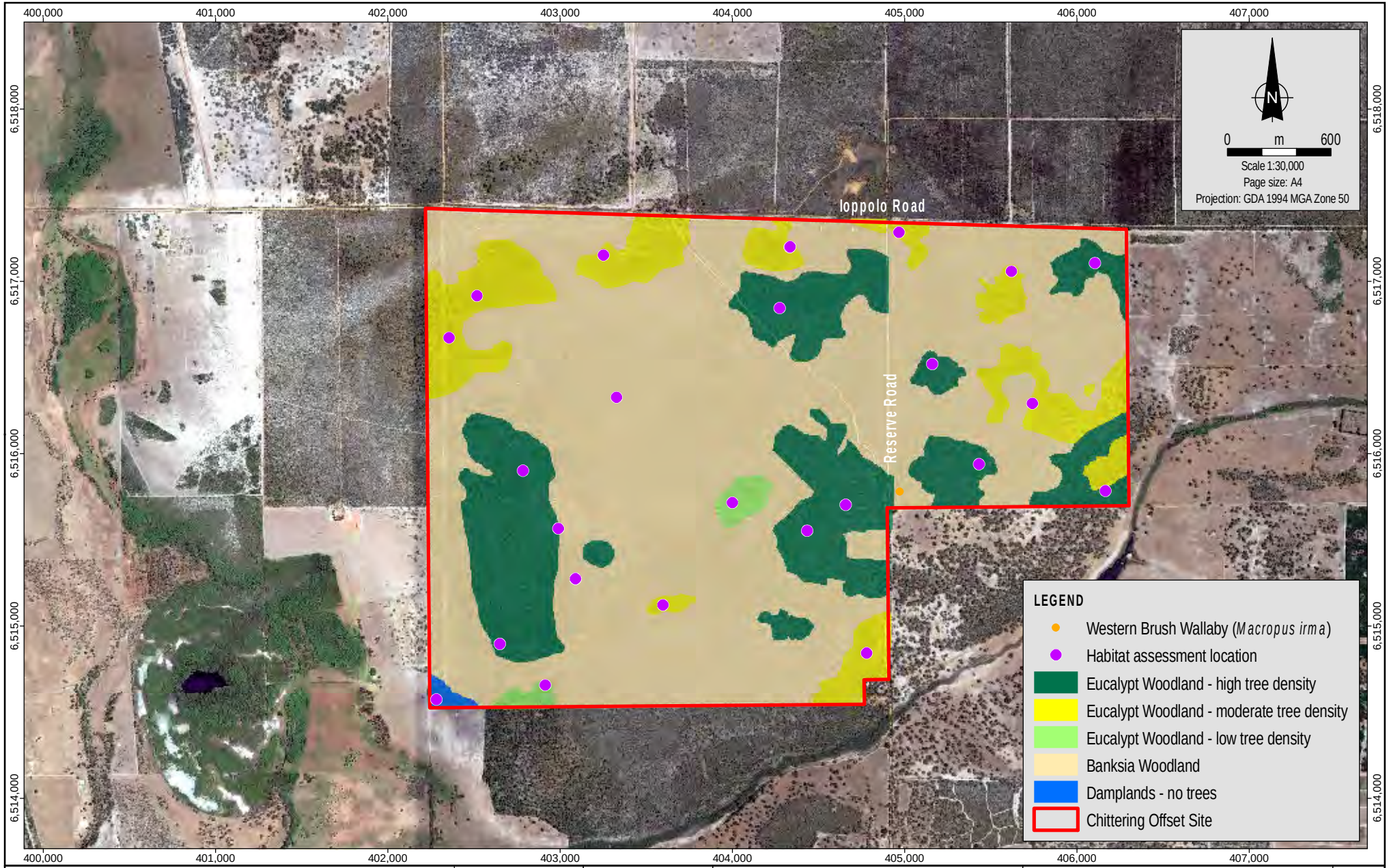
Main Roads WA

NorthLinkWA

Conservation Significant Flora and Vegetation

Flora, Vegetation and Fauna Assessment

Figure No: **9**



Source & Notes
Fauna habitat and tree density from Coffey (August 2014).
Aerial Imagery from Google Earth Pro (10.01.2015).

coffey

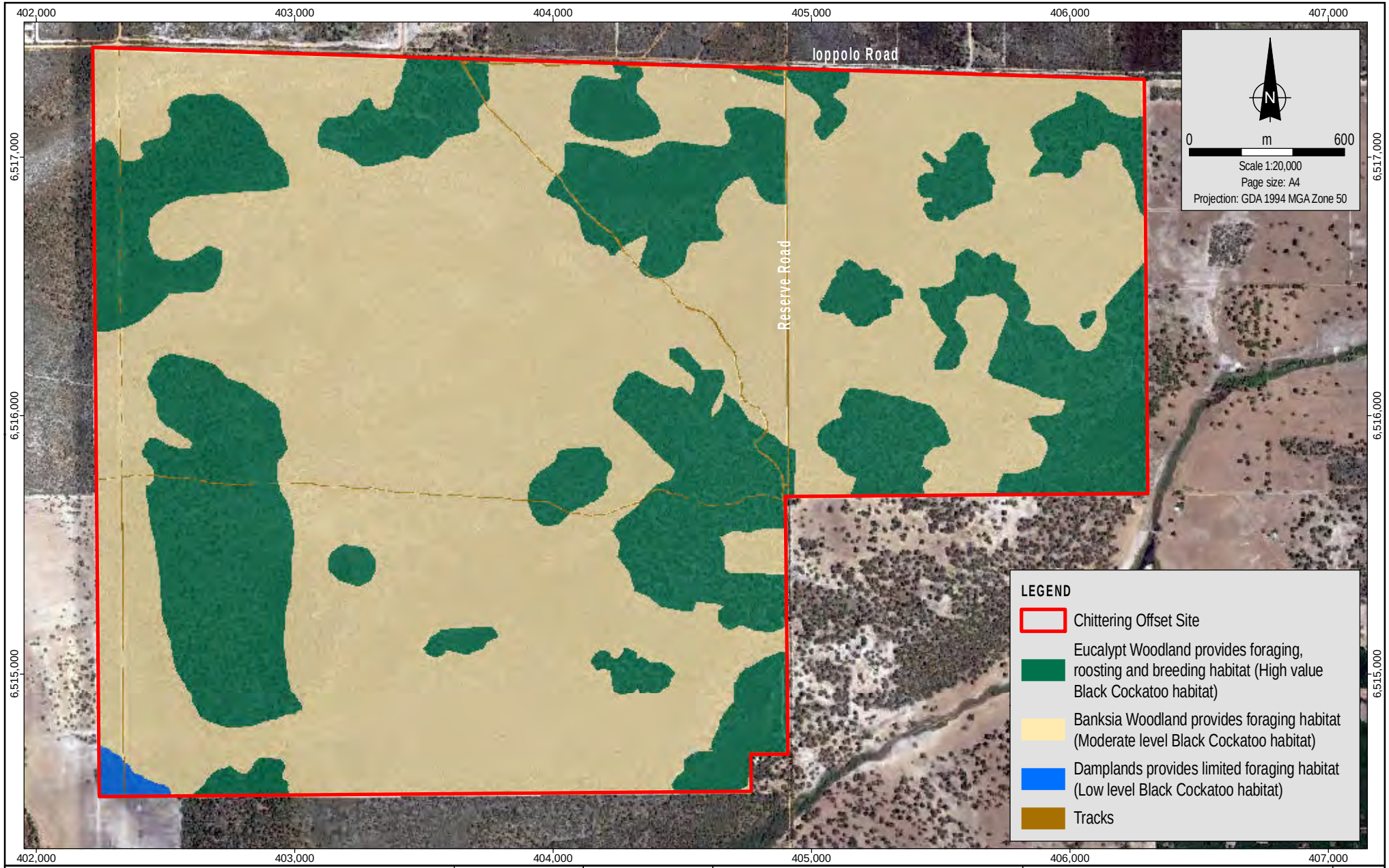
Date: 14.04.2015
MXD: 4483AA_06_GIS011_1
File Name: 4483AA_06_F010_GIS

Main Roads WA

NorthLinkWA

Fauna Habitat and Tree Density
Flora, Vegetation and Fauna Assessment

Figure No: 10



Source & Notes
Black Cockatoo habitat mapping from Coffey (August 2014).
Aerial Imagery from Google Earth Pro (10.01.2015).

coffey

Date: 14.04.2015
MXD: 4483AA_06_GIS020_1
File Name: 4483AA_06_F011_GIS

Main Roads WA

NorthLinkWA

Black Cockatoo Habitat
Flora, Vegetation and Fauna Assessment

Figure No: 11

APPENDIX A

Department of Parks and Wildlife Database Searches

Government of **Western Australia**
Department of **Parks and Wildlife**

Your Ref:
Our Ref: **12-0614FL**
Enquiries: Myrto Robert
Phone: (08) 9218 8760
Fax: (08)
Email: flora.data@dpaw.wa.gov.au

Coffey Environments
PO Box 4223
Victoria Park WA 6979

Attention: John Trainer

Dear John Trainer,

REQUEST FOR THREATENED AND PRIORITY FLORA INFORMATION

I refer to your request of 30 May 2014 for Threatened (Declared Rare) and Priority Flora information in the Chittering area. The search was conducted within 5km radial area of the central coordinates you submitted.

A search was undertaken for this area of **(1)** the Department's *Threatened (Declared Rare) and Priority Flora* database (for results, *if any*, see "TPFL" – coordinates are GDA94), **(2)** the *Western Australian Herbarium Specimen* database for priority species opportunistically collected in the area of interest (for results, *if any*, see "WAHERB"- coordinates are GDA94 – see condition number 9 in the attached 'Conditions in Respect of Supply' and **(3)**, the Department's *Threatened and Priority Flora List* [this list is searched using 'place names'. This list, which may also be used as a species target list, contains species that are declared rare (Conservation Code R or X for those presumed to be extinct), poorly known (Conservation Codes 1, 2 or 3), or require monitoring (Conservation Code 4) – for results, *if any*, see "TP List"]. The results are attached electronically to this email.

Attached also are the conditions under which this information has been supplied. Your attention is specifically drawn to the seventh point, which refers to the requirement to undertake field investigations for the accurate determination of Threatened and Priority flora occurrence at a site. *The information supplied should be regarded as an indication only of the Threatened and Priority flora that may be present and may be used as a target list in any surveys undertaken.*

The information provided does not preclude you from obtaining and complying with, where necessary, land clearing approvals from other agencies.

An invoice for $300 (plus GST) to supply this information will be forwarded.

It would be appreciated if any populations of Threatened and Priority flora you encounter in the area could be reported to this Department to ensure their ongoing management.

If you require any further details, or wish to discuss Threatened and Priority flora management, please contact Dr Ken Atkins, Manager, Species and Communities Branch, on (08) 9334 0455.

Yours faithfully

Miss Myrto Robert
.....
A/THREATENED FLORA DATABASE OFFICER
for the Director General

9 June 2014

Species and Communities Branch
17 Dick Perry Ave, Technology Park, Kensington
Phone: (08) 9334 0455 Fax: (08) 9334 0278
Locked Bag 104, Bentley Delivery Centre, Bentley, Western Australia 6983
www.dpaw.wa.gov.au

DEPARTMENT OF PARKS AND WILDLIFE

THREATENED (DECLARED RARE) AND PRIORITY FLORA INFORMATION

CONDITIONS IN RESPECT OF SUPPLY OF INFORMATION

1. All requests for data to be made in writing to the Director General, Department of Parks and Wildlife, Attention: Threatened Flora Database Officer, Species and Communities Branch.

2. The data supplied may not be supplied to other organisations, nor be used for any purpose other than for the project for which they have been provided, without the prior written consent of the Director General, Department of Parks and Wildlife.

3. Specific locality information for Threatened and Priority Flora is regarded as confidential, and should be treated as such by receiving organisations. Specific locality information may not be used in public reports without the written permission of the Director General, Department of Parks and Wildlife. Publicly available reports may only show generalised locations or, where necessary, show specific locations without identifying species. Species and Communities Branch is to be contacted for guidance on the presentation of Threatened and Priority Flora information.

4. Note that the Department of Parks and Wildlife respects the privacy of private landowners who may have Threatened and Priority Flora on their property. Threatened and Priority Flora locations identified in the data as being on private property should be treated in confidence, and contact with property owners made through the Department of Parks and Wildlife.

5. Receiving organisations should note that while every effort has been made to prevent errors and omissions in the data provided, they may be present. The Department of Parks and Wildlife accepts no responsibility for this.

6. Receiving organisations must also recognise that the database is subject to continual updating and amendment, and such considerations should be taken into account by the user.

7. **It should be noted that the supplied data do not necessarily represent a comprehensive listing of the Threatened and Priority Flora of the area in question. Its comprehensiveness is dependant on the amount of survey carried out within the specified area. The receiving organisation should employ a botanist, if required, to undertake a survey of the area under consideration.**

8. Acknowledgment of the Department of Parks and Wildlife as source of the data is to be made in any published material. The unique reference number that is given upon the request for information should be quoted when referencing the data. Copies of all such publications are to be forwarded to the Department of Parks and Wildlife, Attention: The Manager, Species and Communities Branch.

9. The development of the PERTH Herbarium database was not originally intended for electronic mapping (eg. GIS ArcView). The latitude and longitude coordinates for each entry are not verified prior to being databased. It is only in recent times that collections have been submitted with GPS coordinates. Therefore, be aware when using this data in ArcView that some records may not plot to the locality description given with each collection.

Species and Communities Branch
17 Dick Perry Ave, Technology Park, Kensington
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DECLARED RARE AND PRIORITY FLORA LIST

CONSERVATION CODES
for Western Australian taxa

T: **Threatened Flora** (Declared Rare Flora - Extant)
Schedule 1 under the *Wildlife Conservation Act 1950* Rare Flora Notice

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. The assessment of the conservation status of these species is based on their national extent.

X: **Presumed Extinct Flora** (Declared Rare Flora – Extinct)
Schedule 2 under the *Wildlife Conservation Act 1950* Rare Flora Notice

Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such.

Threatened Flora (Schedule 1) are further ranked by the Department according to their level of threat using IUCN Red List criteria:

CR: **Critically Endangered** – considered to be facing an extremely high risk of extinction in the wild.

EN: **Endangered** – considered to be facing a very high risk of extinction in the wild.

VU: **Vulnerable** – considered to be facing a high risk of extinction in the wild.

A list of the current rankings can be downloaded from DPAW's Listing of species and ecological communities webpage at
http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities

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Species that have not yet been adequately surveyed to be listed under Schedule 1 or 2 are added to the Priority Flora and Priority Fauna Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna. Species that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Conservation Dependent species are placed in Priority 5.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

1: Priority One: Poorly-known species

Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.

2: Priority Two: Poorly-known species

Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.

3: Priority Three: Poorly-known species

Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.

4: Priority Four: Rare, Near Threatened and other species in need of monitoring

(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands.
(b) Near Threatened. Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.
(c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

5: Priority Five: Conservation Dependent species

Species that are not threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Recommendations for additions, deletions or changes to the Declared Rare and Priority Flora List should be forwarded to the Flora Administration Officer or Senior Botanist Species and Communities Branch, DEC.

Species and Communities Branch
17 Dick Perry Ave, Technology Park, Kensington
Phone: (08) 9334 0455 Fax: (08) 9334 0278
Locked Bag 104, Bentley Delivery Centre, Bentley, Western Australia 6983
www.dpaw.wa.gov.au

ABBREVIATIONS USED IN THREATENED AND PRIORITY FLORA DATABASE

VESTING

AAP	Aboriginal Planning Authority
AGR	Chief Executive, Dep. of Agriculture
ALT	Aboriginal Land Trust
APB	Agricultural Protection Board of WA
BGP	Botanical Gardens & Parks Authority
BSA	Boy Scouts Association
CC	Conservation Commission – NPNCA - LFC
CGT	Crown Grant in Trust
COM	Commonwealth of Australia
CRO	Crown Freehold-Govt Ownership
CRW	Crown
DAG	Dep. of Agriculture
DOW	Dep. of Water
DPI	Dep. of Planning
EXD	Exec Direc CALM
FES	Fire and Emergency Services Aust.
HOW	Dep. of Housing/State Housing Commission
ILD	Industrial Lands Develop. Auth
LAC	LandCorp
LGA	Shire/LGA
MAG	Minister for Agriculture
MCB	Metropolitan Cemeteries Board
MED	Ministry of Education
MHE	Minister for Health
MIN	Minister for Mines
MPL	Ministry for Planning
MPR	Minister for Prisons
MRD	Main Roads WA
MTR	Minister for Transport
MWA	Minister for Water Resources
MWO	Minister for Works
NAT	Natural Trust of Australia WA
NON	Not Vested
PLB	Pastoral Lands Board
PRI	Private/Freehold
RAI	Public Transport Authority
REL	Religious Organisation
SPC	State Planning Commission
SYN	Synergy (ex Western Power)
SWA	State of Western Australia
TEL	Telstra
UNK	Unknown
WAT	Water Corporation
WEL	Minister Community Welfare
WRC	Water & Rivers Commission
XPL	Ex-Pastoral Lease

PURPOSES

ABR	Aboriginal Reserve
ACC	Access Track
AER	Aerodrome
AIR	Airport
ARS	Agricultural Research Station
BAP	Baptist Union of WA
CAM	Camping
CAR	Caravan park
CEM	Cemetery
CFA	Conservation of Fauna
CFF	Conservation Of Flora & Fauna
CFL	Conservation of Flora
CHU	Church
CMN	Communications
COM	Common
CON	Conservation Park
CPK	Car Park
CRM	Conservation & Resource Management
DEF	Defence
DRA	Drain
EDE	Educational Endowment
EDU	Educational purposes UWA
ENE	Enjoyment of Natural Environ.
EPL	Ex-pastoral Lease (Sect 33(2) CALM Act)
EPS	Explosives
EXC	Excepted from sale
EXL	Exploration Lease
EXP	Experimental Farm
FIR	Firing Range
FOR	State Forest
FP	Foreshore Purposes
GE	General Lease
GHA	Grain Handling
GOL	Golf
GRA	Gravel Pit
GVT	Government Requirements
HAR	Harbour Purposes
HEP	Heritage Purposes
HER	Heritage trail
HOS	Hospital
KEN	Kennels
LGA	LGA/Shire Requirements
LPR	Landscape Protection
MIN	Mining lease
MUN	Municipal Purposes
NPK	National Park
NRE	Nature Reserve
OTH	Other
PAR	Parkland (& Recreation)
PAS	Pastoral lease
PCR	Proposed for Conservation
PFF	Protection of Flora & Fauna
PFL	Protection of Flora
PIC	Picnic ground
PLA	Plantation
PMC	Protection of Meteorite Crater
POS	Public Open Space
PPA	Public parkland
PRS	Prison site
PUR	Purchase Lease
PUT	Public Utility
QUA	Quarry
RAC	Racecourse
RAD	Radio Station
REC	Recreation
REH	Rehabilitation/Re-establish Native Plants
RRE	Railway Reserve
RUB	Rubbish
SAL	Saleyards
SAN	Sand
SCH	School-site
SET	Settlers requirements
SHO	Showgrounds
SNN	Sanitary
SOI	Soil Conservation
STO	Stopping place
STK	Stock Route
TIM	Timber
TOU	Tourism
TOW	Town-site
TRA	Training Ground
TRI	Trig station
UCL	Unallocated Crown Land
UNK	Unknown
VER	Road Verge
VPF	Vermin Proof Fence
WAT	Water
WLS	Wildlife Sanctuary
WOO	Firewood

ABBREVIATIONS USED IN THE WESTERN AUSTRALIAN HERBARIUM DATABASE

Geocode Method - The method that was used to record the latitude and longitude.

Auto - Indicates that the coordinate data in the record was created automatically (i.e. by software), usually by creating a coordinate from information provided in the Nearest Named Place or Locality textual description fields.

GAP - Acronym for "Generalised Arbitrary Point" as used in HISPID. GAP indicates that the coordinate data was obtained manually from the Nearest Named Place or Locality textual description fields.

GPS - Acronym for "Global Positioning System". GPS indicates that the coordinate data in the record was obtained from a GPS unit by the collector of the specimen.

MAN - Shorthand for manual. MAN indicates that the coordinate data was created by hand using some method not allowed for by one of the other manual Geocode Method values, in particular, TOPO, GAP, or GPS.

TOPO - Shorthand for topographic map. TOPO indicates that the coordinate data was obtained by plotting textual locality details against a topographic map.

None - Indicates that no coordinate data has been supplied by the collector.

Unknown - Indicates that there is no known method for determining the coordinate data. Should be used if the collector provided no indication of how they sampled the specimen's coordinate data.

PREC (Precision) - precision ratings for coordinates.

Precision 1: Absolutely precise (to nearest 100m or nearest second) and must be GPS determined. For example 35°26'42"S 123°40'26"E

Precision 2: Falling within a diameter of 3km (ca 2 minutes) or if no GPS mentioned in collecting notes. (The location must be able to be pinpointed on a 1:250 000 map, a spot locality. For example 35°26'42"S 123°40'26"E

Precision 3: Falling within a diameter of 10km (ca 7 minutes) or for degrees and minutes, where seconds have not been given. For example 35°26'_"S 123°40'_"E

Precision 4: Falling within a diameter of ca 50km (30 minutes). For example 35°26'_"S 123°40'_"E

Precision 5: Where a location is a prescribed large geographical area within a state or only the state is given. Diameter is greater than 50km. For example 35°_'_"S 123°_'_"E

Precision 6: used when localities are New Holland, Eastern Australia or Not given. Fields will be left blank.

Clinton Van Den Bergh

From: Communities Data <Communities.Data@DPaW.wa.gov.au>
Sent: Tuesday, 10 June 2014 2:56 PM
To: John Trainer; Fauna Data; Flora Data; Communities Data
Cc: Denise True; Clinton Van Den Bergh; Paul Mitrovski; Natassja Raymond
Subject: Results of TEC/PEC Search - Coffey (Bindoon) (Our Ref:08-0614EC) (Your Ref:)
Attachments: TEC-PEC_metadata_26072011.pdf; Conditions of supplying TEC and PEC data.pdf; Bindoon_Coffey_TecPecSearchResults_10062014.dbf; Bindoon_Coffey_TecPecSearchResults_10062014.prj; Bindoon_Coffey_TecPecSearchResults_10062014.sbn; Bindoon_Coffey_TecPecSearchResults_10062014.sbx; Bindoon_Coffey_TecPecSearchResults_10062014.shp; Bindoon_Coffey_TecPecSearchResults_10062014.shp.xml; Bindoon_Coffey_TecPecSearchResults_10062014.shx

Hi,

I refer to your request on the 30 of May 2014 for information on threatened and priority ecological communities occurring within a 10km radius of the co-ordinates provided in the email below.

A search was undertaken on the Department's Threatened Ecological Communities database. Please find attached a buffer shapefile from the database where records were found. If you do not use shapefiles please use the (.dbf file) this can be open in excel as a spreadsheet. Please note that this information is not to be given to any external third parties as it may contain information regarding private property.

Please note not all priority ecological communities are currently recorded on our database. You may like to view the current list in related documents at http://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/Priority_ecological_communities_list_Sept2013.pdf

Attached are the conditions under which this information has been supplied. The information supplied should be regarded as an indication only of the threatened and priority ecological communities that may be present.

It would be appreciated if any occurrences of threatened and priority ecological communities encountered by you in the area could be reported to this Department to ensure their ongoing management. An occurrence report form and associated manual can be found at http://www.dpaw.wa.gov.au/plants-and-animals/monitoring/96-standards/140-standard-report-forms?showall=&start=2

Search area response information is only accurate at the time of provision. Over time, new occurrences or modifications to existing occurrences may occur as information becomes available. It is recommended that searches be re-submitted every six months where projects occur over a long period of time.

An invoice for $220 (including GST) for the supply of this information will be forwarded.

Your request for information reference number for this search is: 08-0614EC. Please quote this unique reference number when acknowledging the Department of Parks and Wildlife as a source of the data in any published material.

Kind Regards

Wendy Chow| TEC Ecologist| Species & Communities Branch
Department of Parks and Wildlife | Kensington | Ph. 9334 0554| wendy.chow@dpaw.wa.gov.au

From: John Trainer [mailto:John.Trainer@coffey.com]
Sent: Friday, 30 May 2014 3:23 PM
To: Fauna Data; Flora Data; Communities Data
Cc: Denise True; Clinton Van Den Bergh; Paul Mitrovski; Natassja Raymond
Subject: ecological database search

Hi All,

Could I please request a threatened fauna, flora and ecological communities database searches for the following area with a 10km buffer (or whichever you deem appropriate).
This information will be used for a consultant's report.

Fauna: Species list format
Flora: CSV and DBF format
Ecological Communities: CSV and DBF format

Iopollo Rd muchea

50J 403670 E
6515930 S

Please respond to all parties CC'd into this email as not all members will be in the office.

Thanks

John Trainer
Senior Environmental Consultant/ Zoologist

Suite 2, 53 Burswood Road, Burswood WA 6100
PO Box 4223 Victoria Park WA 6979

t: +61 8 9269 6200

m: +61 400 224 012

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DEPARTMENT OF ENVIRONMENT AND CONSERVATION

THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES INFORMATION

CONDITIONS IN RESPECT OF SUPPLY OF INFORMATION

1. All requests for data are to be made in writing to the Director General, Department of Environment and Conservation Attention: Species and Communities Branch

2. The data supplied may not be supplied to other organisations, nor be used for any purpose other than for the project for which they have been provided, without the prior written consent of the data custodian (Val English), Species and Communities Branch.

3. Specific locality information for threatened and priority ecological communities (TECs/PECs) is regarded as confidential, and should be treated as such by receiving organisations. Specific locality information for TECs/PECs may not be used in public reports without the written permission of the Director General, Department of Environment and Conservation. Publicly available reports may only show generalised locations (ie buffer locations). The TEC database manager is to be contacted for guidance on the presentation of TEC/PEC information.

4. Note that the Department of Environment and Conservation respects the privacy of private landowners who may have threatened and priority ecological communities on their property. Locations of TECs/PECs identified in the data as being on private property should be treated in confidence, and contact with property owners made through the Department of Environment and Conservation.

5. Receiving organisations should note that while every effort has been made to prevent errors and omissions in the data provided, they may be present. The Department of Environment and Conservation accepts no responsibility for this.

6. Receiving organisations must also recognise that the Threatened Ecological Communities database is subject to continual updating and amendment, and such considerations should be taken into account by the user.

7. It should be noted that the supplied data do not necessarily represent a comprehensive listing of the threatened and priority ecological communities of the area in question. Its comprehensiveness is dependant on the amount of survey carried out within the specified area. Private property has been relatively little surveyed. The receiving organisation should employ a consultant, if there is any likelihood of the presence of any threatened or priority ecological community, to undertake a survey of the area under consideration.

8. Acknowledgment of the Department of Environment and Conservation as source of the data is to be made in any published material. Copies of all such publications are to be forwarded to the Department of Environment and Conservation, Attention: Manager, Species and Communities Branch.

Threatened and Priority Ecological Community buffers in WA

UNDER NO CIRCUMSTANCES IS THIS DATA TO BE PROVIDED TO ANY THIRD PARTIES, for more details see conditions for the supply of this information.

Citation

Title: Threatened and Priority Ecological Community buffers in WA

Custodian: Department of Environment & Conservation

Description

Abstract: Ecological communities throughout WA that are "Presumed Totally Destroyed", "Critically Endangered", "Endangered", "Vulnerable", "Priority 1-5", "Lower Risk" and "Not evaluated". Communities are based on various life-forms including plants, invertebrates and micro-organisms.

Geographical Bounding Box

North: -14.788854

South: -35.005719

East: 128.870214

West: 113.765525

Data Currency and Status

Beginning Date: 1/1/94

Ending Date: current

Maintenance/Update: As requested

Access

Stored Data Format: ESRI shapefile

Coordinate System: GCS_GDA_1994

Access Constraints:	Digital data is only available with written permission of the custodian. In addition, some occurrence data eg. location of sites on private land, is password restricted.

Data Quality

Positional Accuracy:	Point location data within occurrences usually from GPS fix, usually within 100 metres. Some digitized from hard copy.
Attribute Accuracy:	Not documented.
Logical Consistency:	Not documented.
Completeness:	Information on specific communities was obtained from regional, subregional or specific habitat surveys of floristic communities, invertebrate communities, wetland assemblages and communities of micro-organisms.

Attributes List:

Name	Description
BDY_ID	Associated boundary polygon unique identifier
OCC_UNIQUE	Unique occurrence identifier
COM_ID	Shortened community name identifier
COM_NAME	Community name
CT_DESC	State listed Category of Threat
S_ID_COUNT	Number of Site IDs within a buffer
FIRST_S_ID	First site identifier
LAST_S_ID	Last site identifier
BUFFER	Buffer radius from site ID or boundary in metres

General Information:

Priority Ecological Communities

- There are 284 known PECs and subtypes , 271 (~95%) of these on the TEC/PEC database
- The location of priority communities is good, but not complete across the state
- There is a formal list of PECs at http://www.dec.wa.gov.au/content/view/849/2017/
- Many PECs are awaiting endorsement as TECs

buffers

- The buffer radius around each occurrence of a TEC or PEC is included to help ensure that developments with potential to impact groundwater or surface water are picked up.
- For wetland TEC or PECs we seek to include an area within the buffer zone that is intended to help protect groundwater and surface water. The area required to protect different types of wetlands from a variety of hydrological impacts will, of course, differ.

- For upland TEC or PECs that are believed not to be groundwater dependent, the buffer area radius encompasses the TEC or PEC site location recorded in the TEC database, and extends at least to the furthest point in the occurrence. This is to ensure that the 'buffer' area encompasses at least the entire TEC or PEC. This means that some linear occurrences may need a larger buffer radius to encompass the entire occurrence.
- Occurrences with a buffer distance of 0 are no longer extant.

Contact Information

Contact Organisation:	Department of Environment & Conservation
Contact Position:	TEC Database Administrator - Species and Communities Branch
Mail Address:	Locked Bag 104, Bentley Delivery Centre
Suburb/Locality:	Kensington
Country/State:	WA
Postcode:	6983
Telephone:	(08) 9334 0116
Fax:	(08) 9334 0300
Email:	communities.data@dec.wa.gov.au

Metadata Information

Metadata Date: current

APPENDIX B

EPBC Act Database Search for MNES

Australian Government

Department of the Environment

EPBC Act Protected Matters Report

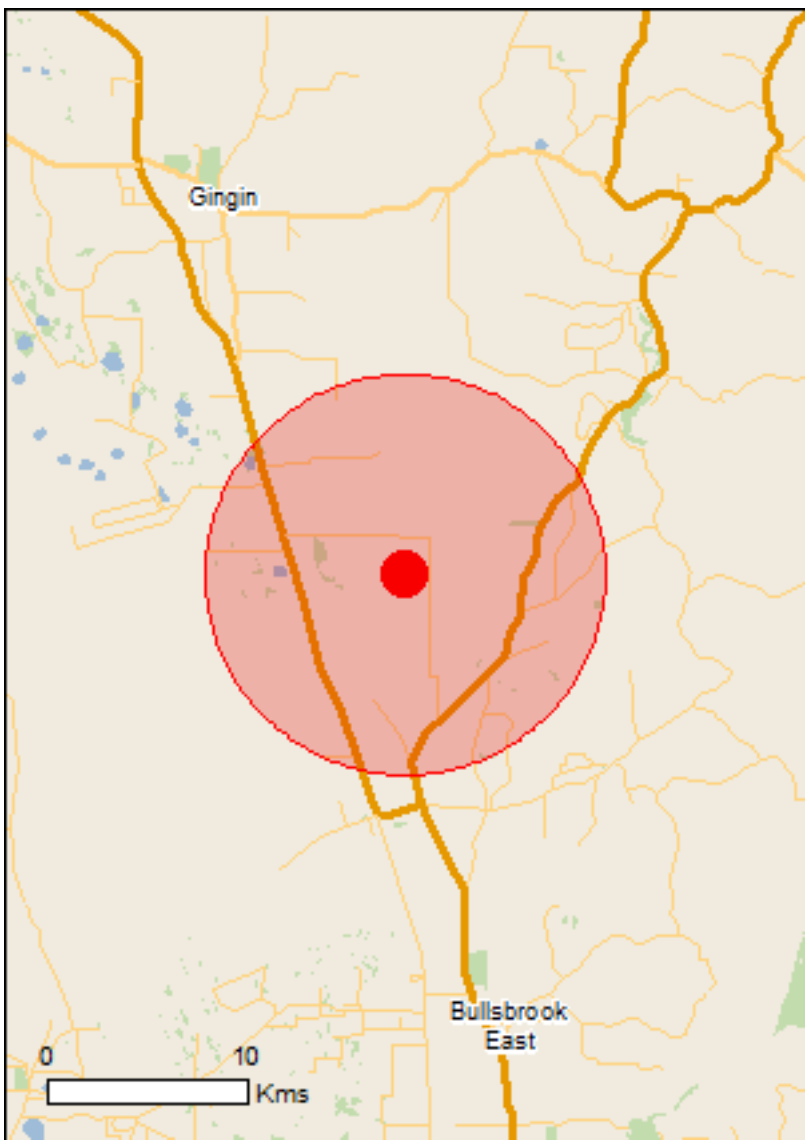
This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

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

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

Report created: 04/07/14 11:16:40

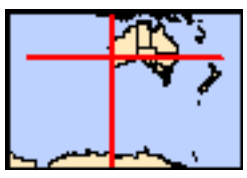
- Summary
- Details
  - Matters of NES
  - Other Matters Protected by the EPBC Act
  - Extra Information
- Caveat
- Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 10.0Km



Summary

Matters of National Environmental Significance

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

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	26
Listed Migratory Species:	6

Other Matters Protected by the EPBC Act

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

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

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

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

Commonwealth Land:	1
Commonwealth Heritage Places:	1
Listed Marine Species:	7
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

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

Place on the RNE:	3
State and Territory Reserves:	6
Regional Forest Agreements:	1
Invasive Species:	38
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

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

Name	Status	Type of Presence
Shrublands and Woodlands on Perth to Gingin ironstone (Perth to Gingin ironstone association) of the Swan Coastal Plain	Endangered	Community known to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding likely to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat likely to occur within area
Anigozanthos viridis subsp. terraspectans Dwarf Green Kangaroo Paw [3435]	Vulnerable	Species or species habitat likely to occur within area
Caladenia huegelii King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Centrolepis caespitosa [6393]	Endangered	Species or species habitat likely to occur within area
Chamelaucium sp. Gingin (N.G.Marchant 6) Gingin Wax [64649]	Endangered	Species or species habitat known to occur within area
Conospermum densiflorum subsp. unicephalatum One-headed Smokebush [64871]	Endangered	Species or species habitat may occur within area
Darwinia foetida Muchea Bell [83190]	Critically Endangered	Species or species habitat known to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat may occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat may occur within area
Drakaea elastica Glossy-leafed Hammer-orchid, Praying Virgin [16753]	Endangered	Species or species habitat likely to occur within area
Eleocharis keigheryi Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat likely to occur within area
Epiblema grandiflorum var. cyaneum Baby Blue Orchid, Blue Babe-in-the-cradle Orchid, Blue Babe-in-a-cradle [67182]	Endangered	Species or species habitat may occur within area
Eucalyptus balanites Cadda Road Mallee, Cadda Mallee [24264]	Endangered	Species or species habitat may occur within area
Eucalyptus leprophloia Scaly Butt Mallee, Scaly-butt Mallee [56712]	Endangered	Species or species habitat may occur within area
Grevillea corrugata a shrub [65445]	Endangered	Species or species habitat known to occur within area
Grevillea curviloba subsp. curviloba Curved-leaf Grevillea [64908]	Endangered	Species or species habitat known to occur within area
Grevillea curviloba subsp. incurva Narrow curved-leaf Grevillea [64909]	Endangered	Species or species habitat known to occur within area
Lepidosperma rostratum Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area
Ptychosema pusillum Dwarf Pea [11268]	Vulnerable	Species or species habitat likely to occur within area
Thelymitra manginii K.Dixon & Batty ms. [67443]	Endangered	Species or species habitat likely to occur within area
Thelymitra stellata Star Sun-orchid [7060]	Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Verticordia plumosa var. pleiobotrya Narrow-petalled Featherflower, Mundijong Featherflower [55803]	Endangered	Species or species habitat may occur within area

Listed Migratory Species

[Resource Information]

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

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land

[Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Defence - MUCHEA ARMAMENT RANGE

Commonwealth Heritage Places

[Resource Information]

Name	State	Status
Natural		
Muchea / Pearce Air Weapons Range	WA	Indicative Place

Listed Marine Species

[Resource Information]

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

Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Pandion haliaetus		
Osprey [952]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Natural		
Muchea / Pearce Air Weapons Range	WA	Indicative Place
Lake Chandala Area	WA	Registered
Yeal - Gnangara Area	WA	Registered

State and Territory Reserves [Resource Information]

Name	State
Barracca	WA
Breera Road	WA
Burroloo Well	WA
Chandala	WA
Timaru	WA
Unnamed WA50678	WA

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
South West WA RFA	Western Australia

Invasive Species [Resource Information]

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

Name	Status	Type of Presence
Birds		
Acridotheres tristis		
Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos		
Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis		
European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia		
Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat likely to occur within area

Nationally Important Wetlands	[Resource Information]
Name	State
Chandala Swamp	WA

Coordinates

-31.48843 115.98843

Caveat

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

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

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

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

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

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

- migratory and
- marine

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

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

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

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

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

Acknowledgements

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

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

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

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

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APPENDIX C

Linear *Phytophthora* Dieback Risk Assessment

Terratree

Linear *Phytophthora* Dieback Risk Assessment of M2091 Ioppolo Road, Chittering

Prepared for Coffey Environments Australia Pty Ltd

Ref: T14008

ecological assessment
& management

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Document Control

Version	Date	Author	Reviewer
Draft	13/10/2014	J. Grehan	C. McGary C. Van Den Bergh
Final	16/12/14	J. Grehan	C. Van Den Bergh

Author: Joseph Grehan

Principal Ecologist

DISCLAIMER

This document is prepared in accordance with and subject to an agreement between Terratree Pty Ltd ("Terratree") and the client for whom it has been prepared ("Coffey Environments Australia Pty Ltd") and is restricted to those issues that have been raised by the client in its engagement of Terratree and prepared using the standard of skill and care ordinarily exercised by Environmental Scientists in the preparation of such documents.

Any organisation or person that relies on or uses this document for purposes or reasons other than those agreed by Terratree and the client without first obtaining the prior written consent of Terratree, does so entirely at their own risk and Terratree denies all liability in tort, contract or otherwise for any loss, damage or injury of any kind whatsoever (whether in negligence or otherwise) that may be suffered as a consequence of relying on this document for any purpose other than that agreed with the client.

Terratree Pty Ltd

Executive Summary

Coffey Environments Australia Pty Ltd commissioned Terratree Pty Ltd to undertake a linear *Phytophthora* Dieback assessment of tracks and other potential disease vectors within and surrounding a block of native vegetation. The site is located in the Shire of Chittering approximately 80 km north of Perth. The site is 983 ha and mainly comprised of Banksia woodland with some areas of Marri (*Corymbia calophylla*) open forest.

The assessment was conducted in accordance with the Department of Parks and Wildlife's (DPaW) *Manual for detecting Phytophthora Dieback disease* (Procedures for DPaW managed lands) (DPaW 2013). Tracks, water courses and hard-hooved feral animals are considered to be the most likely vectors of disease into the study area. A linear Dieback assessment was determined to be an appropriate method for assessing the risk and likelihood of Dieback presence within and adjacent to the site.

Vegetation within the study area was categorised according to three different levels of risk:

1. High Risk: Areas where *P. cinnamomi* has been recovered from samples and disease symptoms are consistent with the presence of Dieback.

2. Moderate Risk: Areas exhibiting past or current disturbances (logging, grazing, dumping etc.) which has altered vegetation structure and composition and areas downslope of confirmed infestations, or vegetation exhibiting disease symptoms but have not returned positive results for *P. cinnamomi*.

3. Low Risk: Areas of protectable uninfested vegetation (as determined by a registered Dieback interpreter), which exhibit multiple healthy indicator species, vegetation in Pristine to Very Good condition (Keighery scale 1-3), no disease pattern or chronology, and no significant risks from disease vectors or current land use.

The total study area, in terms of the linear corridor that was assessed, is 119.2ha. This is comprised of 19.4 ha of High Risk (16.3 %), 12.2 ha of Moderate Risk (10.2 %) and 87.6 ha (73.5 %) of Low Risk vegetation

In total, 11 soil and tissue samples were taken from recently dead and dying disease indicator species. Two positive results for *P. cinnamomi* were reported. In addition, a tissue sample was taken to test for canker and this returned a positive result for *Cytospora* sp.

In conclusion, the linear assessment determined that the majority of the study area (linear assessment corridor) is uninfested and therefore presented a low risk of spreading Dieback into areas outside the study corridor. While it is likely that the majority of the 983 ha site is uninfested, caution must be exercised when extrapolating the disease status and/or risk to vegetation that has not been assessed outside the study area.

Terratree makes the following recommendations in relation to assessment and management of Dieback at the site:

- A comprehensive Dieback assessment of the site should be completed in accordance with current Department of Parks and Wildlife standards (DPaW 2013).
- Protectable areas should be clearly demarcated and signposted.
- Additional sampling should be done in moderate risk areas.
- A Dieback management plan, including an access management strategy, should be developed for the site.

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Appendix 1: Vegetation Health Services Laboratory report on positive identification of *Cytospora* sp. (canker) in CS11

Appendix 2: Sample Results from the Vegetation Health Services laboratory

1 Introduction

Coffey International (Coffey) commissioned Terratree Pty Ltd (Terratree) to undertake a linear *Phytophthora* Dieback (Dieback) assessment of tracks and other potential disease vectors within and surrounding a 983 ha block of native vegetation ('the site') in the Shire of Chittering. The linear assessment corridor includes a 25 m area either side of tracks and unsealed roads within and adjacent to the site, watercourses and other potential disease vectors (hereafter referred to as the 'study area').

1.1 Background

Phytophthora Dieback ('Dieback') is a soil borne pathogen with a range of plant hosts in the southwest of Western Australia. These predominantly belong to the Proteaceae, Ericaceae, Myrtaceae, Xanthorrhoeaceae and Fabaceae plant families. While some plant species are resistant, others are susceptible to the disease caused by the pathogen resulting in chlorosis, dieback and usually death.

According to the most recent Western Australian (WA) State of the Environment Report (Environmental Protection Authority 2007) *Phytophthora* Dieback, a Priority 1 Threat, is the third greatest threat to biodiversity after salinity and climate change. It is a more serious threat than weeds, native vegetation clearing, acid sulphate soils and soil erosion. It is significant in WA because:

- Over 40% (2,300) of the native plant species and half of the endangered plant species in the southwest of WA are susceptible to the pathogen
- The changes in plant community composition and structure that Dieback causes has impacts throughout the whole ecosystem, including on the indigenous fauna
- Dieback can lead to significant soil erosion as a result of the loss of susceptible vegetation

The Dieback pathogen is widespread in areas with greater than 800 mm of annual rainfall, less extensive in areas that receive between 600–800 mm and mainly restricted to water-gaining sites in areas that receive 400–600 mm. The pathogen does not occur in areas that receive less than 400 mm of annual rainfall. In WA, Dieback is a significant environmental issue for projects between Geraldton in the Midwest and Esperance on the South Coast and is widespread in the Southwest region.

1.2 Project Location and Description

The study area is located in the Shire of Chittering approximately 80 km north of Perth, approximately 15 km north of Muchea **(Figure 1)**. The 960 ha site is mainly comprised of Banksia woodland with some Marri (*Corymbia calophylla*) open forest.

1.3 Regulatory Context

Phytophthora Dieback management is required under the following regulatory mechanisms in WA:

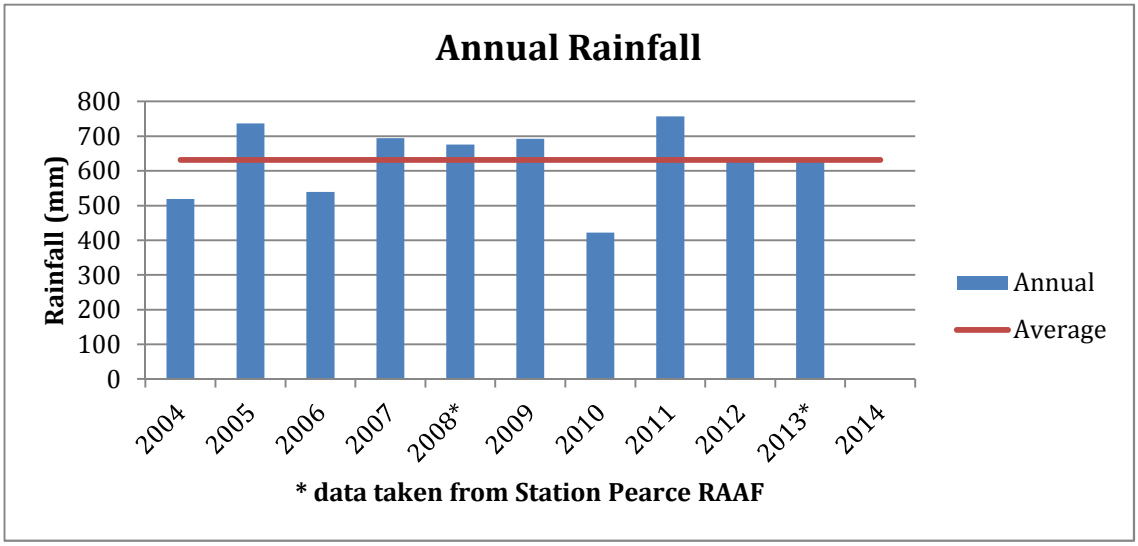
- *Phytophthora* Dieback is listed as a Key Threatening Process with the Federal Government under the *Environmental Protection and Biodiversity Conservation Act* (1999)
- *Environmental Protection Act* (1986) Part V S.50A "Serious Environmental Harm" provisions

2 Existing Environment

2.1 Climate

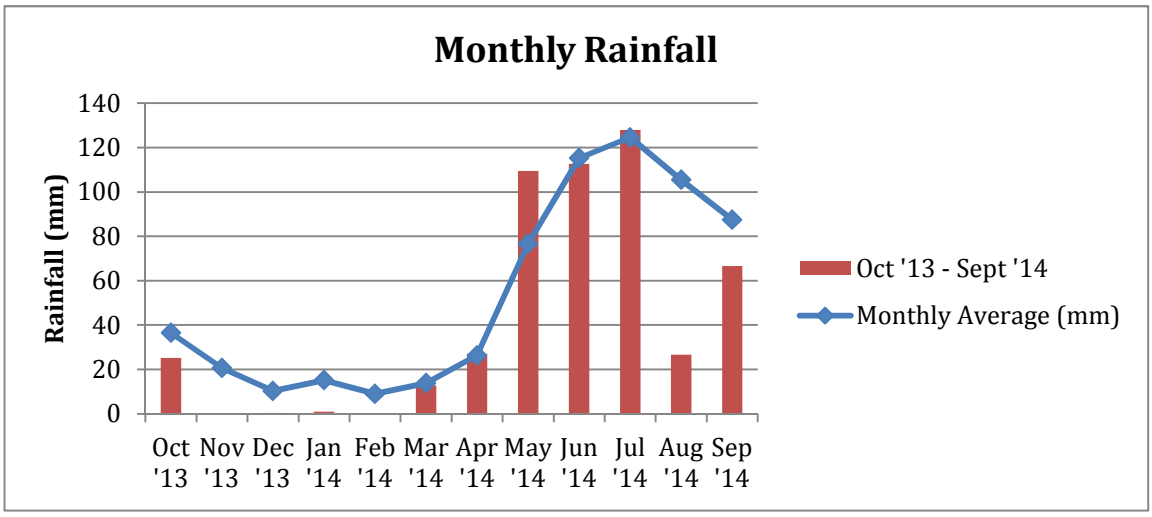
The Swan Coastal Plain region has a Mediterranean type climate with hot dry summers and cool wet winters. The warmest month is February, with an average monthly temperature of 30.4°C. The coolest month is July, with an average temperature of 18.3 °C.

Based on data from the Gingin Aero station (# 9178), the average annual rainfall for Muchea is 631.7 mm. The seasonal rainfall pattern for Muchea indicates an overall reduction in rainfall compared to historical averages, but exhibits variability in this trend, with years of significantly reduced rainfall interspersed with years of average to slightly above average rainfall (**Graph 1**). Significantly, the rainfall for 2010 was only 422 mm, which is 33% below average annual rainfall.



Graph 1: Annual rainfall at Gingin Aero station # 9178 (BoM, 2014)

Most rain falls in the cooler months of June-August. During winter 2014, this station received average or above-average rainfall until July, but a significant drop in rainfall was recorded during August and September compared to the long-term average.



Graph 2: Monthly rainfall at Gingin Aero station (# 9178) (2013-14) (BOM, 2014)

2.2 Biogeography

The study area is located in the Swan Coastal Plain Interim Biogeographic Regionalisation of Australia (IBRA) Bioregion, Perth Sub-Region (SWA02). This sub-region is dominated by woodlands of Banksia and Tuart on sandy soils, Sheoak on outwash plains, and paperbark in swampy areas. The colluvial and aeolian sand areas represent three phases of Quaternary marine sand dune development (which provide relief), and include a complex series of seasonal fresh water wetlands, alluvial river flats, coastal limestone and several off-shore islands. Younger sandy areas and limestone are dominated by heath and/or Tuart woodlands, while Banksia and Jarrah–Banksia woodlands are found on the older dune systems (Mitchell *et. al*, 2002).

2.3 Flora and Vegetation

Five vegetation complexes (Heddle *et. al* 1980) have been identified within the site. Descriptions of these vegetation complexes along with their interpretability for the presence of Dieback are presented below:

Moondah - supports predominantly a low closed to low open forest of *Banksia attenuata*, *B. menziesii, B. prionotes* and *Eucalyptus todtiana* on the slopes; and an open-woodland of Marri-Banksia in the valleys. Along the water courses, the vegetation is dominated by woodland of *E. rudis*, *Melaleuca rhaphiophylla* with some mixture of *M. preissiana* and thickets of *Kunzea vestita* in the understorey. One of the distinctive features of the Moondah vegetation complex is the presence of large number of *B. prionotes*. In other respects, due to the sandy soils, the vegetation has affinities with Mogumber, Cullala and Reagan complexes. Upland areas of the Moondah vegetation complex are highly interpretable for the presence of Dieback; however, the wetland areas are generally uninterpretable.

Reagan - supports vegetation ranging from low open-woodland of *B. attenuata, B. menziesii* and *E. todtiana* to closed heath depending on the depth of the soil. The composition of the understorey varies slightly depending on the proportion of sand and gravel. Plant species include *Adenanthos cygnorum, Petrophile linearis, Mesomelaena tetragona, Casuarina humilis, Mesomelaena stygia, Hakea trifurcata, Daviesia juncea* and species of *Hibbertia, Eremaea, Conospermum* and *Conostephium.* The Regan complex is generally highly interpretable for the presence of Dieback.

Karamel South - is dominated by an open forest of Jarrrah-Marri with a definite second storey of *B. grandis* on the gravelly soils with *B. attenuata* and *B. menziesii* on the sandier soils. Elsewhere on the Dandaragan Plateau, *B. grandis* is restricted mainly to the Gingin complex. Small areas of Wandoo occur in pockets on Karamal South. Other species in the open forest of Jarrah-Marri include *Stirlingia latifolia*, *B. sessilis, B. nivea, Hakea ruscifolia, Petrophile linearis, Jacksonia floribunda* and species of *Calytrix, Conostephium* and *Hakea.* The Karamel South complex is generally highly interpretable for the presence of Dieback.

Mogumber South - is dominated by an open-woodland of Marri with a well-defined second storey of Pricklybark-Banksia (*E. todtiana, B. attenuata, B. menziesii* and *B. ilicifolia*) The same pattern of Marri extending further north than Jarrah, seen of on the northern Swan Coastal Plain, is repeated in this area. Although localised patches of Jarrah are to be found, they are restricted in size and number. As one goes from the higher rainfall in the south to the lower rainfall in the north, Jarrah disappears first, then Marri. The intermingling of Pricklybark and Jarrah evident on the Bassendean sand dunes near Perth and Gnangara is repeated in the Mogumber complex. Understorey species vary considerably depending on proportion of sand and gravel, depth of sand and moisture levels, but include such species as *Nuytsia floribunda, Stirlingia latifolia, Petrophile linearis, Daviesia pectinata, Calothamnus sanguineus, Mesomelaena tetragona, Baeckea camphorosmae, Hypocalymma angustifolium, Leptocarpus scariosus, Casuarina humilis, Lyginia tenax* and *Bossiaea eriocarpa.* The Mogumber South complex is generally highly interpretable for the presence of Dieback.

Coonambidgee complex –this vegetation ranges from a low open forest to low woodland of *E. todtiana, Banksia attenuata, B. ilicifolia* with local admixtures of *B. prionotes,* to an open woodland of *Corymbia calophylla* and *Banksia* species. The Coonambidgee complex is generally highly interpretable for the presence of Dieback.

3 Methods

The Dieback assessment was done by DPAW registered Dieback Interpreter Joseph Grehan and Field Assistant Kelby Jennings in August 27th and 28th, 2014. While the assessment occurred during the optimal time of the year, sampling conditions were sub-optimal due to the lower than average winter rainfall.

The linear Dieback assessment was conducted in accordance with the *Manual for detecting Phytophthora Dieback disease* (Procedures for DPaW managed lands) (DPaW 2013). These recently updated Dieback Interpreters' guidelines now categorise land that has been cleared of native vegetation (such as farmland) as 'excluded' from assessment. Non-vegetated areas that are 'excluded' from assessment include pasture, pits, easements, development, large roads (sealed and unsealed) permanent flooding and parkland tree stands. Excluded areas are distinguished from unmappable areas by the fact that unmappable areas retain the ability to regenerate and eventually become mappable. **Table 1** presents the *Phytophthora* occurrence categories, impacts and syndromes (DPaW 2013), which include the unmappable category.

The unmappable category is allocated to areas of native vegetation which have been disturbed, but native vegetation will recover over time and may become interpretable and therefore mappable. Examples of unmappable areas include vegetation that has been impacted by fire, timber harvesting, flooding or mining with subsequent rehabilitation. The recovery time for unmappable areas may take longer than 3 years (DPaW 2013). **Table 1** presents details of the different Dieback occurrence categories as defined in DPaW's draft Dieback interpreter's guidelines (DPaW 2013).

Table 1: *Phytophthora* occurrence categories, impacts and syndromes (as cited in DPaW 2013)

***Phytophthora* occurrence mapping**	**Impact Rating**	**Syndrome**	**Comment**
Infested: Impacts of *Phytophthora* Dieback are visible	High	Endemic or Extremely destructive Epidemic	
	Moderate	Commonly a variable epidemic but may also exist as or be progressing to an extremely destructive epidemic	This syndrome may not have reached full destructive potential, depending on the age of infestation. It might be progressing to High Impact, epidemic syndrome
	Low None of the susceptible overstorey is affected by disease	Variable epidemic Disease apparent	Although overall impact is low, it is not low enough to be given 'no apparent disease' syndrome
			May consist of very low level endemic disease in an environment not favourable to the pathogen
Uninfested: Areas of natural undisturbed or low disturbance vegetation free of symptoms that Indicate *Phytophthora* Dieback	Nil	No apparent disease	
Uninterpretable: Areas of natural undisturbed vegetation where susceptible plants are too few for interpretation of *Phytophthora* Dieback	None, or none perceptible	No apparent disease	May consist of very low level endemic disease in an environment not favourable to the pathogen
Unmappable: Keighery disturbance rating 4 or greater	Predicted impact rating may be forecast based using landform and vegetation types	Not assessable	

The Keighery vegetation disturbance scale (DPaW 2013) presented in **Table 2** was used to determine the interpretability of the vegetation. Areas with a vegetation condition rating of 1-3 (Pristine - Very Good) are considered to be mappable. In addition, there must be enough disease indicator species present to enable a diagnosis of the disease status. An area with a vegetation condition rating of 4 (Good) is possibly mappable; however, it is up to the interpreter's discretion. Unmappable and excluded areas are given a condition rating of 5 or 6 (Degraded or Completely Degraded).

Table 2: Keighery (1994) Vegetation Disturbance Scale and Assessability (as cited in DPaW 2013)

Interpretability	Scale		Condition
Mappable	1	Pristine	Pristine or nearly so, no obvious signs of disturbance
	2	Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species
	3	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
Possibly Mappable, discretion required	4	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.
Unmappable or Excluded from assessment	5	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 to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, Dieback and grazing.
	6	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.

3.1 Linear Assessment

A linear Dieback assessment was done on the tracks and unsealed roads within and adjacent to the study area. During the assessment, visual evidence of disease absence or presence was recorded within a 50 m wide corridor, 25m either side of the track or unsealed road. Other potential disease vectors including watercourses and disturbed areas in and adjacent to the site were also assessed. Reconnaissance of the study area was completed prior to commencing the linear assessment to determine the following:

- Access
- Identify interpretable vegetation and disease expression if present
- Identify possible disease vectors e.g. tracks, utility corridors, ground disturbance, feral animals etc.
- Determine the location of high risk areas (e.g. areas of high disturbance and water-gaining sites)
- Identify other impacts to vegetation (e.g. drought, cankers, herbivory, *Armillaria luteobubalina,* fire)

The assessment involved driving the tracks and unsealed roads within and surrounding the study area recording evidence of presence or absence of Dieback. When necessary areas outside the linear corridor were assessed, including watercourses and disturbed areas, to determine the broader landscape context and to ensure uninfested areas were protectable.

3.2 Disease Risk Categories

Vegetation within the study area was categorised into three different disease risk categories as described below in **Table 3**.

Table 3: Disease Risk Categories

Disease Risk Category	Description
High	Areas where *Phytophthora cinnamomi* has been recovered from samples and disease symptoms are consistent with the presence of Dieback.
Medium	Areas exhibiting past or current disturbances (logging, grazing, dumping etc.) which have altered vegetation structure and composition. Also includes areas downslope of confirmed infestations, or which exhibit disease symptoms but have not returned positive results for *P. cinnamomi*.
Low	Areas of protectable uninfested vegetation (as determined by a registered Dieback interpreter), which exhibit multiple healthy indicator species, vegetation in Pristine to Very Good condition (Keighery scale 1-3), no disease pattern or chronology, and no significant risks from disease vectors or current land use.

3.3 Sampling

Soil and tissue samples of recently dead or dying disease indicator species were collected and lodged with the DPaW's Vegetation Health Services Laboratory (VHS) where diagnostic baiting was conducted. All sample point locations were recorded with a hand-held GPS. The following sampling strategy was applied when determining sample locations:

Initial standards sampling: Initial samples are taken to determine disease behaviour. The results inform the sampling strategy and enable testing of early hypotheses (e.g. are other factors causing the deaths of susceptible species such as *Armillaria luteobubalina* or drought).

Sampling to support infested diagnosis: Recently dead and dying indicator species are sampled to support an infested diagnosis.

Sampling to support an uninfested diagnosis: Recently dead and dying indicator species are sampled to support an uninfested diagnosis. Caution must be exercised when claiming that a negative result means that an area is uninfested, because false negative results can be recorded when inoculum levels are depleted from prolonged unfavourable environmental conditions for the pathogen.

All sampling strictly adheres to the following procedures:

- All tools used in sampling are thoroughly sterilised with a 70:30 mixture of methylated spirits and water before samples are taken. It must be ensured that the tools are dry prior to sampling so that the results are not compromised.
- The area around the base of the plant being sampled is cleared of leaf litter and debris so that this material is not included in the sample.
- The plant sampled is excavated to suitable depth to ensure that adequate plant tissue material can be obtained from the roots and cambium layer around the collar of the plant being sampled.
- Material from all around the plant is taken in addition to any obvious lesions to avoid missing any infected material. All the plant tissue material and a few handfuls of soil from around the roots and other places in the soil profile are placed in a polythene bag.
- Enough distilled water to moisten the soil is poured into the bag to ensure the survival of any inoculum that may be present in the sample.
- All relevant information pertaining to the plant sampled and sample location is recorded on the Sample Information Sheet.
- Two aluminium tags with the date, project name, sample number, species sampled and the name of the interpreter are written. One tag is placed in the sample bag and the other is tied near the sample site which is also flagged with a day-glow orange flagging banner.
- The sample hole is backfilled to prevent fauna from becoming trapped.
- All tools are brushed off (to remove excess soil) and sterilised to prevent contamination of the next sample site and sample.

3.4 Mapping

Field evidence and observations were used to prepare the Dieback risk map (**Figure 2**) within the study area. The information used in mapping includes:

1. Sample results
2. Interpretability determined from vegetation condition and disease indicator present
3. Topography and drainage

3.5 Limitations

The DPaW's draft Dieback interpreters guidelines (DPaW 2013) discuss the limitations of linear assessment (P.88)

While a linear assessment uses the same methods as comprehensive transect assessments, it is often regarded as significantly more difficult to do, because the linear assessment corridor is easily taken out of context from wider landscape units. Phytophthora *occurrence assessment boundaries may only briefly intersect linear corridors, giving little relative perspective to the wider landscape unit.*

The following limitations were encountered during the assessment:

- The widespread impact of drought on the vegetation made Dieback interpretation more difficult.
- The impacts of canker species on susceptible vegetation, particularly *Banksia* species, made Dieback interpretation more difficult.
- Some areas were uninterpretable due to past disturbance caused by logging and grazing.
- Although the survey was conducted during the optimal time, negative sample results can be due to low inoculum levels for *Phytophthora cinnamomi* and therefore it is possible to obtain false negative results.

4 Results

In total, 11 soil and tissue samples were collected from recently dead and dying disease indicator species. The samples were baited at the VHS laboratory. In addition, a tissue sample was taken to test for canker and this returned a positive result for *Cytospora* sp. *Banksia* species including *Banksia attenuata*, *B. menziesii*, and *B. grandis* were the preferred species to sample because they are highly susceptible to the pathogen (Brandis 1983). The sample results are presented in **Table 4** below.

Table 4: Sample Results

Sample No.	Species	Easting GDA 94, Zone 50	Northing GDA 94, Zone 50	Result
CS01	*Banksia attenuata*	404805	6514443	*P. cinnamomi*
CS02	*Banksia grandis*	404874	6511350	Negative
CS03	*Banksia menziesii*	405328	6517342	Negative
CS04	*Banksia attenuata*	406281	6517239	Negative
CS05	*Banksia grandis*	406273	6516533	Negative
CS06	*Banksia menziesii* & *Banksia attenuata*	402347	6517398	*P. cinnamomi*
CS07	*Banksia attenuata*	402678	6514603	Negative
CS08	*Banksia attenuata*	403319	6514552	Negative
CS9	*Banksia grandis*	404215	6514542	*Cytospora* sp. (Canker)
CS10	*Banksia attenuata*	404459	6517350	Negative
CS11	*Xanthorrhoea preissii*	402356	6516852	Negative

The total study area in terms of the linear corridor that was assessed is 119.2ha. This is comprised of 19.4 ha of High Risk (16.3 %), 12.2 ha of Moderate Risk (10.2 %) and 87.6 ha (73.5 %) of Low risk vegetation (**Figure 2**).

5 Discussion

5.1 High Risk Areas

High risk areas are defined as areas where *Phytophthora cinnamomi* has been recovered and disease symptoms consistent with Dieback have been observed. Depending on disease expression symptoms may include:

- Multiple disease indicator species deaths
- Disease pattern and chronology
- Reduction in species richness and cover
- The presence of a disease vector (e.g. track, watercourse, evidence of animal vectors such as pigs)

The linear assessment identified three high risk areas within and adjacent to the study area:

1. The northern section of the power line track near Ioppolo Road is infested with recently dead *Banksia attenuata* and *B. menziesii* returning a positive result for *P. cinnamomi* (sample CS08). The infestation runs down the slope along the power line but doesn't appear to extend further than 50 to 100m either side of the track. This section of the power line track poses a high risk of spreading Dieback through the site (**Plates 1 & 2**).
2. The unsealed road along the western boundary of the unnamed DPaW reserve to the west of the study area boundary is infested with two historical results for *P. cinnamomi* (VHS 2014). This unsealed road poses a high risk of vectoring disease along Ioppolo Road and into the study area.
3. A section of vegetation on the northern side of the creek located to the south of site boundary is infested. A recently dead *Banksia attenuata* returned a positive result for *P. cinnamomi* (Sample CS01). It is believed that the disease has been vectored into the riparian zone of the creek by feral pigs (**Plate 3**) because there was no distinct disease pattern along the watercourse. The track crossing the creek into the southern boundary of study area poses a high risk as a disease vector.

5.2 Moderate Risk Areas

Two of the moderate risk areas have past disturbances, including logging and grazing, which have resulted altered vegetation structure and some disease indicator species deaths, but have not yielded positive results for *P. cinnamomi* (**Plate 4**). The other moderate risk area is along the power line track downslope of a confirmed infestation. Although this area did not yield a positive result for *P. cinnamomi* there were multiple disease indicator species deaths and additional sampling may recover a positive result

5.3 Low Risk Areas

Low risk areas are areas that have been determined to be uninfested by a DPaW registered Dieback Interpreter. While an uninfested diagnosis can be supported by negative sample results for *P. cinnamomi,* an area cannot be determined to be uninfested on sample results alone (**Plate 5**). Observable factors which can be used in making an uninfested diagnosis include the following:

- Multiple healthy disease indicator species.
- Vegetation condition is rated as 1-3 on the Keighery vegetation condition scale.
- No evidence of disease pattern or chronology.
- Indicator species deaths can be attributed to other factors i.e. drought, canker or *Armillaria*.

5.4 Other Potential Impacts to Vegetation

There may be other factors that caused the observed deaths of disease indicator species, including drought, other *Phytophthora* species, pathogenic fungi and *Armillaria luteobubalina* (Armillaria or Australian Honey Fungus).

5.4.1 Other *Phytophthora* species

Phytophthora arenaria is thought to be a native Australian species of *Phytophthora*, however it centre of diversity is still to be determined (C, Crane. Pers. Comm 16/12/2014). The website '*Phytophthora* Database' describes the characteristics of *P. arenaria* as follows:

Phytophthora arenaria *A. Rea, M. Stukely & T. Jung has been isolated in Western Australia from kwongan heath-land stands since the early 1980s (Burgess et al. 2009, Rea et al. 2011), but was misidentified as* P. citricola. *With the exception of one isolate from Bunbury (south-west coast)* P. arenaria *has been isolated exclusively from the northern sand plains. Most isolates were associated with dead or dying* Banksia *or Eucalyptus species; however, isolates were also recovered in association with asymptomatic* Banksia *and Eucalyptus species. The first isolation of this taxon was from soil in native kwongan vegetation near Kalbarri in 1986.* Phytophthora arenaria *has thick oospore walls and physiological characteristics that appear to be adaptations favouring survival in the harsh kwongan ecosystem suggesting that this species may be endemic to Western Australia. However, the most closely related species is* P. alticola *a species described from South Africa and the origin of both species requires further examination* (http://www.phytophthoradb.org).

Another species, *Phytophthora multivora*, which has often been misdiagnosed for *P. citricola*, can persist in alkaline soil (Scott *et al.* 2009) which is suppressive to *P. cinnamomi.* The ability of *P. multivora* to survive in alkaline soils has implications for hygiene management because using limestone as a sterilising road-base material, as it has been previously used due to its antagonism to *P. cinnamomi*, may not be effective for managing *P. multivora* spread.

5.4.2 Other Pathogenic Fungi

The impact of cankers caused by pathogenic fungus on Proteaceous species was examined by Crane and Burgess (2013). The study examined the impact that aerial cankers are having on coastal vegetation between Esperance and Cervantes and demonstrated pathogenicity in seven *Banksia* spp. over a wide geographic range. The pathogenic fungus was identified as a new genus and species within the *Cryphonectriaceae* (*Diaporthales*) and is described as *Luteocirrhus shearii* gen. sp. *nov*. The fungus causes the death of single branches; however, it can lead to multiple branch deaths or cause complete crown dieback as occurred with some of the *Banksia baxteri* and *B. verticillata* sampled (Crane and Burgess 2013).

A tissue sample taken from a recently dead *Banksia grandis* was tested for the presence of canker at VHS. *Cytospora* sp. was recovered from the sample which is likely to indicate an inability of the plant to contain the fungi because this canker species can also be present on healthy plants (**Appendix 1**). *Banksia* species including *Banksia attenuata, B. grandis*, *B. prionotes* and *B. menziesii* displaying symptoms consistent with those described by Crane and Burgess, but not characteristic of *P. cinnamomi* disease expression, were observed throughout the study area. Canker impacts were observed throughout the study area and were generally discernible from Dieback symptoms by the death of single branches or lesions emanating above the trunk collar (**Plates 6, 7 & 8**).

5.4.3 Drought

Impacts to vegetation as a result of prolonged drought were differentiated from impacts caused by *P. cinnamomi* by the following characteristics:

- No disease pattern or chronology in the surrounding vegetation.
- The plant had senesced gradually rather than succumbing quickly as is usually the case with deaths attributed to *P. cinnamomi.*

- No visible lesions or mycelium on the roots of the dead or dying plant.
- Re-shooting or epicormic growth visible on dying plants (**Plates 9 & 10**).

The presence of single or multiple dead branches with the remainder of the plant appearing to be healthy may be attributed to drought or pathogenic fungi.

5.4.4 *Armillaria* (Australian Honey Fungus)

Armillaria luteobubalina (Armillaria or Australian Honey Fungus) is a species of mushroom which causes Armillaria root-rot in affected plants. The fungus is widespread in Jarrah (*Eucalyptus marginata*) and Karri (*E. diversicolor*) forests of the southwest of WA, but has also been recorded in coastal vegetation between Cape Arid (120 km east of Esperance) to Cervantes (160 km north-west of Perth) (Shearer *et al* 1997). *Armillaria* is dispersed by spores produced by the mushroom and also reproduces vegetatively through the roots of affected plants. It affects many of the same plant genera as *Phytophthora* in particular members of the Myrtaceae and Proteaceae plant families, such as *Eucalyptus* and *Banksia* species. *Armillaria* forms a quite visible white or yellow leathery mycelial sheath which is visible beneath the bark in the roots or lower stem. Other observable factors that can be applied in the diagnosis of *Armillaria* infection include:

- Clusters of fruiting bodies around or near the base of the plant
- A pungent mushroom smell
- An inverted V shaped scar at the base of the plant
- Yellow-white stringy rot under the bark in the roots and base of affected plants (DEC, 2012)

While some of the mycelium observed may be as a result of Armillaria, the assessment occurred at the wrong time of the year to observe fruiting bodies and therefore confirm the presence of the fungus. It is possible that *Armillaria luteobubalina* is present within the study area and contributing to the death of the vegetation.

6 Conclusion and Recommendations

Tracks, water courses and hard-hooved feral animals are considered to be the most likely vectors of disease in the study area. Therefore a linear Dieback assessment was considered an appropriate method for assessing the risk and likelihood of Dieback presence within and adjacent to the study area. The linear assessment determined that the majority of the study area is uninfested and therefore presents a low risk of spreading Dieback into areas outside the study corridor. While it is likely that the majority of the 983 ha site is uninfested, caution should be used when extrapolating the disease status and/or risk to vegetation that has not been assessed outside the study area.

Terratree makes the following recommendations in relation to the linear *Phytophthora* Dieback assessment of the study area:

- A comprehensive Dieback assessment of the site should be completed in accordance with *Manual for detecting and mapping Phytophthora Dieback disease* (Procedures for DPaW managed lands) (DPaW 2013).
- Protectable areas should be clearly demarcated and signposted.
- Additional samples from moderate risk areas should be taken.
- A Dieback management plan, including an access management strategy, should be developed for the site.

7 References

Brandis, A.J. (1983) Introduction to the detection and Interpretation of the symptoms of Jarrah Dieback Disease in Western Australia, Technical Paper No.3, Forests Department of Western Australia.

Bureau of Meteorology (BOM) http://www.bom.gov.au/ accessed October 10th 2014

CALM (2001) *Phytophthora cinnamomi* and the diseases caused by it - Volume 2: Interpreters Guidelines for Detection, Diagnosis and Mapping. WA Department of Conservation and Land Management, Perth, Western Australia.

CALM (2004) *Phytophthora cinnamomi* and disease caused by it. Volume 1 – Management Guidelines.

Commonwealth of Australia (2005) Interim Biogeographical Regionalisation for Australia (IBRA) Mapping, Version 6.1 (2004). Department of Environment and Heritage, March 2005.

Crane, C. and Burgess, T.I. (2013) *Luteocirrhus shearii* gen. sp. *nov*. (*Diaporthales*, *Cryphonectriaceae*) pathogenic to Proteaceae in the south Western Australian Floristic Region. IMA Fungus Volume 4 No.1 (2013) pp111-122

Crone M., McComb, J.A., O'Brien P.A., Hardy G.E.St J. (2012) S*urvival of Phytophthora cinnamomi as oospores*, *stromata*, *and thick-walled chlamydospores in roots of symptomatic and asymptomatic annual and herbaceous perennial plant species*. Fungal Biology 117 (2013) pp112-123.

Department of Environment and Conservation (2012) *Manual for detecting Phytophthora Dieback disease* (Procedures for DPaW managed lands) Draft

Department of Parks and Wildlife (2013) *Manual for detecting Phytophthora Dieback disease* (Procedures for DPaW managed lands) Working Draft

Environmental Protection Authority (2007) *State of the Environment Report*. Report published by the EPA for the Government of Western Australia.

Heddle, E.M., Loneragan, O.W. and Havel, J.J. (1980). Pinjarra Sheet. Vegetation Complexes of the Darling System, Western Australia. In: Atlas of Natural Resources Darling System, Western Australia. Western Australian Department of Conservation and Environment, Perth.

Keighery, B.J. (1994) Bushland Plant Survey. *A Guide to Plant Community Survey for the Community*. Wildflower Society of WA (Inc.), Western Australia.

Mitchell, D, Williams, K & Desmond, A (2002), 'Swan Coastal Plain 2 (SWA – Swan Coastal Plain subregion)', in N McKenzie, J May & S McKenna (eds.), Bioregional Summary of the 2002 Biodiversity Audit for Western Australia, Department of

Conservation and Land Management, Western Australia Scott P.M., Burgess T.I., Barber P.A., Shearer B.L., Stukely M.J.C., Hardy G.E.St J., Jung T. (2009) *Phytophthora multivora sp. nov.*, *a new species recovered from declining Eucalyptus*, *Banksia*, *Agonis and other plant species in Western Australia.* Persoonia. 22: 1–13. *Published online 2009 February 2. doi: 10.3767/003158509X415450*

Shearer, B.L., Crane, C.E., Fairman, R.G., Grant, M.J. (1997) Occurrence of *Armillaria luteobubalina* and Pathogen-mediated Changes in Coastal Dune Vegetation of South-Western Australia. Aust. J. Bot.,(1997), 45, 905–917

Western Australian Native Plants Susceptible and Resistant to *Phytophthora cinnamomi* Compiled by E. Groves, G. Hardy & J. McComb, Murdoch University

Wills, R.T. and Keighery, G.J. (1994). The ecological impact of plant disease on plant communities. *Journal of Royal Society of Western Australia* **77:** 127-132.

8 Glossary of Terms

Assessment – (*Phytophthora* occurrence) any combination of activities including, detection, diagnosis (interpretation), mapping and demarcation of *Phytophthora* Dieback disease in natural ecosystems.

Assessment Area – An area where *Phytophthora* occurrence assessment is possible, or will be possible in the short to medium term. This area may be larger or smaller than the proponent's project area.

Disease - The combination of a pathogen, host and correct environmental conditions, which results in disease symptoms or death of a host.

Environment - The sum of all external factors which act on an individual organism during its lifetime.

Excluded Area – An area of high disturbance in which native vegetation is unlikely to recover.

Host - means the plant which is invaded by a pathogen and from which the pathogen derives its energy.

Indicator species – Plant species that area more susceptible to Phytophthora disease and reliably show symptoms earlier than other species.

Infection – The invasion of a host organism's bodily tissue by disease causing organisms. In relation to Dieback this refers to an individual plant and not the population.

Infested – The state of being invaded or overrun by pests or parasites. In relation to Dieback it refers to a population of plants and not individual plants.

Inoculum – Cells, tissue, or viruses that are used to inoculate a new culture

Pathogen – Any organism or factor causing disease within a host

Pathogenic – Causing or capable of causing disease

***Phytophthora* Dieback –** A term referring to the disease symptoms caused by *Phytophthora* species in susceptible vegetation.

Susceptible – Likely to be influenced or able to be harmed by particular pathogen

Sporulation - a type of reproduction that occurs in fungi, algae, and protozoa and involves the formation of spores by the spontaneous division of a cell into four or more daughter cells, each of which contains a part of the original nucleus.

Symptom – A phenomenon that arises from, and accompanies a particular disease or disorder and serves as an indication of it

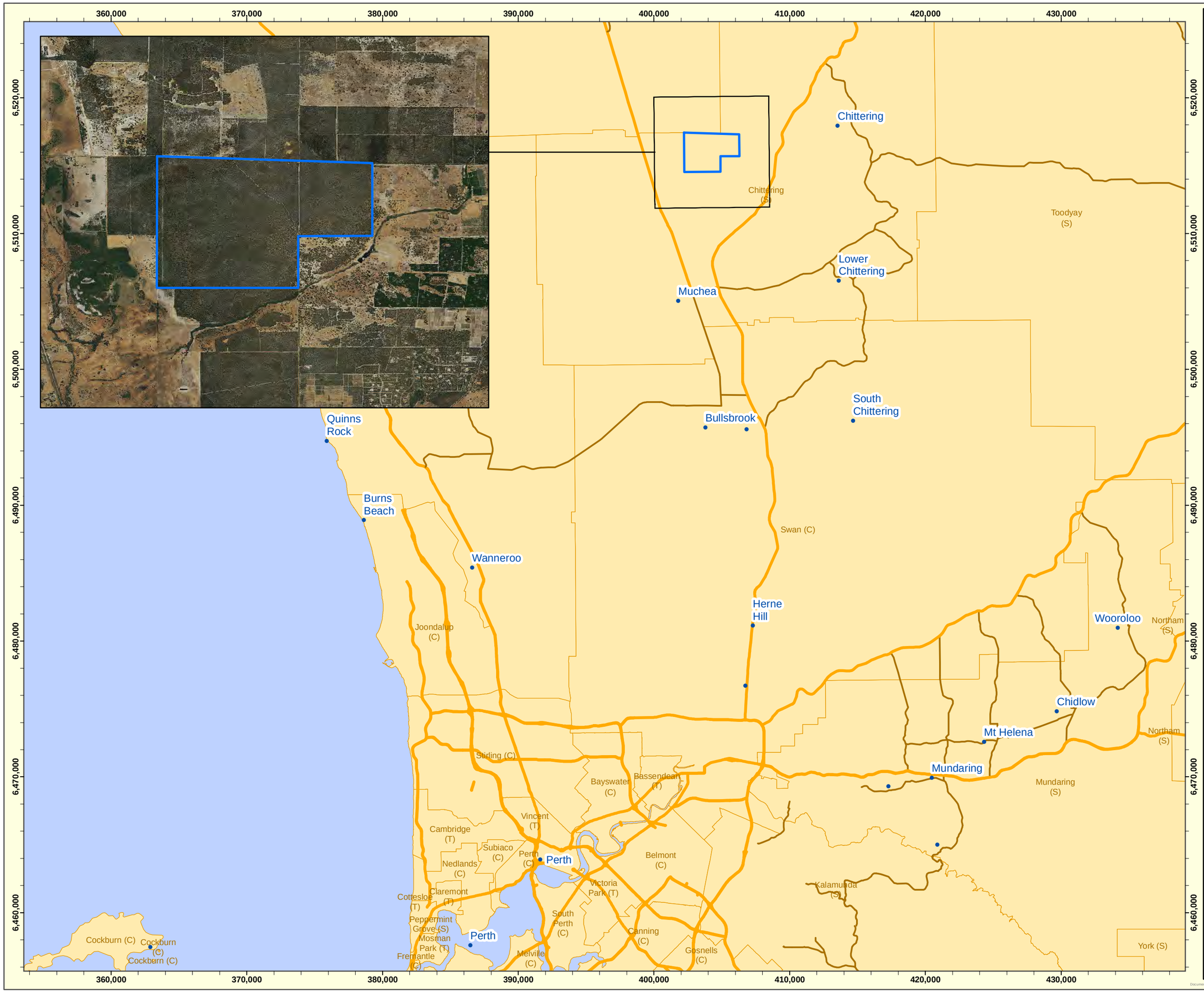
Uninfested – An area that does not contain infected plants or show visible signs of disease

Uninterpretable – a natural area where there are inadequate visible symptoms present to make a diagnosis

Unmappable – A naturally vegetated area that has had disturbance and from which is likely to recover in the short term

Unprotectable – A disease free area that is likely to become infested within a given time

Figures



LEGEND

- Site boundary
- Towns
- Road (Primary Distributor)
- Road (Regional Distributor)

SITE LOCALITY

Chittering Dieback Reconnaissance Survey

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator, Datum: GDA 1994, Units: Meter

0 1 2 4 6 8 10
Kilometers

Scale @ A3:	1:250,000
Date:	22/09/2014
Revision:	Rev A
Project No:	TS14013
Prepared:	R Cullen
Checked:	J Botterill
Reviewed:	N King

Figure 01

Terratree

talis

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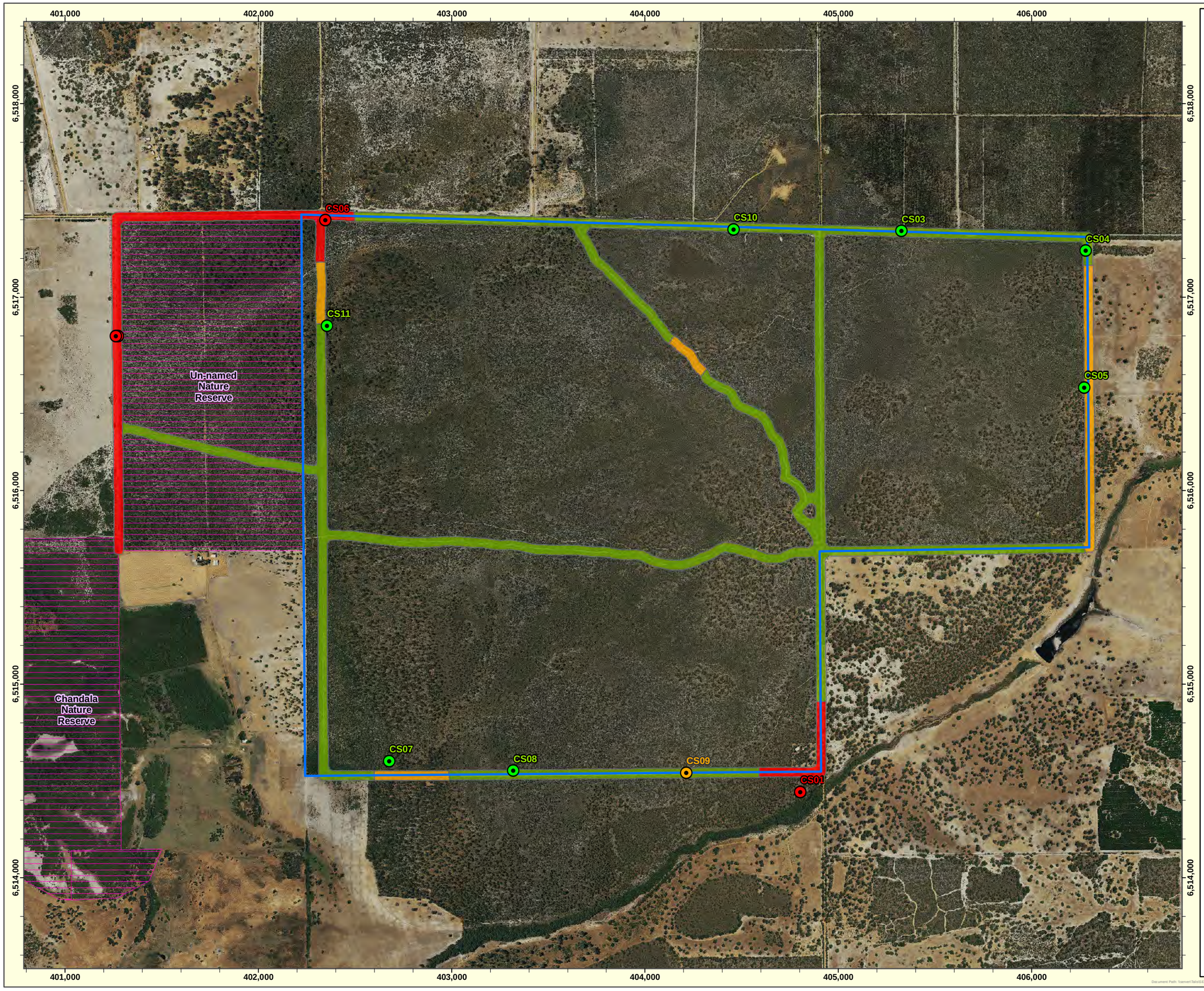

LEGEND

Site boundary

DPaW managed lands

Dieback sample results

Cytospora sp. (canker)

P. cinnamomi

Negative

Dieback risk assessment

High

Moderate

Low

LINEAR DIEBACK RISK ASSESSMENT AND SAMPLE RESULTS

Chittering Dieback Reconnaissance Survey

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator, Datum: GDA 1994, Units: Meter

0 100 200 400 600 800
Meters

Scale @ A3:	1:17,500
Date:	22/09/2014
Revision:	Rev C
Project No:	TS14013
Prepared:	R Cullen
Checked:	J Botterill
Reviewed:	N King

Figure 02

Terratree

talis
delivering solutions

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9 Plates

Plate 1: High risk vegetation: Infested *Banksia* woodland with multiple indicator species deaths, disease pattern and chronology

Plate 2: Dead *Banksia attenuata* adjacent to disease vector (power line access track)

Plate 3: Evidence of feral pig activity, a likely vector for the positive *P. cinnamomi* sample

Plate 4: Medium risk vegetation - Area at risk due to historical disturbance due to logging, nearby areas of Infested vegetation and indicator species deaths.

Plate 5: Low risk vegetation - Uninfested woodland with low levels of disturbance and intact vegetation in Excellent condition

Plate 6*: Banksia grandis* exhibiting canker impacts

Plate 7: *Banksia* trunk exhibiting canker lesions on the cambium layer

Plate 8: *Banksia attenuata* exhibiting partial death due to canker

Plate 9*: Banksia* woodland exhibiting drought impacts

Plate 10*: Banksia attenuata* re-shooting after drought impact

10 Appendices

Appendix 1: Vegetation Health Services Laboratory report on positive identification of *Cytospora* sp. (canker) in CS11

Appendix 2: Sample Results from the Vegetation Health Services laboratory

PLANT DISEASE SAMPLE INFORMATION SHEET

CLIENT NAME Terratree Joe Grehan joeg@terratree.com.au
SAMPLE *Banksia grandis* canker CS 11 (canker) Fig. 1.
DIAGNOSIS A *Cytospora* sp. (Fig 2 & 3) was isolated and most likely indicates some inability of the plant to contain the fungi which can also be present on healthy plants.

Fig. 1 sample

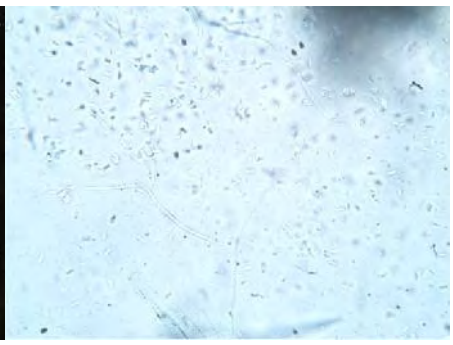


Fig. 2 Curved conidia

Fig.3 Alantoid conidia

THE PATHOGEN *Cytospora* sp. along with other genera in the Valsaceae, are commonly isolated from stem and twig cankers of *Eucalyptus, Hakea* and *Banksia sp*. of south-western Australia (Shearer 1994) They have a worldwide reputation as pathogens and cause extensive damage to tree crops. However in south-western Australia they often exist as benign endophytes (present in host tissues asymptomatically) or wound pathogens causing disease only when the host is compromised in some way. Trees affected by drought, insect attack, defoliation by fungi, sunscald, herbicides or mechanical injury are predisposed to infection and disease development.

SYMPTOMS Twig and branch death.
HOST RANGE Myrtaceae, Proteaceae and Ericaceae
DISTRIBUTION Ubiquitous across the south-west but can have local high inoculum levels in infection pockets.
CONTROL Really need to trial this first to look at host/pathogen/fungicide response. Unsure? Is it warranted?
LABORATORY SAMPLES CC1721 not retained

SITE CS 11 Chittering
Boulder
MAP REFERENCE E 404215 N 6514542 Zone 50

19/9/2014
Colin Crane
Manager Vegetation Health Service
Department of Parks and Wildlife
Science Division
PH. (08) 9334 0482
Fax.(08) 9334 0327
Email: colin.crane@dpaw.wa.gov.au

Shearer BL (1994) The major plant pathogens occurring in native ecosystems of south-western Australia, Journal of the Royal Society of Western Australia 77, 113-122.

VEGETATION HEALTH SERVICE - PHYTOPHTHORA SAMPLE INFORMATION SHEET

SEND TO: Vegetation Health Service, Science Division – D.E.C, 17 Dick Perry Ave KENSINGTON 6151 **Phone:** (08) 9334 0317 **Fax:** (08) 9334 0114

CONTACT DETAILS of sender
Name Joe Grehan Terratree
~~Fax No.~~ Ph. 93354228 Phone No. 0400003688
DEC Office or Company Name Terratree Pty Ltd

GDA (1)
GDA 94 ✓

Job Type (Please indicate)
D.E.C. (C) Alcoa (A)
Recoup (R) FPC
Private (P) Other____

VHS USE ONLY
Date ~~received~~ processed 29/9/14
Date ~~faxed~~ emailed. 12/9/14

VHS Identification Number (VHS USE ONLY)	Sample Date	Sample label (Give location, eg. Forest Block or Shire, etc. and sample number)	Plant species sampled	Site Impact (2)	Zone 50 or 51	Map Reference (3)	Land Tenure (4)	RESULT s/s root (5)	RESULT bait (5)
VHS31279	27/8/14	CS01 (chittering)	Banksia attenuata	M	50	E 404805 N 6514443	P		CIN
VHS31280	27/8/14	CS02 "	Banksia grandis	M	50	E 404874 N 6521350	P		NEG
VHS31281	27/8/14	CS03 "	Banksia menziesii	M	50	E 405328 N 6512242	P		NEG
VHS31282	27/8/14	CS04 "	Banksia attenuata	M	50	E 406281 N 6512232	P.		NEG
VHS31283	27/8/14	CS05 "	Banksia grandis	H	50	E 408213 N 6516533	P		NEG
VHS31284	27/8/14	CS06 "	B. menziesii	L	50	E 401375 N 6516788	P		SUB
VHS31285	28/8/14	CS07 "	B. menziesii	M	50	E 401281 N 6517193	P		AS FOR 31284
VHS31286	28/8/14	CS08 "	B. menziesii + B. attenuata	H	50	E 402347 N 6517398	P		CIN

NOTES:
1. Please tick this box if your map references are supplied in the GDA 94 standard. If not, please specify the datum used.
2. Site impact - Low, Moderate, or High (as in the Dieback Interpreter's Manual).
3. An MGA map reference with prefixes **must** be supplied for all samples.
4. Land Tenure - State Forest (SF), National Park (NP), Reserve (R), Westrail (W), Private (P), Gravel Pit (GP), or other. (Other - describe in comments below).
5. Result codes used – CIN = *Phytophthora cinnamomi*, MUL = *P. multivora*, CRY = *P. cryptogea*, PI = *P. inundata*, ARE = *P. arenaria*, ELO = *P. elongata*, THE = *P. thermophila*, PM = *P. megasperma*, PN = *P. nicotianae*, CON = *P. constricta*, NEG = negative, SUB = subcultured for further tests

Please Note: a). NEG results cannot be used to represent a total absence of *Phytophthora* in the sampled area. b). Information from your samples will be incorporated into the VHS database.

COMMENTS:

VEGETATION HEALTH SERVICE - PHYTOPHTHORA SAMPLE INFORMATION SHEET

SEND TO: Vegetation Health Service, Science Division – D.E.C, 17 Dick Perry Ave KENSINGTON 6151 **Phone:** (08) 9334 0317 **Fax:** (08) 9334 0114

CONTACT DETAILS of sender
Name Joe Graham
~~Fax~~ No. Mob 0400003688 Phone No. 93354228
DEC Office or Company Name Terratree Pty Ltd

GDA
(1)
GDA 94 ✓

Job Type (Please indicate)
D.E.C. (C) Alcoa (A)
Recoup (R) FPC
Private (P) Other____

VHS USE ONLY
Date ~~processed~~ received 30/8/14
Date ~~emailed~~ faxed 12/9/14

VHS Identification Number (VHS USE ONLY)	Sample Date	Sample label (Give location, eg. Forest Block or Shire, etc. and sample number)	Plant species sampled	Site Impact (2)	Zone 50 or 51	Map Reference (3)	Land Tenure (4)	RESULT s/s root (5)	RESULT bait (5)
VHS31287	28/8/14	CS09 (chittering)	Banksia attenuata	M	50	E 402678 N 6514603	P		NEG
VHS31288	28/8/14	CS10 "	B. attenuata	L	50	E 403319 N 6514552	P		NEG
	28/8/14	CS11 "	CANKER Sample B. grandis	M	50	E 404215 N 6514342	P		
VHS31289	28/8/14	CS12 "	B. attenuata	L	50	E 404459 N 6512350	P.		NEG
VHS31290		CS13 "	Xanthorrhoea preissii	M	50	E 402356 N 6516552	P.		NEG
						E ------ N -------			
						E ------ N -------			
						E ------ N -------			

NOTES:
1. Please tick this box if your map references are supplied in the GDA 94 standard. If not, please specify the datum used
2. Site impact - Low, Moderate, or High (as in the Dieback Interpreter's Manual).
3. An MGA map reference with prefixes must be supplied for all samples.
4. Land Tenure - State Forest (SF), National Park (NP), Reserve (R), Westrail (W), Private (P), Gravel Pit (GP), or other. (Other - describe in comments below).
5. Result codes used – CIN = *Phytophthora cinnamomi*, MUL = *P. multivora*, CRY = *P. cryptogea*, PI = *P. inundata*, ARE = *P. arenaria*, ELO = *P. elongata*, THE = *P. thermophila*, PM = *P. megasperma*, PN = *P. nicotianae*, CON = *P. constricta*, NEG = negative, SUB = subcultured for further tests

Please Note: a). NEG results cannot be used to represent a total absence of *Phytophthora* in the sampled area. b). Information from your samples will be incorporated into the VHS database.

COMMENTS:

APPENDIX D

Conservation Significant Flora Known to Occur or Potentially Occur Within the Study Area

Species[1]	Conservation code[2]			Habit[3]	Habitat[3]	Flowering period[3]	Likelihood of occurrence
	EPBC Act	WC Act	DPAW				
Acacia anomala	VU	VU		Slender, rush-like shrub	Lateritic soils. Slopes.	Aug to Sep	Possible
Acacia cummingiana			3	Sprawling, straggly, rush-like shrub	Grey or yellow sand, lateritic gravel. Sandplains, lateritic breakaways.	May to Jun/ Aug	Likely
Acacia drummondii subsp. *affinis*			3	Erect shrub	Lateritic gravelly soils.	Jul to Aug	Likely
Acacia pulchella var. reflexa acuminate bracteole variant (R.J. Cumming 882)			3	Shrub, 0.3-1 m high	Sandy loam or sandy clay over laterite. Woodland.	Jul to Sep	Possible
Adenanthos cygnorum subsp. *chamaephyton*			3	Prostrate, mat-forming, non-lignotuberous shrub	Grey sand, lateritic gravel.	Jul/Sep to Dec/Jan	Possible
Andersonia gracilis	EN	VU		Slender erect or open straggly shrub	White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps.	Sep to Nov	Unlikely
Anigozanthos viridis subsp. *terraspectans*	VU	VU		Rhizomatous, perennial, herb	Grey sand, clay loam. Winter-wet depressions.	Aug to Sep	Unlikely
Caladenia huegelii	EN	CR		Tuberous, perennial, herb	Grey or brown sand, clay loam.	Sep to Oct	Possible
Caustis sp. Gigas (A.S. George 9318)			2	Erect, open sedge	Flat, dry white sand.	Aug to Nov	Likely
Centrolepis caespitosa	EN		4	Tufted annual, herb	White sand, clay. Salt flats, wet areas.	Oct to Dec	Unlikely
Chamaescilla gibsonii			3	Clumped tuberous, herb	Clay to sandy clay. Winter-wet flats, shallow water-filled claypans.	Sep	Unlikely

Species[1]	Conservation code[2]			Habit[3]	Habitat[3]	Flowering period[3]	Likelihood of occurrence
	EPBC Act	WC Act	DPAW				
Chamelaucium sp. Gingin (N.G. Marchant 6)	EN	VU		Unknown	Unknown.	Unknown	Likely
Conospermum densiflorum subsp. *Unicephalatum*	EN	EN		Erect, much-branched shrub	Clay soils. Low-lying areas.	Sep to Nov	Unlikely
Cyathochaeta teretifolia			3	Rhizomatous, clumped, robust perennial, grass-like or herb (sedge),	Grey sand, sandy clay. Swamps, creek.	Unknown	Unlikely
Darwinia foetida	CR	EN		Unknown	Unknown.	Unknown	Unlikely
Diuris micrantha	VU	VU		Tuberous, perennial, herb	Brown loamy clay. Winter-wet swamps, in shallow water.	Sep to Oct	Unlikely
Diuris purdiei	EN	EN		Tuberous, perennial, herb	Grey-black sand, moist. Winter-wet swamps.	Sep to Oct	Unlikely
Drakaea elastica	EN	CR		Tuberous, perennial, herb	White or grey sand. Low-lying situations adjoining winter-wet swamps.	Oct to Nov	Unlikely
Drosera occidentalis Morrison subsp. *occidentalis*				Fibrous-rooted, rosetted perennial, herb	Sandy & clayey soils. Swamps & wet depressions.	Nov to Dec	Unlikely
Drosera sewelliae			1	Fibrous-rooted, rosetted perennial, herb	Laterite & silica sand soils.	Oct	Possible
Eleocharis keigheryi	VU	VU		Rhizomatous, clumped perennial, grass-like or herb (sedge),	Clay, sandy loam. Emergent in freshwater: creeks, claypans.	Aug to Nov	Unlikely
Eucalyptus balanites	EN	CR		Mallee	Sandy soils with lateritic gravel	Oct to Dec	Unlikely

Species[1]	Conservation code[2]			Habit[3]	Habitat[3]	Flowering period[3]	Likelihood of occurrence
	EPBC Act	WC Act	DPAW				
Eucalyptus leprophloia	EN	EN		Mallee	White or grey sand over laterite. Valley slopes.	Aug to Oct	Unlikely
Gastrolobium nudum			2	Spreading, twiggy shrub	Red-brown clay, brown loam, gravel, laterite, granite. Flats, slopes, hilltops, ridges, valleys, breakaways.	Feb	Possible
Grevillea candolleana			2	Spreading shrub	Laterite, lateritic loam. Hillsides.	Aug to Sep	Possible
Grevillea corrugata	EN	VU		Shrub, 1.5-2.5 m high	Gravelly loam. Roadsides.	Aug to Sep	Unlikely
Grevillea curviloba subsp. *curviloba*	EN	CR		Prostrate to erect shrub	Grey sand. Winter-wet heath.	Oct	Possible
Grevillea curviloba subsp. *incurva*	EN	EN		Prostrate to erect shrub	Sand, sandy loam. Winter-wet heath.	Aug to Sep	Possible
Grevillea evanescens			1	Erect, robust shrub	Brown Spearwood sand.	Unknown	Possible
Hibbertia glomerata subsp. *ginginensis*			1	Erect shrub	Sand, brown clay, laterite. Near roadsides.	Jul to Sep	Possible
Hibbertia helianthemoides			4	Spreading to erect, low or prostrate shrub	Clayey sand over sandstone or loam over quartzite. Hills and scree slopes.	Jul/Sep to Oct	Unlikely
Hypocalymma sylvestre		CR		Spreading shrub	Yellow-brown sandy loam. Woodland on lateritic hilltop.	Aug	Unlikely
Hypolaena robusta			4	Dioecious rhizomatous, perennial, herb	White sand. Sandplains.	Sep to Oct	Likely

Species[1]	Conservation code[2]			Habit[3]	Habitat[3]	Flowering period[3]	Likelihood of occurrence
	EPBC Act	WC Act	DPAW				
Isotropis cuneifolia subsp. *glabra* Keighery			2	Prostrate to ascending, spreading perennial, herb or shrub	Sand, clay loam. Winter-wet flats.	Sep	Unlikely
Lepidosperma rostratum	EN	EN		Rhizomatous, tufted perennial, grass-like or herb (sedge)	Peaty sand, clay.	Unknown	Unlikely
Leucopogon squarrosus subsp. *trigynus*			2	Unknown	Unknown.	Unknown	Unlikely
Meionectes tenuifolia			3	Unknown	Unknown.	Unknown	Unlikely
Myriophyllum echinatum			3	Erect annual, herb	Clay. Winter-wet flats.	Nov	Unlikely
Oxymyrrhine coronata			4	Unknown	Unknown.	Unknown	Unlikely
Persoonia rudis			3	Erect, often spreading shrub	White, grey or yellow sand, often over laterite.	Sep to Dec/Jan	Possible
Pithocarpa corymbulosa			3	Erect to scrambling perennial, herb	Gravelly or sandy loam. Amongst granite outcrops.	Jan to Apr	Unlikely
Platysace ramosissima			3	Perennial, herb	Sandy soils.	Oct to Nov	Possible
Ptychosema pusillum	VU	VU		Perennial, herb	Sand. Rises	Aug to Oct	Possible
Schoenus griffinianus			3	Small, tufted perennial, grass-like or herb (sedge),	White sand.	Sep to Oct	Likely
Stylidium cymiferum			3	Rosetted perennial, herb	Brown loam over laterite. Uplands, Wandoo woodland.	Oct to Nov	Unlikely
Stylidium longitubum			3	Erect annual (ephemeral), herb	Sandy clay, clay. Seasonal wetlands.	Oct to Dec	Likely

Species[1]	Conservation code[2]			Habit[3]	Habitat[3]	Flowering period[3]	Likelihood of occurrence
	EPBC Act	WC Act	DPAW				
Stylidium squamellosum			2	Caespitose perennial, herb	Brown to red-brown clay loam. Winter-wet habitats and depressions, open woodland, shrubland.	Oct to Nov	Unlikely
Synaphea grandis			4	Tufted shrub	Laterite.	Oct to Nov	Possible
Tetraria sp. Chandala (G.J. Keighery 17055)			2	Unknown	Unknown.	Unknown	Likely
Tetratheca pilifera			3	Spreading shrub	Gravelly soils.	Aug to Oct	Unlikely
Thelymitra stellata	EN	EN		Tuberous, perennial, herb	Sand, gravel, lateritic loam.	Oct to Nov	Unlikely
Trichocline sp. Treeton (B.J. Keighery & N. Gibson 564)			2	Tuberous, perennial, herb	Sand over limestone, sandy clay over ironstone. Seasonally wet flats.	Unknown	Unlikely
Verticordia lindleyi subsp. *lindleyi*			4	Erect shrub	Sand, sandy clay. Winter-wet depressions.	May/Nov to Dec/Jan	Unlikely
Verticordia rutilastra			3	Shrub	Sand & lateritic gravel. Hills.	Sep to Nov	Likely
Verticordia serrata var. *linearis*			3	Shrub, to 1 m high	White sand, gravel. Open woodland.	Sep to Oct	Likely

1. See Section 4.1 for a comprehensive list of databases and reports reviewed to obtained the list of conservation significant flora.
2. See Appendix D for the descriptions of the conservation codes.
3. Descriptions and flowering periods obtained from DPAW (2014).

APPENDIX E

State and Federal Conservation Code Descriptions

1 STATE CONSERVATION CODES

1.1 Flora and fauna

T: Threatened species

Specially protected under the *Wildlife Conservation Act 1950*, listed under Schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora (which may also be referred to as Declared Rare Flora).

Species 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.

X: Presumed extinct species

Specially protected under the *Wildlife Conservation Act 1950*, listed under Schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice for Presumed Extinct Fauna and Wildlife Conservation (Rare Flora) Notice for Presumed Extinct Flora (which may also be referred to as Declared Rare Flora).

Species which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such.

IA: Migratory birds protected under an international agreement

Specially protected under the *Wildlife Conservation Act 1950*, listed under Schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice.

Birds that are subject to an agreement between governments of Australia and Japan, China and The Republic of Korea relating to the protection of migratory birds and birds in danger of extinction.

S: Other specially protected fauna

Specially protected under the *Wildlife Conservation Act 1950*, listed under Schedule 4 of the Wildlife Conservation (Specially Protected Fauna) Notice.

Threatened Fauna and Flora are further recognised by the Department of Parks and Wildlife according to their level of threat using IUCN Red List criteria. The ranking are:

CR Critically Endangered - considered to be facing an extremely high risk of extinction in the wild.

EN Endangered – considered to be facing a very high risk of extinction in the wild.

VU Vulnerable – considered to be facing a high risk of extinction in the wild.

Species that have not yet been adequately surveyed to be listed under Schedule 1 or 2 are added to the Priority Flora and Priority Fauna Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna. Species that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Conservation Dependent species are placed in Priority 5.

1: Priority One: Poorly-known species

Species that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, rail reserves and Main

Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.

2: Priority Two: Poorly-known species

Species that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.

3: Priority Three: Poorly-known species

Species that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

4: Priority Four: Rare, Near Threatened and other species in need of monitoring

(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands.

(b) Near Threatened. Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

(c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

5: Priority Five: Conservation dependent species

Species that are not threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

1.2 Ecological Communities

Presumed Totally Destroyed (PD)

An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future.

An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies (A or B):

A) Records within the last 50 years have not been confirmed despite thorough searches of known or likely habitats or

B) All occurrences recorded within the last 50 years have since been destroyed

Critically Endangered (CR)

An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated.

An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C):

A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and either or both of the following apply (i or ii):

i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 10 years);

ii) modification throughout its range is continuing such that in the immediate future (within approximately 10 years) the community is unlikely to be capable of being substantially rehabilitated.

B) Current distribution is limited, and one or more of the following apply (i, ii or iii):

i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 10 years);

ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes;

iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes.

C) The ecological community exists only as highly modified occurrences that may be capable of being rehabilitated if such work begins in the immediate future (within approximately 10 years).

Endangered (EN)

An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future.

An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B, or C):

A) The geographic range, and/or total area occupied, and/or number of discrete occurrences have been reduced by at least 70% since European settlement and either or both of the following apply (i or ii):

i) the estimated geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term future (within approximately 20 years);

ii) modification throughout its range is continuing such that in the short term future (within approximately 20 years) the community is unlikely to be capable of being substantially restored or rehabilitated.

B) Current distribution is limited, and one or more of the following apply (i, ii or iii):

i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 20 years);

ii) there are few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes;

iii) there may be many occurrences but total area is small and all or most occurrences are small and/or isolated and very vulnerable to known threatening processes.

C) The ecological community exists only as very modified occurrences that may be capable of being substantially restored or rehabilitated if such work begins in the short-term future (within approximately 20 years).

Vulnerable (VU)

An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.

An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B or C):

A) The ecological community exists largely as modified occurrences that are likely to be capable of being substantially restored or rehabilitated.

B) The ecological community may already be modified and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations.

C) The ecological community may be still widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.

Possible Threatened ecological communities that do not meet survey criteria or that are not adequately defined are added to the Priority Ecological Community List under priorities 1, 2 and 3. These three categories are ranked in order of priority for survey and/or definition of the community, and evaluation of conservation status, so that consideration can be given to their declaration as Threatened ecological communities. Ecological communities that are adequately known, and are rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

Priority One: Poorly-known ecological communities

Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤5 occurrences or a total area of ≤ 100 ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.

Priority Two: Poorly-known ecological communities

Communities that are known from few occurrences with a restricted distribution (generally ≤10 occurrences or a total area of ≤200 ha). At least some occurrences are not believed to be under immediate threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.

Priority Three: Poorly known ecological communities

(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:

(ii) Communities known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;

(iii) Communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.

Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.

Priority Four: Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.

(i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.

(ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

(iii) Ecological communities that have been removed from the list of threatened communities during the past five years.

Priority Five: Conservation Dependent ecological communities

Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

2 FEDERAL CONSERVATION CODES

2.1 Flora and fauna

Extinct

A native species is eligible to be included in the extinct category at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.

Extinct in the wild

A native species is eligible to be included in the extinct in the wild category at a particular time if, at that time:

(a) it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or

(b) 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.

Critically endangered

A native species is eligible to be included in the critically endangered category 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.

Endangered

A native species is eligible to be included in the endangered category at a particular time if, at that time:

(a) it is not critically endangered; and

(b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.

Vulnerable

A native species is eligible to be included in the vulnerable category at a particular time if, at that time:

(a) it is not critically endangered or endangered; and

(b) it is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.

Conservation dependent

A native species is eligible to be included in the conservation dependent category at a particular time if, at that time:

(a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or

(b) the following subparagraphs are satisfied:

(i) the species is a species of fish;

(ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised;

(iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory;

(iv) cessation of the plan of management would adversely affect the conservation status of the species.

2.2 Ecological communities

Critically endangered

An ecological community is eligible to be included in the critically endangered category 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.

Endangered

An ecological community is eligible to be included in the endangered category at a particular time if, at that time:

(a) it is not critically endangered; and

(b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.

Vulnerable

An ecological community is eligible to be included in the vulnerable category at a particular time if, at that time:

(a) it is not critically endangered nor endangered; and

(b) it is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.

APPENDIX F

Relevé Floristic Data

RELEVÉ DATA

Site: COR01
Described: CvdB & LD **Date:** 10/07/2014 **Type:** Releve
MGA Zone: 50 404219mE; 6517177mN
Habitat: Mid to upper north facing slope of a laterite rise
Soil: Black brown sandy loam with laterite
Rock Type: Laterite
Vegetation: *Eucalyptus marginata* and *Corymbia calophylla* mid sparse woodland over *Xanthorrhoea preissii* and *Allocasuarina humilis* mid open shrubland over *Hibbertia hypericoides, Conostephium pendulum* and *Hakea stenocarpa* low open shrubland
Condition: Excellent
Fire Age: >5 years
Notes Leaf Litter (%): 5
Rock Size (cm): 1-15
Exposed Rock (%): 17
Rock Cover (%): 22

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia drummondii subsp. *drummondii*		
Allocasuarina humilis	1	1.5
Astroloma pallidum		
Astroloma stomarrhena		
Banksia bipinnatifida subsp. *multifida*		
Banksia bipinnatifida subsp. *multifida*		
Calectasia narragara		
Calothamnus sanguineus		
Conostephium pendulum	1	0.5
Corymbia calophylla	1	10
Daviesia physodes		
Daviesia physodes		
Eucalyptus marginata	9	11
Gonocarpus cordiger		
Grevillea pilulifera		
Hakea lissocarpha (forma)	1	0.7
Hakea stenocarpa		
Hibbertia hypericoides	5	0.3
Jacksonia floribunda		
Lepidosperma pubisquameum (flat form)		
Mesomelaena tetragona		
Patersonia occidentalis var. *occidentalis*		
Petrophile divaricata		
Synaphea spinulosa subsp. *spinulosa*		
Xanthorrhoea preissii	12	1.8

Site: COR02

Described: CvdB & LD **Date:** 8/07/2014 **Type:** Relve

MGA Zone: 50 405595mE; 6516948mN

Habitat: Consolidated dune rise

Soil: Grey white coarse grained sand

Rock Type: N/A

Vegetation: *Eucalyptus marginata* mid sparse woodland over *Xanthorrhoea preissii* mid sparse shrubland over *Hibbertia hypericoides* and *Melaleuca systena* low heath shrubland over *Lepidosperma pubisquameum* (flat form) and *Mesomelaena pseudostygia* low sparse sedgeland over *Lyginia imberbis* low isolated rushes

Condition: Excellent

Fire Age: >5 years

Notes: Leaf Litter (%): 12

SPECIES LIST

Name	Cover (%)	Height (m)
Bossiaea eriocarpa		
Calytrix flavescens		
Calytrix variabilis		
Conostephium pendulum		0.2
Daviesia physodes		
Eucalyptus marginata	6	13
Gladiolus caryophyllaceus		0.1
Gompholobium tomentosum		
Hakea ruscifolia		
Hibbertia hypericoides	15	0.3
Hibbertia racemosa		
Hyalochlamys globifera		
Isopogon linearis		
Jacksonia floribunda		
Lepidosperma pubisquameum (flat form)	1	0.3
Lepidosperma squamatum		
Leucopogon conostephioides		
Leucopogon gracillimus		
Lomandra hermaphrodita		
Lyginia imberbis	<1	0.3
Melaleuca systena	3	0.3
Mesomelaena pseudostygia	1	0.3
Nuytsia floribunda		
Patersonia occidentalis var. *occidentalis*		
Persoonia saccata		
Stirlingia latifolia		
Xanthorrhoea preissii	7	2

Site: COR03

Described: CvdB & LD **Date:** 8/07/2014 **Type:** Releve

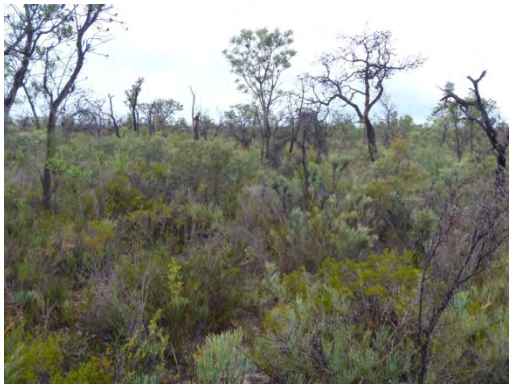
MGA Zone: 50 405202mE; 6516708mN

Habitat: Upper plain on a consolidated dune rise

Soil: Yellow grey brown coarse-grained sand

Rock Type: N/A

Vegetation: *Banksia attenuata* and *B. menziesii* tall sparse shrubland over *Allocasuarina humilis, Daviesia divaricata* subsp. *divaricata* and *Xanthorrhoea preissii* mid heath shrubland over *Eremaea pauciflora* var. *pauciflora* and *Stirlingia latifolia* low open shrubland over *Mesomelaena pseudostygia* low sparse shrubland



Condition: Excellent

Fire Age: >5 years

Notes: Leaf Litter (%): 10

SPECIES LIST

Name	Cover (%)	Height (m)
Allocasuarina humilis	37	1.5
Banksia attenuata	5	3.5
Banksia dallanneyi var. *dallanneyi*		
Banksia menziesii	3	3.5
Bossiaea eriocarpa		
Calectasia narragara		
Calytrix flavescens		
Calytrix sylvana		
Calytrix variabilis		
Conospermum stoechadis		
Conostephium pendulum		
Conostylis aurea		
Daviesia divaricata subsp. *divaricata*	1	2
Daviesia triflora		
Drosera ? erythrorhiza		
Drosera pallida		Creeper
Eremaea pauciflora var. *pauciflora*	4	0.5
Hypocalymma xanthopetalum		
Jacksonia floribunda		
Lomandra sericea		
Lysinema pentapetalum		
Melaleuca systena		
Mesomelaena pseudostygia	2	0.4
Patersonia occidentalis var. *occidentalis*		
Petrophile macrostachya		
Stirlingia latifolia	1	0.8
Stylidium sp.		
Synaphea spinulosa subsp. *spinulosa*		
Xanthorrhoea preissii	1	1.4

Site: COR04
Described: CvdB & LD **Date**: 8/07/2014 **Type:** Releve
MGA Zone: 50 406021mE; 6516192mN

Habitat: Upper plain of a consolidated dune rise
Soil: White brown coarse-grained sand
Rock Type: N/A
Vegetation: *Eucalyptus marginata* mid sparse woodland over *Banksia attenuata, B. grandis* and *Nuytsia floribunda* tall sparse shrubland over *Jacksonia floribunda* and *Adenanthos cygnorum* subsp. *cygnorum* mid open shrubland over *Eremaea pauciflora* var. *pauciflora, Hibbertia hypericoides* and *Melaleuca systena* low heath shrubland over *Mesomelaena pseudostygia* low sparse sedgeland
Condition: Excellent
Fire Age: >5 years
Notes: Leaf Litter (%): 12

SPECIES LIST

Name	Cover (%)	Height (m)
Adenanthos cygnorum subsp. *cygnorum*	1	1.8
Alexgeorgea nitens		0.3
Banksia attenuata	4	4.5
Banksia grandis	1	4
Bossiaea eriocarpa		0.4
Calytrix variabilis		0.4
Cassytha pomiformis		Creeper
Conostephium pendulum		0.2
Conostylis teretifolia subsp. *teretifolia*		0.1
Daviesia divaricata subsp. *divaricata*		2
Daviesia triflora		0.4
Drosera ? erythrorhiza		Prostrate
Eremaea pauciflora var. *pauciflora*	1	0.5
Eucalyptus marginata	2	11
Gladiolus caryophyllaceus		0.1
Hakea ruscifolia		0.5
Hibbertia hypericoides	1	0.4
Hibbertia racemosa		0.3
Isopogon linearis		0.4
Jacksonia floribunda	1	1.1
Lepidosperma pubisquameum (flat form)		0.3
Leucopogon conostephioides		0.3
Lyginia imberbis		0.3
Lysinema ciliatum		0.6
Melaleuca systena	1	0.2
Mesomelaena pseudostygia	1	0.4
Nuytsia floribunda	1	4.5
Patersonia occidentalis var. *occidentalis*		0.4
Persoonia saccata		0.3
Scholtzia involucrata		0.3
Stirlingia latifolia		0.4
Synaphea spinulosa subsp. *spinulosa*		0.4

Site: COR05
Described: CvdB & LD **Date:** 8/07/2014 **Type:** Releve
MGA Zone: 50 406161mE; 6515925mN
Habitat: Upper to mid slope, Moderate slope facing East Southeast
Soil: Brown coarse-grained sandy loam with a laterite subsurface
Rock Type: Laterite
Vegetation: *Eucalyptus marginata* and *Corymbia calophylla* mid woodland over *Xanthorrhoea preissii* mid sparse shrubland over *Hibbertia hypericoides* low open shrubland over *Mesomelaena tetragona* low sparse sedgeland
Condition: Excellent
Fire Age: >5 years
Notes: Leaf Litter (%): 15
Rock Size (cm): 1-10
Exposed Rock (%): <1
Rock Cover (%): <2

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia applanata		0.2
Astroloma pallidum		0.1
Babingtonia camphorosmae		0.3
Banksia bipinnatifida subsp. *multifida*		0.3
Banksia dallanneyi var. *dallanneyi*		0.3
Burchardia congesta		0.3
Conostephium pendulum		0.2
Conostylis teretifolia subsp. *teretifolia*		0.1
Corymbia calophylla	5	12
Daviesia physodes		0.4
Daviesia preissii		0.4
Drosera ? erythrorhiza		
Drosera pallida		Creeper
Eucalyptus marginata	10	12
Gladiolus caryophyllaceus		0.1
Gompholobium marginatum		0.2
Grevillea pilulifera		0.2
Hakea lissocarpha (forma)		0.4
Hibbertia hypericoides	25	0.3
Lagenophora huegelii		
Lepidosperma sp. Northern Sandplains (R. Barrett)		0.1
Lomandra preissii		0.3
Mesomelaena tetragona	2	0.3
Orchidaceae sp.		
Styphelia tenuiflora		0.4
Xanthorrhoea preissii	3	1

Site: COR06

Described: CvdB & LD **Date:** 8/07/2014 **Type:** Releve

MGA Zone: 50 404958mE; 6516136mN

Habitat: Plain on top of a consolidated dune rise

Soil: Grey brown coarse-grained sand

Rock Type: N/A

Vegetation: *Eucalyptus marginata* low sparse woodland over *Banksia attenuata, B. menziesii* and *Adenanthos cygnorum* subsp. *cygnorum* tall open shrubland over *Jacksonia floribunda* mid isolated shrubs over *Hibbertia hypericoides* and *Stirlingia latifolia* low open shrubland over *Hypolaena exsulca* low sparse sedges over *Lyginia imberbis* and *Alexgeorgea nitens* low sparse rushland

Condition: Excellent

Fire Age: >5 years

Notes: Leaf Litter (%): 10

SPECIES LIST

Name	Cover (%)	Height (m)
Adenanthos cygnorum subsp. *cygnorum*	2	4
Alexgeorgea nitens	1	0.1
Astroloma xerophyllum		0.5
Banksia attenuata	16	4.5
Banksia menziesii	2	4.0
Bossiaea eriocarpa		0.2
Calytrix flavescens		0.3
Calytrix variabilis		0.6
Cassytha pomiformis		Creeper
Conospermum crassinervium		0.3
Conostylis teretifolia subsp. *teretifolia*		0.1
Drosera ? erythrorhiza		0.1
Drosera pallida		creeper
Eremaea pauciflora var. *pauciflora*	10	0.5
Eucalyptus marginata	1	7.5
Hibbertia hypericoides	1	0.4
Hibbertia subvaginata		0.5
Hypolaena exsulca	1	0.5
Isopogon linearis		0.4
Jacksonia floribunda	0.25	1.2
Leucopogon conostephioides		0.3
Lyginia imberbis	1	0.2
Melaleuca systena		0.3
Mesomelaena tetragona		0.2
Patersonia occidentalis var. *occidentalis*		0.3
Scholtzia involucrata		0.2
Stirlingia latifolia	1	0.4

Site: COR07

Described: CvdB & LD **Date:** 9/07/2014 **Type:** Releve

MGA Zone: 50 404569mE; 6515568mN

Habitat: Consolidated low dune

Soil: Yellow grey coarse grey sand

Rock Type: N/A

Vegetation: *Eucalyptus marginata* and *Corymbia calophylla* mid sparse woodland over *Xanthorrhoea preissii* and *Calothamnus sanguineus* mid sparse shrubland over *Hibbertia hypericoides, Conostephium pendulum* and *Stirlingia latifolia* low heath shrubland over *Mesomelaena pseudostygia* low sparse sedgeland

Condition: Excellent

Fire Age: >5 years

Notes: Leaf Litter (%): 7

SPECIES LIST

Name	Cover (%)	Height (m)
Banksia dallanneyi var. *dallanneyi*		
Calothamnus sanguineus	1	1
Calytrix variabilis		
Cassytha pomiformis		Creeper
Conostephium pendulum	1	0.5
Corymbia calophylla	1	10
Daviesia physodes		
Drosera pallida		Creeper
Eucalyptus marginata	8	14
Gladiolus caryophyllaceus		
Gompholobium marginatum		
Hibbertia hypericoides	6	0.5
Hibbertia racemosa		
Isopogon linearis		
Kunzea glabrescens		
Lepidosperma pubisquameum (flat form)		
Lepidosperma squamatum		
Macrozamia riedlei		
Mesomelaena pseudostygia	3	0.4
Olearia lehmanniana		0.2
Patersonia occidentalis var. *occidentalis*		
Stirlingia latifolia	1	0.4
Stylidium sp.		Prostrate
Styphelia tenuiflora		
Xanthorrhoea preissii	3	1.5
Xanthosia huegelii		0.1

Site: COR08
Described: CvdB & LD **Date:** 9/07/2014 **Type:** Releve
MGA Zone: 50 404538mE; 6515087mN

Habitat: Top of a consolidated dune
Soil: Yellow brown coarse sand
Rock Type: N/A
Vegetation: *Eucalyptus todtiana* mid sparse mallee woodland over *Banksia attenuata* tall sparse shrubland over *Allocasuarina humilis* and *Xanthorrhoea preissii* mid sparse shrubland over *Hibbertia hypericoides*, *Calothamnus sanguineus* and *Eremaea pauciflora* var. *pauciflora* low open shrubland
Condition: Excellent - Pristine
Fire Age: >5 years
Notes: Leaf Litter (%): 10

SPECIES LIST

Name	Cover	Height
Acacia extensa		
Acacia sessilis		
Allocasuarina humilis		
Astroloma pallidum		
Banksia attenuata		
Banksia dallanneyi var. *dallanneyi*		
Bossiaea eriocarpa		
Burchardia congesta		
Calothamnus sanguineus		
Cassytha pomiformis		Creeper
Conostephium pendulum		
Daviesia triflora		
Drosera ? erythrorhiza		
Eremaea pauciflora var. *pauciflora*		
Eucalyptus todtiana		
Gladiolus caryophyllaceus		
Hakea lissocarpha (forma)		
Hibbertia hypericoides		
Hibbertia racemosa		
Isopogon linearis		
Leptomeria cunninghamii		
Lyginia imberbis		
Mesomelaena pseudostygia		
Nuytsia floribunda		
Patersonia occidentalis var. *occidentalis*		
Persoonia saccata		
Petrophile macrostachya		
Scholtzia involucrata		
Synaphea spinulosa subsp. *spinulosa*		
Xanthorrhoea preissii		

Site: COR09
Described: CvdB & LD **Date:** 9/07/2014 **Type:** Releve
MGA Zone: 50 404642mE; 6514639mN
Habitat: Middle to upper slope, moderate slope facing south
Soil: Brown coarse sandy loam
Rock Type: laterite
Vegetation: *Eucalyptus marginata* mid sparse woodland over *Xanthorrhoea preissii* mid sparse shrubland over *Hibbertia hypericoides* low open shrubland over *Lepidosperma pubisquameum* (flat form) and *Mesomelaena tetragona* low sparse sedgeland
Condition: Excellent
Fire Age: >5 years
Notes Leaf Litter (%): 30
Rock Size (cm): 5-10
Exposed Rock (%): <1
Rock Cover (%): 5

SPECIES LIST

Name	Cover	Height
Acacia nervosa		
Astroloma pallidum		
Banksia bipinnatifida subsp. *multifida*		
Banksia dallanneyi var. *dallanneyi*		
Bossiaea eriocarpa		
Conostephium pendulum		
Conostylis teretifolia subsp. *teretifolia*		
Daviesia preissii		
Drosera ? erythrorhiza		
Drosera pallida		
Eucalyptus marginata	9	11
Gompholobium marginatum		
Grevillea pilulifera		
Grevillea pilulifera		
Hakea lissocarpha (forma)		
Hakea trifurcata		
Hibbertia hypericoides	6	0.3
Hibbertia racemosa		
Lepidosperma pubisquameum (flat form)	1	0.3
Lepidosperma sp. Northern Sandplains (R. Barrett)		
Leucopogon gracillimus		
Leucopogon gracillimus		
Lomandra sericea		
Mesomelaena tetragona	1	0.3
Petrophile striata		
Stylidium sp.		
Synaphea spinulosa subsp. *spinulosa*		
Unknown sp.		
Xanthorrhoea preissii	5	1.5

Site: COR10
Described: CvdB & LD **Date:** 9/07/2014 **Type:** Releve
MGA Zone: 50 403976mE; 6514919mN
Habitat: Mid consolidated dune
Soil: White grey coarse grained sand
Rock Type: N/A
Vegetation: *Eucalyptus todtiana* mid sparse mallee woodland over *Nuytsia floribunda* low sparse woodland over *Banksia attenuata* and *Adenanthos cygnorum* tall sparse shrubland over *Beaufortia elegans* and *Xanthorrhoea preissii* mid sparse shrubland over *Calothamnus sanguineus* and *Hibbertia hypericoides* low sparse shrubland
Condition: Excellent
Fire Age: >5 years
Notes: Leaf Litter (%): 5

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia extensa		
Acacia pulchella var. *pulchella*		
Adenanthos cygnorum	1	4
Banksia attenuata	2	4
Beaufortia elegans	5	1.4
Bossiaea eriocarpa		
Calothamnus sanguineus	3	0.9
Calytrix variabilis		
Cassytha pomiformis		
Conostephium pendulum		
Conostylis teretifolia subsp. *teretifolia*		
Daviesia triflora		
Drosera ? erythrorhiza		
Eremaea pauciflora var. *pauciflora*		
Eucalyptus todtiana	4	6
Hibbertia hypericoides	1	0.5
Hibbertia racemosa		
Hibbertia subvaginata		
Hypolaena robusta		
Isopogon linearis		
Jacksonia floribunda		
Leucopogon conostephioides		
Leucopogon gracillimus		
Lomandra sericea		
Lyginia imberbis		
Nuytsia floribunda	1	6
Patersonia occidentalis var. *occidentalis*		
Persoonia saccata		
Scholtzia involucrata		
Synaphea spinulosa subsp. *spinulosa*		
Xanthorrhoea preissii	3	2

Site: COR11
Described: CvdB & LD **Date:** 9/07/2014 **Type:** Releve
MGA Zone: 50 403705mE; 6515359mN

Habitat: Consolidated dune, small depression in mid slope
Soil: Yellow brown coarse-grained sandy loam
Rock Type: N/A
Vegetation: *Banksia attenuata* and *B. menziesii* tall sparse shrubland over *Allocasuarina humilis* and *Xanthorrhoea preissii* mid sparse shrubland over *Eremaea pauciflora* var. *pauciflora, Hibbertia hypericoides* and *Melaleuca systena* low sparse shrubland over *Mesomelaena pseudostygia* low sparse sedgeland
Condition: Excellent - Pristine
Fire Age: >5 years
Notes: Leaf Litter (%): 8

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia sessilis		
Allocasuarina humilis	1	1.5
Banksia attenuata	7	5
Banksia dallanneyi var. *dallanneyi*		
Banksia menziesii	1	5
Calothamnus sanguineus		
Calytrix flavescens		
Cryptandra scoparia		
Daviesia divaricata subsp. *divaricata*		
Drosera ? erythrorhiza		
Drosera pallida		Creeper
Eremaea pauciflora var. *pauciflora*	8	0.4
Hakea lissocarpha (forma)		
Hibbertia hypericoides	2	0.3
Isopogon linearis		
Jacksonia floribunda		
Lepidobolus preissianus		
Leptospermum spinescens		
Melaleuca systena	2	0.4
Mesomelaena pseudostygia	21	0.3
Nuytsia floribunda		
Petrophile macrostachya		
Scholtzia involucrata		
Stylidium cygnorum		
Xanthorrhoea preissii	1	1.5

Site: COR12

Described: CvdB & LD **Date:** 10/07/2014 **Type:** Releve

MGA Zone: 50 403022mE; 6515040mN

Habitat: Mid to upper west facing slope

Soil: Dark brown coarse-grained sandy loam, rocky

Rock Type: Laterite

Vegetation: *Eucalyptus marginata* and *Corymbia calophylla* mid sparse woodland over *Xanthorrhoea preissii* mid open shrubland over *Hibbertia hypericoides, Acacia celastrifolia* and *Hakea lissocarpha* low sparse shrubland

Condition: Very Good - Excellent

Fire Age: >5 years

Notes: Leaf Litter (%): 18
Rock Size (cm): 1-15
Exposed Rock (%): 1
Rock Cover (%): 4

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia applanata		
Acacia celastrifolia	1	1
Acacia preissiana		
Corymbia calophylla	1	10
Drosera pallida		Creeper
Eucalyptus marginata	3	12
Gompholobium marginatum		
Gonocarpus cordiger		
Grevillea pilulifera		
Hakea lissocarpha (forma)	1	0.4
Hakea stenocarpa		
Hibbertia hypericoides	2	0.7
Hibbertia racemosa		
Hypochaeris glabra		
Lomandra sericea		
Macrozamia riedlei		
Patersonia occidentalis var. *occidentalis*		
Petrophile striata		
Phyllanthus calycinus		
Synaphea spinulosa subsp. *spinulosa*		
Xanthorrhoea preissii	12	2

Site: COR13
Described: CvdB & LD **Date:** 10/07/2014 **Type:** Releve
MGA Zone: 50 403244mE; 6514681mN
Habitat: Top of a rocky rise
Soil: Black brown coarse loamy sand
Rock Type: laterite
Vegetation: *Corymbia calophylla* and *Nuytsia floribunda* mid sparse woodland over *Banksia sessilis* var. *sessilis* tall sparse shrubland over *Xanthorrhoea preissii* mid open shrubland over *Calothamnus sanguineus* and *Hibbertia hypericoides* low open shrubland
Condition: Very Good - Excellent
Fire Age: >5 years
Notes: Leaf Litter (%): 21
Rock Size (cm): 1-11
Exposed Rock (%): 2
Rock Cover (%): 3

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia extensa		
Acacia preissiana		
Banksia dallanneyi var. *dallanneyi*		
Banksia sessilis var. *sessilis*	3	4.5
Boronia ramosa subsp. *anethifolia*		
Bossiaea eriocarpa		
Calothamnus sanguineus	9	0.6
Calytrix variabilis		
Cassytha pomiformis		Creeper
Corymbia calophylla	3	11
Desmocladus flexuosus		
Drosera pallida		Creeper
Gompholobium marginatum		
Hakea lissocarpha (forma)		
Hakea ruscifolia		
Hibbertia hibbertioides		
Hibbertia hypericoides	2	0.3
Isopogon linearis		
Lepidosperma pubisquameum (flat form)		
Lomandra sericea		
Nuytsia floribunda	1	8
Patersonia occidentalis var. *occidentalis*		
Petrophile striata		
Phyllanthus calycinus		
Stirlingia latifolia		
Stylidium cygnorum		
Synaphea spinulosa subsp. *spinulosa*		
Xanthorrhoea preissii	5	2

Site: COR14

Described: CvdB & LD **Date:** 9/07/2014 **Type:** Releve

MGA Zone: 50 402445mE; 6514595mN

Habitat: Depression on mid slope of a consolidated dune

Soil: Brown grey white coarse-grained sand

Rock Type: N/A

Vegetation: *Banksia attenuata* mid sparse woodland over *Kunzea glabrescens* and *Banksia menziesii* tall shrubland over *Macrozamia riedlei* and *Xanthorrhoea preissii* mid sparse shrubland over various sparse herbs

Condition: Very Good

Fire Age: >5 years

Notes: Leaf Litter (%):

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia huegelii		
Banksia attenuata	10	12
Banksia menziesii	1	3.5
Conostephium preissii		
Desmocladus flexuosus		
Dianella revoluta		
Drosera ? erythrorhiza		
Eremaea pauciflora var. *pauciflora*		
Eucalyptus todtiana	1	10
Kunzea glabrescens	25	4
Macrozamia riedlei	2	1.7
Pterostylis sanguinea		
Xanthorrhoea preissii	1	2

Site: COR15

Described: CvdB & LD **Date:** 9/07/2014 **Type:** Releve

MGA Zone: 50 402651mE; 6515634mN

Habitat: Mid slope of a consolidated dune facing west

Soil: Grey brown coarse sand

Rock Type: N/A

Vegetation: *Corymbia calophylla* and *Eucalyptus marginata* mid sparse woodland over *Banksia attenuata* and *B. menziesii* tall sparse shrubland over *Xanthorrhoea preissii* and *Macrozamia riedlei* mid sparse shrubland over *Hibbertia hypericoides, Conostephium pendulum* and *Stirlingia latifolia* low open shrubland over *Mesomelaena pseudostygia* low sparse sedgeland

Condition: Very Good - Excellent

Fire Age: >5 years

Notes: Leaf Litter (%): 30

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia pulchella var. *pulchella*		
Allocasuarina humilis		
Banksia attenuata	3	7
Banksia dallanneyi var. *dallanneyi*		
Banksia menziesii	1	4
Conostephium pendulum		
Corymbia calophylla	7	15
Desmocladus flexuosus		
Drosera pallida		
Eremaea pauciflora var. *pauciflora*		
Eucalyptus marginata	2	15
Hakea lissocarpha (forma)		
Hibbertia hypericoides	4	0.5
Hovea trisperma		
Hypochaeris glabra		
Isopogon linearis		
Lagenophora huegelii		
Lyginia imberbis		
Macrozamia riedlei	1	1.9
Mesomelaena pseudostygia	1	0.4
Phyllanthus calycinus		
Stirlingia latifolia	1	1
Synaphea spinulosa subsp. *spinulosa*		
Xanthorrhoea preissii	3	2

Site: COR16
Described: CvdB & LD **Date:** 10/07/2014 **Type:** Releve
MGA Zone: 50 403124mE; 6516352mN
Habitat: Upper consolidated dune
Soil: Yellow brown coarse-grained sand
Rock Type: N/A
Vegetation: *Eucalyptus todtiana* mid isolated mallee trees over *Banksia attenuata* and *Nuytsia floribunda* tall sparse woodland over *Xanthorrhoea preissii* tall sparse shrubland over *Allocasuarina humilis* mid open shrubland over *Hibbertia hypericoides, H. racemosa* and *Calothamnus sanguineus* low sparse shrubland over *Mesomelaena pseudostygia* low isolated sedges and *Lyginia imberbis* low isolated rushes
Condition: Excellent
Fire Age: >5 years
Notes: Leaf Litter (%): 10

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia extensa		
Acacia sessilis		
Allocasuarina humilis	20	1.9
Banksia attenuata	2	7
Banksia dallanneyi var. *dallanneyi*		
Calothamnus sanguineus	3	0.5
Cassytha pomiformis		
Conostylis teretifolia subsp. *teretifolia*		
Drosera ? erythrorhiza		
Drosera pallida		
Eucalyptus todtiana	1	7
Hakea lissocarpha (forma)		
Hibbertia hypericoides	5	0.4
Hibbertia racemosa	2	0.3
Hibbertia subvaginata		
Isopogon linearis		
Isopogon linearis		
Lomandra sericea		
Lyginia imberbis		
Mesomelaena pseudostygia	2	0.3
Nuytsia floribunda		5
Petrophile macrostachya		
Stylidium cygnorum		
Synaphea spinulosa subsp. *spinulosa*		
Xanthorrhoea preissii	1	2.6

Site: COR17

Described: CvdB & LD **Date:** 10/07/2014 **Type:** Releve

MGA Zone: 50 402519mE; 6516931mN

Habitat: Consolidated dune, upper to mid gently sloping Northwest facing slope

Soil: Brown white coarse-grained sand

Rock Type: N/A

Vegetation: *Corymbia calophylla* mid sparse woodland over *Xanthorrhoea preissii* and *Daviesia divaricata* subsp. *divaricata* tall sparse shrubland over *Hakea trifurcata* mid sparse shrubland over *Conostephium preissii* low sparse shrubland

Condition: Very Good

Fire Age: >5 years

Notes: Leaf Litter (%): 10

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia celastrifolia		
Anigozanthos humilis		
Babingtonia camphorosmae		
Banksia dallanneyi		
Beaufortia elegans		
Bossiaea eriocarpa		
Calothamnus sanguineus		
Calytrix sylvana		
Cheilanthes austrotenuifolia		
Conostephium preissii	1	0.9
Corymbia calophylla	7	12
Daviesia divaricata subsp. *divaricata*	1	5
Daviesia physodes		
Hakea lissocarpha (forma)	1	1.4
Hakea trifurcata	1	2
Hypochaeris glabra		
Isopogon linearis		
Lechenaultia biloba		
Melaleuca systena		
Persoonia saccata		
Pimelea sp. 1		
Scholtzia involucrata		
Xanthorrhoea preissii	7	3

Site: COR18
Described: CvdB & LD **Date:** 10/07/2014 **Type:** Releve
MGA Zone: 50 403130mE; 6517291mN
Habitat: Consolidated dune, lower north facing slope
Soil: Grey brown coarse-grained sand
Rock Type: N/A
Vegetation: *Banksia attenuata, B. menziesii* and *Nuytsia floribunda* mid woodland over *Xanthorrhoea preissii* and *Allocasuarina humilis* mid sparse shrubland over *Hibbertia subvaginata, Phlebocarya ciliata, Eremaea pauciflora* var. *pauciflora* and *Leucopogon conostephioides* low sparse shrubland
Condition: Excellent
Fire Age: >5 years
Notes: Leaf Litter (%): 24

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia huegelii		
Allocasuarina humilis		
Banksia attenuata	8	10
Banksia menziesii	4	8
Bossiaea eriocarpa		
Calytrix sylvana		
Daviesia triflora		
Eremaea pauciflora var. *pauciflora*		
Hibbertia subvaginata	1	0.3
Isopogon linearis		
Lepidosperma pubisquameum (flat form)		
Leucopogon conostephioides	12	0.3
Lyginia imberbis		
Melaleuca systena		
Nuytsia floribunda	1	12
Phlebocarya ciliata	1	0.4
Stirlingia latifolia		
Synaphea spinulosa subsp. *spinulosa*		
Xanthorrhoea preissii	2	1.5

Site: COR19

Described: CvdB & LD **Date:** 10/07/2014 **Type:** Releve

MGA Zone: 50 403985mE; 6516766mN

Habitat: Mid slope of a consolidated dune

Soil: Grey brown coarse-grained sandy loam

Rock Type: N/A

Vegetation: *Banksia attenuata* and *B. menziesii* low sparse woodland over *Adenanthos cygnorum* subsp. *cygnorum* tall open shrubland over *Xanthorrhoea preissii* and *Beaufortia elegans* mid sparse shrubland over *Hibbertia hypericoides, Scholtzia involucrata* and *Calothamnus sanguineus* low sparse shrubland over *Mesomelaena pseudostygia* low sparse sedgeland

Condition: Excellent

Fire Age: >5 years

Notes: Leaf Litter (%): 15

SPECIES LIST

Name	Cover (%)	Height (m)
Adenanthos cygnorum subsp. *cygnorum*	14	3.5
Allocasuarina humilis		
Banksia attenuata	2	6
Banksia menziesii	1	5.5
Beaufortia elegans	1.5	1.3
Calothamnus sanguineus	1	0.8
Calytrix flavescens		
Calytrix sylvana		
Calytrix variabilis		
Conospermum crassinervium		
Conospermum stoechadis		
Daviesia triflora		0.6
Drosera ? erythrorhiza		
Drosera pallida		
Hibbertia hypericoides	3	
Hibbertia racemosa		
Hibbertia racemosa		
Hibbertia subvaginata		
Hypocalymma xanthopetalum		
Hypolaena robusta		
Isopogon linearis	1	0.4
Jacksonia floribunda		3.2
Lyginia imberbis	1	0.4
Mesomelaena pseudostygia	1	0.4
Scholtzia involucrata	2	0.6
Stirlingia latifolia	1	0.7
Stylidium cygnorum		
Synaphea spinulosa subsp. *spinulosa*		0.4
Xanthorrhoea preissii		6

Site: COR20

Described: CvdB & LD **Date:** 10/07/2014 **Type:** Relevé

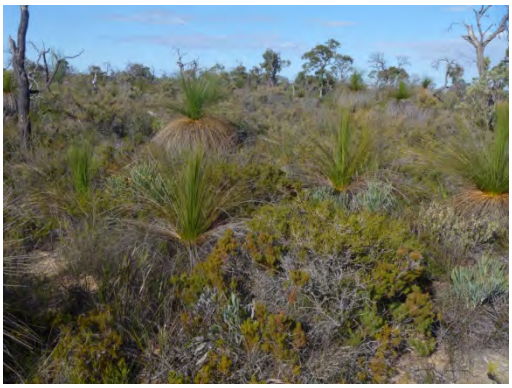
MGA Zone: 50 404709mE; 6516428mN

Habitat: Consolidated dune, upper slope

Soil: Yellow brown coarse-grained sand

Rock Type: N/A

Vegetation: *Corymbia calophylla* mid Isolated trees over *Banksia attenuata* tall sparse shrubland over *Allocasuarina humilis* and *Xanthorrhoea preissii* mid sparse shrubland over *Eremaea pauciflora* var. *pauciflora, Calothamnus sanguineus* and *Stirlingia latifolia* low open shrubland over *Mesomelaena pseudostygia* low sparse sedgeland



Condition: Excellent

Fire Age: >5 years

Notes: Leaf Litter (%): 5

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia sessilis		
Allocasuarina humilis	2	1.8
Banksia attenuata	1	4
Banksia dallanneyi var. *dallanneyi*		
Banksia menziesii	1	4.5
Calothamnus sanguineus	2	0.5
Calytrix sylvana		
Conostephium pendulum		
Conostylis teretifolia subsp. *teretifolia*		
Corymbia calophylla	1	14
Daviesia physodes		
Drosera ? erythrorhiza		
Eremaea pauciflora var. *pauciflora*	9	0.6
Gladiolus caryophyllaceus		
Hakea ruscifolia		
Hibbertia hypericoides		
Hibbertia racemosa		
Hypocalymma xanthopetalum		
Leptospermum spinescens		
Lomandra purpurea		
Lomandra sericea		
Mesomelaena pseudostygia	3	0.3
Nuytsia floribunda		
Patersonia occidentalis var. *occidentalis*		
Stirlingia latifolia	1	0.7
Xanthorrhoea preissii	1	2

Site: COR21

Described: CvdB & LD **Date:** 9/07/2014 **Type:** Releve

MGA Zone: 50 404111mE; 6515797mN

Habitat: Low consolidated dune

Soil: Grey white coarse sand

Rock Type: N/A

Vegetation: *Eucalyptus marginata* mid sparse woodland over *Xanthorrhoea preissii* mid sparse shrubland over *Hibbertia hypericoides*, *Calothamnus sanguineus* and *Conostephium pendulum* low sparse heath shrubland over *Lepidosperma pubisquameum* (flat form), *Lepidosperma squamatum* and *Mesomelaena pseudostygia* low sparse sedgeland

Condition: Excellent

Fire Age: >5 years

Notes: Leaf Litter (%): 20

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia applanata		
Banksia dallanneyi var. *dallanneyi*		
Bossiaea eriocarpa		
Burchardia congesta		
Calothamnus sanguineus	1	0.5
Calytrix sylvana		
Calytrix variabilis		
Cassytha pomiformis		
Conostephium pendulum	1	0.4
Conostylis teretifolia subsp. *teretifolia*		
Drosera ? erythrorhiza		
Eucalyptus marginata	8	12
Gompholobium marginatum		
Haemodorum sp.		
Hibbertia hypericoides	8	0.3
Hibbertia racemosa		
Isopogon linearis		
Lagenophora huegelii		
Lepidosperma pubisquameum (flat form)	1	0.2
Lepidosperma squamatum	+	
Leucopogon gracillimus		
Lomandra hermaphrodita		
Lomandra sericea		
Macrozamia riedlei		
Mesomelaena pseudostygia	1	0.3
Nuytsia floribunda		
Patersonia occidentalis var. *occidentalis*		
Stirlingia latifolia		
Styphelia tenuiflora		
Synaphea spinulosa subsp. *spinulosa*		
Xanthorrhoea preissii	3	2
Xanthosia huegelii		

Site: COR22
Described: CvdB & LD **Date:** 10/07/2014 **Type:** Releve
MGA Zone: 50 403666mE; 6516114mN

Habitat: Consolidated dune, very gently sloping north
Soil: Brown white coarse-grained sand
Rock Type: N/A
Vegetation: *Eucalyptus todtiana* mid isolated mallee trees over *Banksia attenuata, B. menziesii* and *Adenanthos cygnorum* subsp. *cygnorum* tall sparse shrubland over *Allocasuarina humilis* and *Xanthorrhoea preissii* mid open shrubland over *Hibbertia hypericoides*, *Calothamnus sanguineus* and *Conostephium pendulum* low open shrubland
Condition: Excellent
Fire Age: >5 years
Notes: Leaf Litter (%): 8

SPECIES LIST

Name	Cover (%)	Height (m)
Adenanthos cygnorum subsp. *cygnorum*	+	4
Allocasuarina humilis	2	1.6
Banksia attenuata	3	5
Banksia dallanneyi var. *dallanneyi*		
Banksia menziesii	1	4.5
Calothamnus sanguineus	3	1
Calytrix flavescens		
Calytrix variabilis		
Cassytha pomiformis		
Conostephium pendulum	+	0.4
Conostylis teretifolia subsp. *teretifolia*		
Daviesia nudiflora subsp. *nudiflora*		
Daviesia physodes		
Drosera ? erythrorhiza		
Drosera pallida		
Eucalyptus todtiana	1	8
Gladiolus caryophyllaceus		
Hibbertia hypericoides	10	0.4
Hibbertia racemosa		
Hibbertia subvaginata		
Isopogon linearis		
Jacksonia floribunda		
Leucopogon conostephioides		
Lyginia imberbis		
Melaleuca systena		
Mesomelaena pseudostygia		0.3
Nuytsia floribunda		
Patersonia occidentalis var. *occidentalis*		
Scholtzia involucrata		
Stirlingia latifolia	1	0.6
Synaphea spinulosa subsp. *spinulosa*		
Xanthorrhoea preissii	2	1.5

Site: COR23

Described: CvdB & LD **Date:** 10/07/2014 **Type:** Releve

MGA Zone: 50 403043mE; 6515985mN

Habitat: Upper consolidated dune

Soil: Yellow brown coarse-grained sand

Rock Type: N/A

Vegetation: *Eucalyptus todtiana* mid isolated mallee trees over *Nuytsia floribunda* low isolated trees over *Banksia attenuata* and *B. menziesii* tall sparse shrubland over *Allocasuarina humilis* and *Xanthorrhoea preissii* mid open shrubland over *Hibbertia hypericoides* and *Calothamnus sanguineus* low open shrubland over *Mesomelaena pseudostygia* low sparse sedgeland

Condition: Excellent

Fire Age: >5 years

Notes: Leaf Litter (%):

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia pulchella var. *pulchella*		
Acacia sessilis		
Allocasuarina humilis	10	1.7
Banksia attenuata	3	7
Banksia dallanneyi var. *dallanneyi*		
Banksia menziesii		5
Calothamnus sanguineus		
Calytrix variabilis		
Cassytha pomiformis		
Conostephium pendulum		
Daviesia nudiflora subsp. *nudiflora*		
Drosera ? erythrorhiza		
Drosera pallida		
Eucalyptus todtiana	1	8
Gladiolus caryophyllaceus		
Gompholobium marginatum		
Grevillea pilulifera		
Hakea lissocarpha (forma)		
Hakea ruscifolia		
Hibbertia hypericoides	3	0.3
Hibbertia racemosa		
Isopogon linearis		
Jacksonia floribunda		
Lomandra sericea		
Lyginia imberbis		
Lysinema pentapetalum		
Mesomelaena pseudostygia	2	0.3
Nuytsia floribunda		6
Petrophile macrostachya		
Pimelea imbricata var. *piligera*		
Xanthorrhoea preissii	2	1.9

Site: COR24

Described: CvdB & LD **Date:** 17/07/2014 **Type:** Releve

MGA Zone: 50 402604mE; 6516405mN

Habitat: Consolidated dune

Soil: Black/grey coarse grained sand

Rock Type: N/A

Vegetation: *Eucalyptus todtiana* mid isolated mallee trees over *Banksia attenuata, B. menziesii* and *Adenanthos cygnorum* subsp. *cygnorum* tall open shrubland over *Beaufortia elegans* and *Jacksonia floribunda* mid sparse shrubland over *Scholtzia involucrata, Leucopogon conostephioides* and *Eremaea pauciflora* var. *pauciflora* low open shrubland over *Mesomelaena pseudostygia* low isolated sedges over *Lyginia imberbis* low isolated rushes

Condition: Excellent

Fire Age: >5 years

Notes: None

SPECIES LIST

Name	Cover (%)	Height (m)
Acacia pulchella var. *glaberrima*		0.50
Adenanthos cygnorum subsp. *cygnorum*	1	4
Alexgeorgea nitens		0.10
Astroloma xerophyllum		0.60
Banksia attenuata	8	5
Banksia menziesii	2	5
Beaufortia elegans	1	1.7
Boronia ramosa subsp. *ramosa*		0.40
Calytrix flavescens		.20
Calytrix variabilis		0.40
Cassytha pomiformis		Creeper
Conospermum crassinervium		1
Eremaea pauciflora var. *pauciflora*	1	0.80
Eucalyptus todtiana	1	6
Gompholobium tomentosum		0.20
Hibbertia hypericoides		0.30
Hibbertia racemosa		
Hibbertia subvaginata		0.20
Isopogon linearis		0.40
Jacksonia floribunda	+	2
Leucopogon conostephioides	2	0.50
Lyginia imberbis	1	0.50
Mesomelaena pseudostygia	+	0.30
Nuytsia floribunda		0.50
Scholtzia involucrata	7	0.50
Stirlingia latifolia		1.4
Stylidium cygnorum		0.10
Xanthorrhoea preissii		1.3

Site: COR25

Described: CvdB & LD **Date:** 17/07/2014 **Type:** Releve

MGA Zone: 50 405045mE; 6517238mN

Habitat: Consolidated dune. Upper crest

Soil: Grey/white coarse grain sand

Rock Type: N/A

Vegetation: *Eucalyptus marginata* mid woodland over *Banksia attenuata* and *B. menziesii* tall sparse shrubland over *Eremaea pauciflora* var. *pauciflora*, *Hibbertia hypericoides* and *Daviesia triflora* low open shrubland over *Mesomelaena pseudostygia* low isolated sedges over *Lyginia imberbis* low isolated rushes

Condition: Excellent

Fire Age: > 5 years

Notes: None

SPECIES LIST

Name	Cover (%)	Height (m)
Astroloma xerophyllum		0.60
Banksia attenuata	5	4
Banksia dallanneyi var. *dallanneyi*		0.10
Banksia menziesii	2	3.5
Burchardia congesta		0.40
Calytrix flavescens		0.30
Conostephium pendulum		0.40
Conostylis teretifolia subsp. *teretifolia*		0.10
Daviesia physodes		0.50
Daviesia triflora	2	0.40
Drosera ? erythrorhiza		Prostate
Eremaea pauciflora var. *pauciflora*	5	0.60
Eucalyptus marginata	3	12
Hibbertia hypericoides	5	0.50
Hibbertia hypericoides		0.20
Hibbertia racemosa		0.20
Hypolaena exsulca		0.30
Isopogon linearis		0.50
Jacksonia floribunda		1.8
Lyginia imberbis	1	0.40
Melaleuca systena		0.40
Mesomelaena pseudostygia	1	0.40
Patersonia occidentalis var. *occidentalis*		0.30
Stirlingia latifolia		0.40
Synaphea spinulosa subsp. *spinulosa*		0.20
Xanthorrhoea preissii		1.5

Site: COR26

Described: CvdB & LD **Date:** 17/07/2014 **Type:** Releve

MGA Zone: 50 405772mE; 6517198mN

Habitat: Swale-consolidated dune. Low slope gently towards the south

Soil: Yellow/brown coarse grain sand

Rock Type: N/A

Vegetation: *Banksia attenuata, B. menziesii* and *Nuytsia floribunda* tall sparse shrubland over *Xanthorrhoea preissii* mid sparse shrubland over *Allocasuarina humilis, Eremaea pauciflora* var. *pauciflora* and *Melaleuca systena* low open shrubland over *Mesomelaena pseudostygia* and *Schoenus efoliatus* low sparse sedgeland

Condition: Excellent

Fire Age: >5 years

Notes: Dead Banksia - Dieback?

SPECIES LIST

Name	Cover (%)	Height (m)
Alexgeorgea nitens		0.10
Allocasuarina humilis	12	1
Austrodanthonia sp.		0.50
Banksia attenuata	1	3
Banksia dallanneyi var. *dallanneyi*		0.10
Banksia menziesii	+	3
Bossiaea eriocarpa		0.10
Calectasia narragara		0.20
Caustis dioica		0.30
Conostephium pendulum		0.30
Daviesia physodes		0.30
Daviesia triflora		0.40
Eremaea pauciflora var. *pauciflora*	10	0.60
Gladiolus caryophyllaceus		0.30
Hibbertia hypericoides		0.30
Hovea trisperma var. *trisperma*		0.20
Isopogon linearis		0.10
Leptospermum spinescens		0.40
Lyginia imberbis		0.30
Melaleuca systena	2	0.50
Mesomelaena pseudostygia	1	0.30
Nuytsia floribunda	+	4.5
Patersonia occidentalis var. *occidentalis*		0.30
Pimelea imbricata var. *piligera*		0.20
Schoenus efoliatus	2	0.40
Synaphea spinulosa subsp. *spinulosa*		0.20
Xanthorrhoea preissii	1	2

Site: COR27

Described: CvdB & LD **Date:** 17/07/2014 **Type:** Releve

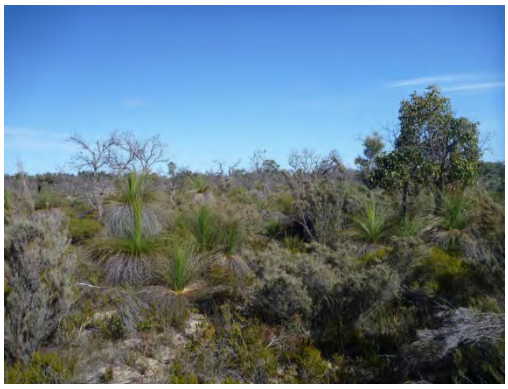
MGA Zone: 50 406089mE; 6516591mN

Habitat: Consolidated dune, mid slope gently sloping to south-east

Soil: Black/grey coarse grain sand

Rock Type: N/A

Vegetation: *Allocasuarina humilis, Banksia attenuata* and *B. menziesii* tall sparse shrubland over *Allocasuarina humilis* and *Xanthorrhoea preissii* mid sparse shrubland over *Eremaea pauciflora* var. *pauciflora* and *Melaleuca systena* low open shrubland over *Mesomelaena pseudostygia* low sparse sedgeland



Condition: Excellent

Fire Age: > 5 years

Notes: Dieback?

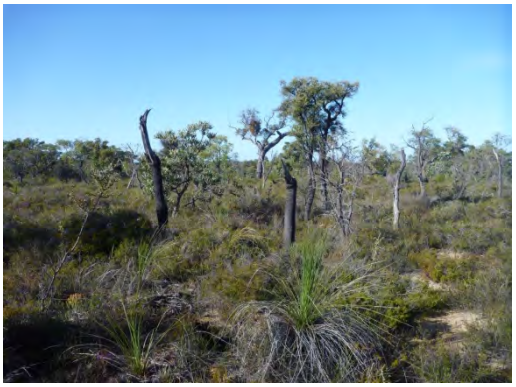
SPECIES LIST

Name	Cover (%)	Height (m)
Allocasuarina humilis	8	1.8
Amphipogon turbinatus		0.20
Banksia attenuata	1	4
Banksia dallanneyi var. *dallanneyi*		0.10
Banksia menziesii	1	4
Bossiaea eriocarpa		0.40
Conospermum stoechadis		0.50
Conostephium pendulum		0.40
Daviesia physodes		0.50
Daviesia triflora		0.40
Eremaea pauciflora var. *pauciflora*	15	0.70
Hibbertia racemosa		0.30
Hovea trisperma var. *trisperma*		0.30
Isopogon linearis		0.20
Jacksonia floribunda		1.3
Lepidosperma sp. Inland Scabrid (R. Barrett)		0.60
Leucopogon gracillimus		0.40
Lomandra sericea		0.30
Lyginia imberbis		0.30
Melaleuca systena	2	0.40
Mesomelaena pseudostygia	2	0.30
Nuytsia floribunda	+	7
Patersonia occidentalis var. *occidentalis*		0.40
Petrophile macrostachya		0.80
Stirlingia latifolia		0.60
Xanthorrhoea preissii	3	2

Site: COR28

Described: CvdB & LD **Date:** 17/07/2014 **Type:** Releve

MGA Zone: 50 405613mE; 6515861mN



Habitat: Consolidated dune, upper to mid gentle slope to south - east

Soil: Yellow / brown coarse –grained sand

Rock Type: NIL

Vegetation: *Corymbia calophylla* mid isolated trees over *Eucalyptus todtiana* mid isolated mallee trees over *Banksia attenuata, B. menziesii* and *Daviesia divaricata* subsp. *Divaricata* tall sparse shrubland over *Eremaea pauciflora* var. *pauciflora*, *Calothamnus sanguineus* and *Hibbertia hypericoides* low sparse heath shrubland over *Mesomelaena pseudostygia* low sparse sedgeland

Condition: Excellent

Fire Age: > 5 years

Notes: none

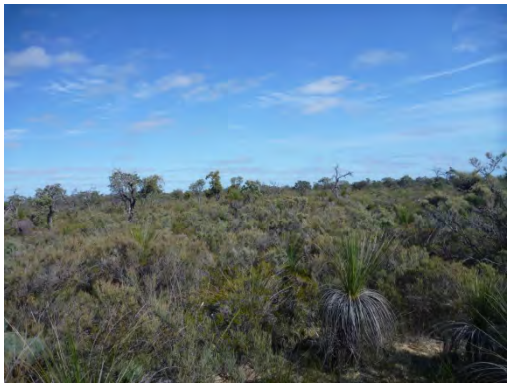
SPECIES LIST

Name	Cover	Height
Allocasuarina humilis		1.2
Banksia attenuata	+	3
Banksia dallanneyi var. *dallanneyi*		0.20
Banksia menziesii	+	3
Calothamnus sanguineus	2	0.40
Calytrix sylvana		0.50
Calytrix variabilis		0.40
Conospermum stoechadis		0.50
Conostephium pendulum		0.50
Conostylis teretifolia subsp. *teretifolia*		0.10
Corymbia calophylla	+	11
Daviesia divaricata subsp. *divaricata*	+	3
Daviesia physodes		0.80
Daviesia triflora		0.30
Drosera ? erythrorhiza		Prostrate
Eremaea pauciflora var. *pauciflora*	15	0.60
Eucalyptus todtiana	1	7
Grevillea pilulifera		0.20
Hakea ruscifolia		2
Hibbertia hypericoides	2	0.40
Hibbertia racemosa		0.30
Isopogon linearis		0.40
Jacksonia floribunda		1.8
Leucopogon racemulosus		0.40
Lomandra purpurea		0.30
Lyginia imberbis		0.40
Lysinema pentapetalum		0.40
Melaleuca systena		0.30
Mesomelaena pseudostygia	2	0.30
Nuytsia floribunda		4
Patersonia occidentalis var. *occidentalis*		0.30
Stirlingia latifolia		0.70
Synaphea spinulosa subsp. *spinulosa*		0.50
Xanthorrhoea preissii		2

Site: COR29

Described: CvdB & LD **Date:** 17/07/2014 **Type:** Releve

MGA Zone: 50 404188mE; 6516321mN



Habitat: Consolidated dune. Upper slope to south-east

Soil: Yellow/brown coarse-grained sand

Rock Type: N/A

Vegetation: *Eucalyptus todtiana* mid isolated mallee trees over *Banksia attenuata, B. menziesii* and *Nuytsia floribunda* tall sparse shrubland over *Allocasuarina humilis, Xanthorrhoea preissii* and *Jacksonia floribunda* mid open shrubland over *Eremaea pauciflora* var. *pauciflora*, *Hibbertia hypericoides* and *Melaleuca systena* low sparse shrubland over *Mesomelaena pseudostygia* low sparse sedgeland.

Condition: Excellent

Fire Age: > 5 years

Notes: None

SPECIES LIST

Name	Cover (%)	Height (m)
Allocasuarina humilis	20	1.8
Amphipogon turbinatus		0.40
Anigozanthos sp.		0.10
Banksia attenuata	1	6
Banksia dallanneyi var. *dallanneyi*		0.20
Banksia menziesii	1	5
Bossiaea eriocarpa		0.20
Calectasia narragara		0.40
Calytrix flavescens		0.30
Conospermum stoechadis		0.60
Conostephium pendulum		0.40
Daviesia nudiflora subsp. *nudiflora*		0.60
Daviesia physodes		0.50
Daviesia preissii		0.60
Drosera ? erythrorhiza		Pro
Eremaea pauciflora var. *pauciflora*	4	0.60
Eucalyptus todtiana	+	7
Hakea ruscifolia		1.1
Hibbertia hypericoides	2	0.30
Hibbertia racemosa		0.20
Isopogon linearis		0.30
Jacksonia floribunda	+	2
Lomandra sericea		0.20
Melaleuca systena	1	0.40
Mesomelaena pseudostygia	2	0.30
Nuytsia floribunda	1	6
Patersonia occidentalis var. *occidentalis*		0.20
Petrophile macrostachya		0.60
Stirlingia latifolia		0.60
Synaphea spinulosa subsp. *spinulosa*		0.30
Xanthorrhoea preissii	1	1.8

Site: COR30

Described: CvdB & LD **Date:** 17/07/2014 **Type:** Releve

MGA Zone: 50 402497mE; 6517323mN

Habitat: Swale. Low swale, depression

Soil: Grey/brown coarse-grained organic sand

Rock Type: NIL

Vegetation: *Banksia attenuata* and *B. menziesii* low woodland over *Melaleuca preissiana* and *Adenanthos cygnorum* subsp. *cygnorum* tall sparse shrubland over *Calytrix angulata* and *Xanthorrhoea preissii* mid sparse shrubland over *Leucopogon conostephioides* and *Hibbertia subvaginata* low sparse shrubland

Condition: Excellent

Fire Age: > 5 years

Notes: None

SPECIES LIST

Name	Cover (%)	Height (m)
Adenanthos cygnorum subsp. *cygnorum*	2	5
Allocasuarina humilis		1.8
Banksia attenuata	20	9
Banksia menziesii	1	6
Bossiaea eriocarpa		0.30
Calytrix angulata		1.4
Calytrix angulata	5	1.6
Conospermum crassinervium		1.1
Conostephium pendulum		0.50
Drosera ? erythrorhiza		Pros
Eremaea pauciflora var. *pauciflora*		1.3
Gladiolus caryophyllaceus		0.30
Hibbertia subvaginata	+	0.30
Isopogon linearis		0.40
Leucopogon conostephioides	1	0.40
Lyginia imberbis		0.30
Macrozamia riedlei		1.4
Melaleuca preissiana	1	6
Nuytsia floribunda		0.50
Phlebocarya ciliata		
Phlebocarya ciliata		0.30
Scholtzia involucrata		0.50
Stylidium cygnorum		0.10
Xanthorrhoea preissii	1	1.5

APPENDIX G

Vascular Plant Taxa Recorded

VASCULAR PLANT TAXA RECORDED

29 PTERIDACEAE

Cheilanthes austrotenuifolia

42 ZAMIACEAE

Macrozamia riedlei

80 LAURACEAE

Cassytha pomiformis

82 ARACEAE

* *Zantedeschia aethiopica* **(Declared Pest)**

109 COLCHICACEAE

Burchardia congesta

115 ORCHIDACEAE

Leporella fimbriata
Orchidaceae sp.
Pterostylis sanguinea
Pterostylis vittata

124 IRIDACEAE

* *Gladiolus caryophyllaceus*
Patersonia occidentalis var. *occidentalis*

126 XANTHORRHOEACEAE

Xanthorrhoea preissii

128 ASPARAGACEAE

Laxmannia sessiliflora
Lomandra hermaphrodita
Lomandra preissii
Lomandra purpurea
Lomandra sericea

130 HEMEROCALLIDACEAE

Dianella revoluta

138 HAEMODORACEAE

Anigozanthos humilis
Anigozanthos sp.

Conostylis aculeata subsp. *cygnorum*
Conostylis aurea
Conostylis teretifolia subsp. *teretifolia*
Haemodorum sp.
Phlebocarya ciliata

147 DASYPOGONACEAE

Calectasia narragara

156 CYPERACEAE

Caustis dioica
Lepidosperma pubisquameum (flat form)
Lepidosperma sp. Inland Scabrid (R. Barrett)
Lepidosperma sp. Northern Sandplains (R. Barrett)
Lepidosperma squamatum
Mesomelaena pseudostygia
Mesomelaena tetragona
Schoenus efoliatus

157 ANARTHRIACEAE

Lyginia imberbis

159 RESTIONACEAE

Alexgeorgea nitens
Desmocladus flexuosus
Hypolaena exsulca
Hypolaena robusta **(Priority 4)**
Lepidobolus preissianus

163 POACEAE

Amphipogon turbinatus
Austrodanthonia sp.
* *Briza maxima*

175 PROTEACEAE

Adenanthos cygnorum
Adenanthos cygnorum subsp. *cygnorum*
Banksia attenuata
Banksia bipinnatifida subsp. *multifida*
Banksia dallanneyi
Banksia dallanneyi var. *dallanneyi*
Banksia grandis
Banksia menziesii
Banksia sessilis var. *sessilis*
Conospermum crassinervium
Conospermum stoechadis
Grevillea pilulifera

Grevillea synapheae subsp. *synapheae*
Hakea amplexicaulis
Hakea costata
Hakea lissocarpha (forma)
Hakea prostrata
Hakea ruscifolia
Hakea stenocarpa
Hakea trifurcata
Isopogon linearis
Persoonia saccata
Petrophile divaricata
Petrophile macrostachya
Petrophile serruriae
Petrophile striata
Stirlingia latifolia
Synaphea spinulosa subsp. *spinulosa*

181 DILLENIACEAE

Hibbertia hibbertioides
Hibbertia hypericoides
Hibbertia racemosa
Hibbertia subvaginata

196 HALORAGACEAE

Gonocarpus cordiger

201 FABACEAE

Acacia applanata
Acacia celastrifolia
Acacia drummondii subsp. *drummondii*
Acacia extensa
Acacia huegelii
Acacia nervosa
Acacia preissiana
Acacia pulchella var. *glaberrima*
Acacia pulchella var. *pulchella*
Acacia sessilis
Bossiaea eriocarpa
Daviesia divaricata subsp. *divaricata*
Daviesia incrassata subsp. *incrassata*
Daviesia nudiflora subsp. *nudiflora*
Daviesia physodes
Daviesia preissii
Daviesia triflora
Gompholobium marginatum
Gompholobium tomentosum
Hovea trisperma

Hovea trisperma var. *trisperma*
Jacksonia floribunda
Jacksonia sternbergiana
Kennedia prostrata
* *Lupinus* sp.

208 RHAMNACEAE

Cryptandra scoparia

217 CASUARINACEAE

Allocasuarina humilis

247 PHYLLANTHACEAE

Phyllanthus calycinus

261 VIOLACEAE

Hybanthus calycinus

281 MYRTACEAE

Babingtonia camphorosmae
Beaufortia elegans
Calothamnus sanguineus
Calytrix angulata
Calytrix flavescens
Calytrix sylvana
Calytrix variabilis
Chamelaucium sp. Gingin (N.G. Marchant 6) **(Threatened)**
Corymbia calophylla
Eremaea pauciflora var. *pauciflora*
Eucalyptus marginata
Eucalyptus todtiana
Hypocalymma xanthopetalum
Kunzea glabrescens
Leptospermum spinescens
Melaleuca preissiana
Melaleuca systena
Scholtzia involucrata
Verticordia nitens

300 RUTACEAE

Boronia ramosa subsp. *anethifolia*
Boronia ramosa subsp. *ramosa*

311 THYMELAEACEAE

Pimelea imbricata var. *piligera*
Pimelea sp. 1

Pimelea sp.2

332 BRASSICACEAE

* *Brassica tournefortii*

338 SANTALACEAE

Leptomeria cunninghamii

339 LORANTHACEAE

Amyema miquelii
Nuytsia floribunda

346 DROSERACEAE

Drosera ? erythrorhiza
Drosera pallida

403 ERICACEAE

Andersonia lehmanniana subsp. *lehmanniana*
Astroloma pallidum
Astroloma stomarrhena
Astroloma xerophyllum
Conostephium pendulum
Conostephium preissii
Leucopogon conostephioides
Leucopogon gracillimus
Leucopogon racemulosus
Lysinema ciliatum
Lysinema pentapetalum
Styphelia tenuiflora

452 STYLIDIACEAE

Stylidium cygnorum
Stylidium sp.

458 GOODENIACEAE

Lechenaultia biloba

460 ASTERACEAE

* *Hypochaeris glabra*
Lagenophora huegelii
Olearia lehmanniana

474 APIACEAE

Xanthosia huegelii

APPENDIX H

Fauna Habitat Assessment Data

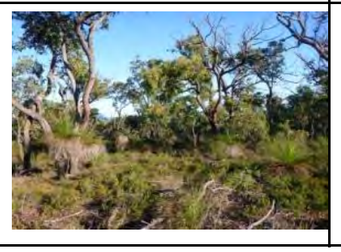
Appendix H

Habitat Assessments

Site		HA1	HA2	HA3	HA4	HA5	HA6
Coordinates	Eastings	406165	405432	405160	405741	404966	405619
	Northings	6515785	6515940	6516520	6516293	6517284	6517059
Describer		JT	JT	JT	JT	JT	JT
Date		08-Jul-14	08-Jul-14	08-Jul-14	08-Jul-14	08-Jul-14	08-Jul-14
Seasonal Conditions		Raining weather conditions	Raining weather conditions	Raining weather conditions	Raining weather conditions	Raining weather conditions	Raining weather conditions
Habitat	Type	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland
	Quality	High habitat quality	High habitat quality	High habitat quality	High habitat quality	High habitat quality	High habitat quality
Tree Denisty		27 p/ha - Jarrah - DBH 500-100mm - Height 6-9 m	30 p/ha - Jarrah - DBH 600-1200mm - Height 6-9m	35 p/ha - Jarrah- DBH 600-1000mm - Height 7-9m	16 p/ha - Jarrah - DBH 500-1000mm - Height 7-10m	12 p/ha - Jarrah - DBH 500-900mm - Height 6-8m	15 p/ha - Jarrah - DBH 500-900mm - Height 6-9m
Litter Cover		> 50%	> 50%	> 50%	> 50%	> 50%	> 50%
Fire Age (years)		> 5	> 5	> 5	> 5	> 5	> 5
Disturbance Levels		low	low	low	low	low	low
Photo Number							

Site		HA7	HA8	HA9	HA10	HA11	HA12
Coordinates	Eastings	406105	404333	404335	404275	404658	404000
	Northings	6517107	6517198	6517202	6516847	6515703	6515715
Describer		JT	JT	JT	JT	JT	JT
Date		08-Jul-14	09-Jul-14	09-Jul-14	09-Jul-14	09-Jul-14	09-Jul-14
Seasonal Conditions		Raining weather conditions	Fine weather conditions	Fine weather conditions	Fine weather conditions	Fine weather conditions	Fine weather conditions
Habitat	Type	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland
	Quality	High habitat quality	High habitat quality	High habitat quality	High habitat quality	High habitat quality	High habitat quality
Tree Denisty		26 p/ha - Jarrah - DBH 500-1000mm - Height 6-9m	13 p/ha - Jarrah - DBH 600-1000mm - Height 7-10m	21 p/ha - Jarrah - DBH 500-900mm - Height 6-9m	22 p/ha - Jarrah /Marri - DBH 600-1400 - Height 7-12m	23 p/ha - Jarrha/Marri - DBH 600-1000mm - Height 7-9m	8 p/ha - Jarrah - DBH 500-900mm - Height 6-8m
Litter Cover		> 50%	> 50%	> 50%	> 50%	> 50%	> 50%
Fire Age (years)		> 5	> 5	> 5	> 5	> 5	> 5
Disturbance Levels		low	low	low	low	low	low
Photo Number							

Site		HA13	HA14	HA15	HA16	HA17	HA18
Coordinates	Eastings	402784	402353	402517	403251	404433	403595
	Northings	651715	6516674	6516918	6517153	6515552	6515122
Describer		JT	JT	JT	JT	JT	JT
Date		09-Jul-14	09-Jul-14	09-Jul-14	09-Jul-14	10-Jul-14	10-Jul-14
Seasonal Conditions		Fine weather conditions	Fine weather conditions	Fine weather conditions	Fine weather conditions	Fine weather conditions	Fine weather conditions
Habitat	Type	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland
	Quality	High habitat quality	High habitat quality	High habitat quality	High habitat quality	High habitat quality	High habitat quality
Tree Denisty		22 p/ha - Jarrah/Marri - DBH 600-1000mm - Height 7-10m	11 p/ha - Marri/Jarrah - DBH 500-900mm - Height 7-9m	18 p/ha - Marri - DBH 500-1000mm - Height 7-10m	16 p/ha - Jarrah/Marri - DBH 500-900mm - Height 6-8m	20p/ha - Jarrah - DBH 500-900mm - Height 6-8m	11 p/ha - Jarrah/Marri - DBH 500-10000mm - Height 7-10m
Litter Cover		> 50%	> 50%	> 50%	> 50%	> 50%	> 50%
Fire Age (years)		> 5	> 5	> 5	> 5	> 5	> 5
Disturbance Levels		low	low	low	low	low	low
Photo Number							

Site		HA19	HA20	HA21	HA22	HA23	Dampland
Coordinates	Eastings	403088	403088	402649	402913	404778	402280
	Northings	6515273	6515275	6414895	6514657	6514842	6514574
Describer		JT	JT	JT	JT	JT	JT
Date		09-Jul-14	10-Jul-14	10-Jul-14	10-Jul-14	10-Jul-14	10-Jul-14
Seasonal Conditions		Fine weather conditions	Fine weather conditions	Fine weather conditions	Fine weather conditions	Fine weather conditions	Fine weather conditions
Habitat	Type	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland	Eucalypt Woodland	Damlands
	Quality	High habitat quality	High habitat quality	High habitat quality	High habitat quality	High habitat quality	Moderate quality
Tree Denisty		23 p/ha - Jarrah/Marri - DBH 600-1000mm - 8-10m	24 p/ha - Jarrah/Marri - DBH 500-1000mm - Height 7-9m	21p/ha - Jarrah/Marri - DBH 600-1100mm - Height 8-11m	10 p/ha - Marri - DBH 500-1000mm - 7-9m	16 p/ha - Jarrah - DBH 600-1000mm - Height 7-10m	N/A
Litter Cover		> 50%	> 50%	> 50%	> 50%	> 50%	> 50%
Fire Age (years)		> 5	> 5	> 5	> 5	> 5	> 5
Disturbance Levels		low	low	low	low	low	low
Photo Number							

Site		BW1	BW2
Coordinates	Eastings	403327	402989
	Northings	6516329	6515567
Describer		JT	JT
Date		10-Jul-14	10-Jul-14
Seasonal Conditions		Fine weather conditions	Fine weather conditions
Habitat	Type	Banksia Woodland	Banksia Woodland
	Quality	Moderate habitat	Moderate habitat
Tree Denisty		N/A	N/A
Litter Cover		> 50%	> 50%
Fire Age (years)		> 5	> 5
Disturbance Levels		low	low
Photo Number			

APPENDIX I

Black Cockatoo Breeding Trees

Appendix I
Trees of Significance

Code	Tree Species	Easting	Northing	DBH	Height	Hollows	Notes
25	Jarrah	406054	6515720	70	8	1 Medium	
29	Jarrah	406009	6515709	80	8	1 Large	
31	Jarrah	405973	6515728	150	8	2 Large	
33	Jarrah	405956	6515744	180	8	1 Small	Burnt
36	Jarrah	405916	6515719	90	7	1 Large	Fire
48	Jarrah	405844	6515754	90	8	1 Medium	
56	Jarrah	405750	6515742	70	8	2 Small	
65	Jarrah	406018	6515823	80	8	1 Small	
70	Jarrah	406056	6515793	70	8	1 Medium	Photo
89	Jarrah	406266	6515860	100	7	1 Large	
101	Jarrah	406054	6515926	80	7	2 Large	
109	Jarrah	405989	6515915	70	6	4 Small/ 1 Large	
115	Jarrah	405958	6515955	150	8	1 Medium / 2 Large	Photo
126	Jarrah	406110	6516000	100	7	2 Small/ 2 Medium	
135	Jarrah	406151	6515929	60	6	1 Medium	
146	Jarrah	405379	6515876	80	6	1 Large	
147	Jarrah	405389	6515873	70	8	2 Large	
148	Jarrah	405454	6515793	120	8	4 Large	
149	Jarrah	405283	6516464	100	8	3 Large	
150	Jarrah	405086	6517290	60	6	1 Small	
151	Jarrah	404912	6517312	60	8	1 Large	
152	Jarrah	405625	6516947	70	8	2 Large	
153	Jarrah	405602	6516964	90	8	2 Large	
154	Jarrah	405964	6517159	80	8	2 Large	
155	Jarrah	404329	6517204	90	9	1 Large	
156	Jarrah	404332	6517102	80	8	1 Large	
157	Jarrah	404313	6516939	140	12	1 Large	Galah nest
158	Jarrah	404167	6516746	60	8	1 Medium	
159	Marri	404699	6515871	90	10	1 Large	
160	Jarrah	404417	6515523	90	8	1 Small/ 1 Large	
161	Jarrah	403077	6515285	70	8	1 Medium	
162	Jarrah	402622	6514838	110	10	1 Large	
163	Jarrah	404878	6514801	100	9	2 Large	
164	Jarrah	404871	6514797	90	10	2 Large	

Appendix I

Tree density survey

Site name	Easting	Nothing	No. of trees	Type of tree	DBH range (mm)	Height range (m)	Photo No.	Notes
HA1	406158	6515797	27	Jarrah	500 - 1000	6 - 9		
HA2	405424	6515951	30	Jarrah	600 - 1200	6 - 9		
HA3	405177	6516518	35	Jarrah	600 - 1000	7 - 9		
HA4	405742	6516304	16	Jarrah	500 - 1000	7 - 10		
HA5	404954	6517302	12	Jarrah	500 - 900	6 - 8		
HA6	405618	6517058	15	Jarrah	500 - 900	6 - 9	Photo 324/25	
HA7	406105	6517105	26	Jarrah	500 - 1000	6 - 9	Photo 326/27	
HA8	404318	6517243	13	Jarrah	600 - 1000	7 -10	Photo 328/29	Note: Due to fire hollows present
HA9	403741	6517069	21	Jarrah	500 - 900	6 - 9		
HA10	404266	6516844	22	21 Jarrah / 1 Marri	600 - 1400	7 - 12		
HA11	404666	6515685	23	21 Jarrah / 2 Marri	600 - 1000	7 - 9	Photo 330/331	
HA12	404007	6515724	8	Jarrah	500 - 900	6 - 8		
HA13	402777	6515915	22	19 Jarrah / 3 Marri	600 - 1000	7 - 10		
HA14	402350	6516687	11	3 Jarrah / 8 Marri	500 - 900	7 - 9		
HA15	402506	6516917	18	Marri	500 - 1000	7 -10		
HA16	403245	6517160	16	11 Jarrah / 5 Marri	500 - 900	6 - 8		
HA17	404437	6515593	20	Jarrah	500 - 900	6 - 8		
HA18	403600	6515137	11	6 Jarrah / 5 Marri	500 - 1000	7 - 10		
HA19	403073	6515294	23	21 Jarrah / 2 Marri	600 - 1000	8 - 10	Photo 334/35	Note: Almost hollow bearing
HA20	402519	6515753	24	21 Jarrah / 3 Marri	500 - 1000	7 - 9		
HA21	402661	6514894	21	11 Jarrah / 10 Marri	600 - 1100	8 - 11	Photo 336/37	
HA22	402915	6514664	10	Marri	500 - 1000	7 - 9		
HA23	404770	6514850	16	Jarrah	600 - 1000	7 - 10	Photo 341/42	

APPENDIX J

Vertebrate Fauna Predicted to Occur within the Study Area

SPECIES	VERNACULAR	Conservation Status	EPBC Search	DPAW Search	NatureMap	Birdata	Tingay, 1994	Burbridge et al, 1996	ATA, 2007	GHD, 2014	Current Survey
Amphibians											
Litoria adelaidensis	Slender Tree Frog				X						
Litoria moorei	Motorbike Frog				X						
Heleioporus eyrei	Moaning Frog				X		X	X	X		
Heleioporus psammophilus	Sand Frog				X						
Limnodynastes dorsalis	Western Banjo Frog				X		X	X	X		
Neobatrachus pelobatoides	Humming Frog				X						
Crinia georgiana	Quacking Frog				X		X				X
Crinia glauerti	Clicking Frog				X		X				
Crinia insignifera	Squelching Froglet				X		X				
Geocrinia leai	Ticking Frog				X						
Myobatrachus gouldii	Turtle Frog							X	X	X	
Pseudophryne guentheri	Crawling Toadlet				X						
Reptiles											
Ctenophorus adelaidensis	Western Heath Dragon				X			X			
Pogona minor	Dwarf Bearded Dragon				X		X	X	X	X	
Strophurus spinigerus	Soft Spiny-tailed Gecko				X		X			X	
Underwoodisaurus milii	Southern Barking Gecko				X						
Christinus marmoratus	Marbled Gecko									X	
Ctrenadaytulus ocellatus								X			
Gehyra variegata					X						
Hemidactylus frenatus	Asian House Gecko	In	X								
Aprasia pulchella					X						
Aprasia repens	Sand-plain Worm Lizard				X			X		X	
Delma fraseri								X			
Lialis burtonis	Burton's Legless Lizard				X				X	X	
Pygopus lepidopodus	Common Scaly Foot				X			X			
Pletholax gracilis								X	X		
Cryptoblepharus buchananii	Buchanan's Snake-eyed Sink				X					X	X
Cryptoblepharus plagiocephalus					X		X	X	X		
Ctenotus australis	West Coast Long-tailed Ctenotus				X				X	X	
Ctenotus fallens								X	X	X	X
Egernia napoleonis					X		X				
Hemiergis initialis									X		
Hemiergis quadrilineata					X		X		X	X	
Lerista christinae					X						
Lerista distinguenda								X		X	
Lerista elegans					X		X		X	X	
Lerista lineopunctulata					X						
Lerista praepedita					X		X	X		X	
Menetia greyii	Common Dwarf Skink				X		X		X	X	
Morethia lineoocelatta										X	
Morethia obscura	Dusky Morethia				X			X	X	X	
Tiliqua occipitalis	Western Bluetongue								X	X	
Tiliqua rugosa	Bobtail Skink							X	X	X	
Varanus gouldii	Bungarra or Sand Monitor								X	X	
Ramphotyphlops australis					X				X	X	
Ramphotyphlops braminus	Flowerpot Blind Snake	In	X								

SPECIES	VERNACULAR	Conservation Status	EPBC Search	DPAW Search	NatureMap	Birdata	Tingay, 1994	Burbridge et al, 1996	ATA, 2007	GHD, 2014	Current Survey
Ramphotypholops pinguis										X	
Ramphotypholops waitii										X	
Antaresia stimsoni	Stimson's Python				X						
Morelia spilota imbricata	Western Carpet Python	S4								X	
Brachyurophis semifasciatus	Southern Shovel-nosed Snake				X			X		X	X
Echiopsis curta	Bardick				X				X		
Elapognathus coronatus	Crowned Snake				X						
Neelaps bimaculatus	Black-naped Snake							X			
Neelaps calonotos	Black-striped Snake	P3		X	X			X			
Notechis scutatus	Tiger Snake				X		X	X			
Parasuta gouldii					X				X		
Pseudonaja affinis	Dugite							X	X	X	
Simoselaps bertholdi	Jan's Banded Snake				X				X	X	
Birds											
Dromaius novaehollandiae	Emu				X	X	X	X	X	X	X
Coturnix pectoralis	Stubble Quail				X	X					
Coturnix ypsilophora	Brown Quail					X				X	
Phasianus colchicus	Common Pheasant (Domestic Pheasant)	In				X					
Elanus caeruleus	Black-shouldered Kite				X		X	X			
Hamirostra isura	Square-tailed Kite					X					
Haliastur sphenurus	Whistling Kite				X	X		X		X	
Accipiter fasciatus	Brown Goshawk				X	X			X	X	
Accipiter cirrocephalus	Collared Sparrowhawk				X	X		X	X		
Aquila morphnoides	Little Eagle				X	X					X
Aquila audax	Wedge-tailed Eagle					X	X	X		X	
Circus assimilis	Spotted Harrier					X					
Circus approximans	Swamp Harrier				X	X					
Falco berigora	Brown Falcon				X	X		X			
Falco cenchroides	Australian Kestrel				X	X		X			
Falco longipennis	Australian Hobby				X	X		X		X	
Falco peregrinus	Peregrine Falcon	S4		X	X	X			X		
Turnix varia	Painted Button-quail					X			X		
Turnix velox	Little Button-quail				X	X					
Burhinus grallarius	Bush Stone curlew	P4				X					
Vanellus tricolor	Banded Lapwing					X					
Columba livia	Domestic Pigeon	In	X			X				X	
Streptopelia senegalensis	Laughing Turtle-Dove	In	X		X	X	X		X		
Streptopelia chinensis	Spotted Turtle-Dove	In	X			X					
Phaps chalcoptera	Common Bronzewing				X	X		X	X	X	
Phaps elegans	Brush Bronzewing	P4				X					
Ocyphaps lophotes	Crested Pigeon				X	X		X	X	X	X
Calyptorhynchus banksii naso	Forest Red-tailed Black Cockatoo	Vu,S1			X	X					
Calyptorhynchus latirostris	Carnaby's Cockatoo	En, S1	X	X	X	X		X	X	X	
Calyptorhynchus baudinii	Baudin's Cockatoo	Vu,S1		X	X	X					
Cacatua roseicapilla	Galah					X	X	X	X	X	X
Cacatua tenuirostris	Eastern Long-billed Corella				X	X					
Cacatua pastinator	Western Long-billed Corella				X	X	X				
Cacatua sanguinea	Little Corella				X	X			X	X	

Previously recorded fauna

SPECIES	VERNACULAR	Conservation Status	EPBC Search	DPAW Search	NatureMap	Birdata	Tingay, 1994	Burbridge et al, 1996	ATA, 2007	GHD, 2014	Current Survey
Cacatua galerita	Sulphur-crested Cockatoo				X	X					
Nymphicus hollandicus	Cockatiel					X					
Trichoglossus haematodus	Rainbow Lorikeet					X				X	
Glossopsitta porphyrocephala	Purple-crowned Lorikeet				X	X		X		X	
Polytelis anthopeplus	Regent Parrot					X					
Platycercus zonarius	Australian Ringneck (Ring-necked Parrot)				X	X	X	X	X	X	X
Platycercus spurius	Red-capped Parrot				X	X		X	X	X	X
Platycercus icterotis	Western Rosella				X	X					
Neophema elegans	Elegant Parrot								X		
Neophema petrophila	Rock Parrot					X					
Melopsittacus undulatus	Budgerigar				X						
Cuculus pallidus	Pallid Cuckoo				X	X		X			X
Cacomantis flabelliformis	Fan-tailed Cuckoo				X	X	X	X		X	
Chrysococcyx osculans	Black-eared Cuckoo										X
Chrysococcyx basalis	Horsfield's Bronze Cuckoo					X		X	X	X	X
Chrysococcyx lucidus	Shining Bronze Cuckoo				X	X	X	X			
Ninox connivens	Barking Owl	P2				X					
Ninox novaeseelandiae	Boobook Owl				X	X		X	X	X	X
Tyto alba	Barn Owl								X	X	
Podargus strigoides	Tawny Frogmouth				X	X		X	X	X	
Aegotheles cristatus	Australian Owlet-nightjar				X			X		X	
Apus pacificus	Fork-tailed Swift	S3	X			X					
Dacelo novaeguineae	Laughing Kookaburra				X	X	X	X	X	X	X
Todiramphus sanctus	Sacred Kingfisher				X	X		X	X	X	
Merops ornatus	Rainbow Bee-eater	S3	X	X	X	X	X	X	X	X	
Climacteris rufa	Rufous Treecreeper					X					
Malurus splendens	Splendid Fairy-wren				X	X	X	X	X	X	X
Malurus lamberti	Variegated Fairy-wren				X	X					
Malurus pulcherrimus	Blue-breasted Fairy-wren				X	X					
Malurus elegans	Red-winged Fairy-wren					X					
Malurus leucopterus	White-winged Fairy-wren				X	X		X			
Stipiturus malachurus	Southern Emu-wren					X					
Pardalotus punctatus	Spotted Pardalote				X	X					
Pardalotus striatus	Striated Pardalote				X	X		X	X	X	X
Sericornis frontalis	White-browed Scrubwren				X	X					
Calamanthus campestris	Rufous Fieldwren					X					
Smicrornis brevirostris	Weebill				X	X		X	X	X	
Gerygone fusca	Western Gerygone				X	X	X	X	X	X	X
Acanthiza apicalis	Broad-tailed Thornbill (Inland Thornbill)				X	X	X	X	X		X
Acanthiza inornata	Western Thornbill				X	X		X	X	X	
Acanthiza chrysorrhoa	Yellow-rumped Thornbill				X	X		X		X	
Lichmera indistincta	Brown Honeyeater				X	X	X	X	X	X	X
Lichenostomus virescens	Singing Honeyeater					X		X		X	X
Lichenostomus ornatus	Yellow-plumed Honeyeater					X		X			
Lichenostomus leucotis	White-eared Honeyeater					X					
Melithreptus brevirostris	Brown-headed Honeyeater				X	X		X		X	
Phylidonyris novaehollandiae	New Holland Honeyeater				X	X		X			
Phylidonyris nigra	White-cheeked Honeyeater					X	X		X	X	

Previously recorded fauna

SPECIES	VERNACULAR	Conservation Status	EPBC Search	DPAW Search	NatureMap	Birdata	Tingay, 1994	Burbridge et al, 1996	ATA, 2007	GHD, 2014	Current Survey
Phylidonyris albifrons	White-fronted Honeyeater					X					
Phylidonyris melanops	Tawny-crowned Honeyeater					X		X			
Acanthorhynchus superciliosus	Western Spinebill				X	X	X	X	X		X
Manorina flavigula	Yellow-throated Miner				X	X		X			
Acanthagenys rufogularis	Spiny-cheeked Honeyeater					X					
Anthochaera lunulata	Western Little Wattlebird				X	X		X		X	
Anthochaera carunculata	Red Wattlebird				X	X	X	X	X	X	X
Epthianura albifrons	White-fronted Chat				X	X		X			
Epthianura tricolor	Crimson Chat					X					
Microeca fascinans	Jacky Winter					X				X	
Petroica multicolor	Scarlet Robin					X		X	X	X	X
Petroica goodenovii	Red-capped Robin				X	X		X			X
Petroica cucullata	Hooded Robin					X		X			
Eopsaltria australis	Yellow Robin					X				X	
Eopsaltria georgiana	White-breasted Robin					X					
Daphoenositta chrysoptera	Varied Sittella				X	X		X	X	X	X
Oreoica gutturalis	Crested Bellbird					X					
Pachycephala pectoralis	Golden Whistler				X	X		X		X	
Pachycephala rufiventris	Rufous Whistler				X	X	X	X	X	X	X
Colluricincla harmonica	Grey Shrike-thrush				X	X	X	X	X	X	X
Rhipidura fuliginosa	Grey Fantail				X	X	X	X	X	X	X
Rhipidura leucophrys	Willie Wagtail				X	X	X	X	X	X	
Grallina cyanoleuca	Magpie-lark				X	X	X	X		X	
Coracina novaehollandiae	Black-faced Cuckoo-shrike				X	X	X		X	X	X
Lalage tricolor	White-winged Triller					X		X		X	
Artamus personatus	Masked Woodswallow					X					
Artamus cinereus	Black-faced Woodswallow				X	X		X			
Artamus cyanopterus	Dusky Woodswallow				X	X		X			X
Cracticus torquatus	Grey Butcherbird				X	X		X	X	X	X
Cracticus nigrogularis	Pied Butcherbird				X	X					
Cracticus tibicen	Australian Magpie				X	X		X	X	X	X
Strepera versicolor	Grey Currawong				X	X				X	
Corvus coronoides	Australian Raven				X	X		X	X	X	X
Ptilonorhynchus maculatus	Spotted Bowerbird					X					
Sturnus vulgaris	Common Starling	In	X								
Acridotheres tristis	Common Myna	In	X								
Cheramoeca leucosternus	White-backed Swallow					X		X			
Hirundo neoxena	Welcome Swallow				X	X		X		X	X
Hirundo nigricans	Tree Martin				X	X		X		X	
Hirundo ariel	Fairy Martin					X					X
Zosterops lateralis	Grey-breasted White-eye (Silvereye)				X	X	X	X	X	X	
Acrocephalus australis	Australian Reed Warbler				X	X	X				
Megalurus gramineus	Little Grassbird				X	X					
Cincloramphus mathewsi	Rufous Songlark				X	X		X			
Cincloramphus cruralis	Brown Songlark				X	X					
Dicaeum hirundinaceum	Mistletoebird				X			X		X	
Passer domesticus	House Sparrow	In	X								
Passer montanus	Eurasian Tree Sparrow	In	X								

Appendix J

Previously recorded fauna

SPECIES	VERNACULAR	Conservation Status	EPBC Search	DPAW Search	NatureMap	Birdata	Tingay, 1994	Burbridge et al, 1996	ATA, 2007	GHD, 2014	Current Survey
Stagonopleura oculata	Red-eared Firetail					X					
Lonchura castaneothorax	Chestnut-breasted Mannikin					X					
Anthus australis	Australian Pipit					X					
Carduelis carduelis	Goldfinch (European Goldfinch)	In	X			X					
Mammals											
Tachyglossus aculeatus	Echidna				X			X		X	
Dasyurus geoffroii	Western Quoll, Chuditch	Vu,S1	X	X	X						
Sminthopsis griseoventer	Grey-bellied Dunnart							X			
Isoodon obesulus fusciventer	Southern Brown Bandicoot	P5		X	X		X			X	
Macropus fuliginosus	Western Grey Kangaroo				X		X	X		X	X
Macropus irma	Western Brush Wallaby	P4						X			X
Macropus robustus	Euro, Biggada				X						
Trichosurus vulpecula	Common Brushtail Possum									X	
Cercartetus concinnus	Western Pygmy-possum, Mundarda				X						
Tarsipes rostratus	Honey Possum, Noolbenger						X	X	X		
Chalinolobus gouldii	Gould's Wattled Bat				X			X		X	
Nyctophilus geoffroyi	Lesser Long-eared Bat				X			X		X	
Nyctophilus gouldi	Gould's Long-eared Bat				X			X			
Vespadelus regulus	Southern Forest Bat							X			
Tadarida australis	White-striped Freetail-bat									X	
Mus musculus	House Mouse	In	X		X		X	X	X	X	
Pseudomys albocinereus	Ash-grey Mouse				X			X			
Rattus norvegicus	Brown Rat	In	X								
Rattus rattus	Black Rat	In	X		X		X			X	
Funambulus pennanti	Indian Palm Squirrel	In	X								
Oryctolagus cuniculus	Rabbit	In	X				X	X		X	
Canis lupus	Dog	In	X							X	
Vulpes vulpes	Red Fox	In	X				X	X		X	X
Felis catus	Cat	In	X		X			X		X	
Sus scrofa	Pig	In	X								
Bos taurus	European Cattle	In	X								
Capra hircus	Goat	In	X								
Cervus elaphus	Red Deer	In	X								

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Appendix C. Completed EPBC Offset Guide

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Offsets Assessment Guide

For use in determining offsets under the *Environment Protection and Biodiversity Conservation Act 1999*
2 October 2012

This guide relies on Macros being enabled in your browser.

Matter of National Environmental Significance	
Name	CBC
EPBC Act status	Endangered
Annual probability of extinction Based on IUCN category definitions	**1.2%**

Key to Cell Colours
User input required
Drop-down list
Calculated output
Not applicable to attribute

Impact calculator

Protected matter attributes	Attribute relevant to case?	Description	Quantum of impact		Units	Information source
Ecological communities						
Area of community	No		**Area**			
			Quality			
			Total quantum of impact	0.00		
Threatened species habitat						
Area of habitat	Yes	Clearing of CBC Habitat	**Area**	52.54	Hectares	
			Quality	**7**	Scale 0-10	
			Total quantum of impact	36.78	Adjusted hectares	
Protected matter attributes	**Attribute relevant to case?**	**Description**	**Quantum of impact**		**Units**	**Information source**
Number of features e.g. Nest hollows, habitat trees	Yes	Known Nesting Tree	6		Count	CBC Survey
Condition of habitat Change in habitat condition, but no change in extent	No					
Threatened species						
Birth rate e.g. Change in nest success	No					
Mortality rate e.g Change in number of road kills per year	No					
Number of individuals e.g. Individual plants/animals	No					

Offset calculator

Protected matter attributes	Attribute relevant to case?	Total quantum of impact	Units	Proposed offset	Time horizon (years)		Start area and quality		Future area and quality without offset		Future area and quality with offset		Raw gain	Confidence in result (%)	Adjusted gain	Net present value (adjusted hectares)	% of impact offset	Minimum (90%) direct offset requirement met?	Cost ($ total)	Information source
Ecological Communities																				
Area of community	No				**Risk-related time horizon (max. 20 years)**		**Start area (hectares)**		**Risk of loss (%) without offset**		**Risk of loss (%) with offset**									
									Future area without offset (adjusted hectares)	0.0	**Future area with offset (adjusted hectares)**	0.0									
					Time until ecological benefit		**Start quality (scale of 0-10)**		**Future quality without offset (scale of 0-10)**		**Future quality with offset (scale of 0-10)**									
Threatened species habitat																				
Area of habitat	Yes	36.78	Adjusted hectares	Land with vegetation in excellent condition	**Time over which loss is averted (max. 20 years)**	20	**Start area (hectares)**	200	**Risk of loss (%) without offset**	30%	**Risk of loss (%) with offset**	5%	50.00	90%	45.00	35.45	37.26	101.32%	Yes	
									Future area without offset (adjusted hectares)	140.0	**Future area with offset (adjusted hectares)**	190.0								
					Time until ecological benefit	1	**Start quality (scale of 0-10)**	**7**	**Future quality without offset (scale of 0-10)**	**6**	**Future quality with offset (scale of 0-10)**	**7**	1.00	90%	0.90	0.89				
Protected matter attributes	**Attribute relevant to case?**	**Total quantum of impact**	**Units**	**Proposed offset**	**Time horizon (years)**		**Start value**		**Future value without offset**		**Future value with offset**		**Raw gain**	**Confidence in result (%)**	**Adjusted gain**	**Net present value**	**% of impact offset**	**Minimum (90%) direct offset requirement met?**	**Cost ($ total)**	**Information source**
Number of features e.g. Nest hollows, habitat trees	Yes	6	Count	Artificial hollows	1		1		1		8		7	90%	6.30	6.23	103.75%	Yes		
Condition of habitat Change in habitat condition, but no change in extent	No																			
Threatened species																				
Birth rate e.g. Change in nest success	No																			
Mortality rate e.g Change in number of road kills per year	No																			
Number of individuals e.g. Individual plants/animals	No																			

Offsets Assessment Guide

For use in determining offsets under the *Environment Protection and Biodiversity Conservation Act 1999*
2 October 2012

This guide relies on Macros being enabled in your browser.

Matter of National Environmental Significance	
Name	Banksia Woodlands TEC
EPBC Act status	Endangered
Annual probability of extinction Based on IUCN category definitions	**1.2%**

Key to Cell Colours
User input required
Drop-down list
Calculated output
Not applicable to attribute

Impact calculator

Protected matter attributes	Attribute relevant to case?	Description	Quantum of impact		Units	Information source
Ecological communities						
Area of community	Yes	Remnant Vegetation (below 30% threshold)	**Area**	7.49	Hectares	
			Quality	7	Scale 0-10	
			Total quantum of impact	5.24	Adjusted hectares	
Threatened species habitat						
Area of habitat	No		**Area**			
			Quality			
			Total quantum of impact	0.00		
Protected matter attributes	**Attribute relevant to case?**	**Description**	**Quantum of impact**		**Units**	**Information source**
Number of features e.g. Nest hollows, habitat trees	No					
Condition of habitat Change in habitat condition, but no change in extent	No					
Threatened species						
Birth rate e.g. Change in nest success	No					
Mortality rate e.g Change in number of road kills per year	No					
Number of individuals e.g. Individual plants/animals	No					

Offset calculator

Protected matter attributes	Attribute relevant to case?	Total quantum of impact	Units	Proposed offset	Time horizon (years)		Start area and quality		Future area and quality without offset		Future area and quality with offset		Raw gain	Confidence in result (%)	Adjusted gain	Net present value (adjusted hectares)		% of impact offset	Minimum (90%) direct offset requirement met?	Cost ($ total)	Information source
Ecological Communities																					
Area of community	Yes	5.24	Adjusted hectares	Land with vegetation in excellent condition	**Risk-related time horizon (max. 20 years)**	20	**Start area (hectares)**	28.15	**Risk of loss (%) without offset**	30%	**Risk of loss (%) with offset**	5%	7.04	90%	6.33	4.99	5.25	100.04%	Yes		
									Future area without offset (adjusted hectares)	19.7	**Future area with offset (adjusted hectares)**	26.7									
					Time until ecological benefit	1	**Start quality (scale of 0-10)**	7	**Future quality without offset (scale of 0-10)**	6	**Future quality with offset (scale of 0-10)**	7	1.00	90%	0.90	0.89					
Threatened species habitat																					
Area of habitat	No			Land with vegetation in a good condition	**Time over which loss is averted (max. 20 years)**		**Start area (hectares)**		**Risk of loss (%) without offset**		**Risk of loss (%) with offset**										
									Future area without offset (adjusted hectares)	0.0	**Future area with offset (adjusted hectares)**	0.0									
					Time until ecological benefit		**Start quality (scale of 0-10)**		**Future quality without offset (scale of 0-10)**		**Future quality with offset (scale of 0-10)**										
Protected matter attributes	**Attribute relevant to case?**	**Total quantum of impact**	**Units**	**Proposed offset**	**Time horizon (years)**		**Start value**		**Future value without offset**		**Future value with offset**		**Raw gain**	**Confidence in result (%)**	**Adjusted gain**	**Net present value**		**% of impact offset**	**Minimum (90%) direct offset requirement met?**	**Cost ($ total)**	**Information source**
Number of features e.g. Nest hollows, habitat trees	No																				
Condition of habitat Change in habitat condition, but no change in extent	No																				
Threatened species																					
Birth rate e.g. Change in nest success	No																				
Mortality rate e.g Change in number of road kills per year	No																				
Number of individuals e.g. Individual plants/animals	No																				